Development of puffed ginseng-rice snack from ginseng powder and map rice flour using steam and compression process

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Abstract A new manufacturing method for producing a puffed ginseng-rice snack (PGRS) was developed using ginseng powder and map rice flour through a steam and compression process (SCP). The physical and sensory properties of the PGRS were characterized. The pellets for puffing were prepared from ginseng powder and map rice flour. The pellets were subjected to 16, 18, and 20% moisture contents and were puffed at 225, 235, and 245°C. The specific volumes of the PGRSs increased with heating temperature and moisture content. However, the breaking strength of the PGRSs decreased. In addition, the SCP imposed special features in the PGRSs that made them more acceptable. The Hunter L-value increased with heating temperature and moisture content. These results indicate that a PGRS with functional additives could be effectively developed into a functional food with the use of a puffing machine, and that the PGRS shows potential as a new snack product.

Keywords Puffed ginseng-rice snack · Steam · Compression · Map rice

Introduction

Currently, snack food makes up a significant part of the world food market. It was estimated that, in terms of retail sales, the total value of the market increased by 12% between 2005 and 2009 to reach 2.39 billion in the UK snack foods market (Research and Markets 2010) and is still

growing. The puffed cake and puffed snack are some of the major successful snack foods whose market has seen rapid growth, as they possess the image of being natural and healthy products. Already, many studies have been conducted to produce nutritive cakes and snacks from different cereal or grain sources such as corn cakes (Hsieh et al. 1989) and wheat cakes (Fan et al. 1999). However, to our knowledge, there have been no reports on the development of puffed ginseng-rice snack (PGRS) manufactured from pellets of ginseng powder and map rice flour.

There has been a recent explosion of consumer interest in the health-enhancing role of specific foods or physiologically-active food components, so-called functional foods (Hasler 1998). Many plant sources such as oats, soy, flax seed, tomatoes, garlic, and tea have been successfully used to produce functional foods (Hasler 1998). The root of ginseng, *Panax ginseng* C.A. Meyer (Araliaceae), has been frequently used in Asian countries as a traditional medicine (Fuzzati 2004). It has been known to be effective as an anti-cancer (Mochizuki et al. 1995), anti-diabetic (Yokozawa et al. 1985), anti-fatigue and anti-stress (Saito et al. 1974; Wang et al. 1983), and anti-inflammation (Matsuda et al. 1990) supplement. Depending on the preparation method, two different ginseng products are available: white and red ginseng. Red ginseng, which is prepared by heat-treating white ginseng, has more pharmacological activities than white ginseng (Nam 2005; Takagu et al. 1990). Therefore, various processed foods containing ginseng or ginseng powder have been developed in East Asia.

Puffed snacks are produced by submitting grain to high temperature and high compression. The principle process involved is the phase-change of starch at high temperature and high compression. Recently, it was reported that a puffed okara/rice cake was developed with blends of okara pellets and parboiled rice (Huff et al. 2008; Mahanta and

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Bhattacharya 2010). The increase in rice content led to greater specific volume, hardness, and lighter color as puffing expansion is very highly correlated with starch changes (Mahanta and Bhattacharya 2010). The general process for making puffed snacks using grain powder poses problems in developing high-quality products. They are irregular in cell size and moisture control. To solve these problems, we added two new steps in the manufacturing process: steam and compression. In this study, we developed a new process to make puffed ginseng-rice snack from pellets of blends containing ginseng powder and rice flour by adding a new method, SCP and determining the optimal conditions towards good snacks through evaluating the physical and sensory properties of the products.

Materials and methods

Three dough samples were prepared by mixing ingredients in different ratios. Sample 1 for rice snack (Ric) contained 600 g of map rice (a kind of Korean rice with very sticky properties) flour (100-mess powder, purchased from market), 3 g of salt, and 336 mL of water. Sample 2 for rice-saccharine snack (Ric-Sac) contained 600 g of map rice flour, 3 g of salt, and 336 mL of a 0.05% saccharine solution. Sample 3 for ginseng-rice snack (Gin-Ric) contained 594 g of map rice flour, 3 g of salt, 6 g of ginseng powder which was prepared by grinding the 4 year-old root of the ginsengs, which were purchased from Gyung-dong market, the largest market of medicinal plants in Korea, through 80-mesh using a grinding machine (Foss Cyclo-tec™ 1093, Denmark) and 336 mL of a 0.05% saccharine solution. The dough samples were subjected to steam for 20 min in a steamer. The hot products were compressed by a compression molding machine of the worm-screw type (Model NJE-3530, UNC electronic, Daegu, Korea). The nozzle size of the machine was 4 mm in diameter. The noodle strips were dried for 1 to 1.5 h to make their moisture content 16, 18, and 20% at 65 °C. The dried noodle strips were cut into pellets 4 mm in length. By changing the drying time of the noodle strips, the moisture content of the pellets was controlled to be 16, 18, and 20%. The pellets were puffed using a Deli POP Machine (DDP-1, Delice Co. Ltd., Sungnam, South Korea: www.delimanjoo.co.kr). Puffing was conducted at 225, 235 and 245 °C, sequenced from low to high temperature, for a heating time of 6 s. The ratio of the cake volume to the cake weight is called the specific volume of the cake (Park 1976). The specific volume was measured by the method proposed by Hsieh et al. (1989) and Park (1976). Hardness was measured with a Texture Analyzer (TAHDI/500, Stable Micro Systems, Boochun, South Korea) using a published method with different probes (Balasubramanian and Viswanathan 2010). The

chromaticity of the sample was measured by a Colorimeter (Chroma Meter CR-400, Konica Minolta Sensing Inc., Japan). The lightness of the puffed snacks was determined by their L-values. Lightness values range from 0 (darkness) to 100 (bright). The L (lightness), a (redness), and b (yellowness) values were measured as described before (Falade and Oyedele 2010; Hsieh et al. 1989; Rai et al. 2010). The moisture content of the pellets was measured with a Moisture Analyzer (XM-60, Precisa Gravimetrics AG, CH-Dietikon, Switzerland). The sensory evaluation of the puffed snacks was performed by selecting a panel of 30 graduate students from Chung-Ang University. Preference of puffed rise snack was measurement by five-grade point. It is indicative of five points to good and one point to bad.

Statistical analysis All data were expressed as the mean $\pm$ S. D. calculated from four average values obtained from four independent experiments ($n=4$). An average value was obtained from three measurements of each parameter in an independent experiment. Data were analyzed by one way ANOVA using SAS 9.2 (TS2M3 2002) software package and means were compared by Duncan's multiple range test. Values were considered significant at $p<0.05$.

Results and discussion

The results are summarized in Table 1. Ric-Sac snack showed the highest specific volume of 10.2 cm³/g at 20% moisture contents and 245 °C temperature and Gin-Ric snack showed the lowest specific volume of 4.1 cm³/g at 18% moisture contents and 225 °C temperature. From the table it is clear that the specific volume increases with increasing puffing temperature and moisture content. Huff et al. (1992) suggested that increasing the puffing induces the acceleration of melting and evaporation of water from rice kernels, which imparts elasticity, increases the degree of expansion and specific volume. Therefore, the results of this study are in agreement with their conclusions that the increase in the specific volume may be due to the phase-change of soluble water at high temperature and high pressure. Moreover, it is clear that the addition of ginseng powder to rice flour reduces the specific volume at lower moisture contents when Ric and Ric-Sac snacks are compared with Gin-Ric snack. The reduction is probably due to the repression of pellet expansion, as ginseng powders are mostly composed of cellulose (Byun et al. 1997) Table 1 indicates that Ric snack shows the highest hardness of 2139.8 g at 18% moisture content and 225 °C and Gin-Ric snack showed the lowest hardness of 549.26 g at 20% moisture content and 245 °C. Therefore, it is clear that the overall hardness of the snacks appeared to decrease with increasing

Table 1 Quality characteristics of puffed rice snacks prepared at different moisture contents and puffing temperatures

Puffing temp. (°C)	Moisture contents (%)				20			
	16		18		225		245	
	225	235	245	225	235	245	235	245
Specific vol. (cm ³ /g)								
Ric ¹	5.4±0.35 B ^p	6.6±0.58 B ^{rs}	7.8±0.55 B ^u	5.7±0.35 C ^{pq}	6.8±0.22 C st	7.6±0.31 B ^u	6.2±0.62 A ^{qr}	7.4±0.43 A ^u
Ric-Sac	4.5±0.30 A ^p	5.1±0.41 A ^{pq}	7.2±1.07 C ^r	4.8±0.38 B ^{pq}	5.6±0.29 B ^q	7.4±0.38 B ^{rs}	6.8±0.82 A ^r	10.2±0.40 C ^t
Gin-Ric	4.3±0.19 A ^{pq}	4.9±0.28 A ^q	5.7±0.83 A ^r	4.1±0.21 A ^p	4.9±0.51 A ^q	6.5±0.47 A ^s	6.7±0.49 A ^s	8.8±0.81 B ^u
Hardness (g)								
Ric	1889.2±710.13 A ^{rs}	1675.2±290.68 AB ^{qr}	1553.6±629.03 A ^{qr}	2139.8±629.29 B ^s	1379.0±337.37 B ^{pq}	803.4±108.59 A ^p	1292.0±304.47 A ^{pq}	764.8±202.86 A ^p
Ric-Sac	2101.7±590.07 A ^s	1822.7±416.76 B ^{rs}	1617.5±346.59 A ^{qr}	1941.3±162.94 B ^s	1500.2±272.11 B ^{qr}	1214.2±385.80 B ^{pq}	1320.3±628.89 A ^{qr}	703.7±81.87 A ^p
Gin-Ric	1558.6±189.92 A ^s	1274.7±230.61 A ^{rs}	1039.2±212.58 A ^{qr}	1268.3±265.81 A ^{rs}	976.3±160.02 A ^{qr}	704.3±137.81 A ^{pq}	1256.9±382.09 A ^{rs}	549.3±147.32 A ^p
L-value ²								
Ric	72.0±4.66 B ^q	71.7±4.28 B ^q	67.7±5.50 B ^p	71.4±3.74 B ^{pq}	70.4±3.48 B ^{pq}	69.8±2.81 B ^{pq}	69.6±2.58 B ^{pq}	69.2±2.94 B ^{pq}
Ric-Sac	76.6±2.63 C ^r	73.6±4.48 B ^{qr}	69.8±4.18 B ^p	73.9±4.18 B ^{qr}	72.8±3.17 B ^{pq}	71.0±4.00 B ^{pq}	71.9±4.02 B ^{pq}	70.4±5.79 B ^{pq}
Gin-Ric	67.9±3.40 A ^t	62.8±3.99 A ^{qr}	61.2±4.39 A ^{pq}	63.5±10.47 A ^{rs}	63.0±4.25 A ^{rs}	59.7±4.46 A ^p	64.6±3.09 A st	60.3±5.89 A ^{pq}
a-value ³								
Ric	-1.0±0.33 A ^p	0.0±0.75 A ^r	0.7±0.76 A ^t	-1.1±0.28 A ^p	0.1±0.78 A ^{rs}	0.5±0.82 A st	-0.9±0.43 B ^p	0.2±0.78 B ^{rs}
Ric-Sac	-1.0±0.33 A ^{pq}	0.2±0.59 A st	1.1±1.02 A ^u	-1.2±0.25 A ^p	-0.5±0.52 A ^{rs}	0.2±0.58 A ^t	1.2±0.27 A ^u	-0.4±0.41 A ^{rs}
Gin-Ric	2.3±1.11 B ^q	4.2±1.67 B ^t	4.5±1.23 B ^t	2.3±0.72 B ^q	4.0±1.50 B ^t	4.6±1.09 B ^t	0.3±0.42 C ^p	2.2±1.41 C ^q
b-value ⁴								
Ric	12.6±2.07 A ^{pq}	14.1±2.50 A ^{qr}	13.7±2.33 A ^{qr}	12.8±2.72 A ^{pq}	14.5±3.30 A ^t	14.1±2.46 A ^{qr}	11.7±3.30 A ^p	12.4±2.67 B ^{pq}
Ric-Sac	13.9±2.82 A ^{qr}	14.4±2.67 A ^{qr}	16.0±3.07 AB ^t	12.4±2.16 A ^{pq}	13.7±3.16 A ^{qr}	13.8±2.19 A ^{qr}	11.2±1.52 A ^p	10.7±2.72 A ^p
Gin-Ric	17.2±2.46 B ^q	17.9±2.11 B ^q	16.7±1.43 B ^q	17.4±1.80 B ^q	18.0±2.05 B ^q	17.0±1.41 B ^q	12.1±1.58 A ^p	13.3±2.70 B ^p

¹ Three different puffed snacks: Ric, Ric-Sac, and Gin-Ric indicate puffed snacks prepared by rice flour, rice flour and saccharine, and ginseng powder and rice flour, respectively

² L, a, and b-value determine the chromaticity properties of puffed products. L-value determines black to white coloration at the range of 1(black) to 100 (white)

³ a-value determines red to green coloration; a>0 indicates redness and a<0 indicates greenness

⁴ b-value determines yellow to blue coloration; b>0 indicates yellowness and b<0 indicates blueness

⁵ All data were expressed as the mean ± S.D. calculated from four average values obtained from four independent experiments (*n*=4). An average value was obtained from three measurements of each parameter in an independent experiment. Means were measured by using SAS software and compared with Duncan's multiple range test. Mean ± SD with different letters within the same row (p-u) and within the same column (A-C) are significantly different (*p*<0.05)

moisture content and puffing temperature. Fan et al. (1999) reported that raising the moisture content from 14% to 16% causes the hardness to decrease in wheat cakes. Eun et al. (2006) also observed the trend of high hardness at low moisture content while using 50% rice flour. However, Kim et al. (1997) observed lower hardness at low puffing temperature with the addition of 16–20% rice flour. Our study showed that hardness decreases gradually due to the increase in the puffing temperature. Total hardness increases gradually due to the addition of 0.05% saccharin solution and 1% ginseng powder. This may be due to the inhibition of cell development by binding force reinforcement of pellets with the addition of ginseng due to its cellulose contents. This study showed that increasing hardness due to cell development inhibition changed the quality of pellets by SCP. This study produced results different from those reported by Eun et al. (2006) with the addition of 50% plain flour. This study used 99% map rice flour, which is thought to have an influence on hardness when combined with amylase and any protein (Marshall and Wordsworth 1994). At 16%, 18%, and 20% moisture contents, Ric-Sac snack showed the highest L-values of approximately 76.6, 73.9, and 71.9, respectively, at 225 °C, and Gin-Ric snack showed the lowest L-values of approximately 61.2, 59.7, and 60.3, respectively, at 245 °C. Therefore, the L-values were shown to decrease with increasing moisture content and heating temperature. At 16%, 18%, and 20% moisture contents, Gin-Ric showed the highest a-values of approximately 4.5, 4.6, and 2.2 respectively at 245 °C, and Ric snack showed the lowest a-values of approximately 0.0, 0.1 at 235 °C and 0.2 at 245 °C. Therefore, the a-values were observed to decrease with increasing moisture content and increase with increasing puffing temperature. At 16%, 18%, and 20% moisture contents, Gin-Ric snack showed the highest b-values of 17.9, 18.0, and 13.3, respectively. Ric snack showed the lowest b-value of 11.7. In the other two cases, Ric-Sac snack showed the lowest b-values of 12.4 and 10.6. The b-values more or less decreased with increasing moisture content and temperature. Moisture content was reported to have no affect on chromaticity (Han et al. 2008). However, this study showed the influence of altering the moisture content. Pellets produced via SCP are strengthened by the moisture absorption force. Thus, the increase in the moisture content of the pellets causes a slow phase-change at high temperature and high compression. This may be due to inhibited heat delivery to the pellets, which produces lower chromaticity in puffed rice cakes. Fan et al. (1999) reported the acceleration of browning at high temperature. The results of this study show similar phenomena. One peculiar observation was the change in brightness and browning due to the addition of 0.05% saccharin solution and 1% ginseng powder. The puffed rice snack produced with the 0.05% saccharin melting solution showed higher mean L-values than the puffed rice snack produced using dH₂O. It was expected because

saccharin is a kind of compound which is resistant to heat, relatively compared to rice flour. Therefore it decreased blackness of the puffed snack (increasing L-value). In contrast, the addition of 1% ginseng powder was shown to decrease L-values and increase browning.

Sensory evaluation revealed that Ric snack was the most preferred at a moisture content of 18%. With respect to hardness, snacks were most preferred at moisture contents of approximately 18% and 16%. The most preferred chromaticity was also observed at a moisture content of 18%. Snacks prepared under these conditions exhibited some different trends in acceptability before and after the addition of additives. Before the addition of ginseng powder, their hardness decreased, and their L-value increased. After the addition of ginseng powder, the L-values remained the same, but the preference toward the snacks increased as their hardness increased. Therefore, preference toward puffed rice snacks prepared from pellets via the SCP is influenced by hardness and L-value.

This study revealed that puffed rice snacks made via the SCP have lower L-values and higher a- and b-values at increased moisture contents and heating temperatures and lower a- and b-value at decreased moisture contents and heating temperatures.

Conclusion

We aimed to determine the most suitable conditions for manufacturing puffed rice snacks from pellets via the SCP. Our results show that the specific volume tends to increase with increasing moisture content and puffing temperature but decreases with the addition of melting solution and ginseng powder. On the other hand, increasing the heating temperature and moisture content causes a decrease in L-value and an increase in a- and b-values of chromaticity. Preference tests show that preference levels increased with decreasing hardness and increasing L-value. However, the preference toward puffed rice snacks prepared from pellet via the SCP increased with the addition of ginseng powder. The preference toward PGRSs was influenced by hardness, peak number and L-value. Brittleness and chewiness increased with peak number that produce puffed rice snacks with tiny cell structure. From our findings we believe that the manufacture of puffed rice snacks into high-quality foodstuffs can be achieved by using a moisture contents between 16% and 18% and at temperature 245 °C with the addition of 1% ginseng powder via the SCP.

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