생활과학석사학위논문

Physicochemical Characteristics and Sensory Acceptability of Crackers Containing Red Ginseng Marc

홍삼박 첨가 크래커의 이화학적 특성 및 관능적 기호도

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ABSTRACT

Physicochemical Characteristics and Sensory Acceptability of Crackers Containing Red Ginseng Marc

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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. Proximate composition, ginsenosides, dietary fibers, aroma compounds, color, texture, and sensory characteristics were analyzed. The sum of ginsenoside Rb1, Rg1 and Rg3, dietary fibers, and

major aroma compounds 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 results suggest that low temperature-long time may be a suitable baking condition to utilize RGM in baking products and a proper amount of RGM may improve not only nutritional quality but also sensory properties.

Keywords: Cracker, Dietary fibers, Ginsenosides, Red ginseng marc

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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 1,000 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*., 2006; Zang *et al*., 2014). 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*., 2018). Ginsenosides and dietary fibers, 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 baking products in the world. Cracker is considered to be a proper baking good 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 baking 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 physicochemical properties of crackers containing RGM and to determine effect of different levels of RGM on physicochemical characteristics and sensory acceptability of the crackers.

MATERIALS AND METHODS

1. 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.

2. Materials

RGM, remaining after red ginseng was extracted with water at 89 °C for 53 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.

3. 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.

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. For analysis of proximate composition, dietary fibers and ginsenosides, all the crackers and dough were lyophilized.

Table 1. Formulation of crackers containing red ginseng marc

Ingredient (%, w/w)	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

4. 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. Moisture content was determined at 105 °C until the weight became constant. Crude lipid was extracted by Soxhlet method and crude protein was determined by Kjeldahl method. Ash content was determined after burning at 550 °C overnight.

5. 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 10,000xg for 10 min at 4 °C. Two mL of supernatant was injected into a Sep-Pak Plus C-18 cartridge (Waters Co., Milford, MA, USA). 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.

6. 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. In brief, 1 g of the sample was gelatinized by heat stable α-amylase at 100 °C for 30 min. After gelatinization, protease and amyloglucosidase were added to eliminate protein and starch. Insoluble dietary fiber was filtered and then washed by distilled water. After filtration, 4 volumes of 95% ethanol were added to the filtrate, suspending the mixture for an hour to precipitate soluble dietary fiber. The precipitate (soluble dietary fiber) was filtered and drying at 105 °C, until the weight became constant. Protein and ash contents of the insoluble and soluble dietary fibers were determined for correction. Total dietary fiber was calculated by summing up the insoluble fibers and soluble dietary fibers.

7. Analysis of aroma compounds

Major aroma compounds in the crackers were determined using an HS-SPME-GC/MS system according to Mildner-Szkudlarz *et al*. (2011) with a slight modification. One g of ground sample was placed into a 10 mL headspace glass vial. The vial was equilibrated in a 50 °C water bath for 30 min. After equilibration, fiber coated with divinylbenzene/carboxen/polydimethylsiloxane (50/30 μm film thickness, Supelco) was inserted into the vial, which was then kept at 50 °C for 30 min to absorb aroma compounds. The absorbed aroma compounds in the fiber were analyzed by a GC-MS Shimazdu QP2010 Plus gas chromatography (Shimazdu Co., Kyoto, Japan) equipped with a capillary column (DB-5MS, 30 m × 0.25 mm × 0.25 μm, J&W Scientific, Folsom, CA, USA). The flow rate of helium carrier gas was 0.8 mL min^{-1}. Injector temperature was kept at 250 °C and splitless mode was used for injection. Oven temperature was programmed as follows: 45 °C held for 2 min, from 45 °C to 51 °C at 0.5 °C min^{-1}, from 51 °C to 170 °C at 8 °C min^{-1}, from 170 °C to 230 °C at 18 °C min^{-1} and held for 8 min. Ion source temperature was 250 °C and electron energy was 70 eV. Mass spectra were scanned from 30 to 1000 *m/z*. Aroma compounds were identified compared with the mass spectrum and similarity indices of the National Institute of Standards (NIST) library 08 (Gaithersburg, MD, USA).

8. 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).

9. 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 sec 1^{-1} until the crackers were broken. Maximum power (N) required to break the crackers was defined as hardness.

10. Sensory evaluation

Sensory acceptability of the crackers was evaluated by 54 untrained panelists. The crackers 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 (Figure 1). The research protocol was approved by Institutional Review Board (IRB) at Seoul National University (IRB No. 1812/003-001).

Sample number:

Appearance

☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

Dislike extremely neither like nor dislike Like extremely

Aroma

☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

Dislike extremely neither like nor dislike Like extremely

Color

☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

Dislike extremely neither like nor dislike Like extremely

Flavor

☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

Dislike extremely neither like nor dislike Like extremely

Texture

☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

Dislike extremely neither like nor dislike Like extremely

Overall acceptability

☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

Dislike extremely neither like nor dislike Like extremely

■ Thank you ■

Figure 1. Sensory evaluation sheet for crackers containing different levels of red ginseng marc

11. 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

1. 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.

2. Effects of baking conditions on the crackers containing red ginseng marc

2.1. Effect on ginsenoside composition

All the baking conditions used in this study were set to produce organoleptically acceptable crackers based on preliminary experiments. Although appearances of all the crackers were consistent with 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 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, at the same baking temperature (170 °C), ginsenoside Rb1, Rb2, Rc, Rd and Rg3(S) tended to decrease as baking time increased. Li *et al*. (2018) reported that ginsenoside Rb1, Rb2 and Rd in ginseng flower decreased with increasing baking time at 180 °C. Lee *et al*. (2011) also reported that ginsenoside Rb2 and Rc decreased with increasing heating time at 95 °C. 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 crackers baked at

120 °C for 60 min were the highest in the sum of ginsenoside Rb1, Rg1 and Rg3.

Total mole numbers of protopanaxadiol (PPD) type ginsenosides analyzed in this study were calculated based on the Table 2 (Table 3). Total mole number of ginsenosides was the most in the crackers baked at 120 °C for 60 min and the least in the crackers baked at 220 °C for 10 min. At the same baking temperature (170 °C), the mole numbers of ginsenosides tended to decrease as baking time increased. The decreased mole numbers of ginsenosides might be due to longer heat treatment causing cleavage of glycosidic bond at C-3 or C-20 position (Li *et al*, 2018). With cleavage of glycosidic bond by heat treatment, ginsenoside F2, Rh2, Rg5, compound K, and PPD could be formed (Figure 2). 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.

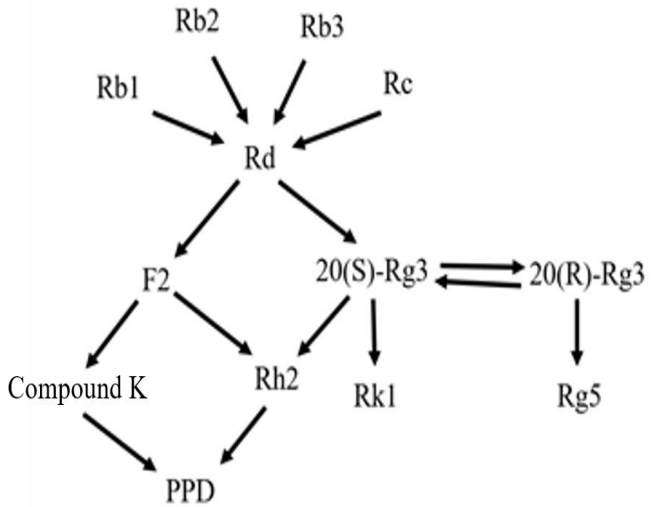
Table 2. Ginsenosides in red ginseng marc crackers baked at different baking conditions

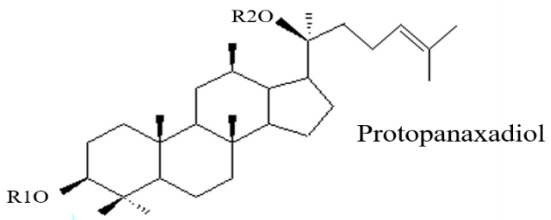
Baking condition	Ginsenoside (mg/100 g, dry basis)									
	Rb1	**Rb2**	**Rc**	**Rd**	**Rg1**	**Rg2**	**Rg3(R)**	**Rg3(S)**	**Rk1**	**Rb1+Rg1+Rg3**
120 °C 60 min	16.35 ± 1.80^{a}	1.71 ± 0.16^{a}	6.86 ± 0.17^{a}	6.65 ± 1.14^{a}	ND	1.81 ± 0.47^{a}	19.35 ± 0.46^{b}	22.99 ± 0.73^{a}	11.02 ± 2.65^{ab}	58.69 ± 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. Different superscripts indicate significant differences within the same columns ($p<0.05$; one-way ANOVA and Duncan's multiple range test).

ND: not detected.





Ginsenoside	R1	R2
Rb1	-glc(2-1)glc	-glc(6-1)glc
Rb2	-glc(2-1)glc	-glc(6-1)ara(p)
Rb3	-glc(2-1)glc	-glc(2-1)xyl
Rc	-glc(2-1)glc	-glc(2-1)ara(f)
Rd	-glc(2-1)glc	-glc
20(S)-Rg3	-glc(2-1)glc	-H
20(R)-Rg3	-glc(2-1)glc	-H
F2	-glc	-glc
Compound K	-H	-glc
Rh2	-glc	-H
PPD	-H	-H
Rk1	-glc(2-1)glc	-H
Rg5	-glc(2-1)glc	-H

Figure 2. Possible pathways of protopanaxadiol (PPD) type ginsenosides by thermal treatment (Li *et al*., 2018).

Ara(f), α-L-arabinofuranosyl; Ara(p), α-L-arabinopyranosyl; Glc, α-D-glucopyranosyl; Xyl, β-L-xylopyranosyl.

Table 3. Protopanaxadiol type ginsenosides in crackers baked at different baking conditions

Baking condition	Sum of ginsenosides (μmol/g)
120 ℃ 60 min	0.98 ± 0.07^{a}
170 ℃ 15 min	0.84 ± 0.05^{b}
170 ℃ 20 min	0.77 ± 0.04^{bc}
170 ℃ 25 min	0.72 ± 0.01^{cd}
220 ℃ 10 min	0.63 ± 0.07^{d}
Unbaked	0.94 ± 0.05^{a}

Ten percent of wheat flour in the crackers was replaced with red ginseng marc.

Sum of Rb1, Rb2, Rc, Rd, Rg3(S), Rg3(R), and Rk1.

Values are means and standard deviations. Different superscripts indicate significant differences within the same columns ($p<0.05$; one-way ANOVA and Duncan's multiple range test).

2.2. Effect on dietary fibers

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 4). 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 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 the same temperature (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 4. Dietary fibers in red ginseng marc crackers baked at different baking conditions

Baking condition	Dietary fibers (%, w/w, dry basis)		
	Soluble dietary fiber	Insoluble dietary fiber	Total dietary fiber
120 ℃ 60 min	1.05 ± 0.15^{a}	6.48 ± 1.17^{a}	7.52 ± 1.22^{a}
170 ℃ 15 min	0.75 ± 0.06^{bc}	5.41 ± 1.33^{ab}	6.17 ± 1.29^{ab}
170 ℃ 20 min	0.80 ± 0.09^{b}	5.80 ± 0.61^{ab}	6.59 ± 0.53^{ab}
170 ℃ 25 min	0.67 ± 0.11^{bc}	4.46 ± 0.91^{b}	5.14 ± 0.97^{ab}
220 ℃ 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.

Different superscripts indicate significant differences within the same columns ($p<0.05$; one-way ANOVA and Duncan's multiple range test.

2.3. Effect on aroma compounds

Ginsinsene, β-panasinsene, β-elemene, β-gurjunene and ledene were the major aroma compounds present in ginseng (Cho *et al*., 2012; Richter *et al*., 2015; Cui *et al*., 2017). In a preliminary experiment, they were also detected in the RGM. These compounds are all sesquiterpenes which contribute to unique aroma of plants (Cho, 2015). The control had the least aroma compounds (Figure 3). After baking, all of the aroma compounds significantly increased ($p<0.05$) and most increased in the crackers baked at 120 °C for 60 min. At the same baking temperature (170 °C), there was no significant difference in the major aroma compounds with baking time. Low temperature-long time baking condition made the crackers have significantly higher aroma compounds than high temperature-short time baking condition. The aroma compounds increased at 120 °C but decreased at 170 °C or higher. Seong *et al*. (2018) reported that the main volatile compound in red ginseng (β-panasinsene) increased with roasting temperature, but it decreased when roasted at 150 °C or higher. Baking at a low temperature for a long time could increase the major aroma compounds in baking products.

Considering the sum of ginsenoside Rb1, Rg1 and Rg3 and dietary fibers, the baking condition at 120 °C for 60 min was selected to bake the crackers for evaluating the effect of different RGM replacement levels.

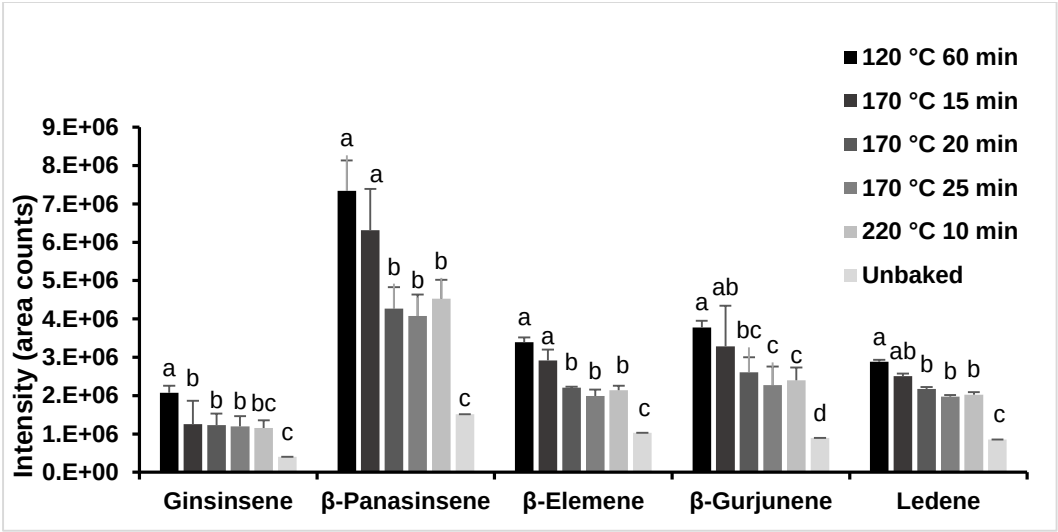


Figure 3. Aroma compounds in red ginseng marc crackers baked at different baking conditions.

Ten percent of wheat flour in the crackers was replaced with red ginseng marc.

Values are means and standard deviations.

Different letters indicate significant differences within the same compounds ($p<0.05$; one-way ANOVA and Duncan's multiple range test.

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

3.1. Proximate composition and dietary fiber contents

Proximate composition of the crackers containing different replacement levels of RGM is shown in Table 5. 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 levels 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%, 1.0% 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.

3.2. Ginsenoside content

Ginsenosides in the crackers containing different replacement levels of RGM are shown in Table 6. 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.

Table 5. Proximate composition and dietary fibers in crackers containing different levels of red ginseng marc

Content (%, w/w, dry basis except moisture)	Replacement level of wheat flour with red ginseng marc				
	0%	**5%**	**10%**	**15%**	**20%**
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}
Insoluble dietary fiber	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 dietary fiber	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 dietary fiber	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}

The crackers were baked at 120 °C for 60 min.

Values are means and standard deviations.

Different superscripts indicate significant differences within the same columns ($p<0.05$; one-way ANOVA and Duncan's multiple range test).

Table 6. Ginsenosides in crackers containing different levels of red ginseng marc

Ginsenoside (mg/ 100 g, w/w, dry basis)	Replacement level of wheat flour with red ginseng marc				
	0%	**5%**	**10%**	**15%**	**20%**
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.

Different superscripts indicate significant differences within the same columns ($p<0.05$; one-way ANOVA and Duncan's multiple range test).

ND: not detected.

3.3. Color

Surface color of the crackers containing different replacement levels of RGM is shown in Table 7. 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.

3.4. Texture

Hardness of the crackers containing different replacement levels of RGM is shown in Figure 4. 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*., 2018) 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 7. Color values 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}

The crackers were baked at 120 °C for 60 min.

Values are means and standard deviations.

Different superscripts indicate significant differences within the same columns ($p<0.05$; one-way ANOVA and Duncan's multiple range test).

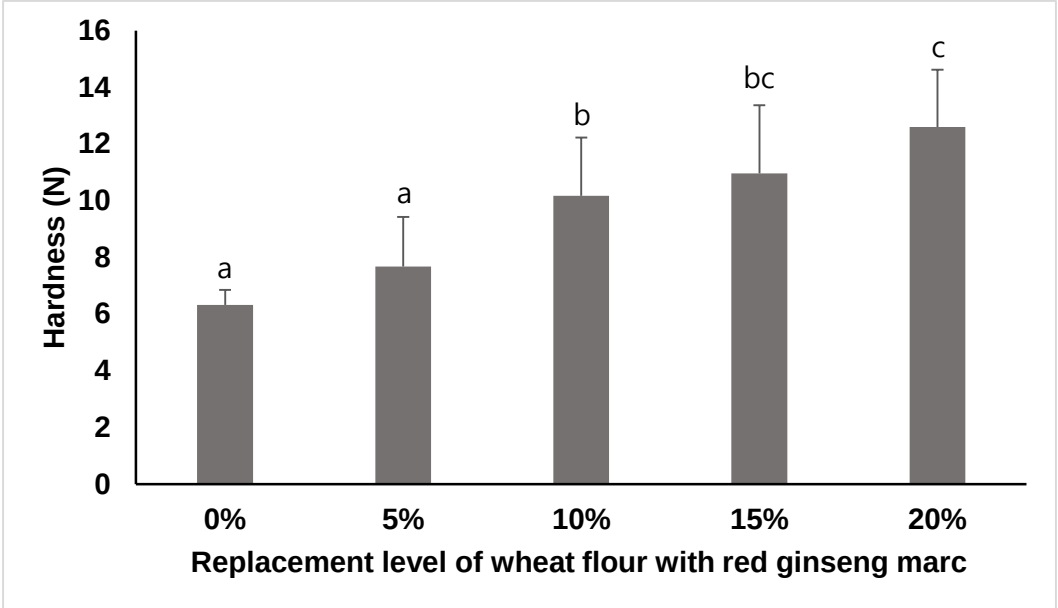


Figure 4. Hardness of crackers containing different levels of red ginseng marc

The crackers were baked at 120 °C for 60 min.

Values are means and standard deviations.

Different letters indicate significant differences within the same columns ($p<0.05$; one-way ANOVA and Duncan's multiple range test).

3.5. Sensory acceptability

Results for the sensory evaluation of the crackers are shown in Table 8. 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 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.

Table 8. 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 columns ($p<0.05$; one-way ANOVA and Duncan's multiple range test).

CONCLUSION

Low temperature-long time could be a suitable baking condition to utilize RGM considering ginsenosides and dietary fibers. 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 a functional ingredient which enhances the nutritional and sensory quality of bakery products.

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국문초록

홍삼박 첨가 크래커의 이화학적 특성 및 관능적 기호도

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홍삼을 추출하고 남은 부산물인 홍삼박은 대부분이 폐기되고 있다. 그러나 홍삼박에는 진세노사이드 및 식이섬유와 같은 유용성분들이 남아 있으며, 이를 활용할 수 있는 연구가 요구되고 있다. 홍삼박을 활용하기 위하여 식빵, 머핀 등의 베이킹 제품에 첨가하는 연구가 진행되었으나, 이는 열에 의한 홍삼박의 주요 유용성분들의 변화를 고려하지 않았다는 한계가 있다. 이에 본 연구에서는 홍삼박을 크래커에 첨가하여 온도와 시간을 달리하여 구워, 베이킹 조건에 따른 홍삼박 유용 성분의 변화를 분석하고자 하였다. 또한 크래커에 홍삼박 첨가량을 달리하였을 때, 홍삼박의 첨가량이 크래커에 미치는 이화학적 및 관능적 특성을 분석하여 유용 성분이 보다 많이 함유되어 있고 관능적 기호도가 높은 크래커를 만들고자 하였다.

10%의 밀가루를 홍삼박으로 대체한 크래커를 다양한 온도와 시간 조건(120℃-60분, 170℃-15, 20, 25분, 220℃-10분)에서 구워 베이킹 조건에 따른 홍삼박의 진세노사이드, 식이섬유, 향미 성분의 변화를 분석한 후 베이킹 조건을 설정하였다. 설정한 베이킹 조건에서 홍삼박의

첨가량(밀가루의 0, 5, 10, 15, 20%를 홍삼박으로 대체)을 달리하여 홍삼박 첨가량에 따른 일반 성분, 식이섬유, 진세노사이드, 색도, 물성, 관능 특성을 분석하였다.

진세노사이드 Rb1, Rg1, Rg3의 합과 수용성 식이섬유 함량은 120℃에서 60분 동안의 베이킹 조건에서 구운 홍삼박 크래커에서 유의적으로 높았다. 홍삼박의 주요 향미 성분인 ginsinsene, β-panasinsene, β-elemene, β-gurjunene, ledene는 베이킹을 하였을 때 유의적으로 증가하였으며, 특히 120℃에서 60분 동안 베이킹할 때 가장 많이 증가하였다. 이 결과를 통하여 실험에 이용한 베이킹 조건들 중 120℃에서 60분 동안 베이킹할 때 홍삼박의 유용성분을 이용하기에 적합하다고 판단하였다.

120℃에서 60분 동안으로 설정된 베이킹 조건에서 홍삼박 첨가량을 달리하여 크래커를 제조하였을 때, 홍삼박 첨가량이 증가함에 따라 수분은 감소한 반면, 조단백, 조회분, 식이섬유, 진세노사이드는 증가하였다. 명도는 홍삼박이 증가함에 따라 감소하였으며, 적색도는 홍삼박 첨가량이 증가함에 따라 함께 증가하였다. 경도는 홍삼박 첨가량이 증가함에 따라 높아지는 경향을 나타냈다. 관능 평가 결과, 밀가루의 5%를 홍삼박으로 대체한 크래커가 맛에 대한 기호도는 가장 높았으며, 외관, 색, 향, 조직감, 전체적인 기호도에 있어서는 홍삼박을 첨가하지 않은 크래커와 유의적인 차이를 보이지 않았다.

결과적으로 홍삼박의 주요 유용성분을 고려하였을 때 본 연구에서

사용한 베이킹 조건 중, 저온 장시간(120℃에서 60분 동안)이 베이킹 조건으로 적합하며, 적당량의 홍삼박을 베이킹 제품에 첨가할 때 영양적인 면뿐만 아니라, 관능적인 특성 또한 향상시킬 수 있을 것이라고 판단한다.

주요어: 진세노사이드, 크래커, 홍삼박, 식이섬유

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