Tropentag 2007
University of Kassel-Witzenhausen and
University of Göttingen, October 9-11, 2007
Conference on International Agricultural Research for Development

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

Saranya Lapsongphol[1], Busarakorn Mahayothee[1], Sarawut Phupaichitkun[2], Hermann Leis[2], Methinee Haewsungcharoen[3], Serm Janjai[4], Joachim Mueller[2]

[1] Silpakorn University, Faculty of Engineering and Industrial Technology, Department of Food Technology, Nakhon Pathom, Thailand
[2] University of Hohenheim, Institute for Agricultural Engineering, Tropics and Subtropics Group 440e, Stuttgart, Germany
[3] Chiangmai University, Faculty of Agro-industry, Department of Food Engineering, Chiangmai, Thailand
[4] Silpakorn University, Faculty of Science, Department of Physics, Nakhon Pathom, Thailand

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 a_w 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 a_w 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, Chompoo, Edor, E-haew and Kahlok). 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

Volatile compounds	Peak area per g sample on dry basis				
	Fresh longan	Dried longan			
		dried at 60°C	dried at 70°C	dried at 80°C	dried at 90°C
Ethanol	7.68E+06	2.00E+07	2.14E+07	2.09E+07	2.35E+07
Ethyl Acetate	6.15E+05	1.40E+06	1.56E+06	2.13E+06	2.14E+06
Butanal, 3-methyl-	-	2.43E+06	3.83E+06	6.82E+06	8.38E+06
1-Butanol, 3-methyl-	-	7.19E+06	3.61E+06	-	-
Cyclopropanal, methylene-	-	-	1.41E+06	-	-
Butanoic acid, 3-hydroxy-, ethyl ester	-	2.20E+06	-	-	2.18E+06
1-Octen-3-ol	-	-	3.95E+06	2.30E+06	-
5-Hepten-2-one, 6-methyl-	-	1.68E+06	-	-	-
Benzoic acid, 3-methyl-2-trimethylsilyloxy-, trimethylsilyl ester	-	-	-	1.37E+06	-
Trans-β-ocimene	6.85E+05	4.44E+07	2.06E+06	1.34E+06	1.62E+06
Cis-β-ocimene	3.25E+07	1.21E+07	9.74E+07	5.76E+07	6.61E+07
Phenylethyl Alcohol	-	4.52E+06	7.78E+06	6.15E+06	5.53E+06
Allo-ocimene	-	-	8.68E+05	-	1.65E+06
Octanoic acid, ethyl ester	-	6.18E+05	6.36E+05	7.18E+05	6.32E+05

Acknowledgments

We gratefully acknowledge Deutsche Forchungsgemeinschaft (DFG), Germany and Thailand Research Fund (TRF) for their financial support.

References

Achariyaviriya, A. (2001). Simulation and optimization of the drying strategy for longan drying. King Mongkut's Institute of Technology, Thonburi, Thailand.

Chen, J.L., Yan, S., Feng, Z., Xiao, L., Hu, X.S. (2006). Changes in the volatile compounds and chemical and physical properties of Yali pear (*Pyrus bertschneideri* Reld) during storage. Journal of Food Chemistry, 97:248–255.

Chyaua, C.C., Ko, P.T., Chang, C.H., Mau, J.L. (2003). Free and glycosidically bound aroma compounds in lychee (*Litchi chinensis* Sonn.). Journal of Food Chemistry, 80:387–392.

Diczbalis, Y. (2002). Longan: Improving yield and quality. RIRDC Publication No 02/135, Rural Industries Research and development Corporation (RIRDC), Kingston, Australia.

Guillot, S., Peytavi, L., Bureau, S., Boulanger, R., Lepoutre, J.P., Crouzet, J., Schorr-Galindo, S. (2006). Aroma characterization of various apricot varieties using headspace–solid phase microextraction combined with gas chromatography–mass spectrometry and gas chromatography–olfactometry. Journal of Food Chemistry, 96:147–155.

Janjai, S., Bala, B.K., Tohsing, K., Mahayothee, B., Haewsungcharern, M., Mühlbauer, W., Muller, J. (2006a). Equilibrium moisture content and heat of sorption of longan (*Dimocarpus longan* Lour.). Drying Technology, 24(12):1691-1696.

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

(2006b). Improvement of the air flow and temperature distribution in a conventional longan dryer. International Symposium Towards Sustainable Livelihoods and Ecosystems in Mountainous Regions; 7-9 March 2006; Chiang Mai, Thailand

Jiang, Y., Ghang, Z., Joyce, D.C., Ketsa, S. (2002). Posthavest biology and handling of longan fruit (*Dimocarpus longan* Lour.). Posthavest Biology and Technology, 26:241-252.

John, K.S., Rao, L.J.M., Bhat, S.G., Rao, U.J.S.P. (1999). Characterization of aroma components of sap from different Indian mango varieties. Phytochemistry, 52: 891-894.

Mahayothee, B., Wongtom, R., Keowmaneechai, E., Phupaichitkun, S., Haewsungcharern, M., Janjai, S., Müller, J. (2006). Influence of drying on browning and sensory characteristics of dried whole longan. Proceedings of the 15th International Drying Symposium (IDS 2006); 20-23 August 2006; Budapest, Hungary.

Phupaichitkun, S., Mahayothee, B., Heawsungcharern, M., Janjai, S., and Müller, J. (2006). Drying behaviour of Thai unpeeled longan: modeling of shrinkage inside fruit. Proceedings of the 15th International Drying Symposium (IDS 2006); 20-23 August 2006; Budapest, Hungary.

Phupaichitkun, S., Mahayothee, B., Heawsungcharern, M., Janjai, S., Müller, J. (2005). Single-layer drying behavior of longan (Dimocarpus longan Lour.). In Deutscher Tropentag 2005 Stuttgart-Hohemheim, Germany.

Porter, A.E.A., Griffiths, D.W., Robertson, G.W., Sexton, R. (1999). Floral volatiles of the sweet pea *Lathyrus odoratus.* Phytochemistry, 51:211-214.

Rangkadilok, N., Worasuttayangkurn, L., Bennett, R.N., Satayavivad, J. (2005). Identification and quantification of polyphenolic compounds in longan (*Euphoria longana* Lam.) fruit. Journal of Agricultural and Food Chemistry, 53:1387-1392.

Robertson, G.W., Griffiths, D.W., Woodford, J.A.T., Birch, A.N.E. (1995). Changes in the chemical composition of volatiles released by the flowers and fruits of the red raspberry (*Rubus Idaeus*) cultivar glen prosen. Phytochemistry, 38:1175-1179.

Susawaengsup, C., Rayanakorn, M., Wangkarn, S. (2005). Gas chromatography–mass spectrometry of volatile components of some local fruits in Northern Thailand. Proceedings of the 31st Congress on Science and Technology of Thailand; 18-20 October 2005; Suranaree University of Technology, Nakhonratchasima, Thailand.

Thai Customs Department. (2007). Export Statistics: HS-CODE 0813400104; dried longan. Available from: http://www.customs.go.th/Statistic/StatisticIndex.jsp Accessed May 14, 2007.

Zhang, Zhuo-Min, Li, Gong-Ke. (2007). A preliminary study of plant aroma profile characteristics by a combination sampling method coupled with GC–MS. Microchemical Journal 86:29–36.