QUALITY OF KOREAN GINSENG DRIED WITH A PROTOTYPE CONTINUOUS FLOW DRYER USING FAR INFRARED RAY AND HEATED-AIR

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ABSTRACT

This study was performed to examine the effects of infrared (IR)/heated-air combination drying on some quality attributes of Korean white ginsengs. Ginseng roots were dried in a dryer where both the far infrared ray and heated-air are available as drying energy sources. Diametral shrinkage, external color, total saponin content, and ginsenosides and free sugar composition of the IR/heated-air combination dried ginsengs were measured and compared with those of commercial white ginseng products. The external color became lower in lightness and higher in saturation as the IR radiating plate temperature increased. IR/heated-air combination dried white ginsengs at IR plate temperature of 100°C was comparable to the commercial white ginseng products in color characteristics. Diametral shrinkage ratios ranged from 20 to 36% and appeared to be independent on the different drying methods. No definite evidence could be found whether the IR/heated-air combination drying and the conventional hot-air drying practice resulted in white ginsengs having different ginsenoside contents and compositions. No conclusion could be made on whether the various drying treatments used in the study had effects on the free sugar contents and compositions of white ginsengs.

Key Word : White ginseng, Infrared drying, External color characteristics, Shrinkage ratio, Saponin and free sugar components

INTRODUCTION

Ginseng is a herbaceous perennial plant in the Araliaceae family that is cultivated for its highly valued root. Ginseng roots contain chemical constituents called saponin glycosides or ginsenosides that are claimed to be responsible for many medical effects such as promotion of basic metabolism, recovery from fatigue, development of resistance to cancer and diabetes, and the like (Anonymous, 1978). Ginseng root reaches marketable

size in four to six years and is spindle or round in shape, two to four inches long and up to one and half inches thick in size.

Raw ginseng roots are processed into various products. White ginsengs are made of raw ginseng roots four years of age or over, with or without the epidermis removed, through the processes of cleaning, small lateral root trimming, washing, peeling (optional), drying, grading, and packaging. The market price of white ginseng is based on color, maturity, size, and shape. Drying of ginseng is thus a significant process in terms of not only the energy consumption and efficiency, but also the final product quality. Artificial drying using 40-50°C hot air has been replacing the traditional sun-drying of ginseng. Hot-air drying is the most common drying method but its limitations on energy consumption and product quality have evolved many novel drying techniques for a variety of agricultural and food products. For the drying of ginseng, the authors developed a prototype IR/heated-air combination dryer by which ginsengs could be dried with less energy compared to the conventional hot-air drying (Park et al., 2000).

The objective of this study is to examine the differences in the quality of white ginsengs obtained by the IR/heated-air combination drying and the conventional drying.

MATERIALS AND METHOD

Materials

Medium-sized (dia.=23-25mm) four-year raw ginseng roots (75% w.b.) grown in Chinan county, Chonbuk province were harvested in September 1998 and temporarily stored in a low-temperature walk-in for two weeks. They were cleaned, cut, peeled, washed, and placed in room conditions for the residual wash water to evaporate. The prepared ginseng samples are then put in vinyl packs and kept in a refrigerator until used for the drying experiments.

Drying treatments

A prototype continuous flow IR/heated-air combination dryer was used for this study. Ginsengs are dried by combined or sole application of infrared ray and heated air when they are passing through the two tiers of drying section. The drying section has three air inlets through which atmospheric air is introduced and heated by 2-kW electric heaters to supply heated drying air, if necessary.

Except for the surface color tests, 11 drying treatments were used in this study. For the two conventional hot-air drying, the electric heater at the air inlet was turned on to provide 50°C and 60°C drying air while the IR radiating plate heater was turned off. The nine IR/heated-air combination drying runs were conducted with three IR radiating plate heater temperature settings (80, 100, 120°C) and three drying air heater temperature

settings (23, 40, 50°C). In IR/heated-air combination drying, the actual temperatures of drying air inside the dryer were higher than the above-mentioned drying air heater temperature settings due to the convective heat transfer from the IR radiating plates. The maximum and minimum discrepancy was found to be 43.3°C and 11.1°C, respectively.

Total drying time was 12 hrs and the drying air velocity was maintained at 0.4 m/s for the IR/heated-air combination drying and 0.2 m/s for the conventional hot-air drying treatments. Temperatures of atmospheric air, drying air inside the dryer, and the ginseng sample were measured continuously by type-T thermocouples. The moisture contents of the ginsengs were determined by drying in a forced convection oven at 70°C for 48 hrs.

Diametral shrinkage and external color measurement

Maximum diameters approximately 20-30 mm from the top end of the ginseng root were measured by a calipers before and after drying in two directions perpendicular to each other and the average value was used to calculate the shrinkage ratio as follow.

$$\textit{Diametral shrinkage ratio}\,(\%) = \left(1 - \frac{\textit{Average root diameter after drying}}{\textit{Average root diameter before drying}}\right) \times 100\,\Lambda \quad (1)$$

Surface color of the dried ginsengs was measured by a colorimeter (Minolta Chroma Meter CR-200, ϕ8 mm measuring head). Measurement on the equally spaced three points along the circumference at the maximum root diameter yielded tristimulus value Y and chromaticity coordinates x and y. Test samples were obtained from the IR/heated-air combination drying runs where the IR plate and drying air heater temperature setting ranges were 80-150°C and 23-60°C, respectively. Commercially available 1st, 2nd, and 3rd grade white ginsengs (30-40 roots per each grade) were purchased and included in the surface color comparison as controls, as well.

Saponin and free sugar components measurement

Effects of drying methods and conditions on the chemical quality attributes were studied on 13 groups of white ginseng samples. In addition to the 11 sample groups previously mentioned, 1st grade commercial white ginsengs and white ginsengs mildly dried in a laboratory environmental chamber were included in the analysis. Dried white ginsengs similar in the size of main root system (taproot and branch root) were selected and their lateral and hair roots were removed. They were then crushed and used for the saponin and free sugar components analysis.

(1) Total saponin and ginsenosides

The contents of crude saponin and individual saponin components in white ginsengs were measured by using the method of Ando et al. (1971). A Waters Model 244 HPLC equipped with a RI 401 differential refractometer was used for the ginsenoside analysis.

A Lichrosorb-NH_2 column (Merck Co.; 10μm, 4.6mm I.D.×250mm) was used with a mixture of acetonitrile/water/n-butanol (80:20:10, v/v) as mobile phase.

(2) Free sugar components

The content and composition of free sugars in white ginsengs were measured by using the method of Ko (1994). The HPLC system used was a Waters Model 244 equipped with a RI 401 differential refractometer. A Lichrosorb-NH_2 column (Merck Co.; 10μm, 4mm I.D.×250mm) was used with acetonitrile/water (84:16, v/v) mixture as a mobile phase.

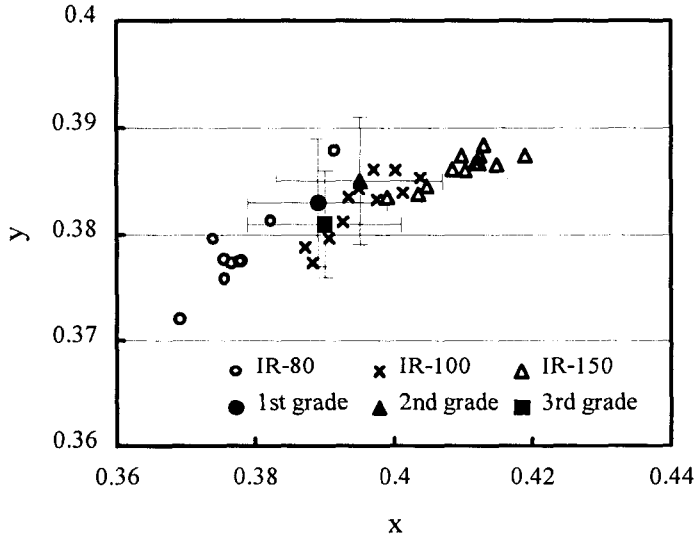

Figure 1. Comparison of chromaticity coordinates x, y of white ginsengs between commercial products and IR/heated-air combination dried samples.

RESULTS AND DISCUSSION

External color

Test results show that the Y value decreases but the x and y values increase as the temperature of the IR radiating plate increases. This indicates that the color characteristics become lower in lightness and higher in saturation with the high temperature IR/heated-air combination drying. The x, y measurement data of the IR/heated-air dried ginseng samples are plotted in Fig. 1 along with the average and standard deviations of the chromaticity coordinates x, y of the commercial white ginsengs. Ginsengs dried at IR plate temperature of 100°C are considered to have virtually no color

differences from the commercial white ginseng products of which color is light milk-white. With the IR plate temperature of 80°C and 150°C, however, white ginsengs with a light, pale egg-white and a dark, vivid lemon yellow color are obtained, respectively.

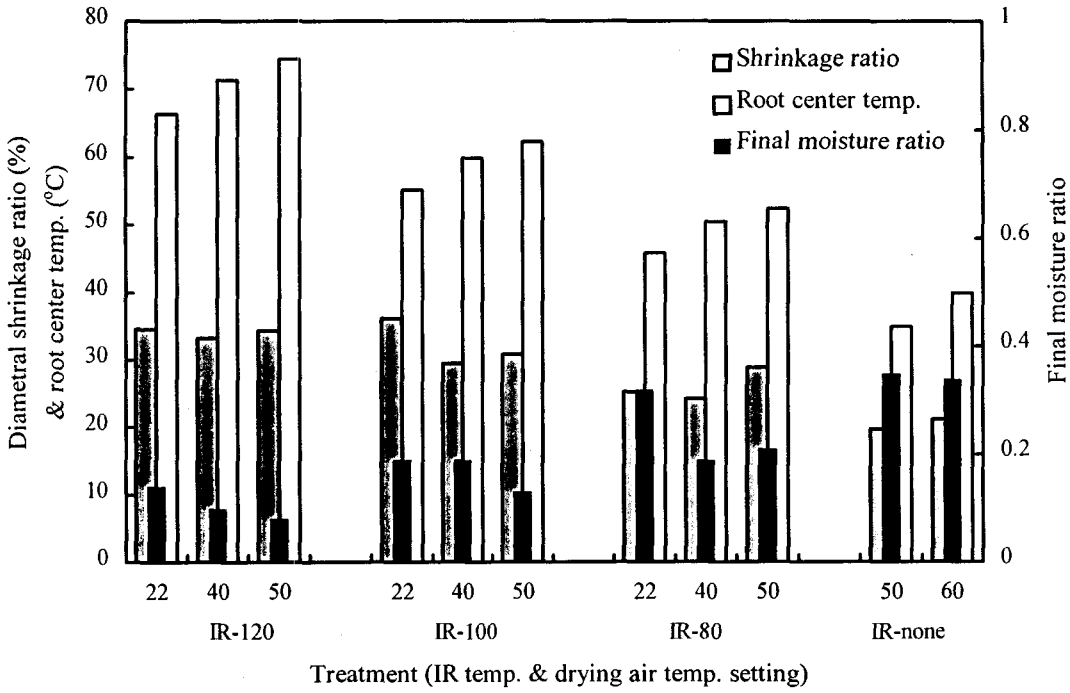

Figure 2. Diametral shrinkage ratio, center temperature, and final moisture ratio of ginseng roots for 12 hr drying under various drying conditions.

Diametral shrinkage

Diametral shrinkage ratios, final moisture ratios, and average temperatures of the ginseng root center for various drying runs are shown in Fig. 2. Diametral shrinkage ratios of 24-36% and 20-21% were obtained for the IR/heated-air combinations drying and the conventional hot-air drying tests, respectively. Fig. 2 shows a general trend that the diametral shrinkage ratios are proportional and the final moisture ratios are inversely proportional to the average temperatures of ginseng root center during drying. An interrelation between the diametral shrinkage and the final moisture ratio was deducted from the above relationships and is shown in Fig. 3. The effect of different drying methods (IR/heated-air combination drying vs. conventional hot-air drying) on the diametral shrinkage ratio was evaluated by examining the residuals of the data points in Fig. 3 but the test result was inconclusive.

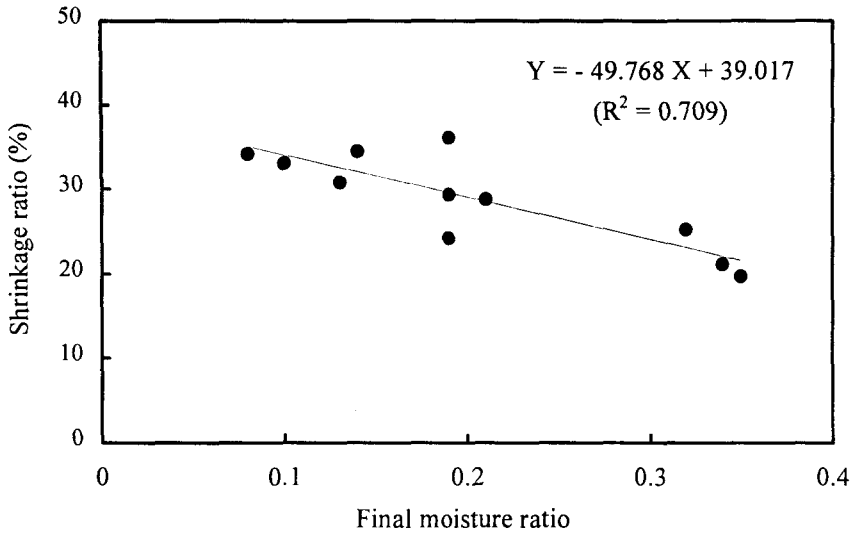

Figure 3. Relationship between diametral shrinkage and final moisture ratio of ginseng roots obtained from both 12 hr IR/heated-air combined drying and heated-air drying.

Saponin and free sugar components

The crude saponin contents were found to be 3.22-3.92 % of dry wt. and comparable with the reported values by others (Cho, 1977; Lee et al., 1996). Total saponin contents comparison among the sample groups did not reveal any significant difference.

The individual saponin components of the ginseng are called ginsenosides. Ginsenosides are further classified into the protopanaxadiol, protopanaxatriol, and oleanolic acid series saponins where most ginsenosides belong to the first two groups. Some scholars, therefore, suggest to estimate the medical effects of ginsengs by the panaxadiol (PD)/panaxatriol (PT) ratio as well as by the absolute saponin content.

Fig. 4 shows the contents of three panaxadiol ginsenosides (Rb_1, Rb_2, Rc) and two panaxatriol ginsenosides (Rg_1, Re) as well as the PD/PT ratios of white ginsengs obtained from the different drying runs. Comparing with the existing findings (Ko, 1994; Lee et al., 1996), the white ginseng samples obtained from this study provided compatible results in general. Although the absolute amounts of individual ginsenoside contents differ among the drying treatments, the magnitudes of the five representative ginsenosides follow the same order of $Rb_1 > Rg_1 > Re > Rc > Rb_2$. When the amounts of each ginsenoside Rb_1, Rg_1, Re, Rc, and Rb_2 are compared among the sample groups, also no noticeable trend according to the different drying treatments could be found. Therefore, use of IR/heated-air combination drying seems to neither improve nor deteriorate the quality of white ginsengs. The PD/PT ratios ranged from 0.94 to 1.25 and it was unable to draw any conclusion regarding their dependence on the drying treatments used in the study.

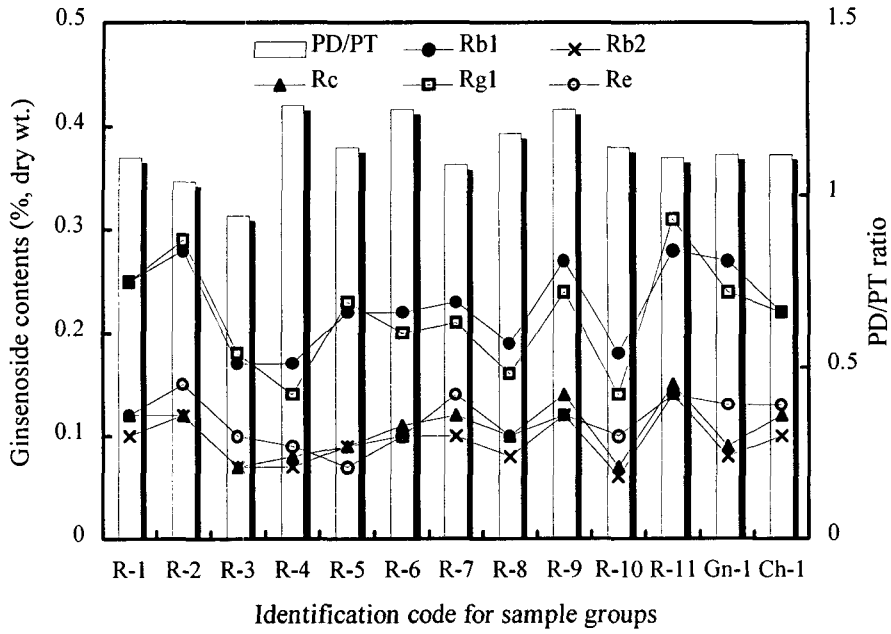

Figure 4. Major ginsenosides contents and panaxadiol/panaxatriol ginsenosides ratio of white ginsengs according to different drying treatments.

The free sugars in white ginsengs were composed of fructose, glucose, sucrose, and maltose and the content of sucrose was 92-94% of total free sugars. Others reported similar results for the composition of free sugars as well as for the relative content of sucrose (86-93%) in total free sugars (Choi et al., 1981; Ko, 1994). Based on the results, however, no conclusion could be made on whether the various drying treatments had effects on the free sugar contents and compositions nor the IR/heated-air combination dried ginsengs were not significantly different to the commercial white ginsengs in both the free sugar content and composition.

CONCLUSIONS

1. As the IR radiating plate temperature increased, the color characteristics of white ginsengs became lower in lightness and higher in saturation. IR/heated-air combination dried white ginsengs at IR plate temperature of 100°C was not different in color characteristics from 1st and 2nd grade commercial white ginseng products.
2. Diametral shrinkage ratio of ginsengs during drying was in the range of 20-36%. Shrinkage ratio was proportional to the final moisture ratio. Diametral shrinkage ratio appeared independent to the difference in drying methods used in the study.

3. Comparison of total saponin content and individual ginsenosides composition among the samples did not reveal any noticeable trend due to the various drying treatments used in the study. The PD/PT ratios also did not show any definite evidence for their dependence on the drying methods and drying conditions.
4. It was unable to verify whether the various drying treatments used in the study had any effects on the free sugar contents and compositions of white ginsengs.

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