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# Hot Pepper Extract Enhanced the Quality Characteristics and Antioxidant Potentials of Scorched Rice Chips, *Nuroong-gi*

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**Abstract:** Scorched rice chip, locally known as Nuroong-gi, is a famous processed rice product in Korea. Nutritionally enriched Nuroong-gi, an easy-to-make rice product, is of great importance, especially to supply nutritious diets to the rural poor who reside in the less developed countries. In this study, Nuroong-gi was produced by addition hot pepper extract in order to enhance its nutritional value. The objective of this study was to investigate the effect of the pepper extract on antioxidant potential and quality characteristics of fresh as well as stored (90 days) Nuroong-gi. The addition of pepper extract significantly enhanced the antioxidant potential and the overall acceptance of Nuroong-gi, however the viscosity was not notably altered, compared to the regular product. The results of this study suggest that pepper extract could be one of the efficient ways to enhance the antioxidant potential and the overall acceptance of Nuroong-gi.

**Keywords**: Antioxidant Potential, Hot Pepper, Nuroong-gi, Overall Acceptance

**Introduction**

Rice is an important crop as it is the staple food for nearly half of the world's population (Godfray et al., 2010). Although people, especially in the developing countries, are fortunate to have access to at least a monotonous diet in which a single crop such as rice predominates, are deprived of having nutritious foods. There have different technologies been developed, including agricultural biotechnology, to nutritionally enhance the contents and bioavailability of essential nutrients, such as iron and vitamin A (Gilani and Nasim, 2007; Pachón et al., 2009; Pérez-Massot et al., 2013). Under such circumstances, enhancing nutritional value of easily accessible foods such as scorched rice chips (SRCs) is of great importance, especially to supply nutritious diets to the rural poor who reside in the developing countries. SRCs, locally known as Nuroong-gi in Korea, are an oriental food that is consumed in the form of porridge, beverages, or snacks. They are produced without frying or baking the cooked rice kernels which are used as a primary ingredient. In a commercial scale, Nuroong-gi is produced by soaking rice in water, later the rice is drained and steamed, then formed to shape and roasted to obtain a crispy texture with flavor development (Lee et al., 2015).

Various studies have been conducted to investigate the textural and sensory properties of Nuroong-gi (Leelayuthsoontorn and Thipayarat, 2006; Yadav and Jindal, 2007) as well as physicochemical characteristics and quality properties of baking- and frying-based rice chips and rice snacks (Siegel and Lineback, 1976; Keeratipibul et al., 2008; Maneerote et al., 2009; Nakamura et al., 2012). However, researches to enhance nutritional values, including antioxidant potentials, are lacking.

Pepper is a very important spicy food with different nutrients and phytochemicals having health promoting effects like anti-obesity activity (Jeon et al., 2010) and antioxidant activity (Jang et al., 2015). Peppers also contain various therapeutic-related materials such as capsaicinoids, phenolic compounds, and carotenoids (Hernandez-Ortega et al., 2012). A study (Yazdizadeh Shotorban et al., 2012) conducted with rats showed that the antioxidant activity of bell


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pepper had a protective effect on brain cells. The fresh fruit of pepper is known as an excellent source of Vitamin C and E as well as provitamin A, carotenoids and polyphenols (Nazzaro et al., 2009; Yazdizadeh Shotorban et al., 2012; Shaha et al., 2013).

Although pepper is a widely grown and used spice crop, no scientific study on the use of peppers to enhance the functional properties of Nuroong-gi has been reported so far. The objective of present study was to investigate the effect of pepper on the physicochemical and antioxidant potentials of Nuroong-gi.

## Materials and methods

### Materials

Brown rice, harvested at yoengchun-si, Korea and hot pepper, grown at youngyang-gun, Korea, were obtained for making Nuroong-gi.

### Extraction of hot pepper

The hot peppers were oven-dried (60℃) and ground into powder using a commercial grinder (HIL-G501, Hanil Co., Seoul, Korea). One kilogram of hot pepper powder was extracted with 10 L of prethanol-A, an ethanol-based food preservative, at 20±1℃ for 24 h with occasional shaking. The mixture was kept stand-still for sedimentation and was filtered through Whatman No. 4 filter paper. The filtrate was concentrated by using a rotary evaporator.

### Nuroong-gi preparation

Brown rice (1 kg) was washed with tap water and soaked in 5 L water for 3 h and drained for 30 min. The rice was cooked with four different concentrations of extract prepared with the hot pepper extract diluted with water (0:1, 1:0, 1:5 and 1:10 v/v) followed by roasting for Nuroong-gi preparation (Lee et al., 2015).

### Packaging and storage of Nuroong-gi

The Nuroong-gi samples were packed into polyethylene terephthalate (PET) bags under atmospheric conditions. Each sample was packed separately. Nuroong-gi samples were stored in a climate chamber (Hanil, SK-202, Gimpo, Korea) at ambient and elevated temperature (22±1℃ and 30±1℃, respectively). The relative humidity was set at a constant value of 35~40%. The storage period was 90 days for Nuroong-gi samples kept at elevated temperature. The Nuroong-gi samples were analyzed at 0 and 90 days for their physicochemical characteristics.

### Evaluation of sensory properties

The freshly prepared and 90-day stored Nuroong-gi samples were used for evaluating the sensory properties. Different Nuroong-gi samples were assessed for color, flavor, texture and overall acceptance using the scale values 1= very bad, 2= bad, 3= moderate, 4= good, 5= very good. Twenty volunteer panelists (10 women and 10 men) selected from the list of graduate students of College of Agriculture and Life Sciences of Kyungpook National University, Deagu, Korea were assigned to evaluate the sensory properties (Kim et al., 2015).

### Color measurement

L* (lightness), a* (redness, + or greenness, –), and b* (yellowness, + or blueness, –) values of Nuroong-gi were measured using a Chroma Meter (CR-300, Minolta Corp., Japan). A Minolta calibration plate (YCIE = 94.5 XCIE = 0.3160 YCIE = 0.330) and a Hunter Lab standard plate (L* = 82.13, a* = –5.24, b* = –0.55) were used to standardize the instrument with D65 illuminant. Color was measured directly on three zones of the samples and the average was calculated (Kim et al., 2014).

### Viscosity measurement

A Brookfield viscometer (model-DVII, Brookfield Engineering Labs, Middleborough, MA, USA) was used to determine the viscosity of prepared Nuroong-gi. The conditions to measure the apparent viscosity of prepared Nuroong-gi suspensions involved a stirring speed of 100 rpm for 3 min at 35℃. The suspensions were prepared with 10 g of Nuroong-gi powder and 300 mL of distilled water in a mixer (KT-325, Hanil, Gimpo, Korea).

### Determination of DPPH scavenging potential

The DPPH free radical scavenging potential of Nuroong-gi was determined following the method described by Shyu and Hwang (2002) with some modification. One hundred microliters of the methonolic sample extract (1: 10 w/v) was added to 2 mL of acetate buffer (0.05 M, pH 5.5), 1.9 mL of methanol and 1 mL of DPPH solution (0.5 mM). Blank contained 2 mL of acetate buffer, 1.9 mL of methanol and 0.1 mL of sample extract, while the control contained 2 mL of acetate buffer, 1 mL of DPPH and 2 mL of methanol. The mixture was shaken immediately after adding DPPH and allowed to stand at room temperature in the dark for 30 min. The absorbance was measured at 517 nm using a spectrophotometer (UV-1700, Shimadzu, Kyoto, Japan). The DPPH radical scavenging potential of the samples was calculated using the following equation:

Scavenging effect (%) = $[(A_0 - (A - A_b)) / A_0] \times 100$

where $A_0$ is the absorbance of DPPH without sample (control), A is the absorbance of sample and DPPH, and $A_b$ is the absorbance of sample without DPPH (blank).

**Determination of total phenol**

The total phenol content was measured following the Folin-Ciocalteu method (Singleton et al., 1999). A 0.79-mL of distilled water, 0.01 mL of methanolic sample extract (1:10 w/v) and 0.05 mL of phenol reagent were mixed in a 1.5-mL Eppendorf tube. After 1 min, 0.15 mL of 20% sodium carbonate was added to the mixture and allowed to stand at room temperature for 2 h. The absorbance of reaction mixture was measured at 750 nm using a spectrophotometer (UV-1700, Shimadzu, Kyoto, Japan) and the total phenol content was calculated based on the calibration curve plotted by using gallic acid as a standard.

**Statistical analysis**

Data were subjected to analysis of variance (ANOVA) using SAS 9.4 (SAS Institute Inc., Cary, NC, USA). Differences between means, at $p<0.05$, were identified using Tukey test. Average values are presented as mean±standard deviation (SD).

**Results and Discussion**

**Sensory characteristics of Nuroong-gi**

Evaluation of sensory characteristics showed that addition of hot pepper extracts could significantly affect the color, flavor, texture and overall acceptance of fresh (Table 1) and 90-day stored (Table 2) Nuroong-gi. Overall acceptance value of the freshly prepared (4.3) and the stored (4.5) Nuroong-gi prepared with 1:5 ratio of hot pepper extract and water was significantly high compared to the other samples. The overall acceptance values were lower for both the highest (1:0) and lowest (1:10) concentrations of hot pepper extracts those added to prepare the Nuroong-gi samples.

The change in sensory characteristics of Nuroong-gi might be because of color of pepper itself and chemical reactions with other ingredients. Overall acceptability of a sample determines the consumer perceptions towards general acceptance of a product. Although consumers are quite conscious of the nutritional values (Bae et al., 2010), safety (Wilcock et al., 2004) and even the trademark (Guerrero et al., 2000) or price (Caporale and Monteleone, 2001) of the product, and their benefits cannot outweigh the sensory characteristics of foods (Siró et al., 2008). The perception of oral sensations regarding the overall acceptance of foods and beverages is complex and can be influenced by various factors like ethnicity (Prescott and Bell, 1995), gender and age (Mojet et al., 2003), overall health/medication (Schiffman, 2007), and other psychological and physiological factors.

Table 1. Effect of hot pepper extracts on sensory characteristics of freshly prepared Nuroong-gi.

| Sample[1)] | Characteristics[2)] | | | |
|---|---|---|---|---|
| | Color | Flavor | Texture | Overall acceptance |
| 0:1 | 3.7±0.1a[3)] | 3.9±0.1a | 3.3±0.1bc | 3.5±0.1c |
| 1:0 | 3.8±0.2a | 3.8±0.1a | 3.6±0.2b | 3.0±0.2d |
| 1:5 | 3.9±0.1a | 4.0±0.1a | 4.2±0.1a | 4.3±0.1a |
| 1:10 | 3.4±0.2b | 3.3±0.1b | 3.2±0.1c | 4.0±0.1b |

1)Nuroong-gi samples were prepared by mixing different ratios of hot pepper extracts:water.
2)Sensory values were determined based on 5-point score (very poor, 1; poor, 2; fair, 3; good, 4; very good, 5).
3)Quoted values are means±SD. The values followed by different letters in the same column are significantly different, according to Tukey test ($p<0.05$).

Table 2. Effect of hot pepper extracts on sensory characteristics of Nuroong-gi stored at 30°C for 90 days.

| Sample[1)] | Characteristics[2)] | | | |
|---|---|---|---|---|
| | Color | Flavor | Texture | Overall acceptance |
| 0:1 | 3.5±0.1b[3)] | 3.5±0.2b | 3.0±0.1c | 3.6±0.1c |
| 1:0 | 3.0±0.2c | 3.6±0.1b | 3.5±0.2b | 3.1±0.2d |
| 1:5 | 3.8±0.1a | 4.1±0.1a | 4.0±0.1a | 4.5±0.1a |
| 1:10 | 3.5±0.1b | 4.0±0.1a | 3.0±0.1c | 4.1±0.2b |

1)Nuroong-gi samples were prepared by mixing different ratios of hot pepper extracts:water.
2)Sensory values were determined based on 5-point score (very poor, 1; poor, 2; fair, 3; good, 4; very good, 5).

3)Quoted values are means±SD (n=20). The values followed by different letters in the same column are significantly different, according to Tukey test ($p<0.05$).

**Hunter's color value of Nuroong-gi**

Significant variation in color value was observed among the Nuroong-gi samples prepared by adding different proportions of hot pepper extracts (Tables 3 and 4). The samples showed a significant decrement in lightness value with the addition of the pepper extracts for both the fresh (63.00–75.00) and 90-day stored (60.21–71.09) compared to the regular Nuroong-gi, that is, 80.12 and 78.00, respectively. However, the variation in redness and yellowness values of fresh and stored Nuroong-gi were independent of the pepper extract.

The variations in color expression showed that addition of pepper extract would promote development of darker color of Nuroong-gi. The darker color of Nuroong-gi might be because of color of pepper (Minguez-Mosquera et al., 1992; Lobo et al, 2018) itself and chemical reactions with other ingredients. Natural colorant areas like anthocyanins, betalains, chlorophylls, carotenoids, flavonoids, monascus, hemes, quinones, biliproteins, safflower, turmeric may be found as such and a variety of hues can be obtained ranging from green through yellow, orange, red, blue, and violet, depending on the source of colorant (Francis and Markakis, 1989).

Table 3. Effect of hot pepper extracts on Hunter's color value of freshly prepared Nuroong-gi.

| Sample[1)] | Color value[2)] | | |
|---|---|---|---|
| | L* (Lightness) | a* (Redness) | b* (yellowness) |
| 0:1 | 80.12±0.13a[3)] | 0.71±0.03d | 9.31±0.21c |
| 1:0 | 63.00±0.16d | 2.91±0.02a | 15.21±0.10a |
| 1:5 | 75.00±0.07b | 1.11±0.06b | 10.00±0.23b |
| 1:10 | 70.12±0.09c | 0.09±0.05c | 8.66±0.18d |

1)Nuroong-gi samples were prepared by mixing different ratios of hot pepper extracts:water.
2)L*: lightness (100, white; 0, black), a*: redness (–, green; +, red), b*: yellowness (–, blue; +, yellowness).
3)Quoted values are means±SD of triplicate measurements. The values followed by the different letters in the same column are significantly different, according to Tukey test ($p<0.05$).

Table 4. Effect of hot pepper extracts on Hunter's color value of Nuroong-gi stored at 30°C for 90 days.

| Sample[1)] | Color value[2)] | | |
|---|---|---|---|
| | L* (Lightness) | a* (Redness) | b* (yellowness) |
| 0:1 | 78.00±0.21a[3)] | 2.71±0.03b | 10.00±0.21d |
| 1:0 | 60.21±0.56c | 5.99±0.17a | 17.12±0.41a |
| 1:5 | 70.00±1.20b | 2.00±0.14c | 12.33±0.36b |
| 1:10 | 71.09±1.31b | 1.96±0.02d | 11.66±0.22c |

1)Nuroong-gi samples were prepared by mixing different ratios of hot pepper extracts:water.
2)L*: lightness (100, white; 0, black), a*: redness (–, green; +, red), b*: yellowness (–, blue; +, yellowness).
3)Quoted values are means±SD of triplicate measurements. The values followed by the different letters in the same column are significantly different, according to Tukey test ($p<0.05$).

**Viscosity of Nuroong-gi**

The viscosity values of Nuroong-gi samples were not significantly varied with the addition of pepper extracts (Table 5). Various starch-related properties, including pasting viscosity, are important in determining the eating and cooking quality of cooked rice (Bao, 2012). Although studies have not shown correlation of sensory data with any viscosity parameter (Champagne et al., 1999), addition of pepper extract, in the present study, significantly altered the sensory characteristics of Nuroong-gi. The variation in sensory characteristics but not in the viscosity of Nuroong-gi might be due to the addition of only a small amount of pepper extract which contained various phytochemicals and colorants but was not sufficient to influence the viscosity. Peak viscosity indicates the water-binding capacity and ease with which starch granules are disintegrated, and it is often crucial in determining the final product quality (Thomas and Atwell, 1999; Tran et al., 2001).

Table 5. Effect of hot pepper extracts on viscosity (CPS) of Nuroong-gi during storage.

| Sample[1)] | Storage time (day) | |
|---|---|---|
| | 0 | 90 |
| 0:1 | 354.37±18.26a[2)] | 350.21±20.24a |
| 1:0 | 380.12±42.00a | 371.22±18.99a |
| 1:5 | 369.33±23.21a | 360.99±16.88a |
| 1:10 | 323.00±19.12a | 329.14±15.55a |

[1)]Nuroong-gi samples were prepared by mixing different ratios of hot pepper extracts:water.
[2)]Quoted values are means±SD of triplicate measurements. The values followed by the different letters in the same column are significantly different, according to Tukey test ($p<0.05$).

**DPPH scavenging potential and total phenol content of Nuroong-gi**
The DPPH radical scavenging activities and total phenol content of pepper extract-added Nuroong-gi were significantly ($p<0.05$) high as compared to the regular Nuroong-gi (Table 6). The DPPH radical scavenging potentials and total phenol content of the Nuroong-gi prepared with 1:0 ratio of pepper extract to water were significantly high for fresh (82.13% and 401.33 µg GAE/g) as well as 90-day stored (75.12% and 351.77 µg GAE/g) samples, respectively. The results showed a linear relationship with the concentration of pepper extract and the DPPH radical scavenging potential and total phenol content. The results also showed a constant decline in the values at 90 days of storage.

The higher DPPH radical scavenging activities of pepper extract-added Nuroong-gi varieties might be due to higher antioxidant potential of peppers (Domínguez-Martínez et al., 2014; Jang et al., 2015). The reduced DPPH radical scavenging potential of Nuroong-gi samples during storage might be due to lowered reducing power. The results were also in agreement with those of the previous studies (Li et al., 2016; Yang et al., 2017).

High phenolic content of the pepper (Hernandez-Ortega et al., 2012; Nagy et al., 2015; Byun et al., 2016) might be the reason for elevated total phenol content of the pepper extract-added Nuroong-gi. The reduced total phenol content during storage were in agreement with those of the previous studies (Li et al., 2016). Addition of green pepper prominently enriched the antioxidant potential and total phenolic contents of Nuroong-gi.

Table 6. Effect of hot pepper extracts on DPPH radical scavenging activities and total phenol content of Nurung-gi during storage.

| Sample[1)] | Storage time (day) | | | |
|---|---|---|---|---|
| | DPPH (% inhibition) | | Total phenol content (µg GAE[2)]/g) | |
| | 0 | 90 | 0 | 90 |
| 0:1 | 43.12±1.66d[3)] | 40.39±2.00d | 45.66±3.00d | 39.32±2.22d |
| 1:0 | 82.13±0.67a | 75.12±2.31a | 401.33±1.69a | 351.77±4.21a |
| 1:5 | 70.31±0.17b | 66.33±2.66b | 253.17±2.11b | 211.37±3.23b |
| 1:10 | 60.13±0.88c | 55.32±1.99c | 201.37±3.22c | 181.29±2.31c |

[1)]Nuroong-gi samples were prepared by mixing different ratios of hot pepper extracts:water.
[2)]GAE: gallic acid equivalent.
[3)]Quoted values are means±SD of triplicate measurements. The values followed by the different letters in the same column are significantly different, according to Tukey test ($p<0.05$).

**Conclusion**
Nuroong-gi, a famous oriental rice product, was prepared with hot pepper extract. The addition of pepper extract significantly enhanced the antioxidant potentials and the overall acceptance of Nuroong-gi without altering its viscosity property. Since the overall acceptance value of any food product is a key determinant for quality preference, the optimum proportion of the pepper extract to be added was 1:5 ratio of pepper extract to water. The antioxidant potentials of the Nuroong-gi prepared with the ratio (1:5) in the present study was also significantly higher than those of the regular Nuroong-gi. The results of this study suggest that pepper extract could

be used to enhance the antioxidant potential and the overall acceptance of Nuroong-gi.

## Conflict of interest

The authors declare no conflict of interest.

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