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ORIGINAL ARTICLE

Physicochemical characteristics and sensory acceptability of crackers containing red ginseng marc

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Abstract Red ginseng marc (RGM), a by-product from ginseng industry, still contains bioactive compounds such as ginsenosides and dietary fibers. The objective of this study was to investigate effects of baking conditions and formulations on physicochemical and sensory characteristics of crackers in which RGM was incorporated. The sum of ginsenoside Rb1, Rg1 and Rg3 (58.69 ± 2.93 mg/100 g, dry basis) and dietary fibers (7.52 ± 1.22 g/100 g) were the highest in the crackers baked at 120 °C for 60 min. The crackers with 5% replacement of wheat flour with RGM scored the highest in taste and overall acceptability. The baked crackers still contained relatively high amounts of ginsenoside Rb1 (7.62 ± 0.34 mg/100 g), Rg3(R) (7.51 ± 0.99 mg/100 g) and Rg3(S) (8.65 ± 0.77 mg/100 g) and dietary fiber (2.59 ± 0.17 g/100 g). The results suggest that low temperature-long time may be a suitable baking condition to retain bioactive ginsenosides in RGM and using proper amount of RGM in bakery products may improve not only nutritional quality but also sensory properties.

Keywords Red ginseng marc · Cracker · Ginsenosides · Dietary fiber

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Introduction

Ginseng (*Panax ginseng* Meyer) is one of the most well-known medicinal herbs since it has a variety of biological activities such as anti-oxidative, anti-carcinogenic and anti-aging activities (Xu et al. 2016). Ginseng can be processed into red ginseng, which is known to possess more potent biological activities and fewer side effects than plain ginseng (Lee et al. 2015). Because red ginseng is usually consumed as an aqueous extract, almost 1000 metric tons of red ginseng marc (RGM) is produced per year in Korea and mostly discarded (Kim et al. 2017; Jung et al. 2015).

Ginsenosides and dietary fibers still remain in RGM (Park et al. 2008; Zang et al. 2014). Ginsenosides are a family of triterpene saponins only found in ginseng cultivars and known to have anti-allergic, anti-obesity and antioxidant activities and control the immune system (Park et al. 2017). In order to utilize RGM, researchers have tried to use it as an ingredient in bakery products such as cakes and muffins (Park et al. 2008; Jung et al. 2015). It has been reported that nutritional compositions of a food product can be changed during baking process (Slavin et al. 2013; Patel et al. 2019). Ginsenosides, the major bioactive compounds in RGM, are known to undergo thermally-induced compositional modifications (Saa et al. 2017; Hwang et al. 2010). Therefore, it is important to determine a suitable baking condition to properly utilize RGM as a food ingredient. However, the effect of different baking conditions on physicochemical properties of RGM in a food system has been little studied.

Cracker is one of the most popular bakery products in the world. Cracker is considered to be suitable for investigating the changes in physicochemical properties of RGM upon baking condition (Slavin et al. 2013). It might be because cracker is composed of simple ingredients, which minimizes interactions of the ingredients. Cracker is also a suitable bakery product for fortification of bioactive materials. As demand for health-promoting foods has increased, even snacks are expected to be beneficial to health. Many researchers have attempted to improve nutritional quality of crackers by adding bioactive ingredients. Pulse flour (Millar et al. 2017), bambara groundnut (Yeboah-Awudzi et al. 2018) and black currant pomace (Schmidt et al. 2018) were successfully incorporated into crackers increasing not only nutritional quality but also sensory properties. Both ginsenosides and dietary fibers in RGM could be valuable sources to improve nutritional quality of crackers. Incorporation of RGM into crackers could be a novel way utilizing bioactive compounds in RGM as well as improving nutritional quality of crackers.

The objectives of this study were to investigate how baking conditions affect the ginsenosides in a food system, crackers, and to determine effect of different levels of RGM on physicochemical characteristics and sensory acceptability of the crackers.

Materials and methods

Chemicals

Ginsenoside Rb1, Rb2, Rc, Rd, Rg1, Rg2, Rg3(R), Rg3(S) and Rk1 were purchased from Chem Faces (Wuhan, China). Total dietary fiber assay kit was purchased from Megazyme (Wicklow, Ireland). Acetonitrile and methanol were purchased from JT Baker (Phillipsburg, NJ, USA). Acetone, ethanol and ether were purchased from Samchun Pure Chemicals (Pyeongtaek, Korea). Sodium sulfate was purchased from Yakuri Pure Chemicals Co., Ltd. (Osaka, Japan). All chemicals were of analytical grade.

Materials

RGM, remaining after red ginseng was extracted with water at 89 °C for 54 h, was provided by Hongsamae (Seoul, Korea). RGM was lyophilized using a freeze dryer (FDI06-85, Soritech, Hwaseong, Korea) and milled to fine powder using a blender (Hanil Co., Bucheon, Korea), which was then stored at − 20 °C for further analysis. Wheat flour, sugar, salt, butter and baking powder were purchased from a local market in Seoul, Korea.

Preparation of crackers

Formulation for making crackers is shown in Table 1. Ingredients were mixed, rolled into 3 mm sheet and then cut into a round shape, weighing about 4 g each. The cracker mix with 10% replacement of wheat flour with RGM (10RC) was baked with 5 different temperature–time combinations: 120 °C-60 min, 170 °C-15, 20 or 25 min and 220 °C-10 min to determine a proper baking condition. Unbaked cracker dough was used as control. The baking conditions used in this study were selected based on the preliminary study.

In order to investigate physicochemical and sensory characteristics of crackers containing different levels of RGM (0, 5, 10, 15 and 20% replacements of wheat flour with RGM: designated as 0RC, 5RC, 10RC, 15RC and 20RC, respectively) were baked at 120 °C for 60 min. All baking experiments were performed in triplicate. For analysis of proximate composition, dietary fibers and ginsenosides, all the crackers and dough were lyophilized.

Proximate composition

Moisture, crude lipids, crude proteins and ash were analyzed according to AOAC (2000) Official Methods of Analysis 925.10, 920.85, 976.05 and 923.03, respectively.

Analysis of ginsenosides

Ginsenosides were extracted by the method of Chang and Ng (2009) with some modifications. Five mL of 70% methanol was added to 1 g of ground cracker, followed by ultrasonic extraction for 90 min using an ultrasonic bath (5510E-DTH, 139 W, 42 kHz, Bransonic, Danbury, CT, USA) at room temperature. The mixture was centrifuged (2236R, Gyrozen Co., Daejeon, Korea) at 10,000×g for 10 min at 4 °C. Sep-Pak Plus C-18 cartridge (Waters Co., Milford, MA, USA) was used for the solid phase extraction. Two mL of supernatant was injected into the activated Sep-Pak cartridge. The eluate was filtered using a 0.22 µm syringe filter (Pall Co., Port Washington, NY, USA). Ginsenosides were analyzed using a reversed-phase HPLC (Ultimate 3000; Thermo Scientific Dionex, Waltham, MA, USA) equipped with an XBridge C18 column (4.6 × 250 mm, 5 µm, Waters, USA). Mobile phases were water (A) and 100% acetonitrile (B) with a gradient as follows: 0–6 min, 21% B; 6–7 min, 21–23% B; 7–25 min, 23–24% B; 25–30 min, 24–32% B; 30–35 min, 32–50% B; 35–50 min, 50–65% B; 50–51 min, 65–100% B; 51–61 min, 100% B; 61–71 min, 100–21% B; and 71–90 min, 21% B. Flow rate was 0.8 mL min^{-1} and injection volume was 20 µL. Column oven temperature was 30 °C. Detection wavelength was 203 nm.

Table 1 Formulation of crackers containing red ginseng marc

Ingredient (g/100 g)	Replacement level of wheat flour with red ginseng marc				
	0%	5%	10%	15%	20%
Wheat flour	55	52.25	49.5	46.75	44
Red ginseng marc	0	2.75	5.5	8.25	11
Sugar	4	4	4	4	4
Salt	0.5	0.5	0.5	0.5	0.5
Baking powder	2	2	2	2	2
Butter	15.5	15.5	15.5	15.5	15.5
Water	23	23	23	23	23

Analysis of dietary fibers

Soluble, insoluble and total dietary fibers were determined according to AOAC (2000) Official Methods of Analysis 991.43 using total dietary fiber assay kit.

Analysis of color

L^* (lightness), a^* (redness) and b^* (yellowness) values of the crackers were determined using a colorimeter (CM-5, Konica Minolta Co., Tokyo, Japan).

Analysis of texture

Texture of the crackers was evaluated using a texture analyzer (TA/XT2, Stable Micro System, UK) according to Millar et al. (2017) with some modification. Three-point bending rig was used to evaluate hardness of the crackers. The upper blade moved at a speed of 2 mm s 1^{-1} until the crackers were broken. Maximum power (N) required to break the crackers was defined as hardness.

Sensory evaluation

Acceptability evaluation was used to evaluate the preference of crackers with different levels of RGM. Sensory acceptability of the crackers was evaluated by 54 untrained panelists. The crackers (0RC, 5RC, 10RC, 15RC and 20RC) placed side by side on white plates with 3-digit random numbers were presented to the panelists using the Williams Latin square in separate testing booths. The panelists were informed that the crackers contained RGM. Water (room temperature) was provided to rinse the panelists' mouths between evaluating the samples. Nine-point hedonic scale (1—dislike extremely, 5—neither like nor dislike and 9—like extremely) was used for evaluating appearance, flavor, aroma, color, texture and overall acceptability of the crackers. The research protocol was approved by Institutional Review Board (IRB) at Seoul National University (IRB No. 1812/003-001).

Statistical analysis

The texture analysis was repeated 7 times and the color analysis was repeated 4 times. All the other experiments were repeated 3 times. Results were expressed as means ± standard deviations. Data were subjected to one-way analysis of variance (ANOVA) and Duncan's multiple range test ($p < 0.05$) using a SPSS program (version 23.0, SPSS, Chicago, IL, USA).

Results and discussion

Proximate composition of wheat flour and RGM

The wheat flour used in this study had 11.7 ± 0.06% moisture, 1.2 ± 0.2% crude lipids, 5.4 ± 0.9% crude proteins, 0.3 ± 0.1% ash and 0.6 ± 0.4% total dietary fibers. The RGM had 5.7 ± 0.6% moisture, 1.0 ± 0.0% crude lipids, 6.5 ± 0.1% crude proteins, 3.0 ± 0.0% ash and 38.3 ± 1.3% total dietary fibers. The RGM had more ash and total dietary fiber than the wheat flour.

Effects of baking conditions on the crackers containing RGM

Effects of baking conditions on ginsenoside composition in crackers

All the baking conditions used in this study were set to produce organoleptically acceptable crackers based on a preliminary experiment. Although appearances of all the crackers looked similar to each other, ginsenoside compositions were different (Table 2). Ginsenoside Rg1, one of the prevalent ginsenosides found in red ginseng, was not detected in all the cracker samples. It might be transformed into other ginsenosides while extracting at high temperature (89 °C) for long time (54 h). Lee et al. (2011) reported that ginsenoside Rg1 in ginseng flower disappeared after 12 h of thermal treatment at 95 °C. Ginsenoside

Table 2 Ginsenosides in red ginseng marc crackers baked at different baking conditions

Baking condition	Ginsenoside (mg/ 100 g, dry basis)									
	Rb1	Rb2	Rc	Rd	Rg1	Rg2	Rg3(R)	Rg3(S)	Rk1	Rb1 + Rg1 + Rg3
120 °C 60 min	16.35 ± 1.80^{a}	1.71 ± 0.16^{a}	6.86 ± 0.17^{a}	6.65 ± 1.14^{a}	ND	1.81 ± 0.47^{a}	19.35 ± 0.46^{b}	22.99 ± 0.73^{a}	11.02 ± 2.65^{ab}	58.69 ± 2.93^{a}
170 °C 15 min	13.80 ± 1.69^{b}	1.32 ± 0.21^{b}	6.20 ± 0.39^{b}	5.91 ± 0.26^{a}	ND	1.75 ± 0.71^{a}	14.59 ± 0.97^{c}	17.59 ± 1.44^{b}	13.21 ± 1.47^{ab}	45.98 ± 2.69^{b}
170 °C 20 min	10.74 ± 0.92^{c}	0.74 ± 0.21^{c}	4.16 ± 0.22^{c}	5.36 ± 0.14^{ab}	ND	1.52 ± 0.71^{ab}	13.88 ± 1.19^{c}	16.75 ± 0.62^{bc}	13.68 ± 1.00^{ab}	41.37 ± 2.38^{c}
170 °C 25 min	9.90 ± 0.78^{c}	0.63 ± 0.11^{c}	3.82 ± 0.23^{c}	4.37 ± 0.26^{bc}	ND	0.92 ± 0.41^{ab}	13.80 ± 0.74^{c}	15.26 ± 0.64^{c}	13.10 ± 1.53^{ab}	38.96 ± 1.76^{c}
220 °C 10 min	5.48 ± 0.64^{d}	0.02 ± 0.00^{d}	2.05 ± 0.28^{d}	3.51 ± 0.45^{c}	ND	0.71 ± 0.34^{b}	13.24 ± 1.32^{c}	13.07 ± 1.15^{d}	14.74 ± 3.28^{a}	31.78 ± 2.02^{d}
Unbaked	16.13 ± 0.64^{a}	1.72 ± 0.18^{a}	7.26 ± 0.45^{a}	6.08 ± 1.38^{a}	ND	1.57 ± 0.16^{ab}	22.33 ± 1.26^{a}	17.97 ± 1.67^{b}	10.01 ± 1.86^{b}	56.42 ± 3.28^{a}

Ten percent of wheat flour in the crackers was replaced with red ginseng marc. Values are means and standard deviations for triplicate experiments. Different superscripts indicate significant differences within the same columns ($p < 0.05$; one-way ANOVA and Duncan's multiple range test)

ND not detected

compositions were not significantly different between the control and the crackers baked at 120 °C for 60 min except for ginsenoside Rg3(S) and Rg3(R). In the crackers baked at 120 °C for 60 min, ginsenoside Rg3(R) increased while ginsenoside Rg3(S) decreased. Ginsenoside Rg3(S) might be changed into ginsenoside Rg3(R) because it was suggested that these two optical isomers were to be possibly in a reversible relationship during thermal treatment (Li et al. 2018). Ginsenoside composition in the crackers baked at 220 °C for 10 min was significantly different from the crackers baked at 120 °C for 60 min and the control. As the temperature increased, it is likely to cleave the glycosyl moiety at the C-3 and C-20 positions of ginsenosides, consequently transforming into other ginsenosides (Hwang et al. 2010). Hwang et al. (2014) also reported that ginsenoside composition in ginseng leaves and roots changed with heating temperature. In this study, ginsenoside Rb1, Rb2, Rc, Rd and Rg3(S) in the crackers baked at 170 °C tended to decrease as baking time increased. Ginsenoside Rb1, Rb2, Rc and Rd have been reported to decrease with increasing baking time (Li et al. 2018; Lee et al. 2011). With cleavage of glycosidic bond by heat treatment, ginsenoside F2, Rh2, Rg5, compound K and protopanaxadiol (PPD) could be formed (Li et al. 2018). However, as these ginsenosides were not analyzed in this study, it is uncertain whether they increased. Thus, it would be needed to analyze ginsenoside F2, Rg5, Rh2, compound K and PPD to understand the fate of ginsenosides after baking.

Collectively, ginsenoside composition changed significantly more in the high temperature-short time baking condition than in the low temperature-long time. Also, ginsenoside composition tended to change with increasing baking time at the same temperature. Even though all the baking conditions could similarly produce acceptable crackers, ginsenoside composition among the crackers changed significantly by the baking temperature and time.

The sum of ginsenoside Rb1, Rg1 and Rg3 is used as a marker for red ginseng to be claimed as a functional health food in Korea (Ministry of Food and Drug Safety of Korea 2018). The baking condition at 120 °C for 60 min was selected to bake the crackers for evaluating the effect of different RGM replacement levels because the crackers baked at the condition were the highest in the sum of ginsenoside Rb1, Rg1 and Rg3.

Effects of baking conditions on dietary fibers in crackers

Dietary fibers have been known to lower serum lipid concentrations, enhance glucose tolerance and lower the risk of cardiovascular diseases (Roehrig et al. 1988). Soluble dietary fibers were the most in the crackers baked at 120 °C for 60 min ($p < 0.05$) (Table 3). This result may be attributed to the long thermal treatment that can cause insoluble dietary fibers to transform into soluble ones (Seo and Kim 1995). Total dietary fiber content was higher in the crackers baked at 120 °C for 60 min than in the ones baked at 220 °C for 10 min. It may be due to formation of resistant starch which is considered to be one of insoluble dietary fibers. Liljeberg et al. (1996) reported that bread baked at a lower temperature for a longer time contained a higher amount of resistant starch than bread baked at a higher temperature for a shorter time. Yadav (2011) also reported that resistant starch increased in low temperature-long time baking condition than in high temperature-short time and increased with baking time (15 to 45 min) at 200 °C. However, in this study, there was no significant difference in dietary fibers with baking time (15 to 25 min) at 170 °C. This result might be because baking time was not long enough to generate resistant starch. Low temperature-long time baking condition could be suitable for increasing dietary fibers in crackers added with a fiber-rich ingredient.

Table 3 Dietary fibers in red ginseng marc crackers baked at different baking conditions

Baking condition	Dietary fiber (g/ 100 g, dry basis)		
	Soluble	Insoluble	Total
120 °C 60 min	1.05 ± 0.15^{a}	6.48 ± 1.17^{a}	7.52 ± 1.22^{a}
170 °C 15 min	0.75 ± 0.06^{bc}	5.41 ± 1.33^{ab}	6.17 ± 1.29^{ab}
170 °C 20 min	0.80 ± 0.09^{b}	5.80 ± 0.61^{ab}	6.59 ± 0.53^{ab}
170 °C 25 min	0.67 ± 0.11^{bc}	4.46 ± 0.91^{b}	5.14 ± 0.97^{ab}
220 °C 10 min	0.60 ± 0.09^{c}	4.85 ± 0.90^{ab}	5.45 ± 0.89^{b}
Unbaked	0.68 ± 0.09^{bc}	5.78 ± 0.66^{ab}	6.45 ± 0.68^{b}

Ten percent of wheat flour in the crackers was replaced with red ginseng marc. Values are means and standard deviations for triplicate experiments. Different superscripts indicate significant differences within the same columns ($p < 0.05$; one-way ANOVA and Duncan's multiple range test)

Effect of different RGM replacement levels on physicochemical and sensory characteristics of crackers

Proximate composition and dietary fiber contents

Proximate composition of the crackers containing different replacement levels of RGM is shown in Table 4. Moisture decreased from 1.59 to 0.23% with increasing replacement level of RGM. Lower moisture content contributes to longer shelf life, which is one of the important properties of crackers (Ahmed and Abozed 2015). Crude proteins and ash increased with the replacement level of RGM from 8.81 and 1.69 to 10.44 and 2.62%, respectively. These results may be related to the replacement level of RGM, which had higher proteins and ash than wheat flour. Crude lipid content was not significantly different among the crackers. The soluble, insoluble and total dietary fibers increased with the replacement level of RGM from 1.59, 1.00 and 2.59 to 2.44, 9.26 and 11.7%, respectively. This result may be due to RGM which is higher in dietary fibers than wheat flour.

Ginsenoside content

Ginsenosides in the crackers containing different replacement levels of RGM are shown in Table 4. All the ginsenosides increased with the replacement level of RGM. Since ginsenosides have been found in ginseng cultivars only, ginsenosides were not detected in the 0RC.

Color

Surface color of the crackers containing different replacement levels of RGM is shown in Table 5. The 0RC was higher in L^* and the lowest in a^* than the crackers containing RGM ($p < 0.05$). L^* decreased with increasing replacement level of RGM, while a^* increased. Consistent with these findings, the same results were obtained in other RGM-added products (Zang et al. 2014; Park et al. 2008). These results may be due to the replacement of wheat flour with RGM which was lower in lightness and higher in redness.

Texture

Hardness of the crackers containing different replacement levels of RGM is shown in Table 5. Hardness of the crackers increased from 6.32 N in the 0RC to 12.60 N in the 20RC ($p < 0.05$). Similar results were observed in crackers containing fibrous ingredients, such as broccoli (Lafarga et al. 2019) and pea flour (Kohajdova et al. 2013). Millar et al. (2017) reported a negative correlation between hardness and moisture content and a positive correlation between hardness and fiber content. The increased hardness of the crackers containing RGM might be due to increase in dietary fibers and decrease in moisture.

Table 4 Proximate composition, dietary fibers and ginsenosides in crackers containing different levels of red ginseng marc

	Replacement level of wheat flour with red ginseng marc				
	0%	5%	10%	15%	**20%**
Proximate composition (g/ 100 g, dry basis except moisture)					
Moisture	1.59 ± 0.08[a]	1.51 ± 0.10[b]	0.91 ± 0.08[c]	0.42 ± 0.06[d]	0.23 ± 0.07[d]
Crude lipids	19.24 ± 0.47	19.39 ± 0.26	19.25 ± 0.60	18.71 ± 2.93	19.89 ± 0.65
Crude proteins	8.81 ± 0.28[a]	9.86 ± 0.71[ab]	10.18 ± 0.81[ab]	10.24 ± 0.86[b]	10.44 ± 0.81[b]
Ash	1.69 ± 0.12[a]	1.77 ± 0.02[a]	1.70 ± 0.13[a]	2.18 ± 0.04[b]	2.62 ± 0.13[c]
Dietary fiber (g/ 100 g, dry basis)					
Insoluble	1.00 ± 0.05[a]	3.40 ± 0.72[b]	6.47 ± 1.18[c]	6.75 ± 0.52[c]	9.26 ± 0.13[d]
Soluble	1.59 ± 0.21[ab]	1.87 ± 0.10[b]	1.35 ± 0.21[a]	1.92 ± 0.16[b]	2.44 ± 0.43[c]
Total	2.59 ± 0.17[a]	5.28 ± 0.82[b]	7.81 ± 1.00[c]	8.67 ± 0.66[c]	11.70 ± 1.67[d]
Ginsenoside (mg/ 100 g, dry basis)					
Rb1	ND	7.62 ± 0.34[a]	16.35 ± 1.80[b]	22.78 ± 0.68[c]	31.53 ± 5.40[d]
Rb2	ND	0.22 ± 0.06[a]	1.71 ± 0.16[b]	2.62 ± 0.30[c]	3.61 ± 0.60[d]
Rc	ND	3.44 ± 0.32[a]	6.86 ± 0.17[b]	11.12 ± 0.84[c]	14.09 ± 2.18[d]
Rd	ND	2.51 ± 0.11[a]	6.65 ± 1.14[b]	9.89 ± 2.02[c]	11.07 ± 2.09[c]
Rg1	ND	ND	ND	ND	ND
Rg2	ND	1.08 ± 0.01[a]	1.81 ± 0.47[a]	4.84 ± 0.60[b]	6.14 ± 0.56[c]
Rg3(R)	ND	7.51 ± 0.99[a]	19.35 ± 0.46[b]	22.89 ± 3.62[b]	35.73 ± 1.68[c]
Rg3(S)	ND	8.65 ± 0.77[a]	22.99 ± 0.73[b]	29.57 ± 1.91[b]	41.23 ± 7.49[c]
Rk1	ND	6.66 ± 1.36[a]	11.02 ± 2.65[a]	19.63 ± 4.67[b]	27.76 ± 2.92[c]
Rb1 + Rg1 + Rg3	ND	23.78 ± 2.00[a]	58.69 ± 2.93[b]	75.22 1 + 6.11[c]	108.50 + 12.88[d]

The crackers were baked at 120 °C for 60 min. Values are means and standard deviations for triplicate experiments. Different superscripts indicate significant differences within the same rows ($p < 0.05$; one-way ANOVA and Duncan's multiple range test)

ND not detected

Table 5 Color values and hardness of crackers containing different levels of red ginseng marc

	Replacement level of wheat flour with red ginseng marc				
	0%	5%	10%	15%	20%
L*	60.60 ± 1.55[a]	53.79 ± 1.27[b]	46.37 ± 1.26[c]	44.13 ± 1.49[d]	41.41 ± 0.83[e]
a*	0.56 ± 0.25[a]	3.24 ± 0.29[b]	4.44 ± 0.06[c]	4.97 ± 0.09[d]	5.46 ± 0.13[e]
b*	18.64 ± 0.65[ab]	18.27 ± 0.74[a]	18.56 ± 0.20[a]	18.46 ± 0.39[a]	19.38 ± 0.28[b]
Hardness (N)	6.32 ± 0.53[a]	7.68 ± 1.78[a]	10.17 ± 2.05[b]	10.96 ± 2.40[bc]	12.60 ± 2.02[c]

The crackers were baked at 120 °C for 60 min. Values are means and standard deviations. Different superscripts indicate significant differences within the same rows ($p < 0.05$; one-way ANOVA and Duncan's multiple range test)

Sensory acceptability

Results for the sensory evaluation of the crackers are shown in Table 6. The 5RC scored the highest for flavor liking ($p < 0.05$). As the replacement level of RGM increased over 5%, the score for flavor tended to decrease. Hyun and Kim (2005) reported that the sensory scores for bitterness increased with incorporation of red ginseng. Bitterness of RGM might lower flavor liking of the crackers. As the replacement level of RGM increased, texture and color liking decreased. The decline in the texture liking seems to be associated with the increased hardness (N) of the crackers. In addition, the lower the lightness of the crackers and the higher the redness, the lower the color preference. These results suggest that higher hardness, lower lightness and higher redness of crackers may not be preferred. There was no significant difference in aroma liking except for the 20RC, which had the lowest liking for aroma. The 5RC was the highest in overall acceptability liking, although it was not

Table 6 Sensory acceptability of crackers containing different levels of red ginseng marc

Parameter	Replacement level of wheat flour with red ginseng marc				
	0%	5%	10%	15%	20%
Appearance	6.80 ± 1.68[a]	6.30 ± 1.51[ab]	5.85 ± 1.59[bc]	5.48 ± 1.74[cd]	5.09 ± 2.02[d]
Aroma	5.76 ± 1.72[ab]	6.09 ± 1.47[a]	6.09 ± 1.47[a]	5.59 ± 1.71[ab]	5.22 ± 2.01[b]
Color	6.58 ± 2.01[a]	6.26 ± 1.79[a]	6.02 ± 1.78[a]	5.26 ± 1.73[b]	4.80 ± 2.13[b]
Flavor	5.96 ± 1.88[b]	6.78 ± 1.57[a]	5.85 ± 1.80[b]	4.81 ± 2.11[c]	3.33 ± 2.36[d]
Texture	6.63 ± 1.67[a]	6.37 ± 1.83[ab]	5.70 ± 1.77[bc]	5.48 ± 2.00[c]	3.80 ± 2.01[d]
Overall acceptability	6.37 ± 1.75[ab]	6.81 ± 1.28[a]	6.07 ± 1.63[b]	5.26 ± 1.79[c]	3.65 ± 1.98[d]

Nine-point hedonic scale: 1—dislike extremely, 5—neither like nor dislike and 9—like extremely. The crackers were baked at 120 °C for 60 min. Values are means and standard deviations. Different superscripts indicate significant differences within the same rows ($p < 0.05$; one-way ANOVA and Duncan's multiple range test

significantly different from the 0RC. Jung et al. (2015) found that muffins with 3–6% RGM were the highest in overall acceptability. Zang et al. (2014) also reported that yackwa, Korean traditional cookies, with 1–10% replacement of wheat flour with RGM had no impact on the overall acceptability compared to the ones without RGM ($p > 0.05$). Collectively, the current study demonstrated that the crackers with 5% replacement of wheat flour with RGM were acceptable to the panelists.

Conclusion

Low temperature-long time in baking crackers could be a suitable condition to utilize RGM considering the sum of ginsenoside Rg1, Rb1 and Rg3 in the baked crackers. Further research might be needed to figure out detailed combination of temperature and time to utilize RGM as a baking ingredient in crackers. Crackers with replacement of wheat flour with RGM had more ginsenosides and dietary fibers. Especially, the crackers with 5% replacement of wheat flour with RGM tasted the best. If an adequate amount of RGM is used, it may be used as a functional ingredient which can enhance the nutritional and sensory quality of bakery products.

Abbreviation

RGM Red ginseng marc

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Compliance with ethical standards

Conflicts of interest The authors declare any conflicts of interest.

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