JOURNAL OF FOOD AND DRUG ANALYSIS XXX (2017) 1–7

Available online at www.sciencedirect.com

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journal homepage: www.jfda-online.com

Original Article

Characterization of key aroma-active compounds in lychee (*Litchi chinensis* Sonn.)

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ARTICLE INFO

Article history:
Received 16 February 2017
Received in revised form
4 July 2017
Accepted 7 July 2017
Available online xxx

Keywords:
AEDA
Aroma-active compounds
GC-MS/O
SAFE
Sensory analysis

ABSTRACT

Volatile compounds in 'Sweetheart' lychee were examined using gas chromatography-olfactometry/mass spectrometry (GC-O/MS). Solvent assisted flavor evaporation (SAFE) technique was used to identify the aroma-active compounds in lychee. Further characterization of the most important odorants in 'Sweetheart' lychee was achieved using aroma extract dilution analysis (AEDA). Thirty-one key aroma-active odorants were identified in the flavor dilution (FD) factor range of 2–1024. Methional (cooked potato) and geraniol (sweet, floral) exhibited the highest FD factors of 1024 and 512, respectively, these were followed by furaneol (sweet, caramel), nerol (floral, sweet), dimethyl trisulfide (DMTS) (preserved vegetable, sulfury), linalool (floral), (*E,Z*)-2,6 nonadienal (cucumber) and nerolidol (metalic, sesame oil). Furthermore, the flavor profile of 'Sweetheart' lychee was described by sensory analysis. Floral, tropical fruit, peach/apricot and honey were scored with relatively high scores for each aroma attribute. The sweetness rating was the highest score among all the attributes.

1. Introduction

Lychee (*Litchi chinensis* Sonn.), also known as litchi, originates from the northern tropical and southern sub-tropical regions of south China with records of cultivation dating back to 111 B.C. [1]. It is a commercially important member of the Sapindaceae family, which also includes longan (*Dimocarpus longan* Lour.) and rambutan (*Nephelium lappaceum* L.). Asian countries such as China, India, Thailand and Vietnam play leading roles in worldwide lychee production, while in the United States, Florida makes the biggest contribution, followed by Hawaii and California [1,2]. Although native to Asia, lychee has increased in popularity in other countries outside of Asia and has attracted much attention from the mainstream markets.

At full maturity, lychee flesh consists of a white, juicy aril that surrounds a large brown seed and is covered with a red

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http://dx.doi.org/10.1016/j.jfda.2017.07.013

Please cite this article in press as: Feng S, et al., Characterization of key aroma-active compounds in lychee (*Litchi chinensis* Sonn.), Journal of Food and Drug Analysis (2017), http://dx.doi.org/10.1016/j.jfda.2017.07.013

leathery skin [3]. Lychee has a distinctive flavor and is usually described as rose-floral and fruity-floral in aroma with a desirable, sweet taste [4]. An early study identified 42 volatiles from lychee fruit grown in Florida [5]. Using these results, a basic portrayal describing volatile constituents of lychee fruit was compiled. For the next twenty years, few investigations into lychee aroma were conducted until free and glycosidically bound aroma compounds in lychee were studied [6], which contributed additional information to the understanding of volatile constituents in lychee fruit. More recently, gas chromatography-olfactometry (GC-O) has been used to examine odor-active compounds in lychee cultivars [3]. Similarly, volatile profiles of nine lychee cultivars with a high commercial value in southern China were studied and interpreted using odor active value (OAV) [7]. It has become increasingly clear that in order to understand lychee aroma, the study of volatile compositions alone is not enough. It is also necessary to closely examine the odor-active compounds as well as understand their roles in the overall aroma profile of lychee fruit.

As previously mentioned, despite existing reports of volatile constituents of various lychee cultivars, a detailed aroma profile of lychee cultivars, which could demonstrate the diverse importance of volatile components to the overall aroma profile, has not yet been investigated. Therefore, the characteristic aroma-active compounds in lychee cultivars are still not clear. 'Sweetheart', a relatively recent introduction is hearty and thrives in South Florida's sub-tropical climate. Therefore, it is considered a rising star that exhibits superior quality. This high quality lychee cultivar is characterized by fresh, large, luscious lychee fruits with very small seeds. The demand of 'Sweetheart' has grown far greater than its supply since released. Therefore, 'Sweetheart' shows great competitive potential in the lychee market, which has been dominated by 'Mauritius' and 'Brewster'. The goal of this study was to identify which major odor components contribute to the aroma profile of 'Sweetheart' lychee by using solvent assisted flavor evaporation (SAFE) coupled with gas chromatography-olfactometry/mass spectrometry (GC-O/MS). The aroma extract dilution analysis (AEDA) was applied to further elucidate the importance of volatile components in lychee fruit. Information collected has the potential to further benefit studies into the lychee breeding program and lychee related products, such as dried lychee, lychee juice, lychee wine, and canned lychee.

2. Materials and methods

2.1. Lychee samples

Lychee cultivar (Sweetheart) was obtained from the Tropical Research and Education Center, University of Florida (Homestead, FL). The Brix/acid ratio of freshly made lychee juice was measured as 65.4. Fresh lychee fruits were used for sensory evaluation upon arrival while the rest were stored at −20 °C before analytical analysis.

2.2. Chemicals

2,3-Butanedione, 3-methyl-3-buten-2-one, 2-methyl-2-butanol, myrcene, α-phellandrene, 3-methyl-3-buten-1-ol, p-cymene, octanal, 1-octen-3-one, 6-methyl-5-heptene-2-one, (*Z*)-rose oxide, dimethyl trisulfide, (*E*)-2-octenal, methional, linalool, (*E,Z*)-2,6-nonadienal, isovaleric acid, (*E,E*)-2,4-nonadienal, citronellol, nerol, geraniol, guaiacol, nerolidol, 4-hydroxy-2,5-dimethyl-3(2*H*)-furanone (furaneol) and 2-ethyl-4-hydroxy-5-methyl-3(2*H*)-furanone (homofuraneol) were purchased from Sigma–Aldrich Chemicals Co. (St. Louis, MO). A mixture of *n*-alkanes (C7–C30) was used for the retention index (RI) analyses and was purchased from Sigma–Aldrich Chemicals Co. The extraction solvent, dichloromethane, was also purchased from Sigma–Aldrich Chemicals Co. and freshly distilled before use. Hexane was purchased from EMD Millipore Corporation (Darmstadt, Germany). Anhydrous sodium sulfate and sodium chloride were purchased from Fisher Scientific Co. (Hampton, NH).

2.3. Sensory analysis

Freshly peeled lychee fruits were randomly mixed and served in plastic cups at room temperature. Eleven pre-identified flavor attributes including cabbage, honey, tropical fruit, garlic/onion, floral, sweetness, astringency, sourness, citrus, green/woody, and peach/apricot were determined by 7 trained panelists and then used to evaluate lychee samples by 60 untrained panelists in the age range of 23–55. Samples were scored using a nine-point scale ranging from 1.0 (very slight) to 9.0 (very intense), at intervals of 1.0. All of the sensory tests were carried out within 48 h after the fruits were received.

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. The study protocol and consent procedure received ethical approval from the Institutional Review Board (IRB) of the University of Florida. Informed consent was obtained from all individual participants included in the study.

2.4. Solvent assisted flavor evaporation (SAFE)

Fifteen lychee fruits were peeled, pitted, and subsequently mixed with liquid nitrogen. The mixture was then pulverized in a Waring blender (Model 51BL31, Waring Co., Torrington, CT, USA) for 1 min. One hundred and ninety-seven grams of lychee powder were obtained, transferred into a centrifuge bottle, and mixed with 400 mL of distilled dichloromethane and 100 ppm of cyclohexyl butyrate (internal standard). The mixture was then placed on an Excella E5 platform shaker (New Brunswick Scientific Co, Inc., Enfield, CT) at 200 rpm for 1 h. The solvent extract was separated from the crude-extract through centrifugation at 5000 rpm for 5 min followed by separation through a separatory funnel. The final extract was collected and subsequently introduced into the SAFE apparatus [8]. A balanced thermostat throughout the SAFE system was maintained at 40 °C using a pre-warmed, circulating water bath, while the condensation chamber was kept frozen using liquid nitrogen. The final distillate condensed in a liquid nitrogen cooled round-bottom flask. It was then thawed at room temperature before being dehydrated using anhydrous

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