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Physicochemical and Sensory Properties of Dough and Cookie Added with Black Rice Flour

Jun Ho Lee, Gyeong Hwa Kim and Yang Sun Kim

Division of Food, Biological and Chemical Engineering, Daegu University

Abstract

This study was carried out to investigate the effect of adding black rice flour on dough and cookie properties. Cookie dough was prepared according to the AACC methods with a slight modification by adding 5, 10, 15, and 20% black rice flour. After aging and sheeting, cookies were baked at 180°C for 12 min in an oven. The baked cookies were cooled to room temperature for 1 hr and packed in airtight bags prior to all measurements. pH of dough was higher than that of cookie regardless of black rice content. pHs of both dough and cookie increased as the black rice content increased in general ($P<0.05$). Specific volume was significantly increased after baking (at least 4 times from dough to cookie). In addition, specific volume tended to increase as the amount of black rice increased in cookie but not in dough. Moisture content of dough varied from 16.16% (wb) to 16.56% (wb) while that of cookie changed from 1.66% (wb) to 2.40% (wb) depending on the black rice content. Spread factor of the control was significantly lower than that of samples with black rice flour ($P<0.05$). Lightness (L*) and yellowness (b*) significantly decreased as the black rice content increased in both dough and cookie ($P<0.05$) as expected. Redness (a*), on the other hand, increased significantly as the amount of black rice increased in both dough and cookie ($P<0.05$). Hardness of dough appeared to increase with the addition of black rice flour; however, dough sample with 5% black rice content was significantly hard unexpectedly ($P<0.05$). There was no significant difference in fracture force among cookie samples. All sensory properties were also significantly influenced by black rice content ($P<0.05$). Samples with 10% black rice flour received the significantly higher flavor score. In general, with the addition of 15% black rice flour distinctively increased the sensory qualities.

Key words: dough, cookie, black rice flour, physicochemical, sensory quality

Introduction

Black rice (*Oryza sativa* L. Indica type), a special variety of brown rice having dark purple-colored seeds, is a major rice crop in south Asia and main China (Choi *et al.*, 1994a; Choi *et al.*, 1994b). It contains high amounts of protein, phytofats, cellulose, minerals (Fe, Zn, Cu, Mn, etc.), vitamins (B1, B2, B6, D, etc.), and niacin (Jung and Eun, 2003). Especially anthocyanin pigments in the black rice have been reported to be highly effective in reducing the cholesterol levels in humans (Kahlon *et al.*, 1990). Many Koreans prefer to blend black rice with medium-grain rice in their cooking and this led to increase in the production of black rice in Korea recently (Kim *et al.*, 2001).

Due to recent increasing interests in the black rice functionality and its applications, several researches related to those aspects have been reported. Hwang and Kim (2000) investigated the characteristics of colored rice bread using the extruded *HeugJinJu* rice while Kim *et al.* (2000) studied the quality of uncooked-colored wine using black rice. Other researchers studied the effects of black rice addition in the manufacturing of *Injulmi* (traditional Korean sticky rice cake) (Cho and Cho, 2000), rice cake (Kim *et al.*, 2002), and bread (Jung *et al.*, 2002).

Despite previous investigations, no study has been reported so far on the quality of cookie added with black rice. Attempts were made to produce a snack having a

Corresponding author: Jun Ho Lee, Professor, Division of Food, Biological and Chemical Engineering, Daegu University, Gyeongsan, Gyeongbuk 712-714, Korea.
Phone: +82-53-850-6535, Fax:82-53-850-6539
E-mail: leejun@daegu.ac.kr

chocolate image and at the same time, taking advantages of functional properties of black rice including carcinogenic, mutagenic, and antioxidative activities. The objectives of present study was to provide reliable experimental data for dough and cookies made with black rice flour and investigate the effects on dough and cookie making properties.

Materials and Methods

Preparation of raw material

The wheat flour (weak flour; CJ Corp., Seoul, Korea), black rice, shortening, butter, salt, and sugar were procured from a local market. All samples were stored at room temperature until used. Black rice was ground using an analytical mill (model M20, IKA Works, Inc., Wilmington, NC, USA) at maximum speed for 5 min and sieved using a strainer to obtain uniform particle size (c. 40 mesh) before use.

Preparation of dough and cookie

Cookie dough was mixed in a bowl as described in AACC (1995) methods with a slight modification by adding 5, 10, 15, and 20% black rice flour. The dough was aged for 30 min in a refrigerator and then sheeted to a thickness of 0.4 cm with the help of a rolling pin. The cookie were cut with a cookie die of diameter 4.26 cm and transferred to a lightly greased baking tray. The cookies were baked at 180°C for 12 min in a multi-functional convection oven (model GOR-704C, Tong Yang Magic Corp., Seoul, Korea). The baked cookies were cooled to room temperature for 1 hr and packed in airtight bags.

Physicochemical properties evaluation

The pHs of dough and cookie were determined by a pH meter (model 340, Mettler Delta Co., Halstead, UK) after mixing each 5 g of sample with 45 mL of distilled water. Moisture contents of dough and cookies were measured using a dry oven at 105°C overnight. Densities of dough was determined by water displacement method while specific volumes of black rice cookies were measured by rapeseeds displacement method as described in AACC (1995), respectively. The spread factor was measured according to AACC (1995) and it was calculated as follows:

$$\text{Spread factor} = \frac{\text{Diameter of cookie (mm)}}{\text{Height of 6 cookies (mm)}} \times 10$$

The texture profile test and fracture force test were conducted on the dough and cookies, respectively using a Texture Analyzer (TA-XT2, Stable Micro Systems, UK). Hardness of dough was recorded, as the maximum force required for penetrating 20 mm in depth of 30 g of dough placed in a 34 mL crucible with the help of 5 mm cylinder probe. Fracture forces of the cookies were recorded, as force required to shattering the cookies (at least 10 cookies) with the help of a blade (Shin *et al.*, 1999). The cross head speed was 30 mm/min and span between the two platforms was 40 mm. Color parameters (L^*, a^*, and b^*) of dough and cookies were measured using a Chromameter (model CR-200, Minolta Co., Osaka, Japan) calibrated with a white tile (L^*=100.00, a^*=-0.43, and b^*=+0.03). All measurements were repeated at least three times.

Sensory evaluation

Black rice flour added dough and cookies were submitted to sensory assessment by a panel constituted of 10 trained panelists (students majoring in Food Science and Engineering). Attributes evaluated were: flavor, savory taste, color, and texture (hardness). Panelists expressed judgements about samples using a structured numeric scale of nine points for each attribute evaluated. All the samples, randomly coded using a three-digit number, were evaluated in each session. Panelists received a tray containing the samples, a glass of water, and a evaluation sheet. The evaluation was done in duplicate. Panelists were instructed to rank the samples from the strongest one to the weakest one.

Statistical analysis

The statistical analysis was done using the SAS Statistical Analysis System for Windows v8.1 (SAS Inst. Inc., Cary, N.C., U.S.A.) (1998). The means were compared with Duncan's Multiple Range test at á=0.05.

Results and Discussion

Basic properties

Table 1. Basic properties of dough and cookie as affected by black rice content

Black rice content (%)	pH		Specific volume(mL/g)		Moisture content(%, wb)		Spread factor
	Dough	Cookie	Dough	Cookie	Dough	Cookie	Cookie
0	6.42±0.029d	5.88±0.012c	0.24±0.002a	1.14±0.050c	16.45±0.161a	2.32±0.127a	10.28±0.055c
5	6.45±0.000c	5.56±0.025d	0.25±0.000a	1.02±0.089d	16.56±0.122a	1.66±0.052b	11.11±0.067b
10	6.49±0.010b	5.85±0.031c	0.22±0.000b	1.37±0.047b	16.40±0.570a	2.40±0.122a	11.23±0.153b
15	6.51±0.006ab	5.97±0.012b	0.25±0.004a	1.43±0.026b	16.25±0.099a	2.26±0.168a	11.50±0.045a
20	6.53±0.015a	6.09±0.021a	0.24±0.007a	1.62±0.045a	16.16±0.096a	1.87±0.381b	11.24±0.060b

a-d Means within the same column without a common letter are significantly different (*P*<0.05).

Basic properties including pH, specific volume, moisture content, and spread factor of dough and cookie as influenced by black rice content are summarized in Table 1. pH of dough was higher than that of cookie regardless of black rice content. pHs of both dough and cookie increased as the black rice content increased in general (P<0.05). Specific volume was significantly increased after baking (at least 4 times from dough to cookie). Again, specific volume tended to increase as the amount of black rice increased in cookie but not in dough. Similar trends were observed with cookies made with various levels of functional rice flour (Kim *et al.*, 2002) and fish snacks made with rice and corn flour (Sim *et al.*, 1998).

Moisture content of dough varied from 16.16% (wb) to 16.56% (wb) while that of cookie changed from 1.66% (wb) to 2.40% (wb) depending on the black rice content. It was obvious that major portion of moisture inside of dough disappeared during baking as expected; however, there was no direct relationship between moisture content and black rice content. Spread factor of the control was significantly lower than that of samples with black rice flour (P<0.05). The spread factor can be affected by the rheological properties of dough and high amount of moisture content in the dough may result in the low value of the spread factor (Kim *et al.*, 2002; Miller *et al.*, 1997). Even though there was no direct relationship between spread factor and black rice content, low amount of moisture content resulted in high value of spread factor. Kim *et al*. (2002) reported similar results with cookies made of functional rice flour.

Color

Changes of color parameters as influenced by black rice content are shown in Figs. 1-3 for L*-, a*-, and b*-value, respectively. Lightness (L*) significantly decreased

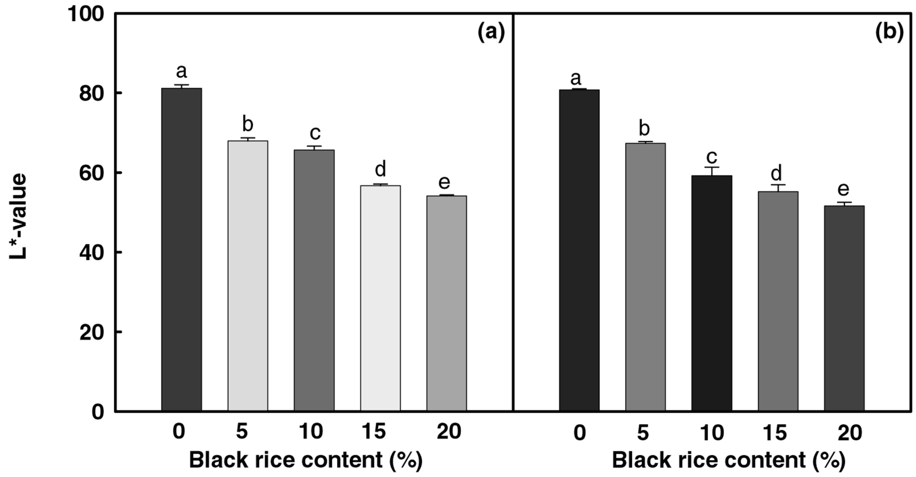

Fig. 1. Change of L*-value as influenced by black rice content in (a) dough and (b) cookie.

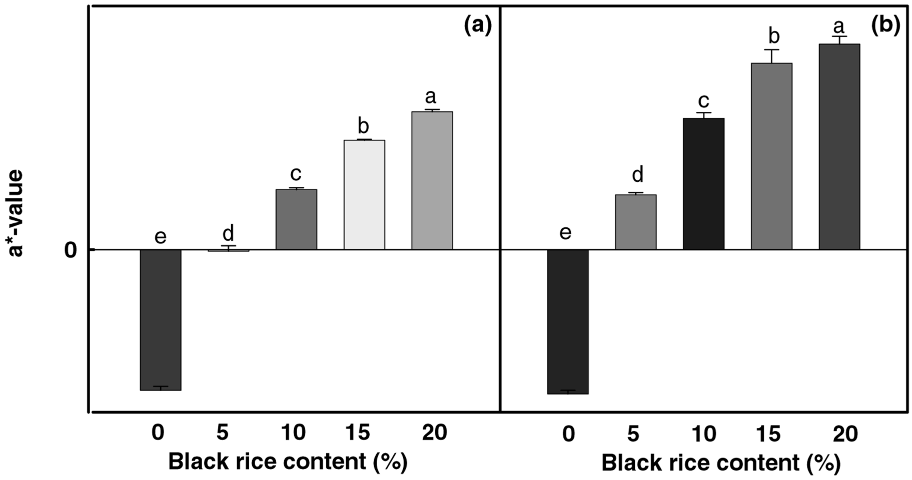

Fig. 2. Change of a*-value as influenced by black rice content in (a) dough and (b) cookie.

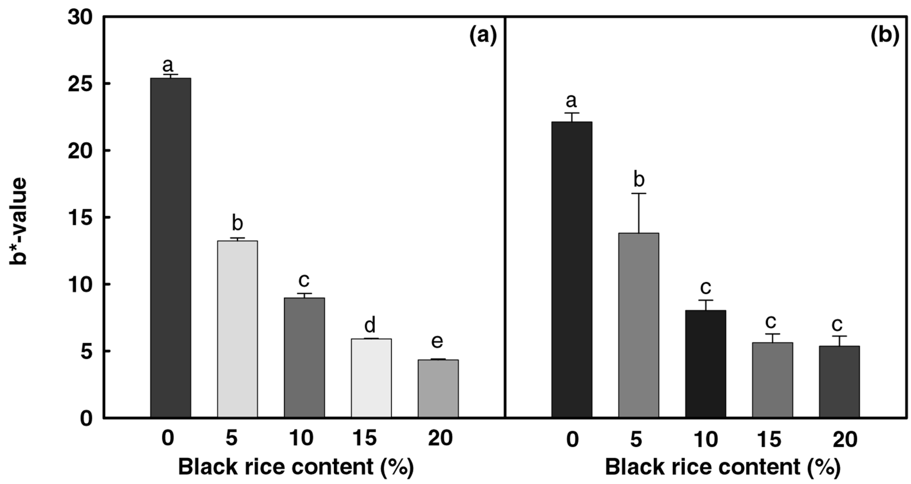

Fig. 3. Change of b*-value as influenced by black rice content in (a) dough and (b) cookie.

as the black rice content increased in both dough and cookie ($P<0.05$) as expected. Lightness of dough control decreased 33.3% while that of cookie control decreased 36.1% in value when 20% of black rice flour were added in the sample. Redness (a*), on the other hand, increased significantly as the amount of black rice increased in both dough and cookie ($P<0.05$). Similar changes in the lightness and redness were reported for rice cake made with black rice (Kim *et al.*, 2001) and *Injulmi* made with black rice (Cho and Cho, 2000). Again, yellowness (b*) significantly decreased with increase in black rice content. Very similar pattern of reduction was found for dough and cookie. Similar results were also found for bread made with black rice flour (Jung *et al.*, 2002). This is due to the natural color of black rice flour, mainly influenced by color pigments of cyanidin 3-glucoside and malvidin-3-glucoside (Yoon *et al.*, 1995). It was also noted that color characteristics of dough were well carried onto the cookie. This natural color of the black rice is well presented in the cookie and can be easily predicted. A chocolate-like cookie can be produced with black rice with the control of color by the concentration of black rice flour added.

Texture

Change of hardness and fracture force as influenced

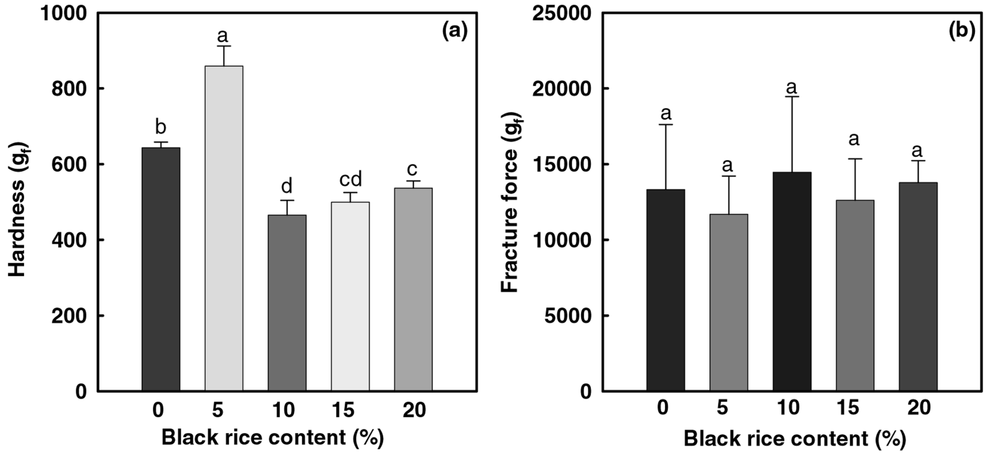

Fig. 4. Change of hardness and fracture force as influenced by black rice content in (a) dough and (b) cookie.

by black rice content in dough and cookie is shown in Fig. 4(a) and 4(b), respectively. Hardness of dough appeared to increase with the addition of black rice flour; however, dough sample with 5% black rice content was significantly hard unexpectedly (P<0.05). There was no significant difference in fracture force among cookie samples. Kim *et al.* (2002) reported no significant effect of addition of garlic on cookie texture. Similar results were also reported for cookies with various levels of functional rice flour (Kim *et al*., 2002). On the other hand, Kim *et al*. (2001) indicated that the hardness of rice cake increased as black rice content increased in general. Similar results were also found for *Injulmi* (Cho and Cho, 2000), cooked rice added with black rice (Kim *et al*., 1998) and bread made of black rice flour (Jung *et al*., 2002). However, this unchanged hardness of cookie sample with the addition of black rice flour is perhaps desirable since the increased hardness of cookie may not be favorable to consumers. In other words, black rice cookie can be made with the benefit of functional properties of black rice without sacrificing its texture property which is one of the most important quality parameters. Hwang and Kim (2000) found a similar result for *HeugJinJu* rice bread and indicated that no increase in the hardness of the bread with the addition of *HeugJinJu* rice was desirable.

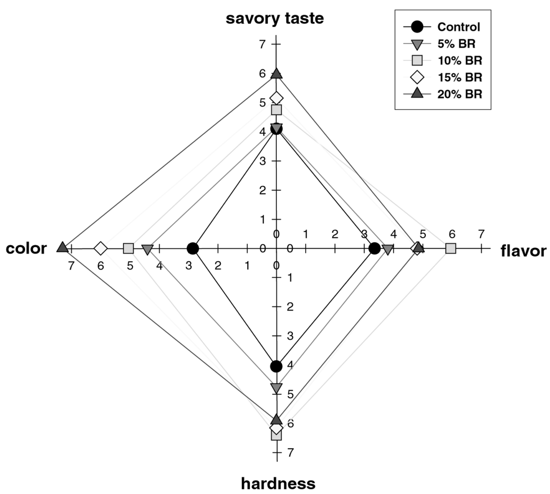

Fig. 5. Sensory properties of black rice cookies as affected by black rice content.

Sensory

Sensory properties of black rice cookie as affected by black rice content are presented in Fig. 5. All sensory properties were significantly influenced by black rice content (P<0.05). Samples with 10% black rice flour received the significantly higher flavor score. Other properties including savory taste, color, and texture increased as black rice content increased in the sample. In general, with the addition of 15% black rice flour distinctively increased the sensory qualities. This suggests that cookies made with black rice flour up to 20% would have a distinctive sensory quality depending on the formulation. A additional consumer preference testing might be recommended to be acceptable to general consumers without negative influence in overall quality while taking advantage of functional properties of black rice.

References

American Association of Cereal Chemist. 1995. Approved Methods of the Am. Assoc. Cereal Chem. (Method 10-50D, First approval 2-24-75; Revised 10-28-81) St. Paul MN USA

Cho, J.A. and H.J. Cho. 2000. Quality properties of *Injulmi* made with black rice. Korean J. Soc. Food Sci. **16**: 226-231

Choi, S.W., W.W. Kang and T. Osawa. 1994. Isolation and identification of anthocyanin pigments in black rice. Foods and Biotechnol. **3**: 131-136

Choi, S.W., W.W. Kang, T. Osawa and S. Kawakishi. 1994. Antioxidative activity of crysanthemin in black rice hulls. Foods and Biotechnol. **3**: 233-237

Hwang, Y.K. and T.Y. Kim. 2000. Characteristics of colored rice bread using the extruded *HeugJinJu* rice. Korean J. Soc. Food Sci. **16**: 167-172

Jung, D.S., F.Z. Lee and J.B. Eun. 2002. Quality properties of bread made of wheat flour and black rice flour. Korean J Food Sci. Technol. **34**: 232-237

Jung, D.S. and J.B. Eun. 2003. Rheological properties of dough added with black rice flour. Korean J. Food Sci. Technol. **35**: 38-43

Kahlon, T.S., R.M. Saunders, F.I. Chow, M.M. Chiu and A.A. Betschart. 1990. Influence of rice bran, oat bran and wheat bran on cholesterol and triglycerides in hamsters. Cereal Chem. **67**: 439-442

Kim, D.W., J.B. Eun and C.O. Rhee. 1998. Cooking conditions and textural changes of cooked rice added with black rice. Korean J. Food Sci. Technol. **30**: 562-568

Kim, H.L., I.S. Lee, J.Y. Kang and G.Y. Kim. 2002. Quality characteristics of cookies with various levels of functional rice flour. Korean J. Food Sci. Technol. **34**: 642-646

Kim, H.Y., S.J. Jeong, M.Y. Heo and K.S. Kim. 2002. Quality characteristics of cookies prepared with varied leveld of shredded garlics. Korean J. Food Sci. Technol. **34**: 637-641

Kim, J.D., J.C. Lee, F.H. Hsieh and J.B. Eun. 2001. Rice cake production using black rice and medium-grain brown rice. Food Sci. Biotechnol. **10**: 315-322

Kim, S.D., M.H. Kim and S.S. Ham. 2000. Preparation and quality of uncooked-colored wine using black rice. J Korean Soc. Food Sci. Nutr. **29**: 224-230

Miller, R.A., R.C. Hoseney and C.F. Morris. 1997. Effect of formula water content on the spread of sugar-snap cookies. Cereal Chem. **74**: 669-671

SAS Institute, Inc. 1998. SAS/STAT User's Guide. Version 8.1, Cary NC USA

Saunders, R.M. 1990. The properties of rice bran as a food stuff. Cereal Food World **35**: 632-636

Shin, I.Y., H.I. Kim, C.S. Kim and K. Whang. 1999. Characteristics of sugar cookies with replacement of sucrose with sugar alcohols (II) Textural characteristics of sugar alcohol cookies. J Korean Soc. Food Sci. Nutr. **28**: 1044-1050

Sim, Y.J., B.M. Jung and K.C. Rhee. 1998. Effect of amylose content on quality of rice bread. Korean J. Food Sci. Technol. **30**: 590-595

Yoon, H.Y., Y.S. Paik, J.B. Kim and T.R. Hahn. 1995. Indentification of anthocyanins from Korean pigmented rice. Agric. Chem. Biotechnol. **38**: 581-583