Tropical flavours to tempt consumers

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Abstract

Tropical fruits are visually and texturally unique and exhibit a broad range of odours and flavours from delicate and sweet to pungent and obtrusive. The nutritional and health benefits from tropical fruits are thought to be significant and are recognised by consumers. Nevertheless, if the taste of the fruit is bland or unpalatable, the consumer will not eat it despite the apparent health benefits in doing so. Understanding and optimising a balance between desirable flavours and bioactivity in tropical fruits is vital to ensure consumer acceptability and success of commercial products in a competitive fruit marketplace. Techniques we can use to assess the flavour and acceptability of tropical fruit include consumer assessments, sensory evaluation and compositional flavour analysis methodologies. Recent work by our group at Department of Primary Industries & Fisheries (DPI&F) Innovative Food Technologies has involved consumer studies assessing teenager's preferences for some exotic tropical fruits, and sensory and volatile flavour studies of mango as part of the DPI&F tropical fruit genomics initiative. Our results demonstrate the importance of flavour acceptability to the consumer and highlight the need to study flavour in more detail to understand its compositional and genetic basis in tropical fruits.

Introduction

Flavour is one of the most important criteria in consumer acceptability of food, including fruit. For the consumer, if the taste of a fruit is bland or unpalatable, they will not eat it, despite the apparent health benefits that could be obtained from doing so (Krystallis et al., 2008). Pleasurable eating experiences from fruit have the potential to create a 'halo effect', which can reinforce and boost consumers' perceptions of health benefit attained. Flavour of fruit comes from a balance between sugars, acids and volatile aroma compounds. It is the volatile aroma compounds in fruit that gives rise to the distinctive flavour of a particular fruit.

The volatile compounds produced in plant foods, including tropical fruit, represent less than 1% of the total fruit composition and comprise a broad range of chemical compounds with varying sensory potencies and concentrations. Only a small sub-set of these compounds are detectable to the human olfactory system. In fruits, compounds such as monoterpenes, norisoprenoids, furans and lactones, short-chain branched fatty acids, esters and alcohols of those acids, and sulphur and nitrogen-containing compounds have all been identified as important to the flavour of different fruits (Winterhalter, 1991). Many of the important flavour-contributing volatiles found in fruits are metabolites of bioactive compounds and may indeed be sensory cues for health and nutritional value (Goff and Klee, 2006). Our knowledge of the unique flavour nuances of exotic tropical fruits, and the consumer preferences for those fruits in Australia, is limited.

The techniques that can be applied to understand and measure flavour quality in tropical fruits include consumer evaluation, sensory studies using trained panellists and compositional flavour analyses. Our group at DPI&F Innovative Food Technologies in Hamilton, Queensland, have recently conducted two projects related to tropical fruit quality. The first study involved consumer evaluation of exotic tropical fruits with teenagers to understand preferences for different fruits. The second study involved a detailed sensory and compositional flavour analysis of mango. These two studies are the topic of the present paper.

A consumer study with teenagers for exotic tropical fruit preferences

The projected value for exotic tropical and sub-tropical fruits such as longan, rambutan, mangosteen and durian in Queensland by 2010 is $25M (O'Connor and Diczbalis, 2003). Consumer demand for an exotic 'tropical fruit category' anchored with some stable baseline tropical fruits (e.g. mango) has been clearly identified and is expected to drive market growth rather than individual exotic fruit crops on their own (Horsburgh and Noller, 2005). The increasing importance of consumer perceptions as a strong market driver is well-recognised. However, documented information on consumer behaviour with respect to exotic tropical fruit consumption is fairly limited.

A recent consumer study showed that drivers for familiar fruits were that they were 'well-liked' and 'easily available in the shops', whereas unfamiliar fruits were considered to be 'expensive' (Jaeger et al., 2006). Consumer drivers of exotic tropical fruit are likely to be the attraction to novel and exciting eating experiences. Another report stated that 'consumers are interested by tropical fruit but not necessarily to take it home' (Horsburgh and Noller, 2005). Barriers to tropical fruit consumption could include lack of knowledge of taste and use of the products, the preparation time required and an association between 'exotic' and 'luxury' which result in only small volumes being purchased for special occasions.

This preliminary investigation aimed to gain a first insight into the experience and preferences of teenage consumers for a selection of four exotic tropical fruits with the dual benefit of promoting the consumption of exotic tropical fruits among a group of young people in Brisbane.

Material and methods

A total of 60 year-nine (~15 year old) students (38% male and 62% female) took part in the tasting during a workshop at the 'revolutionary science day' on the 9 May 2008 at Toowong College, Indooroopilly. With the exception of one participant, all students indicated they consumed fruits weekly and 77% daily. The questionnaire involved a section on background information, including fruit consumption habits and knowledge of tropical exotic fruits. The tasting section questionnaire involved ranking the preference order based on four fruits presented and describing specifically liked and disliked characteristics about each fruit.

The exotic tropical fruits included in the tasting were mangosteen, red dragon fruit (pitaya), carambola (star fruit) and persimmon which were purchased locally from Clayfield Fresh Market in Brisbane during the same week in May. The fruits were presented in a ready-to-eat format in cups labelled with three-digit codes as shown in Figure 1. Mangosteens were peeled and quartered, persimmons were sliced in segments, carambolas were sliced laterally in star-shaped pieces and dragon fruits were peeled and cut in wedges. An analysis of variance (ANOVA) was performed on the ranking data to assess any significant difference between the fruits in terms of preference order.

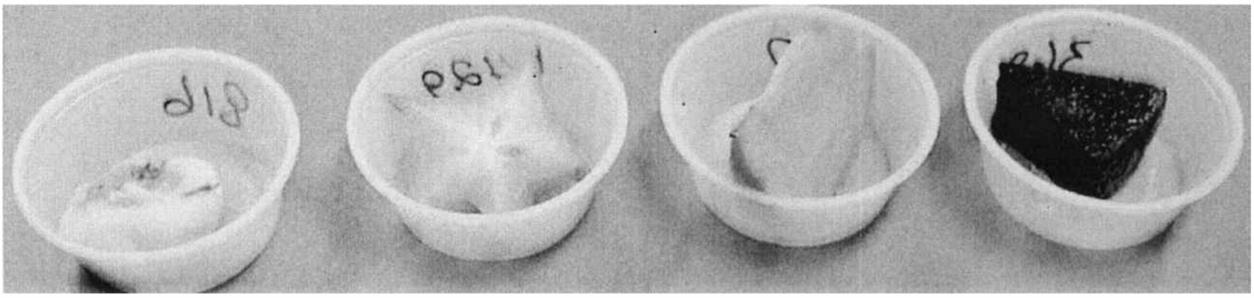

Figure 1. Photo of four tropical fruits presented to teenage consumers for evaluation, mangosteen, carambola, persimmon and dragon fruit (left to right).

Results and discussion

A summary of the percentage of teenage participants who had previously tasted a range of tropical fruits at least once is shown in Table 1. Not surprisingly, almost all the teenage consumers had tasted pineapple, banana and mango. Interestingly, papaya had only been tasted by about one third of respondents despite its year-round availability in supermarkets and green grocers in the Brisbane area. Lychee, however, had been tasted by 83% of the teenagers despite lychee's restricted seasonal availability and relatively high price.

Table 1. Percentage of participants who had previously tasted various tropical fruits.

Fruit	%	Fruit	%
pineapple [c]	97	star apple [r]	23
banana [c]	97	durian [r]	15
mango [c]	92	rambutan [r]	10
lychee [r]	83	jackfruit [r]	8
passion fruit [c]	77	mangosteen [r]	3
carambola/star fruit [r]	47	soursop [r]	3
guava [r]	47	black sapote [r]	3
custard apple [r]	42	breadfruit [r]	2
dragon fruit/pitaya [r]	37	abiu [r]	2
papaya/ pawpaw [c]	33	rollinia [r]	0
persimmon [r]	30		

[c] fruits classified as 'common' tropical fruits in the questionnaire.
[r] fruits classified as 'rare' tropical fruits in the questionnaire.

In terms of variety of fruits previously tasted, 23% of the students had tasted more than five of the 'rare' tropical fruits (i.e. other than pineapple, banana, mango, passionfruit and papaya). Most students (49%) indicated they ate 'rare' fruits rarely or never, or a monthly (31%). It is possible that most students had previously tried some of these exotic fruits only once.

None of the students indicated they had tasted rollinia previously and only one student indicated they had previously tasted either breadfruit or abiu. It is possible that many of the names of the exotic fruits were not recognised by the students. Students were given an exercise to match images of tropical exotic fruit to the fruit name. Most students performed well; however, only a small sub-set of the rare fruits were included in this exercise (Table 2).

Table 2. Percent of students who associated the fruit picture to its correct name.

Fruit	%
custard apple	85
carambola/star fruit	82
pitaya/dragon fruit	79
persimmon	54
rambutan	47
mangosteen	44

In the preference ranking exercise, the mangosteen was selected by 41% of the teenagers as their favourite fruit and was significantly preferred over dragon fruit and carambola (Table 3). Although the appearance and colour of the dragon fruit and carambola appealed to the students, the lack of flavour or unappealing 'sour' flavour may have resulted in an overall low ranking for these fruits. The comments for the appearance of the mangosteen segments were typically negative; however, the sweet 'tropical' flavour appealed to the students resulting in this fruit being the overall favourite.

Table 3. Results of the fruit preference ranking exercise (% of students).

	mangosteen	persimmon	dragon fruit	carambola
overall ranking*	A	AB	B	B
favourite fruit	41	25	18	16
2nd preferred fruit	21	28	30	21
3rd preferred fruit	25	25	21	30
least preferred fruit	13	23	31	33

* different letters indicate a significant difference in ranking by ANOVA

This workshop was designed for the target audience and facilitated the promotion of the tropical exotic fruit category to a group of Brisbane teenagers. Teenagers, and by extension children, can be considered significant players in purchase decisions made for the family and it can be useful to understand their preferences and requirements for tropical exotic fruits.

Mango flavour

Mango (*Mangifera indica*) fruit is one of the most popular tropical fruits among Australian consumers. The Australian National Mango Breeding Program has been linked to a QDPI&F mango fruit genomics research initiative which aims to profile the genetic and phenomic basis of fruit quality characteristics (Dietzgen et al., 2007). This research will provide marker-assisted breeding systems to fast-track plant breeding efforts to deliver mango varieties with improved horticultural and health properties, while retaining and enhancing consumer preferred flavour characteristics. The work conducted at Innovative Food Technologies involved profiling and understanding the flavours of parent and hybrid mango varieties in the breeding program and determining key compounds responsible for desirable flavour characteristics.

Material and methods

Two seasons (2006 and 2007) of mangoes including a number of varieties (Kensington Pride, Irwin, R2E2, Nam Doc Mai, Indian H-10, Calypso, and four other selections) were quantitatively assessed using sensory descriptive analysis techniques. A panel of ten trained tasters developed a defined attribute list for appearance, aroma, flavour, texture and aftertaste, together with a set of sensory reference standards. Five replicate mango samples of each variety were assessed using the defined attributes rating on line scales under controlled conditions.

Samples of mango were stored at −80°C for chemical analyses. Composite samples of ripe mangoes from more than 400 hybrid varieties from three breeding populations in Mareeba (North Queensland) were also stored for analysis during 2007 and 2008. Volatile chemical analysis was conducted on all samples using headspace solid-phase microextraction and gas chromatography mass spectrometry (GCMS).

Results and discussion

The results from sensory evaluation demonstrated a diversity of flavour types between different cultivars (Figure 2). Kensington Pride had high scores for terpene, fermented, buttery, tropical and floral aroma, while the Irwin variety had more cut grass and musty/dank odours. The Indian variety was perceived as having high green banana, cut grass and melon aromas. The Nam Doc Mai had some musty/dank aroma but was overall fairly low in aroma. The R2E2 variety has some fermented and buttery aromas, but was also high also melon aroma. The selections, hybrids of Kensington Pride and Irwin, had some similarities to both parents ranging in aroma between terpene, musty/ dank and cut grass.

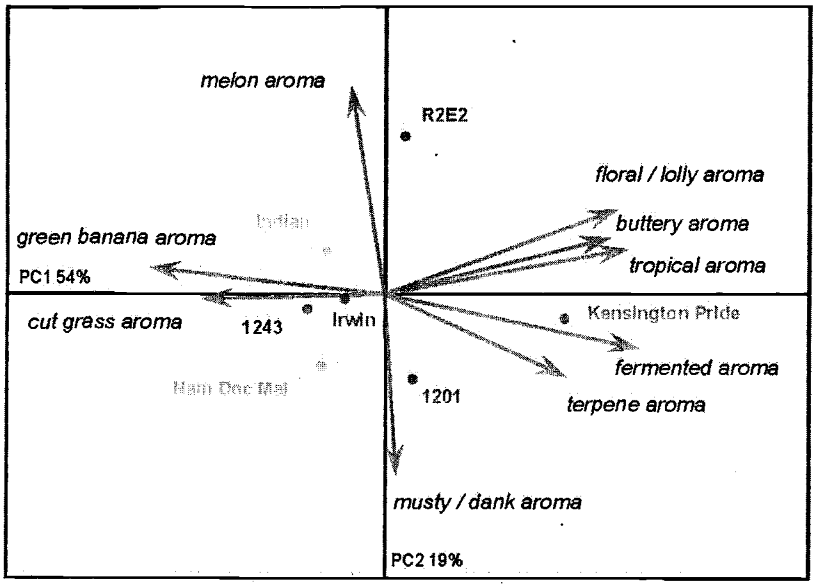

Figure 2. Principal component analysis bi-plot showing mean results of aroma sensory scores for 2006 season mango fruit (n = 5) (PC1 versus PC2).

The volatile profiles were combined with the sensory data and explored using Principal Component Analysis (PCA) to identify relationships between sensory attributes and volatile aroma compounds. In Figure 3, the chemical data is plotted with the sensory data as vectors. Vectors that are closely plotted with one another demonstrate a high correlation between those variables and may indicate a cause-and-effect relationship between chemical compounds and sensory attributes perceived. The Kensington Pride variety that had high scores for terpene aroma also had high levels of α-terpinolene, limonene and α-phellandrene. This aroma is distinctive for this variety and is considered to be a desirable flavour to target in the breeding program. It is likely that these compounds, particularly α-terpinolene, play a role in the perception of this important flavour attribute.

In the top right of the PCA plot (Figure 2), the cut grass aroma correlates well with hexanol and cis-3-hexanol. Both of these have strong grassy aromas as neat compounds. The Indian variety, with higher levels of melon aroma also had high levels of β-ocimene, furanone, alloocimene and carophyllene.

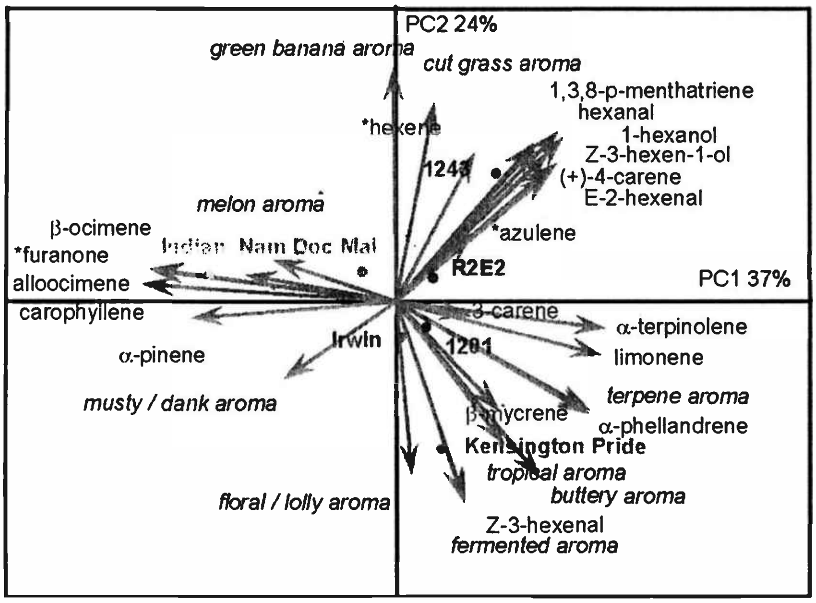

Figure 3. PCA bi-plot of sensory and volatile results for 2006 season mango fruit (n = 5) (PC1 versus PC2).

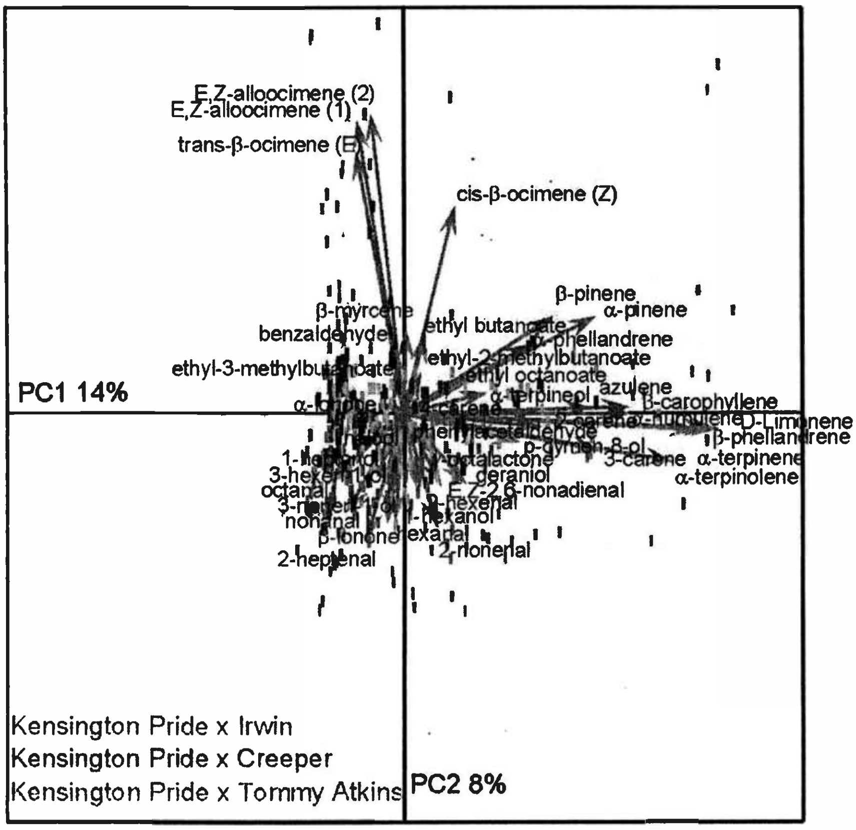

Figure 4. Summary of volatile compound results for three hybrid populations of mango.

The compounds identified as important to the sensory attributes of these varieties were targeted for quantitative method development so that a rapid and routine GCMS analysis could be applied to the varieties of mango in the hybrid populations. These populations included Kensington Pride cross Irwin, Kensington Pride cross Tommy Atkins and Kensington Pride cross Creeper (a dwarf variety). More than 400 varieties have been analysed to date. A PCA plot of the results from the chemical analyses of the hybrids is shown in Figure 4.

According to the PC analysis, the three populations were fairly overlapped in terms of volatile composition and did not neatly separate into clusters. This is not surprising considering the common parent (Kensington Pride) to all the hybrids. The Irwin hybrids were slightly separated as they cluster towards the bottom of the plot (Figure 4) and were distinguished as having low levels of ocimene and alloocimene and higher levels of aldehydes. The most important separation of the samples, which is shown across the PC1 axis, was due to the difference in concentration of terpenes, specifically, α-terpinolene, phellandrene, limonene and carophyllene. Most of the hybrids from all the populations had relatively low levels of terpenes (left half of the plot) while only a few hybrids had moderate and very high levels of terpenes (on the right half of the plot). It is the samples on the right side of the plot which, according to our sensory investigations, are also likely to have high levels of the desirable *terpene* aroma due to the higher concentration of α-terpinolene in these samples.

The flavour data collected from these populations is currently being linked to the database of expressed genes and associated DNA markers to identify genes that relate to α-terpinolene production and the biosynthesis of other volatile aroma compounds in mango fruit.

Conclusion

Without a good eating experience, health and nutritional value are not, on their own, good enough reasons for a consumer to actually eat a particular fruit. Increasing 'functionality' of fruits beyond 'normal' levels could have negative consequences on organoleptic attributes and may result in a decrease in consumption probability despite persuasive claims about health (Krystallis et al., 2008). Understanding and optimising a balance between desirable flavours and bioactivity in tropical fruits is therefore vital to ensure consumer acceptability and success of commercial products in a competitive fruit marketplace. These two studies demonstrate the broad range of techniques that can be applied to understand the flavour quality of tropical and exotic fruits and ensure consumer satisfaction.

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