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Research article

Effects of extrusion cooking on physicochemical properties of white and red ginseng (powder)

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ABSTRACT

A systematic comparison of the physicochemical properties of white ginseng (WG), extruded white ginseng (EWG), red ginseng (RG), and extruded red ginseng (ERG) was performed. The aim of the present study was to identify the effects of the physicochemical properties of ginseng by extrusion cooking. The highest value of the water absorption index (WAI) was 3.64 g/g obtained from EWG, and the highest value of the water solubility index (WSI) was 45.27% obtained from ERG. The ERG had a better dispersibility compared with other samples. Extrusion cooking led to a significant increase in acidic polysaccharide and total sugar content but resulted in a decrease in crude fat and reducing sugar contents. Enzyme treatment led to a sharp increase in acidic polysaccharide content, especially the cellulose enzyme. Extrusion cooking led to a significant increase in 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging activity and reducing power, and the increases in WG and RG were 13.56% (0.038) and 3.56% (0.026), respectively. The data of this study provide valuable information about the effects of extrusion on quality changes of EWG and ERG.

1. Introduction

Ginseng (*Panax ginseng* Meyer) is a herb mostly used in Asia for its medicinal properties and functional food for over 1,000 years. It is found that ginseng contains a lot of bioactive ingredients such as acidic polysaccharides, ginsenosides, proteins, and phenolic compounds [1–3]. In Asia, there are two traditional preparations of ginseng, white ginseng (WG) and red ginseng (RG), and they have been used for different purposes. WG is produced by sun drying of fresh ginseng and RG is manufactured by steaming fresh ginseng at 90–100°C for a reasonable time and then drying until the moisture content is less than 15%. Ginseng is recognized worldwide as a natural healthy food along with the global trend of preference for natural products. Therefore, in modern times, the biochemical and pharmacological activities of ginseng have attracted a great deal of attention.

Many previous researches have reported that the steaming process increased the effective components and anticancer activities of ginseng products, compared with unsteamed ones [4–6]. However, the production of RG is complicated and time-consuming. In addition, it is also difficult to extract the active components of RG because of its dense texture. Thus, researchers have investigated the production of expanded ginseng using a twin-screw extruder.

Extrusion, classified as a high-temperature short-time process, is a versatile, low cost, efficient, and widely used industrial technology for the continuous production of expanded product from cereals. Recently, a lot of studies have been conducted to improve the physical and chemical properties of extruded ginseng samples [7–9]. Ha and Ryu [10] reported that acidic polysaccharide content increased by 2–3%; crude saponin and ginsenoside (Rg1 and Rg2) content also increased and ginsenoside Rg3 was detected in extruded red ginseng (ERG) after extrusion cooking. Additionally, Han et al [11] reported that α-amylase susceptibility of extruded ginseng has been found to be higher than that of traditionally dried ginseng. By contrast, an antioxidant compound was found in the extruded ginseng sample using the thin layer chromatography method. Although research on functional characteristics of extruded ginseng has been well documented, a comparison of physicochemical properties of extruded white ginseng (EWG) and ERG processed by the same extrusion condition has not yet been conducted.

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With the increased use of twin-screw extruders for the manufacture of ginseng products, it is also necessary to have enough data on the extrusion of ginseng. We have previously reported that white ginseng extruded at a moisture content of 25% and barrel temperature of 110°C showed high antioxidant activity and effective component content [8]. Therefore, the objective of the present study is to give a comprehensive summary of the changes in the physicochemical properties by the extrusion processing of ginseng samples to help us take action for future study in this discipline.

2. Materials and methods

2.1. Materials

The 5-year-old white and red ginseng powder was purchased from a local market in Seoul, South Korea. Standards of ginsenoside Rg1, Re, Rf, Rh1, 20(S)-Rg2, 20(R)-Rg2, Rb1, Rc, Rb2, Rd, 20(S)-Rg3, 20(R)-Rg3, 20(R)-Rh2, and 20(S)-Rh2 were purchased from ChromaDex (Seoul, Korea). HPLC-grade acetonitrile and methanol were purchased from Merck Co. (Merck, Darmstadt, Germany). Deionized water was purified using the Milli-Q system (Millipore, Bedford, MA, USA). Other reagents used in this study were analytical grade.

2.2. Extrusion process

A corotating intermeshing twin-screw extruder (THK31T, Incheon, Korea) with a screw length of 690 mm and a screw diameter of 30 mm (Length/Diameter = 23:1) was used. The screw configuration is shown in Fig. 1. Extrusion parameters were feed moisture content of 25% (dry basis), screw speed of 200 rpm, feed rate of 100 g/min and die diameter of 3.0 mm. The temperature profile from feed section to die exit was set to 50°C/110°C/110°C. The extrudate was dried directly in an air oven at 60°C for 8 hours, and ground in a laboratory grinder to pass through a 400-μm sieve, then stored in plastic bags for further analysis.

2.3. Proximate analysis

Moisture content, crude fat, protein, and ash were analyzed by the standard methods described in the Official Methods of Analysis of the Association of Official Analytical Chemists (AOAC) [12]. Total sugar and reducing sugar contents were determined according to the phenol–H_2SO_4 and dinitrosalicylic acid (DNS) methods, respectively [13,14].

2.4. Physical analysis

The expansion ratio was determined by dividing the diameter of the extrudate by the diameter of the die (3 mm). The specific length was evaluated as the straight length divided by the weight of extrudates. A total of 10 readings were recorded for each sample. Bulk density was determined after the extrudates were cut into pieces of approximately 2 cm in length by using a seed displacement method [15]. The color of the extrudate was measured with a colorimeter (CR-300; Minolta, Osaka, Japan). Color parameters *L*, *a*, and *b* were recorded separately. Water solubility index (WSI) and water absorption index (WAI) were measured by the modified method of Anderson et al [16]. A 1.5 g sample was dissolved in 30 mL of distilled water and shaken in the thermostatic water bath at 30°C for 30 minutes, and then centrifuged at 1000 × *g* for 10 minutes. The supernatant was decanted into a preweighted evaporating dish. The weight of the sediment was taken as WAI and was expressed as the unit g/g. The WSI is the weight of dry solids in the supernatant, which is expressed as a percentage of the original weight of the sample. Measurements were performed in triplicate for each sample. The dispersibility of the ginseng sample powder was determined according to the method of Shin et al [17] with minor modification. One gram of the ginseng powder was mixed with 30 mL distilled water. It was then shaken 10 times by hand and was left standing. The dispersion state after 10 minutes was observed and evaluated.

2.5. Mechanical analysis

Mechanical properties were determined with a Sun Rheometer (Compac-100; Sun Scientific Co., Ltd., Tokyo, Japan) equipped with a 2-kg load cell. The cross-head speed was set at 60 mm/minute. Ten replicates of extrudate were randomly selected and a mean value was recorded.

2.6. Microstructure

The microstructure of extruded sample was examined with a field emission scanning electron microscope (MIRA II LMH; Tescan USA Inc., Cranberry Township, PA, USA). The accelerating voltage of scanning electron microscope was 10.0 kV.

2.7. Chemical analysis

2.7.1. Crude saponin contents

Crude saponin contents were determined according to the water-saturated *n*-butanol extraction method of Park et al [18] with some modification. The ground ginseng samples (4 g) were placed into the body of a reflux machine and extracted with 80 mL 70% ethanol at 70°C for 12 hours. The extract was filtered through Whatman No.1 (Whatman Ltd., Cambridge, UK) filter paper and concentrated at 45–50°C. The concentrate was dissolved in 100 mL of distilled water and washed twice in a separation funnel with 100 mL diethyl ether to remove fats. The aqueous layer was extracted three times with 100 mL water-saturated *n*-butanol. The *n*-butanol extracts were pooled and washed twice with 100 mL of distilled water to remove impurities. The resulting *n*-butanol layer was evaporated at 55°C using a rotary vacuum evaporator. Finally, the round flask with the evaporated residue was dried at 105°C until it reached a constant weight. The weight of the evaporated residue was measured and used as the crude saponin content.

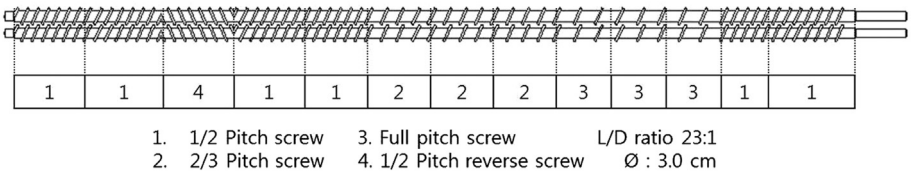

Fig. 1. Screw configuration for extrusion process (model THK 3). Screw length: 690 mm. Screw diameter: 30 mm. Extrusion conditions: moisture content 25%, screw speed 200 rpm, temperature 110°C.