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Volatile flavour compounds and sensory properties of minimally processed durian (*Durio zibethinus* cv. D24) fruit during storage at 4 °C

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Abstract

Flavour volatile compounds and sensory attributes in minimally processed durian (*Durio zibethinus* cv. D24) fruit stored at 4 °C for 42 days were examined. The volatile compounds were extracted by solid-phase microextraction (SPME) and analysed by gas chromatography–time of flight mass spectrometry (GC–TOFMS). Forty compounds were identified, among which sulfur compounds, esters, and alcohols were found to be the major constituents. During storage of minimally processed durian at 4 °C, decreases in levels of the majority of ester compounds were observed after 14 days of storage. All ester compounds decreased significantly ($P \leq 0.05$) after 1 week of storage except for ethyl acetate that decreased after 2 weeks. Ethanethiol, 1-propanethiol, and both isomers of 3,5-dimethyl 1,2,4-trithiolane decreased significantly after 7 days of storage. Total sulfur content of fruit remained unchanged after 42 days of storage. Benzyl alcohol was produced after 4 weeks of storage and increased thereafter. Principal component analysis (PCA) applied to the data differentiated the fruit over the storage period based on 22 compounds exhibiting significant changes between samples and explained 86% of the total variance with two principal components. Quantitative descriptive analysis (QDA) was carried out using sixteen descriptors to describe the surface colour, odour, flavour and texture of fruit during storage. Fruit could be stored for 21 days, after which the green aroma became too intense and rendered the fruit unacceptable. Sulfur notes decreased gradually throughout storage while off odours developed on day 21 and increased to an unacceptable level on day 28 of storage. Sweet and fruity aroma correlated strongly with some ester and aldehyde compounds, while correlations between perceived sulphur aromas and sulphur compounds were poor. A green note and off-odours correlated well with benzyl alcohol and 1-hexanol.

Keywords: Durian; Minimally processed; Flavour; Sensory; Storage

1. Introduction

Durio zibethinus, commonly known as durian, is an exotic, seasonal fruit enjoyed in South East Asia due to its unique aroma, taste and texture. It is a climacteric fruit (Tongdee et al., 1990; Booncherm and Siriphanich, 1991) belonging to the family *Bombacaceae* (Martin, 1980) that grows in the warm, wet conditions of the equatorial tropics. The durian cultivars grown commercially in South East Asian countries are derived from *Durio zibethinus* Murray originating in Peninsular Malaysia.

Durian is a large heavy fruit, covered with a thick husk with sharp hexagonal thorns, which makes peeling a difficult task for untrained people. The fruit can be opened easily by cutting at abscission zones, which develop along the suture at the middle of each locule as the fruit ripen (Siriphanich, 1994). The fruit normally contains five locular units with between 1 and 5 pulps per unit. The pulp unit consists of seed which is completely covered by a creamy, white, yellow or golden yellow aril, the edible portion of the fruit (Nanthachai, 1994).

Most recent fresh-cut research has focused on quality retention based upon visual appearance and rapid biochemical analyses. This approach is questionable with respect to the flavour of fruit and vegetables with high water contents. Hence, shelf-life in terms of flavour quality is becoming an active area of research for fresh-cut produce (Beaulieu and Baldwin, 2000). Very often, the development of off-odours is one of the factors limiting the shelf-life of fresh-cut produce, as shown in honey dew melons (Bai et al., 2003), orange (Rocha et al., 1995), and watermelon (Abbey et al., 1998). Cut fruit products rapidly lose their typical flavour, even when stored under refrigerated conditions. Fresh-cut can-

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taloupe melon, reported by Lamikanra and Richard (2002), developed staleness or loss of freshness within a day of refrigerated storage. Inferior tomato flavour was reported after short-term refrigerated storage of ripe tomatoes (Maul et al., 2000).

Booncherm and Siriphanich (1991) reported that fresh-cut durian could be kept longer than its intact form at low temperature, contrary to common practice with other fruit and vegetable produce. The pulp was found to be less susceptible to chilling injury than the husk. This finding and the fact that durian has a high husk to pulp ratio of 2:1, makes storage of durian pulp instead of the whole fruit more promising.

Storage research has shown that matured but unripened whole durian fruit could be stored at 4 °C for only 20 days (Praditdoung, 1986), while the pulp could be stored at 5 °C for up to 8 weeks, with slight chilling injury observed after 4 weeks of storage (Booncherm and Siriphanich, 1991). Other research has shown that durian pulp could be stored at 4 °C for up to 30 days (Salunkhe and Desai, 1984; Praditdoung, 1986), with the main problems encountered being chilling injury at the base of the seed and contamination by fungi. Refrigerated minimally processed durian is very promising since temperatures that cause a slight amount of chilling injury are preferred over temperatures that cause rapid senescence and microbial deterioration (Watada and Qi, 1999).

Work has been carried out on the effect of storage on physicochemical, microbial and sensory qualities of minimally processed durian at 4 °C for 28 days (Voon et al., 2006). Storage of durian pulp at 4 °C effectively retained fruit firmness, maintained the pH at neutral, increased glucose, fructose and sucrose contents, and maintained the organic acid content of the pulp. Chilling also slowed down the growth of microorganisms, but fruit underwent losses in aroma and developed off-odours on day 21, increasing thereafter and rendering the pulp unacceptable in terms of overall aroma on day 28 of storage (Voon et al., 2006). Thus, the objective of this study was to identify changes that occurred in volatile aroma compounds during storage of minimally processed refrigerated durian and their contribution to sensory attributes.

2. Materials and methods

2.1. Preparation of minimally processed durian

Durian fruit (*Durio zibethinus*) cultivar D24 used in this study were obtained from a farm in Bentong, Pahang Darul Makmur, Malaysia, in mid August 2005. Ripened durian fruit that dropped naturally were collected and transported within 2 h on the same morning (at 30 ± 2 °C). Fruit were selected for uniformity of size and freedom of visual defects, and were dehusked (the rind was cut open), by cutting along the suture on the back of the locules. Upon cutting, 4–6 separated fruit arils (350–420 g) were packed together. Care was taken not to break the epidermis of the pulp when removing it from the husk. The pulps were placed on polystyrene trays and wrapped in a commercially available low-density polyethylene (LDPE) cling film (20 μm) with an oxygen transmission rate of 4.86×10^{-6} nmol s^{-1} mm^{-2} Pa^{-1} at 25 °C and 75% RH. Dehusking was performed manually in an air-conditioned room (20 °C) using good manufacturing practices. Only pulps with no external injuries (epidermis intact) were selected. Each replicate was composed of pulps taken from three trays and all data are the mean of three replicates. Samples were packaged at 25 °C and stored at 4 °C for 42 days. Flavour volatile compounds and sensory properties of the fruit were evaluated initially and at 7-day intervals.

2.2. Chemicals

Fifteen volatile flavour compounds (acetaldehyde, ethyl acetate, 1-propanethiol, methyl propionate, ethanol, methyl butanoate, methyl 2-methylbutanoate, ethyl butanoate, propyl propanoate, diethyl disulfide, ethyl propanoate, ethyl 2-methylbutanoate, ethyl 3-methylbutanoate, propyl butanoate, 1-butanol, and thiophene, as authentic GC standards with purity ≥98%, were purchased from Sigma–Aldrich Company Ltd. (Milwaukee, WI), while sodium chloride was purchased from Merck (Darmstadt, Germany).

2.3. Isolation of volatile compounds using headspace-solid-phase microextraction (HS-SPME)

A 50/30 μm divinylbenzene/carboxen on polydimethylsiloxane (DVB/CAR/PDMS) fiber (Supelco, Bellefonte, PA) was used in this study as it was found previously to be suitable for extracting durian volatiles (Chin et al., 2007). The fiber was conditioned prior to use according to the supplier's recommendations, for 30 min at 250 °C. Fifty grams of durian pulp were blended with 100 mL distilled cooled ice water in a Waring blender for 1 min. Blended pulp (15 mL) was quickly transferred into a 30 mL vial containing 5.0 g NaCl and a magnetic stirring bar. Thiophene (15 μg) (Sigma, UK) was spiked into the sample before the vial was crimp-sealed with a Teflon septum. After equilibration for 1 h at 30 °C in a water bath, headspace sampling was performed at the same temperature for 30 min with stirring. Desorption of the analytes from the fiber coating was made at the GC injection port at 250 °C for 5 min. Each analytical sample was measured in triplicate.

2.4. Gas chromatography–time of flight mass spectrometry (GC/TOFMS) conditions

An Agilent 6890 N gas chromatography system (Wilmington, DE) equipped with electron ionisation–time-of-flight mass spectrometer (Pegasus III, Leco Corp., St. Joseph, MI, USA) was used. Volatile compounds were separated in a 10 m × 0.10 mm, 0.10-μm film thickness Supelcowax-10 (Supelco MA) capillary column with the injector and detector maintained at 250 °C. The injection port was operated at a splitless mode with purified helium as the carrier gas flowing at 0.4 mL/min. The oven temperature program was isothermal at 40 °C for 1.5 min, ramped to 240 °C at 50 °C/min, and then held at this temperature for 2 min. The interface temperature was 240 °C and the ionizing voltage was 70 eV. The mass spectrometer was operated in a scan mode from 35 to 350 amu, and mass spectra were collected at a rate of 60 spectra/s. Data were ana-