# Flavor Compounds of Pine Sprout Tea and Pine Needle Tea

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Flavor compounds of pine sprout tea and pine needle tea were analyzed and identified in this study. Eighty-one and 39 kinds of flavor compounds were detected in pine sprout tea and pine needle tea by GC, respectively. Among them, 55 and 29 flavor compounds were identified by GC-MS, respectively. Major flavor compounds of pine sprout tea were α-pinene, myrcene, β-thujene, terpinene-4-ol, and δ-cadinene, and major flavor compounds of pine needle tea were α-pinene, isoamyl alcohol, *trans*-caryophyllene, terpinene-4-ol, α-terpineol, and δ-cadinene.

**Keywords:** *Pine sprout tea; pine needle tea; flavor compounds; pine sprout; pine needle*

## INTRODUCTION

For centuries throughout eastern Asia, various parts of the pine tree, such as pine needles, pine cones, pine cortices, and pine pollen, have been widely used for promoting health as folk medicine or as food (Lim et al., 1993; Song, 1993). According to Buddhist scriptures, pine needle extracts were commonly used as a tonic. Along with yoga, consumption of pine needle tonic and food formed part of a regimen of self-discipline that assured a robust physical constitution and spiritual well-being (Song, 1993). There are documents on record that report pine needles and pine cortices were used for food to relieve famine in times of severe drought (Yoo, 1776; Lee, 1715).

In modern-day Korea, there is growing public interest in incorporating pine needle-based products into the diet because of their health-promoting properties. Several manufactured products including pine needle powder, pine needle wine, and pine needle tea are in the marketplace. Most recently, pine sprout tea and pine needle tea have been found on the market in Chang-Seong county, Chonnam, in the southern part of the Korea penninsula. Because these pine teas are becoming increasingly popular, there appears to be significant economic potential in their further industrial development. Despite this bright outlook, very little information exists concerning the nutritional and systematic evaluation of manufacturing methods of pine teas. For example, although there are ~90 kinds of pine trees around the world, including 8 kinds of Korean pine trees (Cho, 1987), questions remain as to the optimum type of pine tree to utilize, the time to harvest needles or sprouts, and even whether needles or sprouts are better for tea. There is little modern information available to guide researchers in answering these questions. In Korea, native red pine and black pine trees are commonly used in folk medicines. According to records in ancient books, Chimjoongki, small amounts of fresh, immature pine needles harvested in late May or early June, should be dried in a cool dark place and then ground into a paste with honey to make a tonic (Lim et al., 1993). Choi et al. (1988) studied the flavor constituents of essential oils in pine needles but not pine sprouts. However, Chung et al. (1996) determined the chemical composition of pine needles and pine sprouts as raw materials for pine teas. The objective of this study was to analyze and compare the flavor compounds of pine sprout and pine needle teas.

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## MATERIALS AND METHODS

**Materials.** Fresh pine sprouts or pine needles were selected and harvested from Korean red pine trees (*Pinus densiflora* Sieb. et Zucc.) in the middle of May to late June 1995. This is the best time to harvest these plant materials for their use as a source to make tea (H. J. Chung, unpublished data, 1995).

**Preparation of Pine Sprout Tea and Oine Needle Tea.** A total of 500 g of fresh pine sprouts or pine needles harvested from pine trees was washed with cool tap water. The remaining water was removed from the surface of the sample. The washed sample was cut into 2.5 cm lengths and mixed well in a bowl with 375 g of brown sugar syrup prepared by dissolving 300 g of brown sugar into 100 mL of water. The mixture was placed into a glass container, soaked, and kept at 20 °C for 60 days. Finally, pine sprout tea or pine needle tea was filtered through four layers of cheesecloth and used in the ensuing experiment.

**Extraction of Flavor Compounds from Pine Sprout Tea and Pine Needle Tea.** Each 150 g of pine sprout tea or pine needle tea was diluted with 200 mL of distilled water and extracted with 50 mL of ethyl ether. The extraction was repeated three times for each sample. The extract was diluted again with 50 mL of distilled water, dehydrated with anhydrous sodium sulfate, and then concentrated by a rotary vacuum evaporator (EYELA type N-N) equipped with a cooling aspirator (EYELA Cool ACE CA-111). This concentrated extract was used for GC-MS analysis.

**Gas Chromatography Analytical Conditions.** The extracted flavor compounds were analyzed by direct injection GC. A Hewlett-Packard model 5890 gas chromatograph was used, equipped with a Hewlett-Packard model 7673 autosampler and a flame ionization detector. Analysis was carried out on a 50 m × 0.32 mm i.d. FFAP capillary column (film thickness = 0.5 μm). Initial column temperature of 60 °C was held for 10 min and increased to 210 °C at 2 °C/min. The carrier gas was helium at 1.3 mL/min. The injector and detector temperatures were maintained at 250 °C.

**Gas Chromatography—Mass Spectrometry Identification Conditions.** The column was directly connected to a Hewlett-Packard model 5970 mass spectrometer. GC-MS

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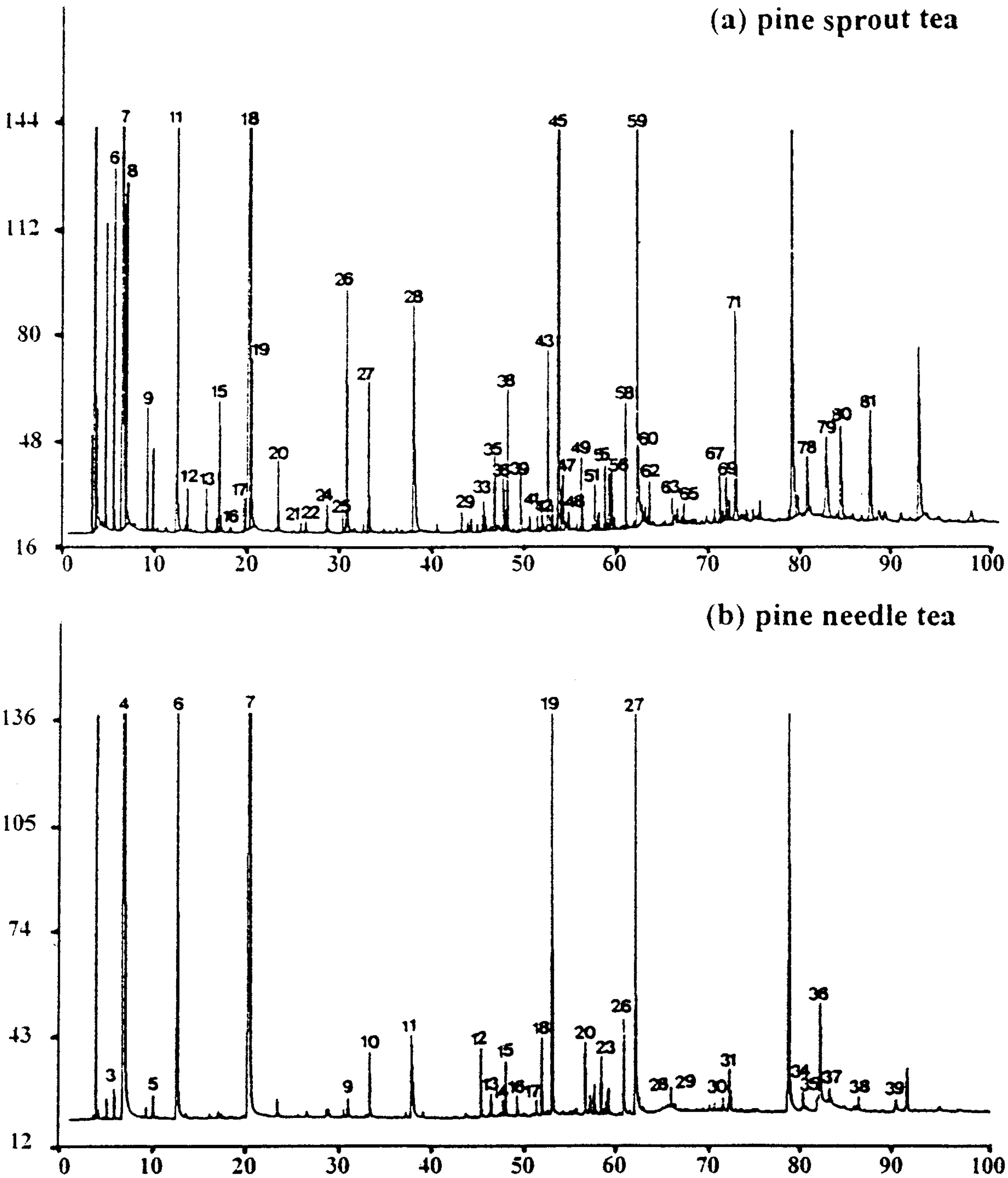


**Figure 1.** Gas chromatogram of flavor compounds in pine sprout tea (a) and pine needle tea (b).

interface temperature was maintained at 200 °C. Electron impact mass spectra were recorded at 70 eV. Identification was on the basis of peak enhancement by comparison with the Wiley/NBS mass spectra library.

## RESULTS AND DISCUSSION

**Flavor Compounds of Pine Sprout Tea and Pine Needle Tea.** Gas chromatographic analysis of pine sprout tea and pine needle tea revealed the presence of ~81 flavor compounds in pine sprout tea and 39 compounds in pine needle tea, respectively (Figure 1). Among them, 55 compounds from pine sprout tea and 29 compounds from pine needle tea were identified by GC and/or MS (Table 1). This finding could be attributed to differences in flavor profiles between pine sprout tea and pine needle tea. Pine sprout tea contained far more flavor compounds compared to pine needle tea. A GC profile of the flavor compounds in pine sprout tea was quite different from that in pine needle tea, whereas major peaks of the flavor compounds in the GC chromatograms of pine sprout tea and pine needle tea were remarkably similar to one another. This is probably due either to the difference of flavor compounds originating from the raw pine sprout and pine needle or the difference of flavor compounds that can be newly formed or lost during the production of pine sprout tea or pine needle tea. The manufacturing conditions might also have an effect on the flavor profile.

Among the 55 flavor compounds of pine sprout tea, α-pinene, β-pinene, myrcene, limonene, β-phellandrene, bornyl acetate, and α-terpineol were detected as major flavor compounds. Trace amounts of alcohols, such as

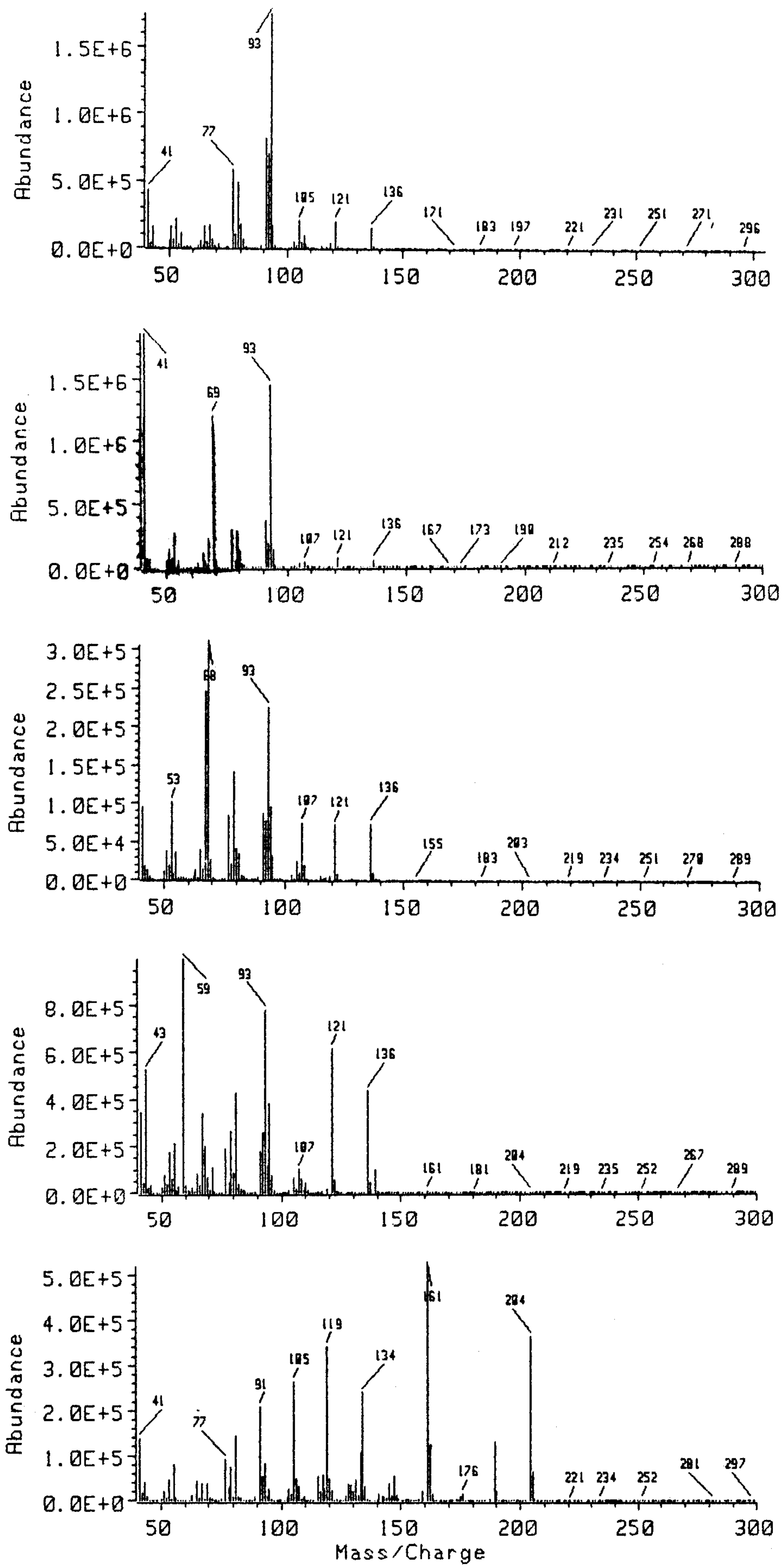


**Figure 2.** Mass spectra of representative flavor compounds (top to bottom: α-pinene; myrcene; *β*-thujene; terpinene-4-ol; *δ*-cadinene) in pine sprout tea or pine needle tea.

**Table 1. Identified Flavor Compounds in Pine Sprout Tea (PS) and Pine Needle Tea (PN)**

| flavor compound | peak PS | peak PN | flavor compound | peak PS | peak PN |
|---|---|---|---|---|---|
| ethyle acetate | 6 | 3 | diethyl succinate | | 18 |
| ethyle alcohol | 7 | 4 | γ-muurrolene | 43 | |
| benzene | 8 | | ρ-isopropyl-2-cyclo-hexenone | 44 | |
| α-pinene | 9 | 5 | | | |
| isobutyl alcohol | 11 | 6 | α-terpineol | | 19 |
| β-pinene | 12 | | borneol | 45 | |
| butanol | 13 | | cyclosativen | 47 | |
| myrcene | 15 | | γ-selinene | 48 | |
| α-thujene | 16 | | δ-cadinene | | 20 |
| limonene | 17 | | myrtenol | 49 | |
| isoamyl alcohol | 18 | 7 | phenyl ethyl acetate | 51 | 23 |
| β-thujene | 19 | | ethyl laurate | 54 | |
| amyl alcohol | 20 | | caproic acid | 55 | |
| *p*-cymene | 21 | | geroniol | 56 | |
| acetoin | 22 | | benzyl alcohol | 57 | 26 |
| 3-methyl-2-buten-1-ol | 24 | | phenyl ethyl alcohol | 58 | 27 |
| ethyl lactate | 25 | | 2-ethylhexenoic acid | 59 | |
| hexanal | 26 | 9 | *trans*-2-hexenoic acid | 60 | |
| *cis*-3-hexenylacetic | 27 | 10 | 2-ylangene | 62 | |
| acid | 28 | 11 | ethyl myristate | | 28 |
| α-copane | 29 | | diethyl malate | 63 | |
| propionic acid | 32 | | phenyl propyl alcohol | 65 | 29 |
| linalool | 33 | 12 | 2-methoxy-4-vinyl-phenol | 67 | 30 |
| isobutyric acid | 34 | | | | |
| jupinene | 35 | 13 | ethyl palmitate | 69 | 31 |
| fenchyl alcohol | 36 | | 1,3-epimanoyl oxide | 71 | |
| methyl thymol ether | 37 | 14 | 4-vinylphenol | | 34 |
| terpinene-4-ol | 38 | 16 | ethyl stearate | 78 | 35 |
| butyric acid | 39 | | benzoic acid | | 36 |
| *trans*-sabinene hydrate | 41 | | ethyl oleate | 79 | 37 |
| *trans*-pinocarreol | | 17 | ethyl linoleate | 80 | 38 |
| 2-methylbutyric acid | 42 | | phenylacetic acid | 81 | 39 |
| α-hamylene | | | | | |

ethyl alcohol, isoamyl alcohol, phenyl alcohol, isobutyl alcohol, and α-terpineol, which were probably produced during tea processing, were also detected. However, these alcohols constituted a much smaller proportion of flavor compounds in pine sprout tea. Among 29 flavor compounds of pine needle tea, α-pinene, isoamyl alcohol, *trans*-caryophyllene, terpinene-4-ol, α-terpineol, and δ-cadinene were detected as major flavor compounds. On the basis of these results, we concluded that the major flavor compounds of pine sprout tea and pine needle tea were α-pinene, myrcene, β-thujene, terpinene-4-ol, and δ-cadinene (Figure 2). These findings were in agreements with Latish et al. (1983), who reported that major flavor compounds in Russian pine trees were α-pinene, champene, β-phellandrene, and myrcene, and also with Choi et al. (1988), who reported that major flavor compounds in Korean pine needles were α-pinene, bornyl acetate, and β-pinene. However, peak areas of flavor compounds of Korean pine needles reported by Latish et al. (1983) and Choi et al. (1988), such as α-pinene, bornyl acetate, β-pinene, and β-phellandrene, were not greater than those in our study. The smaller concentrations of some flavor compounds detected in our study may have been due to the more conventional processing method that was followed in our study. The absence of these flavor compounds could be attributed to the differences in efficiency of flavor extraction in the more conventional method that was used in pine tea production by producers and in our study. From this observation we could point out that more research is needed to develop a more consistent processing method to produce pine teas.

**Conclusion.** Fifty-five flavor compounds from pine sprout tea and 29 compounds from pine needle tea were identified by GC-MS analysis. α-Pinene, myrcene, β-thujene, terpinene-4-ol, and δ-cadinene were identified as major flavor compounds in pine sprout tea, and α-pinene, isoamyl alcohol, *trans*-caryophyllene, terpinene-4-ol, α-terpineol, and δ-cadinene were identified as major compounds in pine needle tea.

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