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Original Article

Development of Cooked Rice with Garlic and *Astragalus membranaceus* Extract for the Health-Friendly Ready-To-Eat Product as Cook-Chill Type

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Abstract: Medicinal cooked rice with *Astragalus membranaceus* extract and garlic was developed as a ready-to-eat product. The response surface methodology was used to examine the effect of garlic and *Astragalus membranaceus* extract addition on the color, texture, and sensory properties to optimize the product. The product was also analyzed for microbiological, sensory, and physical property changes during storage.As for the color, taste, and overall acceptability, the sensory scores increased with the increase of *Astragalus membranaceus* extracts ($p<0.05$). The sensory scores for the product ranged between 9.17~9.92 and foodborne microorganism such as *Bacillus cereus*, *Salmonella*, *Staphylococcu aureus*, and *Eschericha coli* were not detected after 13 storage days. Therefore, the possible shelf life was evaluated for up to13 days of storage. When considering health and convenience are important factors in the development of new food products, the medicinal and biological effects of garlic and *Astragalus membranaceus* could be useful for providing healthy diet options for senior consumers. The results of sensory and microbiological tests showed the potential for the commercialization of ready-to-eat cook-chill product as an alternative of cooked rice for Asian populations and Korean senior consumer market.

Key words: Response surface methodology, *Astragalus membranaceus*, ready-to-eat food, cook-chill product, older adults

I. Introduction

The percentage of people aged over 65 in Korea is expected to increase 21.6% in 2026 from 19.2% in 2024 (Korea Statistical Information Service 2024). As this trend continues, the size of the elderly population is estimated to be four times the size of the young and adolescent population by 2060 (Kwak *et al*. 2013). An aged society not only represents an increasingly older population but also changing cultural, social, and economical structures. With an increase in the elderly population, the main consumers will gradually change, with a greater focus on seniors. Because elderly people may have physical difficulties with meal preparations, the need for convenient foods which are attractive and healthy for elderly people has increased. With this trend, medicinal and convenient foods with nutritional functions such as health promoting effects and the prevention and treatment of diseases have attracted more from older people and food industry including foodservice facilities (Min & Oh 2012).

Garlic (*Allium sativum* L.) is named as one of ten healthiest foods in the world and is widely used for dishes in both its raw and cooked forms (Gorinstein *et al*. 2006; Jastrzebski *et al*. 2007). Many studies have suggested that the biological properties of garlic are effective against metabolic diseases due to their antioxidant, anticarcinogenic, antibacterial, antimutagenic, and blood lipid-lowering activities (Pedraza-Chaverri *et al*. 2000; Benkeblia 2005; Chung 2006; Gorinstein *et al*. 2006; Yoon 2006; Bozin *et al*. 2008; Kang *et al*. 2008). Several studies have shown that the medicinal

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and biological effects of garlic mostly result from organo-sulphur compounds, polyphenols, fibers, and phytosterols (Gorinstein *et al*. 2006; Corzo-Martinez *et al*. 2007; Jastrzebski *et al*. 2007; Han *et al*. 2008). *Astragalus membranaceus* (*Astragalus*) is a traditional Chinese plant also used as amedicinal and health-promoting ingredient. In particular, the dried root extracts of *Astragalus* have shown pharmacological functionalities such as anti-oxidant (Yan *et al*. 2010), antidiabetic (Zou *et al*. 2009), and cardio cerebrovascular activities (Huang *et al*. 2012). Park(2014) studied quality characteristics and effect of diabetes prevention of boiled brown rice with medicinal herbs including *Astragalus* extract. But little attempt has done to develop the convenience food products with garlic or extracts of *Astragalus* known as health effects.

The response surface methodology (RSM) has been largely accepted for the development of new food products with respect to finding the optimal amounts of ingredients (Nath & Chattopadhyay 2007; Wadikar *et al*. 2008; Wadikar *et al*. 2010; Chang *et al*. 2012). According to the Korean Ministry of Food and Drug Safety (2024), “ready to eat (RTE)” is defined as “food cooked instantly or cooked fresh for convenience”, and “instant cooking food” which are already cooked or processed for safe consumption without further cooking. Additionally, RTE food refers tofoods consumed in the purchased state without additional preparation except for washing, thawing, and heating according to the Australia and New Zealand Food Standards Code (2001).

The objective of this study was the development of health-friendly cooked rice for old adults which is easy-to-cook, high quality of sensory and microbiology with long shelf-life and alternative of frozen cooked rice. We conducted to use an experimental design of the RSM with cooked rice with *Astragalus* extract and garlic, to analyze microbiological, sensory, and physical property changes during storage of the ready-to-eat (RTE) product made using an optimized recipe for cooked rice with *Astragalus* extract and garlic, and to assess the possibility of commercializing the RTE product through a consumer market test for elderly people.

II. Materials and Methods

1. Materials

Samples of raw fresh garlic (Danyang, Korea), rice (Imkeumnim, Icheon, Korea), oyster king mushroom (Yangpyeong, Korea), and dried *Astragalus* (Keumsan Food Ltd, China) were obtained from the local market.

2. Experimental design for product development by recipe optimization

The optimized recipe for the cooked rice with garlic, mushroom, and *Astragalus* extracts was determined from literature review (Cho *et al*. 2011) and from 15 preliminary tests. For the central composite design, two independent variables (garlic and *Astragalus* extracts) were determined as garlic and *Astragalus* extracts thank to showing more influences on flavor and texture than mushroom in preliminary tests <Table 1>. Rice was washed 5 times with tap water and soaked in water for 30 minutes. 200 g of dried *Astragalus* was boiled in 1,000 mL of water in Yaktanggi (OC-1000NR, Ocoo, Seoul, Korea) for two hours, and 760 mL of the *Astragalus* extract liquid was Brix-measured using a Refractometer (Bellingham & Stanley Ltd, Hants, UK). Fresh garlic was shredded and soaked in cold water for three hours, then shredded and fried at 180°C for 5 minutes after draining. Shredded mushroom was baked at 180°C in a convection oven (Rational Korea, Seoul) for two minutes. Soaked rice with fried garlic, baked mushrooms, and *Astragalus* extracted water was cooked in a convection oven for 50 minutes at 190°C.

3. Measurement of color, texture, and sensory evaluation

The color values of the cooked rice with garlic and *Astragalus* extract were measured using the Color Techno System (JC-801S; Color Techno System Co., Tokyo, Japan). The L, a, and b values of color represented lightness, redness, and yellowness, respectively. The color values of the sample were measured a total of six times. The texture analyzer (TexturePro CTV1.5 Build.) was used to measure properties such as hardness, springiness, chewiness, cohesiveness,

Table 1. Independent variables and level for central composite design

Independent variables	symbol	Levels (Unit: g)				
		-1.414	-1	0	1	1.414
Garlic	X_1	11.7	20.0	40.0	60.0	68.3
Astragalus m. extracts	X_2	0.0	33.0	115.0	197.0	230.0

adhesiveness, and gumminess six times. The experimental conditions were as follows: measurement type, texture profile analysis (TPA) test type, a pre-test speed of 2.0 mm/s, a test speed of 1.0 mm/s, target speed of 10.0 mm/s, probe type of TA 4/1000, trigger type of auto and force 5 g. A sensory panel of 12 graduate students and researcher trained sensory evaluation was performed the sensory tests of the cooked rice with garlic and *Astragalus* extract. For the sensory evaluation by the sensory panel, preference (color, flavor, and overall acceptability) and strength (color, texture, and taste) tests were conducted using a 15-point rating scale. With the preference test, the rating scale forcolor, flavor, and overall acceptability ranged from 1 - strongly dislike to 15 - strongly like. The rating scale of the strength test also used a 15-point rating scale (color1: 1 - white to 15 - dark brown, texture: 1 - strongly non-glutinous to 15 - strongly glutinous, Taste: 1 - strongly oily to 15 - strongly savory).

4. Quality analysis with storage time

1) Sample preparation

To analyze the effect of storage on the qualities of the experimental (cooked rice with garlic and *Astragalus* extract) and control groups of cooked rice with garlic because of much different flavor and texture between cooked rice with and without garlic, two sample groups were cooked in a steam convection oven (Rational Korea, Seoul) at 190°C for 50 minutes and chilled rapidly to 3°C within 90 minutes using a blast chiller (MF 25.1 31010 Irinox Corbanese, Italy). After the central temperature reached 3°C, 20 g samples from the experimental and control groups were packed in sterilized polyethylene bags (Cheil packaging company, Seoul, Korea) labeled with the production date and sample name for each sample. These samples were stored for 0, 6, 13, and 20 days in the refrigerator at 5°C. To measure the rheological, sensory, and microbiological properties according to the storage time, samples were reheated in a Microwave Oven (700W, Samsung, Korea) for two minutes oneach designated storage day.

2) Microbiological analysis

The samples were treated aseptically using sterilized instruments. Twenty-five grams of the samples were placed in 225 mL of sterile 0.1% (w/v) buffered peptone water and homogenized for 2 minutes in a Stomacher (Easymix; AES, BruzCedex, France). The homogenized samples were evaluated using serial decimal dilutions. For the quantitative microbiological analyses for pathogens such as the total mesophilic plate count (TPC) for *Bacillus cereus*, *Escherichia coli*, and *Staphylococcus aureus*, all samples were tested according to the Korea Food Code (Korea Ministry of Food and Drug Safety 2015a). *Salmonella* spp. was tested with qualitative analysis using VIDAS (Vitek Immuno Diagnostic Assay System, France).

For the detection of *B. cereus*, the homogenized samples were incubated for 24 h at 30°C with the addition of Chromogenic agar (Difco, MI, USA). After incubation, blue circles of colonies in the plates were presumed to be *B. cereus* and counted. When the result was not clear, the sample was incubated for one more day (24 h) at 30°C. To determine the presence of *E. coli*, 1 mL each of the homogenized samples was placed in three fermented test tubes containing EC medium (Difco, MI, USA). Air-foaming tubes were counted todetect *E. coli*. For the detection of *S. aureus*, 0.5 mL of the homogenized samples was smeared on Baird Parker agar (Difco, MI, USA) and incubated for 24 h at 35°C. White colonies in the plates were counted. For *Salmonella* spp. detection, twenty five grams of samples were placed in 225 mL of peptone water and homogenized for one minute in a Stomacher (Easymix; AES, Bruz Cedex, France). The samples were then mixed with 0.5 mL of *Salmonella* supplement and incubated for 24 h at 35°C. After incubation, 0.5 mL of the sample was spread in a VIDAS kit to detect the presence of *Salmonella* spp.

3) Consumer acceptability test with seniors for the cooked rice with garlic and *Astragalus* extracts

A total of 42 senior consumers aged 62 to 85 participated in the consumer test for evaluation of the product. To examine the possibility of product commercialization and evaluation of overall acceptability for the cooked rice with garlic and *Astragalus* extracts, a consumer test was conducted. We chose commercial frozen garlic rice which was the best popular frozen cooked rice in our market for comparing consumer preference between ours and commercial product. The questionnaire consisted of general characteristics such as age, gender, and household income. Product evaluation questions included the acceptability of the product with regards totaste, level of satisfaction, and purchase intention, as well assensory evaluation of the taste, flavor, texture, appearance, color, and overall acceptability using a 5-point rating scale (1; strongly dislike, 5; strongly like).

4) Statistical analysis

RSM was conducted for optimizing the recipe of the

cooked rice with garlic and *Astragalus* extract. The Minitab software package (16.0 version; Minitab Inc.) was used for analyzing data. Results were given as mean and standard deviation (SD) of thirteen independent determinations. Garlic and *Astragalus* extract were set as independent variables and the response variables were the color, texture and sensory properties. Aone-way analysis of variance (ANOVA) was performed to assess the differences among the groups. For product quality analysis, all statistical analyses were performed with SPSS 18.0. The means and standard deviations were calculated with descriptive analysis while ANOVA and paired t-test were used for comparing between samples. The LSD multiple range test was performed for determining differences between samples.

III. Results

1. Determination of optimal combination of ingredients for the cooked rice with garlic and *Astragalus* extracts

The effect of different levels of garlic and *Astragalus* extracts on the sensory test is presented in <Table 2>. The scores for taste, texture, and overall acceptability were affected by the level of *Astragalus* extracts.

The color response scores obtained from the central composite design showed that the value of L increased with decreasing amounts of *Astragalus* extracts and with increasing of garlic <Fig. 1>. On the other hand, the values of a and b increased with increasing amounts of *Astragalus* extracts (p<0.001). For the texture response rates obtained from the central composite design, garlic affected only springiness out of the texture properties evaluated such as hardness, adhesiveness, springiness, cohesiveness, gumminess, and chewiness. The results showed that the springiness decreased with increasing levels of garlic.

Based on the results, the optimum combination was determined as 30 g of garlic and 104 g of *Astragalus* extracts <Fig. 2>. Under these mixing rates, L, a, and b were expected 72.4, 2.3, and 16.3, respectively. Overall acceptability score was estimated as 10.6 out of 15.

2. Changes of sensory quality in cooked rice with garlic and *Astragalus* extracts with storage time

The mean scores of the panel evaluation of the cooked rice with garlic and *Astragalus* extracts as well as two control samples are presented in <Table 3>. The two control samples were cooked rice with garlic and a commercial product. The overall acceptability, color, flavor, and taste of the cooked rice with garlic and *Astragalus* extracts received significantly higher mean scores among the three samples with 0 day storage (p<0.05). For changes in sensory properties after storing for 6 and 13 days, there was no significant difference in all sensory properties among the three samples with the exception of color and taste with 6 day storage and color with 13 day storage of the cooked rice with garlic and *Astragalus* extracts. The maximum possible storage period forthe cooked rice with garlic and *Astragalus* extracts was determined to be13 days because the sensory scores on the 13th day (9.17~9.92) did not decrease compared to scores on the 6th day (8.58~9.58).

3. The changes in chemical and microbiological properties with storage time

<Table 3> shows the changes in color and texture qualities for the three samples according tostorage time (0~13 days). Lightness (L), redness (a), and yellowness (b) across the three samples were differed significantly with storage time over 0 to 13 days (p<0.001). The L values of the cooked rice with garlic and *Astragalus* extracts gradually decreased with increasing storage time. On the other hand, the a and b values of the cooked rice with garlic and *Astragalus* extracts slowly increased with storage time.

The changes in microbiological quality for the samples according to the storage time are presented in <Table 3>. None of the three samples contained *B. cereus*, *E. coli*, *Salmonella* spp., and *S. aureus* during the storage period of 0~13 days except TPC. Based on this result, the experimental product was shown to be safe until 20 days of storage. The reason of testing microbiological test is to identify the product process to meet the quality guideline of RTE product suggested in Food Act of Korea. According to the microbiological standard of RTE or instant convenience foods by the Korea Ministry of Food and Drug Safety (2015b), the acceptable levels of TPC, *S. aureus*, and *B. cereus* are 105/g, 102/g, and 103/g, respectively. For *E. coli* and *Salmonella* spp., the result of examination must be negative.

According to the changes in microbiological levels according to storage days, the cooked rice with garlic and *Astragalus* extracts was safer than the garlic rice or commercial frozen cooked rice from C company because of the antimicrobial effect of *Astragalus* extracts.

4. Consumer acceptability test with seniors

The general characteristics of the seniors (n=42) that

Table 2. Effect of different level of garlic and *Astragalus m.* extracts on the quality properties of the product (Mean±SD)

Run order	Variable[1)] levels		Response									
	X_1	X_2	Overall acceptability	color	flavor	color	texture	taste	L	a	b	Springiness (mm)
1	60	197	8.48±2.9	6.83±2.91	9.23±2.11	12.35±1.38	9.02±1.91	9.48±2.79	70.29±0	3.43±0.1	17.57±0.1	7.22±3.79
2	20	33	9.27±2.18	8.77±3.29	9.9±2.16	5.32±2.27	9.4±2.47	8.52±2.28	76.14±0	1.05±0.1	11.78±0	8.81±3.55
3	60	33	9.27±1.78	10±2.35	9.35±2.44	6.43±1.96	9.85±1.74	8.58±2.09	76.85±0.1	-0.10±0.1	12.38±0	8.79±4.57
4	40	115	10.18±1.6	10.48±2.29	9.85±2.04	9.35±1.98	9.43±1.88	9.83±1.3	73.17±1.1	0.97±0.1	16.61±0.1	7.39±2.59
5	11.7	115	9.68±1.68	11.02±2.46	9.15±2.47	8.9±1.99	9.35±1.9	9.42±1.81	71.23±0	3.53±0.1	16.92±0.1	8.75±3.81
6	40	230	8.92±3.38	6.6±3.04	9.92±2.3	12.5±2.3	9.27±1.92	9.73±2.33	68.34±0.1	4.15±0.1	19.97±0.2	7.02±4.82
7	68.3	115	9.6±1.89	9.93±2.72	9.23±2.1	10.07±1.6	9±2.65	8.42±2.48	74.83±0.1	2.05±0	13.65±0.2	10.54±2.03
8	40	115	9.9±1.33	10.35±1.9	9.73±2.31	9.77±1.88	9.9±2.7	9.48±2.49	71.14±0.1	3.52±0.1	16.8±0	7.86±2.93
9	40	0	8.82±1.93	7.88±2.9	8.65±2.75	3.65±2.11	8.65±1.93	8.00±1.93	77.93±0.1	0.96±0.3	7.622±0.2	7.95±4.61
10	40	115	10.55±1.69	9.4±2.3	10.8±2.19	10.52±1.18	9.55±2.35	10.05±2.48	71.68±0	3.40±0	16.29±0	7.19±5.56
11	40	115	11.18±0.96	11.1±2.17	10.83±1.59	9.75±1.57	9.88±2.44	9.82±2.42	71.72±0	3.09±0	17.14±0.1	7.51±0.4
12	40	115	10.77±1.38	11.1±1.68	10.33±2.03	9.85±1.97	9.68±2.77	10.48±2.73	71.99±0	3.38±0	16.64±0.1	7.88±4.77
13	20	197	10.52±1.71	9.6±2.85	10.17±3.07	10.43±2.16	10.48±2.23	10.48±1.5	69.48±0.1	3.34±0.1	16.58±0.1	7.03±4.12

1) X_1: Garlic, X_2: *Astragalus m.* extracts
2) 15-point scale for overall acceptability - 1: strongly dislike, 7: normal (control), 15: strongly like.
3) 15-point scale for color1 - 1: strongly dislike, 7: normal (control), 15: strongly like.
4) 15-point scale for flavor - 1: strongly dislike, 7: normal (control) 15: strongly like.
5) 15-point scale for color2 - 1: white, 7: ivory, 15: dark brown.
6) 15-point scale texture - 1: strongly non-glutinous, 15: strongly glutinous.
7) 15-point scale for taste - 1: strongly oily, 15: strongly savory.

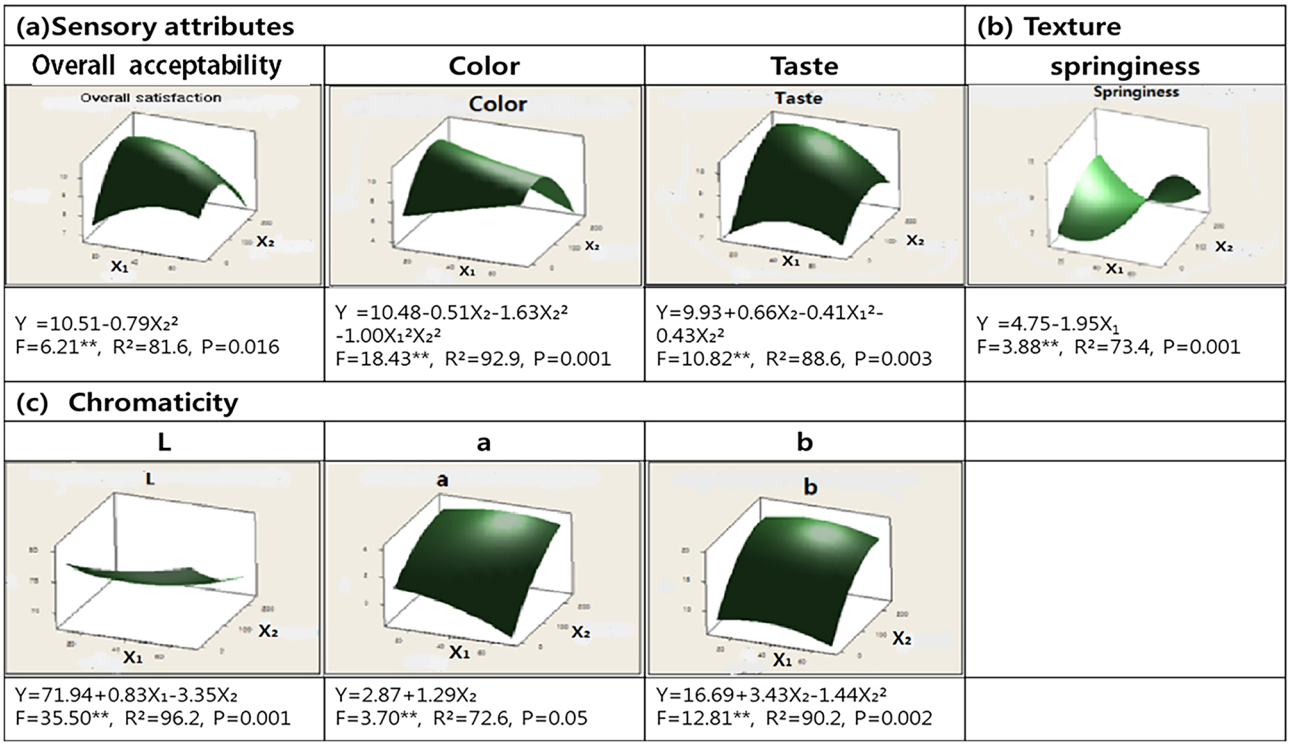
Table 3. The changes of sensory, texture, color, and microbiological properties with storage

Atributes	0 day				6 day				13 day			
	A	B	C	F-value	A	B	C	F-value	A	B	C	F-value
Overall Acceptability	8.07^{b} ±3.49	10.33^{a} ±2.87	10.57^{a} ±1.82	4.05*	8.92 ±1.50	10.79 ±2.73	9.5 ±2.06	1.2	9 ±2.56	10.92 ±2.31	9.25 ±2.34	2.25
Color	8.29^{b} ±3.85	10.93^{a} ±3.1	11.64^{a} ±1.84	4.68*	9.08^{b} ±2.47	11.50^{a} ±2.1	8.58^{b} ±2.93	4.57*	9.33^{b} ±2.67	11.50^{a} ±2.02	9.42^{ab} ±1.92	3.63*
Flavor	8.57^{b} ±3.54	10.50^{a} ±3.80	11.57^{a} ±1.69	3.23*	9.58 ±2.15	10.67 ±2.96	9.42 ±2.50	0.84	9.17 ±2.95	11 ±2.73	9.67 ±2.67	1.39
Texture	7.43 ±3.69	7.64 ±4.24	10.14 ±3.42	2.16	8.83 ±3.12	9.75 ±3.72	9.58 ±2.35	0.29	9.25 ±2.86	10.5 ±2.84	9.92 ±2.57	0.614
Taste	7.86^{b} ±3.15	10.07^{a} ±4.65	11.57^{a} ±1.55	4.05*	9.25^{a} ±2.34	11.83^{b} ±3.53	9.50^{ab} ±1.88	3.39*	9.42 ±2.64	10.92 ±2.35	9.17 ±2.40	1.76
L	78.2 ±2.3^{b}	57.0 ±0.0^{c}	74.1 ±0.1^{a}	376.12***	78.9 ±1.2^{c}	64 ±0.7^{a}	74.3 ±0.3^{b}	495.66***	79.1 ±0.3^{c}	68.4 ±0.1^{b}	72.1 ±0.2^{c}	9,087.29***
a	1.1 ±0.1^{b}	-4.0 ±0.1^{a}	2.7 ±0.1^{c}	6,472.48***	1.1 ±0.3^{b}	-3.7 ±0.1^{a}	3 ±0.1^{c}	1,781.5***	1.7 ±0.1^{b}	-4.3 ±0.1^{a}	3.5 ±0.0^{c}	24,183.58***
b	10.3 ±0.1^{a}	19.7 ±0.1^{c}	16.1 ±0.1^{b}	15,979.27***	10.9 ±0.1^{a}	18.3 ±0.1^{c}	14.6 ±0.3^{b}	1,801.91***	12.3 ±0.1^{a}	27.4 ±0.2^{c}	17.5 ±0.1^{b}	22,750.15***
Adheslveness (unit: mj)	0.4^{a} ±0.3	1.0^{b} ±0.3	0.5^{a} ±0.1	8.628**	1.0^{b} ±0.3	0.4^{a} ±0.3	0.5^{a} ±0.1	8.63**	0.1 ±0.0	0.1 ±0.2	0.1 ±0.1	0.083
Springiness (unit: mm)	4.2 ±4.8	5.0 ±3.9	2.9 ±0.4	0.393	4.9^{ab} ±0.5	3.1^{a} ±0.5	7.9^{b} ±3.4	8.15**	2.3 ±0.2	5.8 ±6.0	9.5 ±6.5	1.501
TPC (unit: CFU/g)	41900.0 ±48931.8	ND	46700.0 ±6611.5		1900.0 ±2687.0	ND	23650.0 ±33446.2		7300.0 ±3959.8	1100.0 ±141.4	185.0 ±233.3	
B. cereus	ND	ND	ND		ND	ND	ND		ND	ND	1850 ±2333.5	
E. coil	ND	700 ±0.0	ND		ND	ND	ND		ND	ND	ND	
Salmonella	ND	ND	ND		ND	ND	ND		ND	ND	ND	
S. aureus	ND	ND	ND		ND	ND	ND		ND	ND	ND	

N.D.: not detected

A: Garlic cooked rice, B: Commercial product by company, C: Garlic cooked rice with Astragalu, TPC: total mesophilic plate count

Values in each row followed by different lower case superscript letters are significantly different at *p<0.05, **p<0.01, and ***p<0.001 (one-way ANOVA, LSD test)



X_1: Garlic; X_2: *Astragalus* extracts

Fig. 1. Polynomial equation for sensory, texture, and color of cooked rice with garlic and *Astragalus* extracts calculated by RMS

participated are given in Table 4. Approximately 76.2 percent of the participants were female, 66.7 percent of them were married, and 66.7 percent of them received more than 6 years of education (elementary). Their monthly spending was mostly under 700 USD (81.2%), the average age was 77, and 85.7 percent of the respondents rated their health status as normal and above.

The cooked rice with *Astragalus* extracts and garlic received higher scores for taste (p<0.01) and flavor (p<0.001) among the three samples <Table 5>. They evaluated the cooked rice with garlic and *Astragalus* extracts as the healthiest product (64.3%) among the three products (the cooked rice with garlic, the commercial frozen garlic rice, and the cooked rice with garlic and *Astragalus m*. extracts). For the product they were most likely to purchase, the commercial product (45.2%) was chosen, followed by the cooked rice with *Astragalus* extracts and garlic (40.5%). For the most delicious product, the participants chose the commercial product (50%), followed by the cooked rice with *Astragalus* extracts and garlic (28.6%).

IV. Discussion

As increased elderly population, it is necessary to develop RTE products which are simple and convenient. With the globalization of food cultures and health functionality of rice, western people as well as eastern has increasingly preferred cooked or fried rice. Moreover, cooked rice with medicinal herbs is thought to be valued on healthy food in eastern countries.

In terms of the above perspective, this study attempted to develop the health-friendly RTE product as cook-chill type. We developed medicinal cooked rice product with *Astragalus* extract and garlic using the RSM, which is known as a scientific methodology. According to the central composite design and overall satisfaction in a sensory evaluation test, the optimum mixture ratio was determined to be 30 g of garlic and 104 g of *Astragalus* extract in one batch cooking size.

Garlic has been generally known numerous medicinal effects as well as a flavoring agent Corzo-Martínez *et al*.

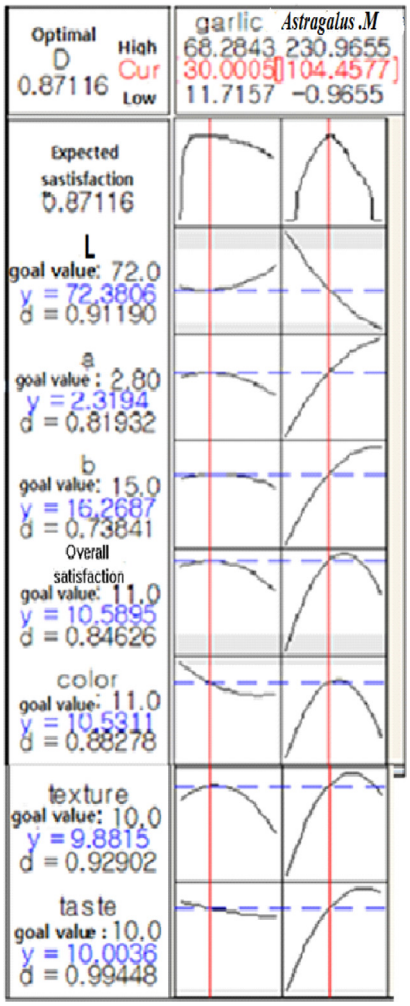


Fig. 2. Plot of depicting effects of sensory properties in the optimum conditions

2007). Garlic has been widely used cooking as a seasoning due to unique taste and flavor. Moreover, stir-fried garlic has been increasingly made use of various cooking recipes due to decreasing spicy taste of garlic and increasing absorption of fat-soluble nutrients. Many studies indicated that biological and medicinal efficacies of garlic are anticarcinogenic, antihypertensive, antimicrobial, antithrombotic, cholesterol-lowering, and antioxidant activities (Bozin *et al*. 2008; Kang *et al*. 2008; Lim *et al*. 2011).

Astragalus extracts contains the *Astragalus* polysaccharides (CAPS) which has a beneficial health effect of antioxidant activity by scavenging not only hydroxyl radical but also hydrogen peroxides. Moreover, it has a higher binding effect on ferrous ions and reduces the risk of cardiovascular disease by having affinity of bile acid-binding ability (Niu *et al*. 2011). Jin *et al*. (2014) also reviewed the health benefit effects of polysaccharides of as anti-diabetic complications,

Table 4. Demographical variables of the respondents

Characteristic	Variables	N (%)
Gender	Male	10 (23.8)
	Female	32 (76.2)
	Total	42 (100)
Education level	No education	2 (4.8)
	Elementary	12 (28.6)
	Middle school	10 (23.8)
	High	12 (28.6)
	University	6 (14.3)
	Total	42 (100)
Income (unit: $)	300 less	14 (33.3)
	310-500 less	14 (33.3)
	510-700 less	6 (14.3)
	710-1,000 less	4 (9.5)
	1,010-1,500 less	1 (2.4)
	1,510-2,000 less	2 (4.8)
	2,000 over	1 (2.4)
Health status	Very healthy	1 (2.4)
	Healthy	10 (23.8)
	Normal	25 (59.5)
	Bad	5 (11.69)
	Very Bad	1 (2.4)

hepatroprotective, and anti-inflammatory activities.

As for the color, taste, and overall satisfaction, the sensory scores increased with increases in the level of *Astragalus* extracts ($p<0.05$). Little study was done to test changes in texture, color, and sensory properties on cooked rice. Kono *et al*. (2015) reported that ice crystal of frozen cooked rice had an influence on textural and sensory properties. The higher diameter of ice crystals of sample was related with the lower score of palatability, chewiness, stickiness, and viscosity of samples. Frozen cooked rice stored at −27°C could be predicted an optimum storage period as 90 days and the samples stored −15°C with microwave reheating be predicted as 40 days.

The L values increased with increasing levels of garlic and decreasing levels of *Astragalus* extract. The a and b values increased with increasing levels of *Astragalus* extract. The level of *Astragalus* extract concentration affected L, a, and b values because the color of *Astragalus* extract usually is dark yellow or brown and garlic is light yellow or ivory color (Shim *et al*. 2016). Therefore, the amount of *Astragalus* extract significantly affected the overall color. As the sensory scores of cooked rice with *Astragalus* extracts and garlic

Table 5. Comparison on customer preference on sensory properties using ANOVA

Attributes	Menu items			
	Garlic rice	*Astragalus* extract & garlic rice	Commercial product	F value
Sensory property[1)]				
Taste	2.98±1.13[b]	3.74±1.25[a]	3.81±1.36[a]	0.694**
Flavor	2.83±1.20[b]	3.83±1.16[a]	3.31±1.29[ab]	7.000***
Texture	3.38±1.22	3.38±0.96	3.55±1.31	0.281
Appearance	3.52±1.15	3.33±1.26	3.45±1.15	0.275
Color	3.76±1.26	3.38±1.32	3.50±1.23	0.981
Overall satisfaction	3.36±1.30	3.76±1.10	3.74±1.17	1.520
Average	3.30±0.89	3.57±0.86	3.55±0.86	
Perception on products[2)]				
Most delicious sample	9(21.4)	12(28.6)	21(50.0)	
Menu that is likely to be the best on health	6(14.3)	27(64.3)	9(21.4)	
Menu that you want to buy the most	6(14.3)	17(40.5)	19(45.2)	

[1)]Represented as mean and standard deviation
[2)]Represented as number and percentage
Values in each row followed by different lower case superscript letters are significantly different at $^{**}p<0.01$, and $^{***}p<0.001$ (one-way ANOVA, LSD test)

ranged between 9.17~9.92 after 13 days of storage, the product's possible shelf life was evaluated as up to 13 days.

The cooked rice with *Astragalus* extracts and garlic did not contain *B. cereus*, *Salmonella*, *S. aureus*, or *E. coli*, therefore, the microbial quality of the sample was considered acceptable for up to 13 days of storage. Min (2009) researched changes of total bacterial cell counts in Korean traditional rice beverage with added *Astragalus* extract and found that the level of total bacterial cell counts decreased with increasing amounts of *Astragalus* extract over 0~12 days of storage. Yoon (2009) reported on the antibacterial activity of garlic by comparing fresh crushed garlic and garlic diluted with sterilized distilled water. The research suggested that garlic extract had an antimicrobial effect on food poisoning bacteria such as *E. coli*, *S. aureus*, *Salmonella typhimurium*, *Vibrio parahemolyticus*, *Bacillus subtilis*, and *Listeria monocytogenes*. Cook-chill process is the food preservation method in which food is prepared and cooked in two minutes at 74°C or over and then chilled within 90 minutes under 5°C in blast chiller. This method offers high moisture retention of foods, high quality of texture and flavor, and inhibition of microbial growth. Our study also shows improvement of taste and microbial quality.

The cooked rice with *Astragalus* extracts and garlic was evaluated as the most healthy product (64.3%) out of three samples. The cooked rice with *Astragalus* extracts and garlic also received the highest scores for taste ($p<0.01$) and flavor ($p<0.001$) out of the three samples. Cooked rice with *Astragalus* extract and garlic was chosen as the healthiest product (64.3 %) among the three products because most of participants recognized that *Astragalus* extracts and garlic are healthy food.

Our study has a limitation. We could not examine functional and biological activities of *Astragalus* and garlic such as antioxidant activity, polyphenol, and flavonoide concentration. Now that a body of experimental researches have presented the functional effect on *Astragalus* and garlic, this study did not test practical effects of functionality. Nonetheless, our research method is great help to develop fresh and healthy rice product comparing current market products which are mainly sold by frozen state. Health and convenience are important factors in the development of new food products. The medicinal and biological effects of garlic and *Astragalus* could be useful for providing healthy diet options for senior consumers. The results of sensory and microbiological tests showed the potential for the commercialization of RTE cook-chill product as an alternative of cooked rice for the senior consumer market.

V. Conclusions

The health-friendly cooked rice with *Astragalus* extract and garlic as an RTE product was developed for elderly people using the RSM. As for the color, taste, and overall satisfaction, the sensory scores increased with increases in the level of *Astragalus* extracts ($p<0.05$). The L values increased with increasing levels of garlic and decreasing levels of *Astragalus* extract. The a and b values increased with increasing levels of *Astragalus* extract. The amount of *Astragalus* extract significantly affected the overall color. According to the experiment of sensory and microbial quality, product's possible shelf life was considered acceptable for up to13 days of storage.

To our knowledge, this work is the first trail for testing the possibility on the product development on the cooked rice product with *Astragalus* extracts and garlic, which are known as the health functional effects in Korea, where no medicinal cooked rice product came out in market as well as no related paper published. Moreover this study was applied the scientific methodology of RSM for determining the best mixing rate of the ingredients which had strong effects on sensory quality of the product. So, the study could provide potential data for developing the health-friendly RTE product targeting Asian peoples as well as the Korean elderly.

Conflicts of Interest

No potential conflict of interest relevant this article was reported.

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