J. Food Sci. Nutr.
Vol. 3, No. 2, p. 119~122 (1998)

# Volatile Flavor Components in Pumpkin Vinegar

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Abstract

**Pumpkin vinegar was produced using autoclaved pumpkin juice by fermenting with *Acetobacter* starter and ethanol at the ratio of 4% and 10% to the volume of pumpkin juice, respectively. Fermentation was carried out at 20°C for 14 days followed by aging at 10°C for 14 days. Flavor components of pumpkin vinegar was determined using GC/MS. Identified components were 2 aldehydes (4.74%), 5 alcohols (30.06%), 4 ketones (8.99%), 4 acids (16.39%), 5 alkanes (11.10%), 11 miscellaneous compounds (27.01%), and 9 unknown compounds (1.71%). Pumpkin vinegar showed very similar flavor characteristics to those of conventional wine vinegar and sherry wine vinegar: in particular, acetoin, methyl acetate, and butanoic acids were typical volatile components of these three kinds of vinegar. Pumpkin vinegar showed possibility to compete with European wine vinegar.**

**Key words**: vinegar, pumpkin, flavor, purge and trap method

## INTRODUCTION

Vinegar is a dilute solution of acetic acid produced by a two-stage fermentation process. In the first stage, fermentable sugars are converted into ethanol by the action of yeast, normally *Saccharomyces cerevisiae*, while, in the second stage, bacteria of the genus *Acetobacter* oxidize the ethanol to acetic acid (1). Vinegar has long been utilized as spice and medicine worldwidely. Most fruits and vegetables can be fermented to acetic acid as well as other organic acids. Apple (2-4), banana (5,6), dates (7,8), persimmon (3,9,10), malt (11-13), peach (3,14), pears (3), pineapple (15-18), and rice (19,20) have frequently been used as raw materials. These vinegars exhibit unique taste and flavor as compared with the vinegar from ethanol because other flavor compounds are produced during the fermentation process.

Oriental pumpkin (*Cucurbita moschata* Duch.) has been favored by Koreans because it becomes very nutritious upon aging. These days pumpkin extract prepared with steam cooking is widely used as a health food for the women after childbirth. Various researches have been carried out to expand its uses such as pumpkin drinks (21), dried pumpkin powder (22), and alcohol production (23). However vinegar fermentation using the pumpkin has never been tried. Since alcohol could be produced with pumpkin (23), organic acid fermentation should be possible.

Several processes were tried to produce pumpkin vinegar and the optimum fermentation condition was determined. The characteristics of pumpkin vinegar largely depended upon the flavor compounds. Therefore, volatile components of pumpkin vinegar was determined using GC and GC/MS.

## MATERIALS AND METHODS

### Fermentation of pumpkin vinegar

Pumpkin was cut into 4 parts, placed in a steam cooker, and autoclave was carried out at 121°C for 15 min. Sterilized pumpkin juice was collected in 500 ml glass bottle, and 95% ethanol and *Acetobacter* starter was added at the ratio of 4% and 10% to the volume of pumpkin juice, respectively. Fermentation was carried out at 20°C for 14 days followed by aging at 10°C for 14 days.

### Chemical and physical characteristics of pumpkin vinegar

Pumpkin vinegar was characterized by measuring brix, pH, acidity, color, and reducing sugar. pH and brix were measured by pH meter and refractometer, respec-

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tively. Acidity and reducing sugar were determined by the titration method (24) and dinitrosalycylic acid method (25), respectively. Color was expressed as L, a, b value using Minolta Chromater (Minolta, Japan).

### Collection of volatiles

Volatiles of pumpkin vinegar were collected by purge and trap method (26) using Techmar LSC-2000 (Techmar Co., Cincinnati, USA). 3 ml of sample was purged with nitrogen gas at the rate of 40 ml/min for 20 min and volatiles were adsorbed onto the trap. Dry purge was followed for 2 min to remove moisture and unadsorbed volatiles. After preliminary heating at 50°C, trap was desorbed by heating at 200°C for 5 min. In addition, to increase the resolution during sample injection, liquid nitrogen was used to cryofocus the volatile compounds. After desorption, the oven temperature was raised to 225°C.

### Identification of volatile components in the pumpkin vinegar

Major volatile compounds were identified by comparing the retention time of corresponding standard compound and confirmed with mass spectral data. Minor volatiles were tentatively identified by Willey library. 0.25 microliter of 1-octanol was used as internal standard.

## RESULTS AND DISCUSSION

### Characteristics of the pumpkin vinegar

Brix, pH, and total acidity of pumpkin vinegar were 9.7%, 3.1, and 5.3%, respectively (Table 1). Reducing sugar content was reduced to 4.1% from 13.2%, indicating that ethanol added was the main source of acetic acid formation. Color of the pumpkin vinegar was relatively bright yellow, which was confirmed by the L, a, and b values.

**Table 1. Chemical and physical characteristics of pumpkin vinegar**

| | | |
|---|---|---|
| Brix | | 9.7% |
| pH | | 3.1 |
| Total acidity | | 5.3% |
| Reducing sugar | | 4.1% |
| Color | L | 71.92 |
| | a | −1.64 |
| | b | +49.64 |

### Volatile analysis by GC/MS using purge and trap method

Thirty two compounds were identified (Fig. 1 and Table 2), which were 2 aldehydes (4.74%), 5 alcohols (30.06%), 4 ketones (8.99%), 4 acids (16.39%), 5 alkanes (11.10%), 11 miscellaneous compounds (27.01%) and 9 unknown compounds (1.71%).

Remaining high concentration of ethanol indicated the acetic acid fermentation was still in progress. That can be confirmed by the area % of acetaldehyde which was oxidized from ethanol. Acetic acid and its ethyl ester were the next major compounds. Acetic acid ethyl ester was presumably formed during the aging process of pumpkin vinegar.

Methyl acetate in pumpkin vinegar was a major component in conventional wine vinegar and sherry wine vinegar (27). Butylacetate was also identified as a minor component in both wine vinegar products. In cider vinegar butylacetate was identified; however, it was not in brown rice vinegar and persimmon vinegar (28).

Butanone was not detected in most vinegar products except sherry wine vinegar (27). Pumpkin vinegar, in this respect, showed characteristics of sherry wine vinegar. Acetoin (3-hydroxy-2-butanone), which was formed from pyruvate and also from acetolactate (29), was found in pumpkin vinegar. Malt vinegar also showed relatively high concentration of acetoin. *Acetobactor*

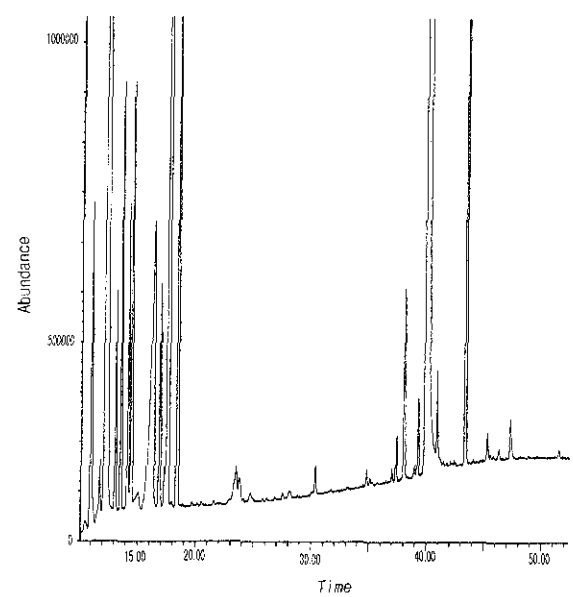


**Fig. 1. Gas chromatogram of volatile compounds from pumpkin vinegar using purge and trap method.**

was reported to dehydrate both isoleucine intermediate, dihydroxy-β-methyl-n-valerate and the valine intermediate, dihydroxyisovalerate (29).

Acetoin was a major flavor component of conventional wine vinegar and sherry wine vinegar. In the study of Yoon et al. (28), only a part of cider and brown rice vinegar products contained acetoin. Mass spectra of acetoin are shown in Fig. 2. Again flavor characteristics of pumpkin vinegar much resembled wine vinegar products, which was also confirmed by the presence of butanone in pumpkin vinegar. None of other vinegar products showed butanone but wine vinegar products (27,28). Butanoic acid (butyric acid) also appeared in pumpkin vinegar; furthermore, wine vinegar products also contained relatively high concentration of butanoic acid.

**Table 2. Identification of volatile components from pumpkin vinegar**

| Retention time (min) | Compound | Area%[1)] |
|---|---|---|
| 6.69 | Unknown | 0.144 |
| 6.75 | Unknown | 0.089 |
| 10.56 | Unknown | 0.201 |
| 11.02 | Acetaldehyde | 4.298 |
| 11.79 | Formic acid methyl ester | 1.116 |
| 12.22 | Ethanol | 25.926 |
| 13.09 | 1.2-Diethoxyethane | 2.292 |
| 13.30 | Unknown | 0.060 |
| 13.56 | 2-Propanone | 4.374 |
| 13.85 | Unknown | 0.153 |
| 14.15 | Isocyanomethane | 3.357 |
| 14.43 | Methylacetate | 4.446 |
| 14.81 | Unknown | 0.256 |
| 14.96 | Unknown | 0.256 |
| 15.07 | Unknown | 0.429 |
| 16.34 | Acetic acid | 9.150 |
| 16.88 | 2.3-Butandione | 2.639 |
| 17.32 | 2-Butanone | 0.466 |
| 17.57 | Acetic acid ethyl ester | 16.590 |
| 18.38 | Trichloroacetic acid | 7.108 |
| 23.50 | 3-Hydroxy-2-butanone(=acetoin) | 1.360 |
| 24.78 | Butanoic acid(=butyric acid) | 0.081 |
| 27.54 | Acetic acid butyl ester (=butylacetate) | 0.087 |
| 28.10 | Ethyllactate | 0.172 |
| 30.37 | 1-Hexanol | 0.316 |
| 34.82 | Decane | 1.702 |
| 35.12 | Caproic acid | 0.054 |
| 37.03 | Octylmethylether (1-methoxy octane) | 0.137 |
| 37.36 | Octanol | 0.442 |
| 38.01 | 2-Ethylhexanol | 2.120 |
| 38.96 | Aniline | 0.167 |
| 39.23 | Undecane | 0.773 |
| 40.00 | 1-Octanol(IST[2)]) | - |
| 40.86 | Nonanol | 1.312 |
| 41.11 | 2-Octanone | 0.212 |
| 43.31 | Dodecane | 8.005 |
| 45.23 | 1-Decanol | 0.390 |
| 45.52 | Unknown | 0.118 |
| 46.24 | Octylacetate | 0.175 |
| 47.20 | Tridecane | 0.541 |
| 51.44 | Tetradecane | 0.083 |

[1)]Area of internal standard was excluded
[2)]Internal standard

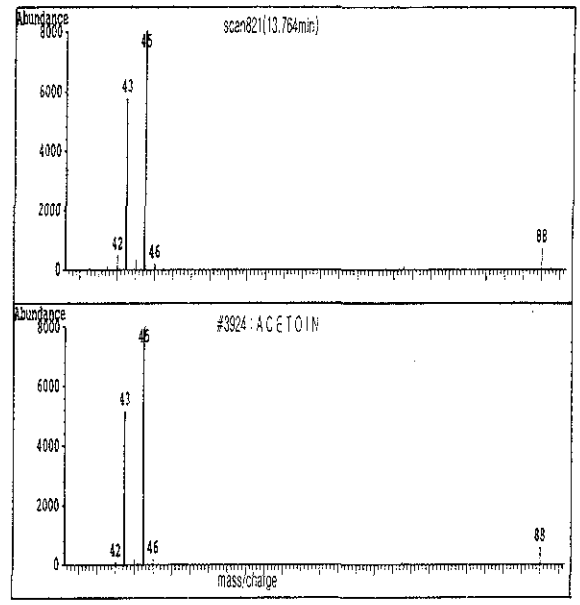


**Fig. 2. Mass spectra of acetoin in pumpkin vinegar.**

In conclusion, flavor characteristics of pumpkin vinegar were very similar to those of conventional wine vinegar and sherry wine vinegar. This suggests that pumpkin vinegar can be competitive with the European wine vinegar. Further research is in progress on the optimization of flavor profiles during fermentation processing of pumpkin vinegar.

## ACKNOWLEDGEMENTS

This research was supported by a grant from Dongeui Institute of Technology Foundation, 1997.

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(Received May 4, 1998)