Shelf-Life Extension of American Fresh Ginseng by Controlled Atmosphere Storage and Modified Atmosphere Packaging

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ABSTRACT
American ginseng roots were treated with an antimicrobial agent, and stored under various CA (2, 5, and 8% CO₂) or MA conditions to extend the shelf-life. Changes in respiration rates during CA storage, gas composition in packages, saponin and free sugar content, and other quality factors were monitored during storage. The respiration rate of ginseng increased rapidly during the first month of high CO₂ CA storage and then slowly decreased to stable levels after 3 mo storage. In MA studies, the equilibrium CO₂ concentration was attained after 20 days. There were no noticeable changes in appearance, saponin content and free sugars after 3 mo CA (5% CO₂) storage and MA packages.
Key Words: ginseng, shelf-life, CA storage, MAP

INTRODUCTION
Ginseng is a well-known medicinal herb marketed as a nutraceutical food. Ginseng roots are usually dried because they contain about 75% moisture and are prone to deterioration within a week after harvest. Postharvest storage of fresh ginseng roots has been a major concern of ginseng growers for many years. A wide seasonal variation in value is mainly due to the short shelf-life of fresh ginseng. Fresh roots respire rapidly and consume nutrients quickly during postharvest storage. Microbial contamination, dehydration, and physical and chemical changes accelerate deterioration of fresh ginseng roots.

Lee et al. (1975) studied the changes in the quality of vacuum packaged ginseng roots during storage and reported changes in skin and textural quality and a decrease in ginsenosides. Attempts were made to preserve fresh ginseng roots by freezing them at −40°C and storing them at −20°C for 3 mo. However, the quality of dried ginseng made from frozen roots was low and keeping ginseng roots by freezing was not recommended (Lee et al., 1976). Microbial growth and increased amylase activity in fresh ginseng roots during 5 wk storage at 2°C were reported (Jang and Shim, 1994). The only current method and the content of crude saponin was determined by a gravimetric method and the content of crude saponin was determined by a gravimetric method (Ando et al., 1971). Total saponin content was mea-
sured by the vanillin-sulfuric acid colorimetry method (Hiai et al., 1975). Six ginsenosides (Rb1, Rb2, Rc, Rd, Re, and Rg) known to have specific biological activities were analyzed by an HPLC method (Choi et al., 1984). Free sugars were analyzed by an HPLC method (Choi et al., 1981). In addition, individual ginsenosides were separated by TLC using plates precoated with 0.25 mm silica gel using the bottom layer of CHCl3:n-BuOH:MeOH:H2O(20:40:15:20 v/v) mixture as a developer. The spots were visualized by spraying with 30% H2SO4 and heating the plate at 110°C for 15 min (Choi et al., 1987).

Since color of ginseng products is an important quality factor, fresh root samples were heated (using steam) for 2 h at 100°C and dehydrated first at 75°C for 24 h and then at 55°C for 72 h according to standard commercial practices. Dehydrated ginseng powder samples (1 g) were extracted with 50 mL of 50% ethanol for 24 h at room temperature for color measurement. The extract was filtered (Whatman No. 42), centrifuged at 8,000 rpm, and then the absorption at 490 nm was measured by a spectrophotometer. Hunter L, a, and b values were also determined by a Chromameter (Minolta CT-200).

RESULTS & DISCUSSION

RESPIRATION RATES OF GINSENG ROOTS VARIED AMONG SAMPLES during different CA storage conditions. Fresh ginseng showed an initial respiration rate for CO2 of 23.4 mL/kg/h at 2°C; however, the rate increased rapidly during early storage (Fig 1). The ginseng stored at 5% CO2 CA and 8% CO2 CA showed higher respiration rates than the control (air) and 2% CO2 CA samples. Both 5% and 8% CO2 CA samples reached maximum respiration rate at 1 mo storage, CO2 53.1 and 62.6 mL/kg/hr, respectively. The respiration rates of both samples then decreased slowly, reaching original levels at 3 mo storage. There was no significant effect on respiration rate in the 2% CO2 CA samples, which showed a similar range as the control.

Of the three packaging films used in the MAP study, high permeable film (PD-941) gave the lowest CO2 concentrations and highest O2 concentrations in the package, while low permeable film (PD-900) gave high concentrations of CO2 and medium O2 concentration (Table 1). The medium permeable film (PD-961) package was relatively high in CO2, but low in O2 throughout storage. It appeared that permeability of this film was appropriate for the respiration rate of ginseng, so that the MA suppressed metabolic activities of ginseng more effectively. Consequently, this condition maintained the moisture in the package at a proper level during storage. This film resulted in best ginseng quality among the three packaging materials.

There was no significant change in visual appearance of fresh ginseng stored for 2 mo under CA conditions. However, the control samples with and without dipping treatment showed discoloration and microbial growth after 20 days storage. The MAP ginseng in low permeable film started to show partial discoloration and skin softening after 40 days. CA storage was more effective in preventing spoilage than MA treatments. At the end of 3 mo storage, the ginseng samples stored under CA at 5% CO2 and MAP in medium permeable film (PD-961) were of higher quality to other treatment samples and were similar in appearance to nonstored fresh ginseng samples.

Saponins or ginsenosides are the major known bioactive compounds in ginseng, so we analyzed for crude saponin and ginsenosides in the samples stored under various conditions (Table 2). A typical thin-layer chromatogram of various ginsenosides is shown in Fig. 2. The crude saponin content in fresh ginseng roots was 5.98% (dry weight basis). It was slightly higher than that of Korean Ginseng (4.92%) reported by Jeon et al. (1995). The crude saponin content increased during 3 mo storage to 7.11%. Total ginsenosides among samples ranged from 5.48–7.26%. These were relatively high compared to Korean ginseng (Jeon et al., 1995). An interesting observation was that Korean ginseng contained higher amounts of ginsenoside Rb1 than American ginseng, while American ginseng contained higher concentrations of ginsenosides Rb1, Rd and Re. No specific
trends or changes in those individual or total ginsenosides during the CA and MA storage were noticed. Ginseng samples stored under CA at 5% CO₂ showed the least change in individual and total ginsenosides during storage. As noted above, this CA condition maintained the best ginseng appearance. Small variations among treatments were found to be insignificant and appeared to be due to variations among samples. We concluded that saponins were relatively stable under the CA and MAP treatments.

Free sugars in fresh ginseng roots are an important quality factor that helps determine the color and appearance of the dehydrated product. The degree of Maillard reactions during heat treatment or dehydration determines the final color of the skins and the grade of the ginseng products. Changes in free sugars in fresh ginseng during CA and MA storage were compared (Table 3). Compared to free sugar content in Korean ginseng (Ko et al., 1996), sucrose and maltose concentrations in American ginseng were higher but no rhamnose was detected in American ginseng. During storage there were no significant changes in fructose and glucose. Sucrose content in the control and the 2% CO₂ sample showed an increase after 3 mo storage, 17.99 and 20.04%, respectively. Among three samples in CA storage, that stored at 5% CO₂ showed the least change in sucrose during storage. It appeared that low CO₂ atmosphere provided favorable conditions for ginseng to accumulate sucrose during storage. An increase in maltose content was also observed in the sample after low CO₂ atmosphere storage (2% CO₂).

Color changes were measured on dry-powder sample extracts at 490 nm (Table 4). All samples, except that with 2% CO₂ CA storage, showed an increase in absorption after 3 mo storage, indicating more brown color after longer storage. The content of monosaccharides appeared to be related to the degree of browning in stored ginseng but was not tested. The ginseng roots packaged in high permeable film showed the highest absorption (0.2) among the samples. The sample from 2% CO₂ CA storage that contained the lowest amounts (0.49%) of fructose and glucose showed the least absorption (0.062). Likewise, the Hunter L value for the MAP samples in high permeable film was the lowest (92.7, darker) and that of MAP:HPF was the highest (93.96, lighter).
2% CO₂ CA samples was the highest (97.6, lighter). After 3 mo storage, all MA samples appeared to have higher b values than CA samples. There have been no published data on color of stored ginseng.

CONCLUSION
THE SHELF-LIFE OF FRESH AMERICAN GINSENG ROOTS COULD BE extended to nearly 3 mo under proper storage conditions. Fresh ginseng roots should be carefully cleaned with cold water and treated with antimicrobial agent and then stored under CA at 5% CO₂ or packaged in MA using medium permeable films (PD-961). These conditions should maintain the shelf-life of fresh ginseng for 3 mo at 2–4°C with little notable loss in quality.

REFERENCES
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