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Food Properties of Ready-to-eat Flavored Ginseng Chips as Affected by Food Formulation and Food Processing+

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+Running title: Food quality of ready-to-eat ginseng chips

Abstract: As a kind of herbal medicine, different processing methods have been studied to improve ginseng qualities. However, as a food material, ginseng processing has not been fully studied. The objective of this study was to develop novel food products for ready-to-eat (RTE) ginseng chips with specific flavors through food processing (soaking with different media, pre-heating, steaming, freezing and freeze drying). Changes in chroma, texture, total phenolic contents (TPC), and DPPH radical scavenging activities (DPPH) of novel ginseng product were investigated. Results showed that ginseng treated with most of soaking media obtained significant differences ($p < 0.05$) in food properties. Typically, significant ($p < 0.05$) color changes in ginseng chips was found in ginseng treated with black soybean soaking water. An obvious enhancement of total phenolic contents (TPC) and DPPH were found in green tea water. RTE ginseng chips with value–added and specific flavor were successfully obtained by food processing technology.

Keywords: Ready-to-eat, flavored ginseng chips, Chroma, Texture, Phenolics, Antioxidants

Practical applications

This research would have practical applications in providing value-added novel food products derived ginseng. Presented information will provide useful information for food industry to develop new ready-to-eat ginseng food products with specific flavors. and textures.

1. Introduction

Ginseng (*Panax ginseng* Meyer) is a kind of nourishing and pervasive herbal medicine in Northeast Asia. As a kind of herbal medicine, different processing methods have been studied to improve ginseng qualities which meet the requirement of market. However, as a food material, ginseng processing has not been fully studied. In 2012, China Ministry of Health approved cultivated ginseng (root and rhizome of *Panax ginseng* C. A. meyer) as a "New Food Material". Five-year-old or younger ginseng was permitted to enter into food market by state approval on August 29 of 2012 and could be used as a food material in China. So ginseng root is no longer only used as therapeutic agents but also marketed as dietary supplements or raw materials of health food. Since then, ginseng started to enter China food field. However, in China historical manufacturing, ginsengs were processed by rough machining which lead to plenty of beneficial compounds wastage.

Recently, a variety of processing methods, including heat processing, alkali treatment and microbial

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conversion have been applied to the preparation of ginsengs products (Liu et al., 2010; Oh et al., 2010). Red ginseng (obtained through a process of steaming and drying from white ginseng) and black ginseng (nine times steaming, nine times drying) were two typical examples which can create or enhance the physiological ingredients of ginseng by a series of processing method (Ban et al., 2010). In addition, compared to raw ginseng, ginsenosides content could be improved by food processing technology, such as activate bioactive components by thermal processing or acid impregnation (Ban et al., 2010; Kim et al., 2000; Kim et al., 2011). As an effective method, food processing could improve the content of ginsenosides and obtain a significant difference for developing the valid values of processed ginseng products.

Read-to-eat ginseng chips marketed in China is not very popular so far, it may be caused by their original flavor, which is more close to herbal flavor of ginseng. Thus, it is necessary to modify the flavor and texture in order to make the end-product as a food through food formulation and food processing techniques.

Therefore, this study aimed to develop a novel ginseng product based on food processing technology include soaking with flavored soaking media, steaming and vacuum freeze-drying, and to develop value added novel ginseng product with specific flavors. Food quality attributes in terms of texture, color, as well as phenolic contents and antioxidant activities of novel ginseng products were evaluated in this study.

2. Materials and Methods

2.1. Ginseng Materials

Dried white ginseng commercial products were purchased from DaQin Specialty Supermarket in DunHua City, Jilin Province, China. The white ginseng products were made from fresh ginseng (five-year ginseng, harvested in 2008) which were cultivated in Fusong County, Baishan City, Jilin Province of China. Ginsengs without obvious defects or injuries were used for further processing. The average moisture content and the average weight of the dried white ginseng was 7.4±0.5% and 21.5±2.3 g, respectively.

2.2. Food Media for Soaking Use

The following soaking media were selected due to their popular application in food processing or popularity as a food. Coca-cola (600 mL, bottled), milk (Yili pure milk, 250 mL), Chinese liquor (Jiujiang Shuangzheng, 29.5% alcoholic content), 9 ° vinegar (Donggu, white vinegar, total acid ≥ 9.0 g/100 mL), 5 ° vinegar (Haitian Jinbiao, rice vinegar, total acid ≥ 5.0 g/100 mL), local beer (Haizhu, ≥ 4.1% alcoholic content), tap water, green tea (Chezi, teabags, 2 g × 25), black tea (Lipton, teabags, 2 g × 25), black soybean, adzuki bean, glucose, sucrose, perilla seed (purchased in herbal medicine store), *Schisandra chinensis* (purchased in herbal medicine store), soy milk (Vitasoy, original flavor, 1L), red wine (Great Wall dry red wine, 12% alcoholic content) were used in this study.

2.3. Chemicals and Reagents

Trolox was supplied from Sigma-Aldrich Co. (St. Louis, MO, U.S.A.). Folin- Ciocalteu reagent was obtained from Shanghai Sanjie Biotechnology Co., Ltd (Shanghai, China). The other chemicals were purchased from Tianjin Damao Chemical Reagent Co, Ltd (Tianjin, China) or Guangzhou Chemical Reagent Company (Guangzhou, China). All other chemicals were of analytical grade.

2.4. Ginseng processing

2.4.1. Soaking- Preparation of Soaking Media

Coca-cola, milk, Chinese liquor, 9℃ vinegar, 5℃ vinegar, beer, tap water, green tea steeped water (6 g soaked in 250 mL tap water), black tea steeped water (6 g soaked in 250 mL tap water), black soybean soaking water (ratio of solid to liquid at 1 : 3), adzuki bean soaking water (ratio of solid to liquid at 1: 3), glucose solution (30 ~ 50%), sucrose-vinegar solution (1 : 1 w/w), sucrose solution (sucrose in water, 1 : 1 w/w), perilla seed soaking water (5 g/100 g), *schisandra chinensis* soaking water (5 g/100 g), soy milk, and red wine. The detailed information was listed in **Table 1**.

2.4.2. Soaking - Selection of Soaking Time

The relationship between soaking time and moisture content of white ginseng was shown in **Fig. 1**. It indicated that moisture content trend to achieve saturation stage when white ginseng slices soaked in water for 3.5 hr. In order to avoid loss nutritional contents, soaking time at 3.5 hr were selected as the optimal time for white ginseng soaking treatment.

2.4.3. Soaking Processing

Sliced ginseng (14 - 15 g) was soaked for 3.5 hr at 4℃ in refrigerator after adding 50 mL different soaking media.

2.4.4. Thermal Processing (pre-heating, steaming, freezing, and freeze drying)

Soaked ginseng were placed in a flat container and then pre-heating in drying oven at 60℃ for 0.5 hr (kept relative humidity between 50 - 98 %), and then steamed for 1 hr at 120℃, followed by freezing at -80℃ refrigerator and freeze dried by vacuum freeze drier (FreeZone 1 liter benchtop, Labconco company). The final products (ready-to-eat (RTE) flavored ginseng chips) were sealed through vacuum packaging and stored in refrigerator for further analysis. The whole processing procedures were shown in **Fig. 2**.

2.5. Determination of Color Values

Chromatism of different samples was determined by following the method of Xu, Yuan and Chang (2007). Color values of the processed RTE flavored chips were measured with a Konica Minolta Chroma Meter (Model CR-410, Minolta Camera Co., Osaka, Japan) using the Hunter scale for *L*, *a*, and *b*. Calibration was conducted on a standard white plate (Y = 86.4, x = 0.3156, y = 0.3231). Results were expressed as tri-stimulus values (*L*: lightness (0 = black, 100 = white), *a* (-*a* = greenness, +*a* = redness), and *b* (-*b* = blueness, +*b* = yellowness)). These values were then used to calculate chromatism by commonly formula $\Delta E = [\Delta L^2+\Delta a^2+\Delta b^2]^{1/2}$, and hue degree ($h^o$ = arc tangent [b/a]), chroma ($C = [a^2+b^2]^{1/2}$), which was the intensity or color saturation.

2.6. Texture Analysis

Textures of processed RTE flavored ginseng chips were analyzed by CT3 texture analyzer (Brookfield, Massachusetts, U.S.A.). TA 7 detector and TA-JTPB fixer were combined to detect the frangibility at room temperature under testing condition with pre-test speed of 2 mm/s, test speed of 0.5 mm/s, post test speed of 0.5 mm/s and target value 2 mm. All machine setting were followed the instruction of operational manual and the results were expressed as g force/processed ginseng chip.

2.7. Determination of Total Phenolic Contents (TPC)

Phenolic compounds were extracted from processed RTE flavored ginseng chips powders follow the description of Singleton and Rossi (1965) with slight modifications by Xu, Yuan and Chang (2007). Total phenolic contents (TPC) was analyzed using Folin-Ciocalteu method followed the instruction of Xu and Chang (2007).

2.8. Determination of DPPH Free Radical Scavenging Activities

The method of extracting DPPH was referred to TPC extraction method as above description which was followed the instruction of Xu and Chang (2007). DPPH was determined based on the method of Chen and Ho (1995) with some modification by Xu and Chang (2007).

2.9. Statistical Analysis

Analyses were performed at least in duplicate, and results were expressed as mean ± standard deviation. Statistical analyses were performed using Microsoft

2010 package and SPSS package (SPSS 17.0, SPSS Inc, Chicago, IL, U.S.A.). Analysis of variance (ANOVA) was conducted by Excel, and Duncan's multiple range tests were used to determine the significant ($p < 0.05$) differences.

3. Results and Discussions

3.1. Morphological Properties of RTE Flavored Ginseng Chips

Morphological properties of processed ginseng products were shown in **Fig. 3**. Typically, it appeared purple color in black tea and obtained dark yellow color in sucrose-vinegar solution soaking medium, and coca-cola soaked ginseng chips appeared a dark browning color.

3.2. Flavor Properties of RTE Flavored Ginseng Chips

Most kinds of ginseng chips were with various specific flavors. Especially, sucrose -vinegar solution soaking medium treated ginseng presented with favorable sour and sweet flavor. Sucrose and glucose solutions contributed sweet flavor to RTE flavored ginseng chips. Ginseng chips soaked with coca-cola created slight coca-cola flavor.

3.3. Color Values of RTE Flavored Ginseng Chips

Chromatism is a kind of problem relates to sensory and subjective explanation. Many factors can change the color of a substance and lead to the chromatism. Thus chromatism will be a good indicator to describe the sensory properties of different novel ginseng products. Also color is an index for grading Asian red ginseng. It has been studied surface color formation of Asian ginseng will be effected by drying time and temperature (Ren et al., 2000). In addition, brightness, chroma, and hue are the properties of color consist of three-dimensional which can describe chromatism concisely and clearly.

Brightness, chroma and hue value of novel ginseng products with soaking media, such as coca-cola, milk, Chinese liquor, vinegar, etc., were shown in **Table 2**. Within expectation, some of the processed ginseng chips presented big color change with significant ($p < 0.05$) differences compared to original ginseng. For *L* value, significant ($p < 0.05$) differences were found among most soaking treatments, but no significant difference was found between perilla seed and 5ºC vinegar, and between coca-cola and green tea water. The highest *L* value (80.3) was obtained from raw ginseng, the lowest *L* value (61.2) from black soybean soaking water which obtained anthocyanin from soaking media, lead to low brightness value. For indicator ***a*** value, most soaking treatments caused significant ($p < 0.05$) differences and the maximum one processed by red wine which contributed the red pigment increase from 3.1 to 7.6. For indicator *b* value, it ranged from 9.3 in black soybean soaking water to 23.7 in sucrose - vinegar solution ginseng chips with significant ($p < 0.05$) differences.

Significant ($p < 0.05$) differences were found in hue degree, chroma and △E among most of soaking treatments. The highest value of hue degree was contributed from soy milk (1.4) and lowest from black soybean soaking water (0.9). The highest chroma value was obtained from ginseng treated with glucose solution (24.3) and sucrose – vinegar solution (24.2) with no significant differences, the lowest from black soybean soaking water (11.7) due to the anthocyanin. △E is the common indicator for chromatism (color different) based on *L*, *a*, *b*. All soaking treatments exhibited color changes compared to raw ginseng (without processing) with significant ($p < 0.05$) differences. Surprisingly, the lowest △E value (19.3) was found in raw ginseng, the highest value (34.6) was found in black soybean soaking water.

The significant changes in color values of processed ginseng could be mostly attributed to the soaking materials, amino acid content changed and Maillard reaction. The proper level and type of free amino acids can improve the color (Wong et al., 2008). Research reported by Wong et al. (2008) also shown that Maillard products of amino acids and reducing sugar will form different degrees browning color after heating.

3.4. Texture of RTE Flavored Ginseng Chips

Crispness is a kind of texture indicator for food quality that relate to hardness, fracture stress and breaking energy. It plays an important role in food structure for consumers to assess the food quality. Nowadays, there is still without a clear evaluation method for analysis crispness, but texture analyzer is widely applied in food area. It has been studied that the maximum force (F_{max}) can be reflected as the characteristic of crispness. Also crispness holds a high positive correlation with hardness (Hu et al., 2010; Yu and Ishiuchi, 1996).

The texture plots of ginseng samples were presented in **Fig. 4**. Hardness of ginseng products made with different soaking medium ranged from 282.5 g in coca-cola treated ginseng to 1829.5 g in red wine treated ginseng, crispness ranged from 280.3 g to 1814.8 g, and hardness deformation (HD) was ranged from 2.15% in adzuki bean soaking water treated ginseng to 10% in sucrose solution treated ginseng (**Table 3**). Significant ($p < 0.05$) differences of hardness and crispness were found among most of soaking media treated ginseng. But no significant differences between ginseng products treated with glucose solution and milk, between raw ginseng and *Schisandra chinensis* treated ginseng, between Chinese liquor and sucrose- vinegar solution, between 9°C vinegar and black soybean soaking water treated ginseng, between 5°C vinegar and soybean milk treated ginseng and among tap water, green tea water and adzuki bean soaking water treated ginseng. The biggest crispness and hardness of soaking medium were shown in red wine treated ginseng. The changes in hardness and crispness among different soaking media treated ginseng, predominantly depended on the process of freeze drying. The differences may attribute partly to the thickness differences of ginseng slices caused by mechanical error of slicer.

3.5. Total Phenolic Content of RTE Flavored Ginseng Chips

Total phenolic content (TPC), an important indicator for antioxidant activity, consists of substantial amount of flavonoids which contain many beneficial effects on human's health (Fraga et al., 2010). It has been studied that TPC values of adlay can be increased by different thermal studied (Xu and Chen, 2013). Therefore, TPC was hopefully to have a big enhancement by the food processing method in this research.

Significant differences ($p < 0.05$) were shown (**Table 4)** among most soaking treatments. The highest TPC value was found in green tea water soaked ginseng, which increased from 1 mg GAE/g to 6.4 mg GAE/g, which has a 6.4 times enhancement. Also black tea water, black soybean soaking water, adzuki bean soaking water and red wine treated ginseng products showed significant advancement compared to raw ginseng. TPC was increased 2.8 times in black tea water treated ginseng. 2.2 times enhancement in black soybean soaking water treated ginseng. Advance for 2 times in adzuki bean soaking water treated ginseng and boosted for 2.5 times in red wine treated ginseng. And the lowest concentration with 40% reduction of initial value presented in milk (0.4 mg GAE/g) treated ginseng with significant ($p < 0.05$) differences.

It has been reported that TPC in ginseng root was around to 3.47 mg/g (Velioglu et al., 1998). A study showed that TPC in ginseng would increase from 4.45 mg GAE/g to 4.90–5.74 mg GAE/g by heating processing (Kim et al., 2007). Differences between the results in current research and previous reports may be attributed partly to the different sources of materials and the differences in extraction method. In addition, TPC improved from 1 mg GAE/g to 1.1-6.4 mg GAE/g, which was increased 110% - 640%. Compared to the study reported by Kim et al (2007), in which only boosted TPC to 110% - 129% of initial value, the food processing method in this research seems to more efficiency in improving TPC. This phenomenon can be attributed to steaming, freeze drying and soaking materials, such as tea and legumes rich in polyphenols.

3.6. DPPH radical scavenging activities of RTE flavored ginseng chips

As a stable radical, DPPH is widely applied in food for determine antioxidant capacity (Xu and Chang, 2007). Therefore, it can be a good indicator and antioxidant to novel ginseng products. DPPH values of ginseng chips made with various soaking media ranged from 0.6 μmole TE/g in raw ginseng to 60.9 μmole TE/g in green tea water treated ginseng (**Table 4**). All soakings treatments were obtained improvement as compared to raw ginseng through food processing. Also significant ($p < 0.05$) differences in DPPH were shown among most of soaking. The highest DPPH value 60.9 μmole TE/g was obtained from green tea water treated ginseng which exhibited 100 times increased as compared to raw ginseng. In addition, DPPH values in ginseng treated with black tea water (15.7 μmole TE/g), adzuki bean soaking water (11.7 μmole TE/g) and red wine (11.3 μmole TE/g) were increased 17-25 times compared to that of raw ginseng. The enhancement in DPPH values could be owed to the soaking materials which has already reported by Satoh et al (2005) that tea high in DPPH with nearly 90% DPPH scavenging rate especially green tea and DPPH in bean was studied that possessed nearly 20 μmole TE/g (Xu and Chang, 2007). Also radical scavenging rate increased by steaming process, and Maillard reaction products and phenolic acids have been suggested as active free radical scavengers from previous study (Kim et al., 2000; Kang et al., 2007). Red wine was the typical soaking sample high in phenolic acid which has been determined by Rafifa et al (2004). In addition, antioxidant activity was induced by steaming and heated treatments which were attributed to Maillard reaction products (Cho et al., 2008; Wong et al., 2008).

4. Conclusions

Value added ginseng products with specific flavor were created by food processing technology in this study. Many of them were improved in terms of key attributes of ginseng quality. Ginseng total phenolic content (TPC), DPPH scavenging activity in most ginseng products were obtained significant ($p < 0.05$) improvement. Also chroma and texture of some novel ginseng products revealed significant ($p < 0.05$) changes. The ginseng processing technology in this study seems to be an effective way to create value added RTE ginseng chips with specific flavors. Typically, green tea treated ginseng with high total phenolic content and DPPH radical scavenging activity (TPC – 5.4 time increased, DPPH – 101 time increased).

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Table 1. Statement of soaking media

ID of soaking media	Soaking medium	Ingredient
1）	Raw ginseng	without processing
2）	Coca-cola	Commercial coca - cola
3）	Milk	Commercial milk
4）	Chinese liquor	29.5% alcoholic content
5）	Vinegar 9℃	total acid ≥ 9.0 g/100 mL
6）	Vinegar 5℃	total acid ≥ 5.0 g/100 mL
7）	Beer	≥ 4.1 % alcoholic content
8）	Tap water	water from tap
9）	Green tea water	3 teabags with 250 mL tap water, 6 g/250 mL
10）	Black tea water	3 teabags with 250 mL tap water, 6 g/250 mL
11）	Black soybean soaking water	Black soybean—water, 1 : 3
12）	Adzuki bean soaking water	Adzuki bean—water, 1:3
13）	Glucose solution	50% glucose aqueous solution
14）	Sucrose-vinegar solution	sucrose - vinegar, 1 : 1 (w/w)
15）	Sucrose solution	sucrose in water, 1 : 1 (w/w)
16）	Perilla seed soaking water	5 g/100 g
17）	*Schisandra chinensis* soaking water	5 g/100 g
18）	Soy milk	Commercial soy milk
19）	Red wine	12 % alcoholic content

Table 2. Color values of RTE flavored ginseng chips

Results are expressed as means of three replicates. Color values marked by the same letter in same column are no

ID of product	Soaking media	*L*	*a*	*b*	*h°*	Chroma	△E
1)	Raw ginseng	80.31±0.02a	3.05±0.01lk	16.11±0.00h	1.38±0.0003c	16.40±0.00ij	19.32±0.01k
2)	Coca-cola	70.42±0.04n	5.29±0.02d	20.23±0.01b	1.32±0.0007h	20.91±0.01b	29.90±0.03d
3)	Milk	77.31±0.02g	2.96±0.01m	17.31±0.01fg	1.40±0.0003b	17.56±0.01gh	22.32±0.01h
4)	Chinese liquor	76.36±0.01i	3.62±0.01i	17.40±0.01f	1.37±0.0004d	17.78±0.00g	23.23±0.00g
5)	Vinegar 9℃	78.84±0.08c	3.04±0.01lk	17.75±0.22def	1.40±0.0016b	18.01±0.22efg	21.47±0.09i
6)	Vinegar 5℃	77.85±0.01e	3.02±0.02lm	17.74±0.04def	1.40±0.0008b	18.00±0.05efg	22.20±0.02h
7)	Beer	78.20±0.03d	3.11±0.01k	18.07±0.01cde	1.40±0.0006b	18.34±0.01ef	22.17±0.01h
8)	Tap water	76.97±0.01h	3.61±0.00i	18.11±0.01cde	1.37±0.0000d	18.47±0.01de	23.20±0.01g
9)	Green tea water	70.53±0.08n	3.50±0.01j	15.60±0.09i	1.35±0.0006f	15.99±0.09j	27.14±0.11f
10)	Black tea water	67.32±0.35o	4.93±0.15f	15.89±1.13hi	1.27±0.0125i	16.64±1.12i	30.67±0.65b
11)	Black soybean soaking water	61.24±0.18q	7.11±0.09b	9.29±0.21k	0.92±0.0047k	11.70±0.22l	34.62±0.22a
12)	Adzuki bean soaking water	70.98±0.01m	5.70±0.01c	18.22±0.01cd	1.27±0.0005i	19.09±0.01c	28.44±0.00e
13)	Glucose solution	73.38±0.09l	5.64±0.02c	23.62±0.03a	1.34±0.0009g	24.28±0.02a	29.82±0.05d
14)	Sucrose-vinegar solution	75.20±0.13k	5.02±0.01e	23.66±0.03a	1.36±0.0005e	24.18±0.03a	28.46±0.07e
15)	Sucrose solution	77.57±0.03f	3.80±0.01h	18.45±0.01c	1.37±0.0007d	18.83±0.00cd	22.99±0.02g
16)	Perilla seed soaking water	77.92±0.02e	2.84±0.02n	16.93±0.04g	1.40±0.0006b	17.16±0.04h	21.60±0.02i
17)	*Schisandra chinensis* soaking water	75.64±0.05j	4.19±0.01g	15.92±0.03hi	1.31±0.0003h	16.46±0.03i	23.07±0.05g
18)	Soy milk	79.14±0.15b	2.66±0.09o	17.69±0.08ef	1.42±0.0051a	17.89±0.08fg	21.16±0.13j
19)	Red wine	66.77±0.16p	7.63±0.05a	12.55±0.06j	1.02±0.0010j	14.69±0.07k	30.30±0.12c

significantly different ($p < 0.05$)(Brightness - *L*, Chroma – *a* and *b* and C, Chromatism - △E, Hue - *h*).

Table 3. Texture properties of RTE flavored ginseng chips

ID of product	Soaking media	Hardness (g)	Crispness (g)	HD [a](%)
1)	Raw ginseng	1157±5.66d	1145.00±9.19d	4.35
2)	Coca-cola	282.50±4.95l	280.25±5.30l	2.65
3)	Milk	1233.50±30.41c	1223.00±30.41c	3.40
4)	Chinese liquor	1057.00±49.50e	1046.25±47.02e	3.55
5)	Vinegar 9℃	756.00±42.43g	750.00±43.13g	4.00
6)	Vinegar 5℃	604.50±34.65i	600.50±33.94i	4.35
7)	Beer	531.50±4.95j	527.50±4.95j	3.70
8)	Tap water	654.00±8.49h	648.75±8.13h	4.85
9)	Green tea water	672.00±12.73h	666.50±13.44h	5.10
10)	Black tea water	1490.00±2.83b	1478.25±3.18b	5.25
11)	Black soybean soaking water	731.00±1.41g	725.00±1.41g	3.05
12)	Adzuki bean soaking water	649.00±0.00h	643.75±0.35h	2.15
13)	Glucose solution	1203.50±9.19c	1193.50±9.19c	9.95
14)	Sucrose-vinegar solution	1082.00±14.14e	1073.00±14.14e	9.85
15)	Sucrose solution	836.00±4.24f	831.00±7.78f	10.00
16)	Perilla seed soaking water	399.00±8.49k	395.75±8.13k	5.10
17)	*Schisandra chinensis* soaking water	1142.00±19.80d	1133.00±19.80d	8.25
18)	Soy milk	584.50±20.51i	580.00±20.51i	2.90
19)	Red wine	1829.50±14.85a	1814.75±15.20a	3.95

Results are expressed as means of two replicates. Texture indicators values marked by the same letter in same column are no significantly different ($p < 0.05$).

[a] HD is expressed as hardness deformation.

Table 4. Total phenolic contents (TPC) and antioxidant activities of RTE flavored ginseng chips

ID of product	Soaking media	Total Phenolic Contents (mg GAE/g)	DPPH Scavenging capacities (μmol TE/g)
1)	Raw ginseng	1.0±0.03h	0.6±0.03i
2)	Coca-cola	1.2±0.08f	1.3±0.09h
3)	Milk	0.4±0.03j	1.3±0.12h
4)	Chinese liquor	0.7±0.01i	1.3±0.10h
5)	Vinegar 9℃	0.7±0.07i	1.6±0.10gh
6)	Vinegar 5℃	1.0±0.01gh	1.8±0.07gh
7)	Beer	1.2±0.08f	3.1±0.21f
8)	Tap water	1.2±0.06f	1.6±0.01gh
9)	Green tea water	6.4±0.10a	60.9±0.99a
10)	Black tea water	2.8±0.08b	15.7±1.02b
11)	Black soybean soaking water	2.2±0.10d	8.1±0.27d
12)	Adzuki bean soaking water	2.0±0.08e	11.7±0.00c
13)	Glucose solution	1.1±0.05fg	3.2±0.04f
14)	Sucrose-vinegar solution	0.9±0.06h	1.7±0.16gh

15)	Sucrose solution	0.7±0.02i	1.4±0.11gh
16)	Perilla seed soaking water	1.2±0.01f	4.8±0.16e
17)	*Schisandra chinensis* soaking water	0.9±0.05h	2.1±0.08g
18)	Soy milk	0.9±0.05h	1.6±0.15gh
19)	Red wine	2.5±0.16c	11.3±0.19c

Results are expressed as means of three replicates. Data were marked by the same letter in same column are no significantly ($p < 0.05$) different.

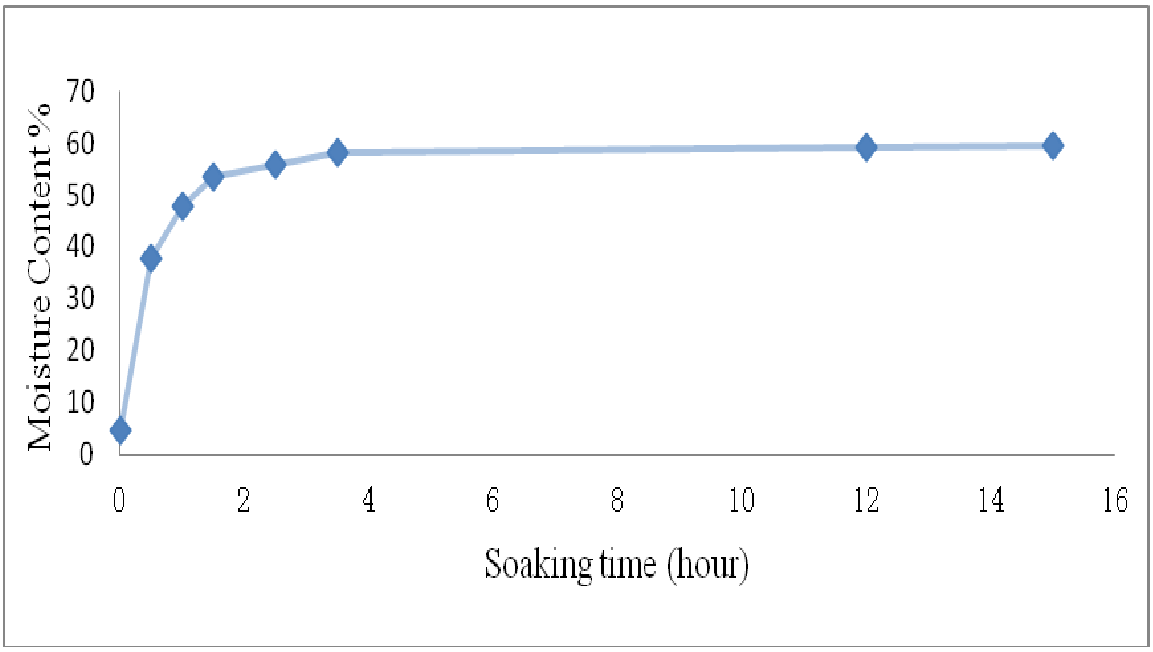
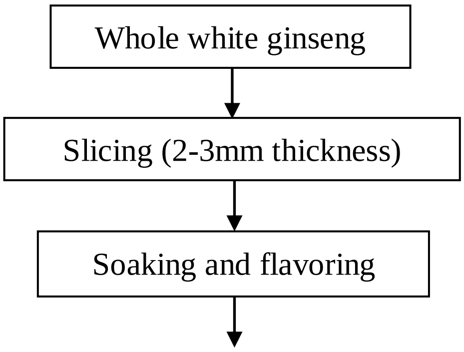


Fig. 1. Soaking time of white ginseng (results were means of three replicates)



Various food media

coca-cola	milk	Chinese liquor	vinegar 9℃	vinegar 5℃	beer
tap water	green tea water	black tea water	black soybean soaking water	adzuki bean soaking water	glucose solution
red wine	sucrose-vinegar solution	sucrose solution	perilla seed soaking water	*Schisandra chinensis* soaking water	soy milk

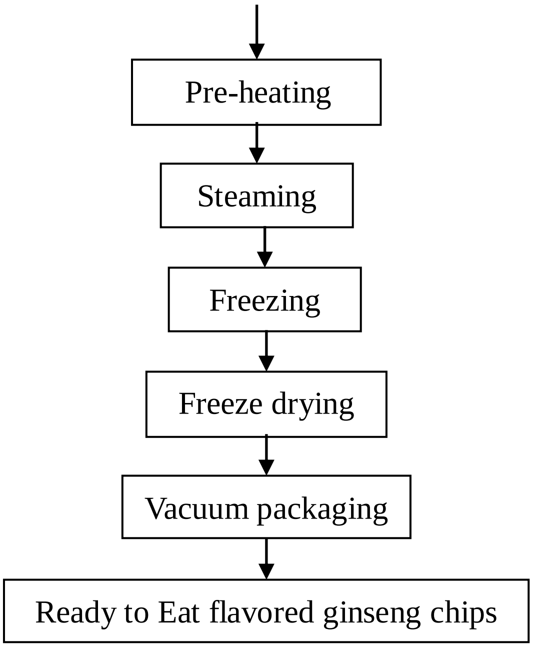


Fig. 2. Processing technology for ready-to-eat flavored ginseng chips

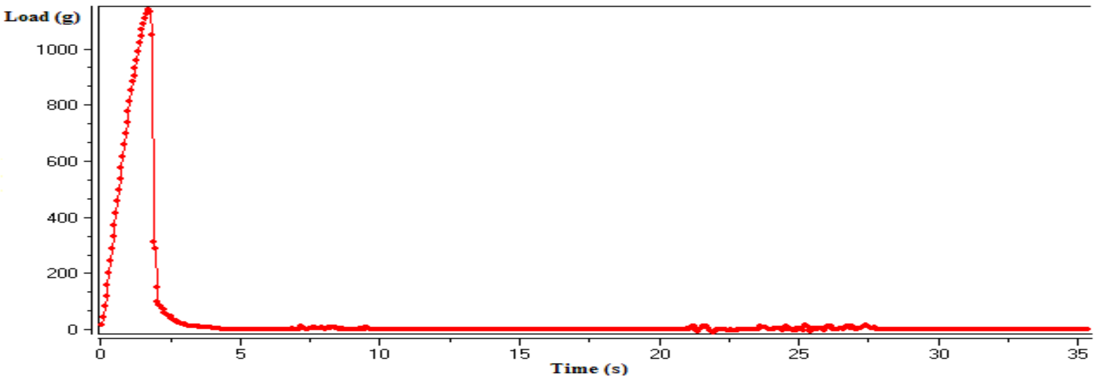
A. Sliced ginseng

B. Soaked ginseng

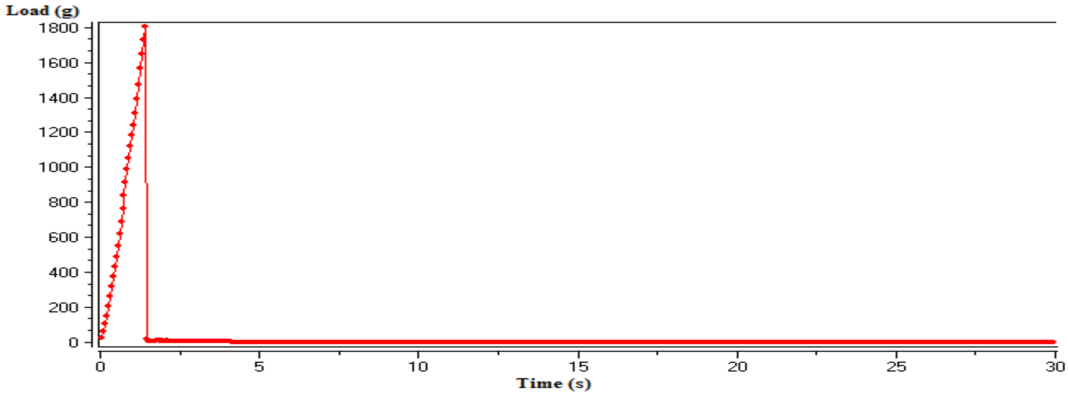
C. Steamed ginseng

D. RTE flavored ginseng chips

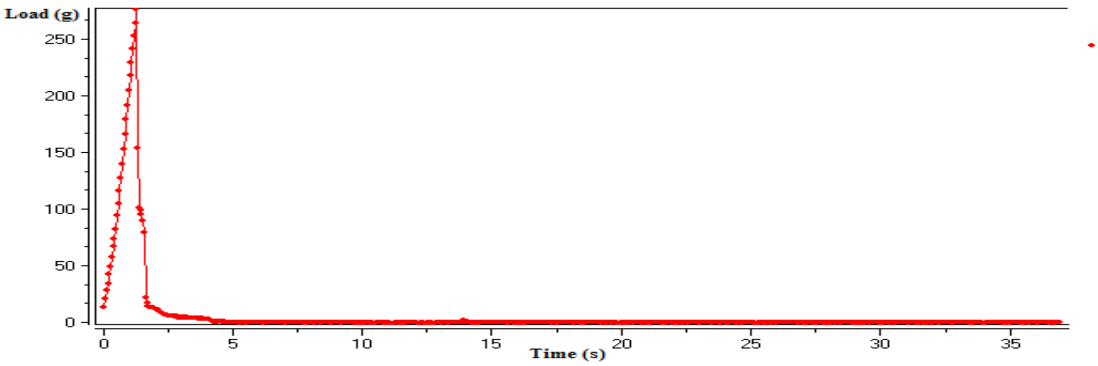
Fig. 3. Processed ginseng products (A. Sliced ginseng; B. Soaked ginseng; C. Steamed ginseng; D. RTE flavored ginseng chips).



A. Texture plot of raw ginseng



B. Texture plot of red ginseng with highest load



C. Texture plot of coca-cola with lowest load

Fig. 4. Texture figures of RTE flavored ginseng chips (A. Texture plot of raw ginseng; B. Texture plot of red ginseng; C. Texture plot of coca-cola with lowest load).