Effect of drying temperature on changes in volatile compounds of longan (Dimocarpus longan Lour.) fruit

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Abstract

Longan is widely grown in South East Asia and China. It is one of the top ten exported fruits in Thailand with an exported value of about 35 million Euro in the year 2006. It is mostly exported to China, Myanmar and Lao as dried fruit. Longan flesh is used in Chinese medicine for example as a stomachic, febrifuge and vermifuge. Longan flavor is an important quality attribute influencing customers’ acceptance especially that of dried product consumed as tea. Therefore, the impact of drying temperature on volatile compounds of dried longan was investigated using a headspace-solid phase microextraction (HS-SPME) coupled with gas chromatography–mass spectrometry (GC–MS). The solid phase microextraction fiber coated with 65 µm mixture of polydimethylsiloxane/divinylbenzene (PDMS/DVB) was applied for the extraction of the volatile components. Longan fruits with peel were dried at 60, 70, 80 and 90°C using a tray dryer with a through flow mode of drying air. The velocity of drying air is constant at 0.2 m/s. The drying process was carried out until the water activity of longan flesh was approximately 0.55 – 0.60. It was found that major volatile compounds detected in fresh and dried longan were cis-ocimene, beta-ocimene, ethyl acetate and ethanol. Many volatile compounds were produced during drying especially acids, ester and alcohol for instances octanoic acid, ethyl ester, phenylethyl alcohol and 1-octen-3-ol. The retention of cis-ocimene and beta-ocimene was found to be the highest in longan flesh dried at 70°C. The higher drying temperature, the more ethanol and ethyl acetate were detected. Drying temperature is, thus, a crucial parameter causing the different flavor profile characteristic of the dried longan fruit which related to customers’ acceptance.

Introduction

Longan (Dimocarpus longan Lour.) is a subtropical fruit of the Sapindaceae family closely related to lychee and rambutan. It is commonly grown in China, Thailand and Vietnam (Jiang et al., 2002; Rangkadilok et al., 2005). Longan is a top-ten commercial fruit of Thailand. The fruit has thin, brittle and light-brown to brown peel. The flesh (aril) is white and translucent, which is sweet, juicy and aromatic. The seed is round, dark black and shiny with a circular white spot at the base, which looks like dragon eyes (Rangkadilok et al., 2005; Diczbalis, 2002). Longan and
its product are popular among the Chinese people since they believe that eating longan with dragon-eye seed is good for health. Therefore, China is a major importer of Thai longan especially as dried unpeeled product with the value of about 35 million Euro in the year 2006 (Thai Customs Department, 2007). In China, dried longan aril is used mainly to prepare refreshing drink and longan tea. Its aroma plays an important role on the quality of product. However, many studies were considered on the drying behavior and improvement of the drying process efficiency (Achariyaviriya, 2001; Janjai et al., 2006a, 2006b; Mahayothee et al., 2006; Phupaichitkun et al., 2006). The work on volatile compounds of fresh (Susawaengsup et al., 2005) and dried longan is limited. Dried unpeeled longans are usually dried in a bin type force convective dryer using LPG gas burner as a heating source for hot air. This type of dryer has non-uniform drying temperature and air flow rate (Janjai et al., 2006b). There is, hence, an urgent need to investigate how drying parameters affect the quality decisive attributes such as volatile compounds. From our previous study, it was found that the drying air flow rate had an insignificant impact on the drying rate of unpeeled longans (Phupaichitkun et al., 2005). The objective of this study is, therefore, to focus on the impact of drying temperature on the volatile quality of dried unpeeled longan.

Materials and Methods

Materials
Longan fruit cultivar Edor in the season 2006 with size AA, Φ 20-25 mm, and free from visual damages and diseases was selected for the study. This cultivar is commercially used for the production of dried longan in Thailand.

Quality analyses of fresh longan
The quality of fresh fruit was determined including volatile compounds, total soluble solids (TSS), moisture content (MC) and water activity (a_w). The volatile compounds were analysed using a headspace-solid phase microextraction (HS-SPME) coupled with gas chromatography–mass spectrometry (GC-MS). Juice from longan pulp was used to measure TSS using a hand refractometer (Atago Co. Ltd., Tokyo, Japan). MC was determined by Karl Fischer titration method. Water activity was determined at 25°C using a Thermoconstanter (Novasina, Inc., Switzerland).

Drying experiments
The unpeeled fruits were dried in a single layer at four various drying air temperatures (60, 70, 80 and 70°C) using a laboratory tray dryer with a through-flow mode system. Drying air velocity was fixed at 0.2 m/s. Fruits were dried until the water activity of flesh was approximately below 0.60 which is safe from microbial growth. The quality of dried longans was determined including volatile compounds, MC and a_w. At each drying temperature, 2 replications were conducted. Sample were kept at -18°C for analysis of volatile compounds.

Extraction of volatile compounds by HS-SPME
Flesh of both fresh and dried longan were cut into 2x2 mm and crushed into small pieces for 5 min using a pestle and mortar. Liquid nitrogen was added every 1 min during crushing for preventing the lost of volatile compounds. Crushed sample was placed in a 20 ml vial (3 grams for fresh sample and 13 grams for dried sample). Vials were closed by a PTFE/silicone septum and equilibrated at an ambient temperature for 30 min. The headspace volatiles were then extracted at 36°C for 45 min using a SPME fused silica fiber coated with 65 μm polydimethylsiloxane/divinylbenzene (PDMS/DVB) from Supelco Co., USA. After the extraction, SPME fiber was immediately inserted into the GC injection port for 3 min at 250°C using the splitless mode. At this stage, volatile compounds were thermally desorbed from the fiber and then were characterized by GC-MS. For each sample, three replications were performed.
**GC-MS conditions**

The GC (Hewlett-Packard (HP) 6890-MS detector HP 5973 (Agilent Technology, USA) was used in this study. A HP-5MS (Agilent Technology, USA) capillary column (0.25 mm I.D. x 30m length x 0.25 μm film thickness) was performed for chromatographic separation. Helium was used as carrier gas with an inlet pressure of 15.9 psi and gas flow rate of 2.0 ml/min. The GC oven temperature was programmed to operate from 38°C to 180°C, first maintaining the temperature at 38°C for 3 min and then increasing it from 38°C to 180°C with a rate of 5°C/min. The electron energy was 70 eV. The ion mass/charge ratio was 30-400 m/z; scan mode. The standard mass spectra of the National Institute of Standards and Technology (NIST98) MS spectral library were applied for identifying volatiles compounds.

**Results, Discussion and Conclusion**

The TSS of fresh longans, presenting their sweetness, was in the range of 17-20°Brix representing mature fruit. MC and aw of fresh longan flesh was approximately 70-74% and 0.99, respectively. The drying time used for drying longan fruits with peel at 60, 70, 80 and 90°C was 55, 33, 22 and 19 hours, respectively. The aw values of flesh obtained from dried longans at 60, 70, 80 and 90°C were 0.60±0.01, 0.59±0.02, 0.60±0.02 and 0.56±0.00, respectively.

Table 1 showed the list and peak area of volatile compounds identified in the flesh of fresh and dried longans obtained from various drying temperatures. Four volatile compounds were found in the flesh of fresh longan. Terpenes were found to be prominent compounds in both fresh and dried longan. The highest normalized amount (peak area) of volatile compounds in fresh and dried longan was β-ocimene which presented in cis- and trans- form. Zhang and Li (2007) reported that ethyl acetate, β-ocimene and allo-ocimene were typical aroma of fresh longan. Three of the identified constituents (ethanol, ethyl acetate and cis-ocimene) have also found by Susawaengsup et al. (2005), using HS-SPME-GC-MS for analysis the volatile components of five fresh longan cultivars (Biew Kiew, Chompoop, Edor, E-haew and Kahlk). Two isomers, cis- and trans-β-ocimene are floral volatiles, which were found in many fruits and vegetables such as sweet pea (Porter et al., 1999), mango sap (John et al., 1999) and lychee (Chyau et al., 2003). Ethanol has an odor description as alcohol, which was found in Yali pear (Chen et al., 2006). Ethyl acetate has aromatic note as fruity (Guillot et al., 2006; Chen et al., 2006) that was the major detectable volatile product of the ripe fruit (Robertson et al., 1995).

In dried longan, more volatile compounds were detected compared to the fresh fruit (Table 1). Many volatile compounds were produced during drying especially aldehyde, acid, ester and alcohol for instances 3-methyl butanal; octanoic acid, ethyl ester; phenylethyl alcohol and 1-octen-3-ol (Table 1). Drying at higher temperature resulted in obviously increase in 3-methyl butanal and ethyl acetate. This increase is might be due to browning reactions. Octanoic acid, ethyl ester or ethyl octanoate has a floral volatile that was found in Yali pear (Chen et al., 2006). Phenylethyl alcohol was found in flowering Mahonia japonica plants as a floral volatile (Picone et al., 2002). More volatile compounds were detected in longan flesh dried at 70°C and the retention of β-ocimene (cis- and trans-form) was found to be the highest in longan flesh dried at this condition. Drying unpeeled longan at 70°C was also recommended, based on browning and sensory results by our previous study (Mahayothee et al., 2006). However, the study on the relationships between aroma profile characteristics of dried longans obtained from various drying temperatures using HS-SPME-GC-MS, sensory evaluation results on aroma attribute and key aroma components identified by GC-olfactometry is currently proceed.
### Table 1 Volatile compounds in flesh of fresh and dried longan

<table>
<thead>
<tr>
<th>Volatile compounds</th>
<th>Fresh longan</th>
<th>Dried longan</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>dried at 60°C</td>
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<td></td>
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<tr>
<td>Ethanol</td>
<td>7.68E+06</td>
<td>2.00E+07</td>
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<tr>
<td>Ethyl Acetate</td>
<td>6.15E+05</td>
<td>1.40E+06</td>
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<tr>
<td>Butanal, 3-methyl-</td>
<td>-</td>
<td>2.43E+06</td>
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<tr>
<td>1-Butanol, 3-methyl-</td>
<td>-</td>
<td>7.19E+06</td>
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<tr>
<td>Cyclopropanal, methylene-</td>
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<td>-</td>
</tr>
<tr>
<td>Butanoic acid, 3-hydroxy-, ethyl ester</td>
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<td>2.20E+06</td>
</tr>
<tr>
<td>1-Octen-3-ol</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>5-Hepten-2-one, 6-methyl-Benzoic acid, 3-methyl-2-trimethylsilyloxy-, trimethylsilyl ester</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Trans-β-ocimene</td>
<td>6.85E+05</td>
<td>4.44E+07</td>
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<tr>
<td>Cis-β-ocimene</td>
<td>3.25E+07</td>
<td>1.21E+07</td>
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<tr>
<td>Phenylethyl Alcohol</td>
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<td>4.52E+06</td>
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<tr>
<td>Allo-ocimene</td>
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<td>-</td>
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<tr>
<td>Octanoic acid, ethyl ester</td>
<td>-</td>
<td>6.18E+05</td>
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</tbody>
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### References


Janjai, S., Intawee, P., Chaichoet, C., Mahayothee, B., Haewsungcharern, M., Müller, J.


