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Identification of Aroma Compounds in 'Sweetheart' Lychee

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Tropical fruit aroma profiles have not been extensively explored. The aroma profile of lychees has not been fully explored, and this paper seeks to identify the aroma characteristics of 'Sweetheart' lychee (*Litchi chinensis* Sonn.). Lychee originated in the tropical regions of south China and is typically recognized by its' tough, red skin and the sweet, floral flavor of the white flesh. By utilizing gas chromatography–olfactometry/mass spectrometry (GC-O/MS), solvent assisted flavor evaporation (SAFE), and aroma extract dilution analysis (AEDA), researchers identified the key aroma-active compounds. Thirty-one significant aroma components were recognized, including nerolidol (metallic, sesame oil) and homofuraneol (floral, caramel), which were identified as aroma-active in lychee for the first time. The flavor dilution (FD) factor ranged from 2 to 1024, with methional (cooked potato) and geraniol (sweet, floral) showing the highest values, but also included furaneol, nerol, dimethyl trisulfide (DMTS), linalool, (E, Z)-2,6-nonadienal, and nerolidol. Researchers also conducted a sensory analysis, where participants identified the various flavor attributes of lychee. Attributes included floral, tropical fruit, peach/apricot, and honey as the most intense and characteristic aromas of 'Sweetheart' lychee. This is the first study to distinguish odor-active compounds from volatile compounds in 'Sweetheart' lychee, which could be helpful for cultivating a more desirable lychee variety or improving the sensory characteristics of lychee flavored products.

Lychee (*Litchi chinensis* Sonn.) is a tropical fruit originating from the northern tropical and southern sub-tropical regions of south China. As part of the Sapaindaceae family, it is related to longan (*Dimocarpus longan* Lour.) and rambutan (*Nephelium lappaceum* L.) fruits which share similar attributes. Lychee has a red, leather-like skin with a firm, white flesh interior surrounding a brown seed. The interior texture of the fruit has been compared to a grape, with a floral, sweet flavor. While it is very popular in Asian food cultures, lychee is not well-known in the American market. However, with food trends in recent years seeking new and exotic flavors, lychees have started to become commonplace, generally seen as canned lychee, lychee syrup, tea, or wine.

Lychee was introduced to Florida in the early 1900s although it was not grown with great success until the 1950s when lychee production was moved to south Florida. However, growers have recognized that current well-known varieties (Brewster and Mauritius), are not optimized for the Florida climate (Knight Jr., 1994), and that advances could be made to optimize the health of the trees and crop yield. 'Sweetheart' lychee was introduced because of its larger fruit and smaller seed, making the crop more profitable.

However, current quality evaluation of the lychee fruit generally depends on the color, size, hardness, total soluble solids, titratable acid, and single fruit weight, with no regard to the flavor profile of the lychee fruit. While the total soluble solids and titratable acid describe the fruit's sweetness, consumers may not enjoy the flavor even if it has a high sugar content. The flavor profile of lychee has not been studied since the 1990s, which leaves an opening for developing flavor profiles of new lychee varieties. By studying the flavor profile of 'Sweetheart' lychee, we can contribute to the lychee breeding program, which can continue to develop more desirable lychees for both fresh and processed consumption. Additionally, by understanding the compounds that comprise lychee flavor, we can continue to optimize the lychee quality during processing (Morton, 1987). We can also understand how lychee quality deteriorates during the supply chain. This could lead to changes that might allow for a longer period of optimal fresh lychees (Kumar et al, 2015). This is especially important as the fresh lychee season in the United States starts in May and continues through summer, with processed lychee products being available all year long (Marzolo and Lee, 2016).

Sensory Evaluation

In order to determine the distinct flavor profile of 'Sweetheart' lychee, a two-part sensory test was conducted. First, seven trained panelists tasted samples of the fruit and determined eleven flavor attributes that they felt described the 'Sweetheart' lychee flavor. These attributes were then used in a consumer sensory test, in which 60 untrained panelists tasted lychee fruit and ranked how strong they perceived each flavor attribute on a scale of 1.0 (very slight) to 9.0 (very intense) at 1.0 intervals. Fig. 1 shows

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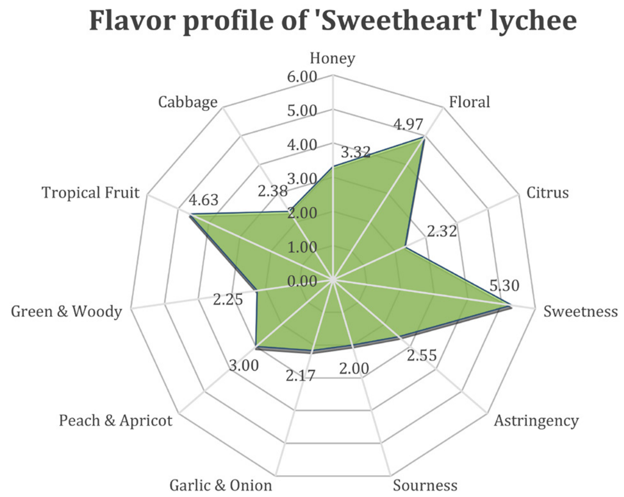

Fig. 1. Flavor profile of 'Sweetheart' lychee.

the averages of each flavor attribute that the panelists perceived. Sweetness, floral, tropical fruit, honey, and peach and apricot are the most significant flavor attributes that characterize 'Sweetheart' lychee. While older research papers have typically characterized many varieties of lychee as sweet (Menzel and Simpson, 1991), little sensory work has been done to determine a distinct flavor profile. This flavor profile, combined with the chemical odorant analysis, will help determine distinct flavor profiles between lychee varieties. Future work can also be conducted on textural attributes of lychee varieties to help determine if there is an optimal lychee texture that consumers prefer. Previous research articles have stated that texture can be a big part of consumer acceptability (Cao et al, 2014) and could be helpful for optimizing the lychee breeding program.

Chemical Analysis

In order to conduct the chemical analysis, solvent assisted flavor evaporation (SAFE), gas chromatography–olfactometry/mass spectrometry (GC-O/MS), and aroma extract dilution analysis (AEDA) were utilized to analyze the aroma of 'Sweetheart'. SAFE was used to extract lychee aroma to be used in the GC-O/MS. AEDA was used to determine the flavor dilution factor, which allows the researchers to determine the most aroma-active compounds. By gradually diluting the lychee extract, researchers can determine which aroma-active compounds have the strongest flavor dilution factors, which also signifies how important the compound is. A very high flavor dilution factor indicates that the aroma is very strong, and is important to the overall aroma profile of the lychee extract. Thirty-one aroma-active compounds were detected. They are shown in order of their flavor dilution factor in Table 1.

Table 1. Chemical analysis results.

Aroma-active odor	Flavor dilution factor	Retention index	Aroma characteristics	Detection/identification[z]
Methional	1024	1432	Cooked potato	O, S
Geraniol	512	1839	Floral, sweet	O, MS, S
Furaneol	128	2044	Sweet, caramel	O, S
Nerol	64	1754	Floral, sweet	O, MS, S
Unknown	32	1313	Nutty, steamed rice	O
DMTS	32	1354	Pickled vegetable, sulfur-y	O, MS, S
Linalool	32	1526	Floral	O, MS, S
(E, Z)-2,6-Nonadienal	32	1573	Cucumber	O, S
Nerolidol	32	2013	Metallic, sesame oil	O, MS, S
Myrcene	16	1128	Grassy, piney	O, MS, S
Unknown	16	1241	Garlic	O
3-Methyl-3-buten-2-one	8	976	Fruity, sweet	O, MS, S
2-Methyl-2-butanol	8	990	Fruity	O, MS, S
p-Cymene	8	1244	Floral, grassy	O, S
1-Octen-3-one	8	1283	Mushroom	O, S
(Z)-Rose oxide	8	1329	Floral	O, MS, S
Isovaleric acid	8	1657	Smelly plant	O, S
Guaiacol	8	1866	Medicine, bitter	O, S
Unknown	8	2145	Sweet, caramel	O
Unknown	8	2170	Sweet, fruity	O
Diacetyl	4	963	Stale, yogurt	O, S
α-Phellandrene	4	1122	Grassy, green	O, S
3-Methyl-3-buten-1-ol	4	1223	Pine	O, MS, S
(E)-2-Octenal	4	1408	Peanut, green	O, S
Unknown	4	1643	Sulfur-y, tropical fruit	O
Citronellol	4	1742	Floral, steamed rice	O, MS, S
Octanal	2	1271	Citrus-like	O, MS, S
6-Methyl-5-heptene-2-one	2	1319	Cooked rice, fruity	O, MS, S
Unknown	2	1603	Paper board	O
(E, E)-2,4-Nonadienal	2	1719	Stale grain, metallic	O, S
Homofuraneol	2	2095	Floral, caramel	O, S

[z]The odorant was detected/identified by matching the standard compounds (S), mass spectrum (MS), and odor quality (O) with the reference odorant.

While some of the odor characteristics may be surprising, they all contribute to the wide variety of flavor attributes that the trained panel identified in the sensory analysis. While the overall flavor-characteristics are identified as sweet, floral or fruity, the other aromas round out the flavor and add the complexity that defines the lychee flavor. These results are consistent with previous lychee studies on Chinese cultivars, which identified geraniol, furaneol, and linalool as the most odor-active compounds (Wu et al, 2009; Ong and Acree, 1998;). Previous studies on Florida cultivars has identified methional, DMTS, linalool and (E, Z)-2,6-nonadienal as major odor volatiles (Mahattanatawee et al, 2007). Further studies could also examine the difference in major aroma-active volatiles by location to determine if the flavor differences are due to location and climate or simply the lychee variety.

Conclusion

Sweetness, floral, tropical fruit, honey, peach and apricot are characteristic flavor attributes of the 'Sweetheart' lychee. Methional, geraniol, furaneol, nerol, DMTS, linalool, (E, Z)-2,6-nonadienal and nerolidol were identified as the most important aroma-active compounds in 'Sweetheart' lychee. By identifying the flavor attributes 'Sweetheart' lychee contains, and by distinguishing the most aroma-active odors in the fruit, the lychee breeding program can continue to create more desirable lychee varieties not only through growing characteristics such as drought and disease tolerability, but also through consumer-desired characteristics like taste and texture. Understanding the aroma-active compounds that are present in lychee can also help food scientists better predict how flavors may change during canning, fermenting, or other types of processing.

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