New and alternative banana varieties designed to increase market growth

Jeff Daniells
Department of Employment, Economic Development & Innovation

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Jeff Daniells *et al.*

Queensland Government
Department of Employment, Economic Development and Innovation

HAL Project Number BA09041 (20 May 2011)

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Report Purpose:
In line with HAL project guidelines, this report provides a project outline including technical summary or aims, outcomes and recommendations related to alternative banana varieties and the potential for their expansion in Australia. This project considers both research and industry development issues.

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Media Summary

Cavendish bananas currently represent 95% of Australian banana production. In recent times leading chains in the Australian marketplace have suggested that overall banana sales could be significantly increased by broadening the range of banana varieties sold. This project set out to:-

- review the literature
- describe the current situation of the alternative banana variety supply chain
- analyse the economics of alternative varieties
- conduct sensory and consumer analyses of promising new varieties
- put together the findings as a roadmap for industry.

The Australian domestic banana industry is characterised by mass marketing of a commodity product. Non-Cavendish varieties are low yielding which requires that they sell at large premiums to be profitable. In Australia the market for varieties other than Cavendish currently caters for the need amongst ethnic communities thus ensuring its success. Development of non-Cavendish varieties beyond this ethnic market will require repositioning them from a commodity to a premium product – one distinguishable by brand, packaging, reliable eating quality, environmental credentials and so forth. Consumer and sensory analyses indicate that a significant gap in the general market exists for an alternative banana to the regular Cavendish. An opportunity may exist for market expansion by developing a market for the variety High Noon.

Recommendations for future R&D include:-

- Further postharvest and consumer study is required for the variety High Noon to better determine its prospects for development as a commercial variety in Australia.
- New variety R&D should continue given the severe disease threats facing the industry but this needs to be closely linked with market research into consumer behaviour so that new varieties are closely matched to the preferences of different groups of consumers to maximise their adoption prospects.

Industry recommendations include:-

- Further develop the existing market for the Lady Finger variety with the support of a marketing group/company responsible for managing the category and promoting its value proposition with a premium brand (short term). If industry growth can be achieved in this way with Lady Finger the approach could then be extrapolated to other niche varieties.
- Identify other varieties required by ethnic communities such as African Plantains and pursue these opportunities (medium term).
- Position/promote other banana varieties as an anchor product (available year round) in an ‘exotic fruit’ category (longer term). The category would include seasonal products such as rambutan, longan, durian, and mangosteen.

Technical Summary

The Australian banana industry produces about 300,000 tonnes of fruit/year and is valued at about $350 Million with almost all production going to the domestic market. Cavendish bananas represent about 95% of this production. A further 4% is Lady Finger whilst the remainder is mostly made up of Ducasse, Sucrier and Pacific Plantain. In recent times leading chains in the Australian marketplace have suggested that overall banana sales could be significantly increased by broadening the range of banana varieties sold. This project set out to determine the current market opportunity for alternative varieties and to lay out in detail how such an industry can be successfully developed to grow this market.

The literature on banana varieties and their marketing was reviewed along with examination of the factors which have contributed to the successful commercialisation of new varieties in other horticultural crops. The alternative banana variety supply chain in Australia was surveyed by interviewing growers, transporters, wholesalers and retailers. This included a tour of the wholesale and retail outlets in Brisbane, Sydney and Melbourne to better understand the issues facing the commercialisation of alternative banana varieties. Using rigorous selection criteria four new banana varieties considered to have the best market prospects were selected for assessment by a consumer panel and trained sensory panel. These results were analysed using cluster analysis and a preference map was generated, providing a detailed profile of the tastes and preferences of discrete segments of the sample. A gross margin and sensitivity analysis for Cavendish and Ducasse bananas was undertaken to estimate average gross margins to examine the numerical economic benefits and costs of growing alternative banana varieties.

The Australian domestic banana industry is characterised by mass marketing of its product which has contributed to the industry's narrow variety focus. Non-Cavendish varieties are not well suited to mass marketing because they are generally low yielding [¼ to ¾ of Cavendish] and need to sell at premiums of between about 20 to 200% to be profitable. The market for non-Cavendish varieties is largely 'ethnic' based. This is particularly true of Ducasse, Sucrier and Pacific Plantain but is also true of Lady Finger whose 'ethnic' group are SE Queenslanders and northern New South Welshman. Thus further growth may be possible by identifying additional ethnic markets. Development of non-Cavendish varieties beyond the ethnic market will require repositioning them from a commodity to a premium product – one distinguishable by brand, packaging, reliable eating quality, environmental credentials and so forth.

Consumer testing found that distinct clusters of consumers exist with diverse preferences for banana varieties. The three consumer clusters were named according to their profile: *Banana Lovers*, *Traditionalists* and *Banana Snobs*. *Banana Lovers* scored all bananas as acceptable, but revealed a clear preference for High Noon and Cavendish bananas. *Traditionalists* favoured only Cavendish and Lady Finger. *Banana Snobs* found the High Noon to be superior to all others. Cluster analysis found that 80 per cent of consumers had a preference for High Noon. The results from preference mapping reveal that High Noon, while similar in some sensory aspects to Cavendish, displayed other features dissimilar to the market dominant variety. This indicates that the sensory needs for the majority of consumers are not being entirely met by industry. These results based on consumer needs and wants suggest that a gap in the general market exists for an alternative banana variety. An opportunity may exist for market expansion by developing a market for High Noon bananas.

Industry recommendations include:-

- In the short term further develop the existing market for the Lady Finger variety with the support of a marketing group/company responsible for managing the category and promoting its value proposition as a premium brand. If industry growth can be achieved in this way with Lady Finger the approach could then be extrapolated to other niche varieties.
- In the medium term identify other varieties required by ethnic communities such as African Plantains and pursue these opportunities.
- In the longer term, position/promote other banana varieties as an anchor product (available year round) in an 'exotic fruit' category. The category would include seasonal products such as rambutan, longan, durian, and mangosteen.

New variety R&D should continue given the severe disease threats facing the banana industry but such efforts need to be closely linked with market research into consumer behaviour so that these varieties are closely matched to the preferences of different groups of consumers to maximise their adoption prospects. Further postharvest and consumer study including the use of focus groups is required for the variety High Noon to better determine its prospects and requirements for development as a commercial variety in Australia.

Introduction

The Australian banana industry produces about 300,000 tonnes of fruit/year and is valued at about $350 Million with almost all production going to the domestic market. Cavendish bananas represent about 95% of this production. A further 4% is Lady Finger whilst the remainder is mostly made up of Ducasse, Sucrier, and Pacific Plantain. Despite the relatively small component of the industry that the non-Cavendish varieties represent they are still valued overall somewhere between $15-20 Million.

From its beginnings in the 19th century the Australian banana industry has been based on Cavendish type bananas. This is also the case these days for the world export trade which amounts to about 16 Million tonnes/year. Despite the disease problems faced in the production of Cavendish it has proved extremely popular because of its favorable production and handling characteristics which are the principal reasons for its dominance in the export trade. However, worldwide it represents only about 45% of world production/consumption. Through many parts of Asia, the Pacific, Africa and Latin America alternative varieties are preferred over Cavendish.

DEEDI has played a leading role in introducing new banana varieties over several years. The introduction process usually takes from 2-3 years as Australia has stringent quarantine to prevent the introduction of exotic pests. Our tissue culture laboratory at Maroochy is a fully accredited quarantine operation which facilitates the importation process whilst preventing the introduction of exotic pests. DEEDI currently has an extensive range of alternative varieties in its field and in vitro collections where in excess of 200 varieties are held. These varieties have been evaluated for production and limited consumer assessment has been undertaken. Some of these varieties have particular attraction to a range of ethnic groups such as the Asian and Pacific communities. Further varieties are likely to have appeal for consumer segments with different usage patterns. For example drivers for purchase might include cooking varieties, alternative dessert types, and nutrient-rich varieties.

In recent times leading chains in the Australian marketplace suggest that overall banana sales can be significantly increased by broadening the range of banana varieties sold. They have used the example of how tomatoes now have greater sales than bananas due to the diversity of product range being more attractive to a wider group of consumers. Unlike some other commodities the alternative varieties available in bananas are relatively low yielding compared to Cavendish – usually one third to two thirds that of Cavendish. Thus much higher prices are required for alternative varieties for their production to be profitable. Nevertheless it is reasonable to assume that much greater [maybe double] sales of alternative varieties is possible. Some of the potential constraints that may be experienced by any commercial development include lack of knowledge on ripening behavior, poor shelf life and limited volumes due to poor productivity.

The purpose of this research project is to determine the current market opportunity for alternative varieties and to provide an outline for their market development.

This project delivers priority activities identified in objective 1 in the industry strategic plan which aims to: Increase consumer demand by 15% by 2014 through marketing and promotion of Australian bananas using the strategies -

1.1 Satisfy our customers by understanding their needs and specifically delivering to their requirements,
1.2 Diversify the range of products and eating occasions for Australian bananas through product development, value adding and placement to increase consumption.

Literature Review

This review details relevant history regarding commercial banana varieties, current Australian and world banana variety situation, recent experiences in the release/adoption of new varieties in Australia and overseas and considers the future and the challenges ahead.

History of banana trade

Overseas

The export of bananas began in the 1860s with shipments of Gros Michel bananas from Central America and the Caribbean to North America (1). Shipments to Europe were to follow. The trade in bananas expanded rapidly as individuals/companies realised the profits that could be made with the fruit. During the 1870s there were 114 banana companies registered in the U.S. (2). However, only 22 companies lasted until the end of the century and only four were of significant size. According to Soluri (2002) (3) "several kinds of bananas reached U.S. markets in the 1880s including the red (*AAA, Red Dacca*), fig (*AAB, Sugar*), strawberry and apple (*AAB, Sugar or AB, Ney Poovan*). By the early twentieth century, Gros Michel fruit made up the bulk of U.S. imports.

Several explanations exist for the narrowing focus on one variety that retain relevance in current markets. Soluri (2002) describes the market factors that influenced the phenomenon:

> Banana-eaters in the U.S. gave the Gros Michel high marks for its flavour, aroma and peel colour, but frequent references to other varieties found in turn-of-the-century cookbooks and popular magazines suggest that aesthetic qualities alone cannot account for its dominant market position. The success of Gros Michel also reflected the interests and perceptions of shippers…..who sought a banana variety that could best withstand the rigorous journey from farm to market.

Gros Michel had large well shaped bunches (for travel), a relatively thick bruise-resisting peel and long fruit greenlife making it excellent for the export trade. "In addition to promoting a single variety, shipping agents graded fruit bunches by the number of hands, fullness…and appearance of peel". Seven- and six-hand bunches were discounted and/or rejected particularly during seasonal lulls in demand. "The tendency to define and standardise product lay at the heart of the commodification process." Andrew Preston, a 19th century executive of the Boston Fruit Company (United Fruit predecessor) was noted as saying "..the successful company of the future is one that controls the growing of its own fruit". "By integrating production, shipping and marketing, Preston believed that a company could more effectively regulate both the quantity and quality of the fruit reaching U.S. markets and thereby reduce the financial risks associated with trading a highly perishable commodity." The simplicity of having just the one variety, Gros Michel, to manage in this complex supply chain made possible very successful mass marketing. Soluri points out that a central paradox of our industrial agriculture is "the transformation of plants into mass commodities (that) involves a simultaneous appropriation of, and reduction in, biological diversity".

However, no variety is perfect (4). Gros Michel proved to be very susceptible to Fusarium wilt (Panama disease) – a disease which eventually kills the plant causing massive yield losses in plantations. The disease was first reported from Panama in the 1890s with subsequent outbreaks occurring in many other countries in the region in the next 20 years. The trade in Gros Michel survived through moving to new production locations. Efforts began in the 1920s to find a disease resistant substitute for Gros Michel. Lacatan, a type of Cavendish, was resistant to Fusarium wilt and was trialled on a large scale. However, these initial efforts to market the variety failed with

various aspects of fruit quality comparing unfavourably with Gros Michel. Soluri quotes from a United Fruit dispatch manager "…even though the skin (of Lacatan) may be yellow, the flesh is not really mellow and not as digestible as the Gros Michel…..There is a question whether or not we are serving the business properly in trying to force Lacatan on the market." Soluri continues "In addition to the Lacatan's distinct flavour and texture, fruit merchants complained about the variety's small bunch size, dull ripening colour and susceptibility to a fungal rot (*crown end rot*)……sales of Lacatan fell when Gros Michel fruit was available." There was a clear preference for Gros Michel. Interestingly in 1929 "…United Fruit commissioned researchers to conduct a marketing study but the question of disease-resistant varieties was not even addressed, a reflection of the extent to which **mass market structures had closed around Gros Michel**". A further influence on banana markets was the advent of chain supermarkets. This business model relied on moving large volumes of product, and the self-service nature meant the visual appearance of food products became critical. Subsequently "the quality of the banana peel….. was hardly a trivial matter."

Fusarium wilt continued to spread and eventually the companies ran out of clean ground to move to. Gros Michel was phased out and replaced with various Cavendish clones. Cavendish was very susceptible to bruising and transported poorly as whole bunches compared to Gros Michel. To overcome this problem Cavendish bunches were dehanded and packed into cardboard boxes in what executives at Standard Fruit Company described as "the greatest innovation in the history of the banana industry". This then greatly facilitated the changeover to Cavendish which was largely completed in the 1960s. Thus the major fruit companies had delayed in converting to Fusarium wilt resistant varieties for nearly fifty years. Soluri concludes with:

> Growers and shippers favoured banana varieties that could best ensure them of making profits in distant market places. Thus shipping needs played a crucial role in favouring Gros Michel. Subsequently, the structures and aesthetic sensibilities of the export trade evolved around Gros Michel in a contingent process that involved producers, distributors and consumers. When Fusarium wilt struck, the only solution perceived to be viable was to find another banana that combined the Gros Michel's outward appearance with resistance to the pathogen when grown in monocultures. Markets in the U.S. therefore shaped the agoecology of banana growing by creating a truly massive demand for a **very specific kind of banana**.

While Fusarium wilt was razing large areas of Gros Michel, banana breeding efforts began in the 1920s to come up with a Fusarium wilt resistant variety as a replacement. One hybrid developed in Trinidad, the IC2, was almost successful. According to Koeppel (2008) (5) by 1950 nearly half a million bunches of IC2 were exported from Honduras to New Orleans. However a lacklustre performance in less than top-quality soil and some evidence of succumbing to Fusarium wilt eventually halted shipments. Following the adoption of Cavendish the breeding emphasis changed from Fusarium wilt resistance to seeking resistance to the leaf diseases yellow and black Sigatoka. But history has so far shown less success in securing a disease replacement for Cavendish than the earlier efforts to replace Gros Michel with a bred hybrid. The situation with leaf disease in Cavendish is not as critical as that for Fusarium wilt in Gros Michel. Application of fungicides, albeit as many as 50 per year, can manage the leaf disease problem. It is the opinion of one report author (JD) that should fungicides become unavailable for any reason it is far more likely that Cavendish export production will be moved to drier locations, where there are less leaf disease problems, rather than any existing varieties being developed as an export replacement for Cavendish.

Australia

The Australian banana industry commenced around 1870 at Buderim, north of Brisbane (6). Banana production in north Queensland commenced in the 1880s mostly in the Innisfail to Port Douglas region (7, 8). The industry in both regions was based on Dwarf Cavendish quite unlike the situation with the tall Gros Michel in the overseas export industries. Gros Michel was introduced on several occasions from 1910 but it did not gain popularity. This is likely due to its taller habit and lower yield than Dwarf Cavendish and its susceptibility to Fusarium wilt (9). Additionally Gros Michel is probably less cold tolerant than Cavendish further reducing its prospects in subtropical production areas.

In Queensland it was not until the late 1950s that Williams, a Giant Cavendish type, became the most widely grown variety (9). David Turner [pers. comm. 2010] suggests that NSW was an earlier adopter of Williams because of different banana bunchy top virus regulations. The slow change in SQ is likely due to farmers being slow adopters; replanting in the then primary area of SQ was not as frequent as current practice is in NQ, and the tighter bunch typical of Dwarf Cavendish probably travelled better as a whole bunch than Williams. However, once packing hands of fruit in crates became important the switch was more achievable.

Lady Finger (AAB, Pome) have been grown in southern production areas since the early days of the industry. Like Gros Michel it is susceptible to Fusarium wilt and its production has been plagued by this disease in subtropical production areas for the past century. A number of early Jamaican and Trinidad hybrids and other varieties including Mysore were imported in the 1960s for evaluation as possible disease resistant replacements for Lady Finger. However, for a number of reasons [soft fruit, tall habit, high matt, choke throat susceptible, susceptibility to Fusarium wilt] none of these succeeded in making an industry impact (10, 11). According to Daniells and O'Farrell (1988) (12) the future for Lady Finger would lie in moving to clean ground with clean planting material rather than the popular belief of "the increasing necessity for the Lady Finger cultivar to be replaced with a Fusarium wilt resistant variety" (11). Some farming of Sugar bananas (AAB, Silk) was evident but production ceased largely due to their greater susceptibility to Fusarium wilt compared to Lady Finger. Until recent years other varieties were largely non-existent commercially.

World banana production

Overseas

Total world production of bananas and plantains was 104 million tonnes in 2006 (13). Cavendish was the most produced type with 44.7% (especially Asia) followed by cooking banana 25.4% (concentrated in Asia and East-Africa), the plantains 18% (concentrated in Central and West Africa and Latin America) and other dessert bananas 11.8% (Asia and Latin America).

Of the total world production of 104 MT the export trade accounted for 16.5MT - over 95% of which was Cavendish. Plantains follow a distant second with 0.6 MT (3.6%). There is also a small volume of international trade in other types such as Apple (*AAB, Sugar presumably but also refers to Lady Finger in Hawaii*), Sucrier/Datil and Red Banana (Red Dacca). About half of the exported plantains go to North America with main production coming from Latin America. They are mainly consumed by African and Latin American immigrant communities.

Australia

Australian production in the period 2002-2005 was approximately 265,000 tonnes/year. About 90% of production comes from north Queensland, followed by NSW, WA, SQ and NT (13). More recent figures from the Australian Banana Grower's Council indicate an overall production increase of

about 10 % in the past 5 years, but production levels have been severely disrupted by major cyclone damage to the industry on two occasions. NSW and SQ have been in major decline for the last 20 years as they have been unable to successfully compete with fruit produced from NQ. The small NT industry virtually collapsed following the outbreak of tropical race 4 Fusarium wilt in the mid 1990s. A minor industry located in Carnarvon, WA has little prospect for expansion due to limited irrigation water.

Ninety-five per cent of Australian production is Cavendish – mostly Williams with a little Grande Naine and Mons Mari. Four percent is Lady Finger – the majority of this being in NSW, though very significant plantings have occurred on the Atherton Tablelands, Queensland in recent years. A little over 100 ha of Ducasse (ABB, Pisang Awak) is grown mostly in NQ but Fusarium wilt affects many of the properties involved. Goldfinger (FHIA-01, AAAB, Pome hybrid) was released to industry in the mid 1990s and at one stage was grown on an area of about 120 ha, mostly in NSW and SQ (14). However, this has now declined dramatically with perhaps 10-20 ha remaining. There is also very minor production of Sucrier, Pacific Plantain and Red Dacca.

Recent experiences with adoption of new banana varieties

The foregoing information on the change from Gros Michel to Cavendish serves to show how difficult the process of change can be. This was despite being faced with one of the most serious disease epiphytotics ever to strike crop plants. In the last 15 years several FHIA hybrids have been adopted to varying extents in many countries. Most notable amongst these have been Cuba which has planted relatively large areas with FHIAs-01, 02, 03, 18, 21 and 23 (15). The black Sigatoka resistant Plantain hybrid, FHIA-21, has been fairly widely accepted elsewhere in Latin America. Adoption of FHIA hybrids is also occurring to varying extents in parts of Asia and Africa. Daniells (2006) (16), reflecting on the adoption of Goldfinger in Samoa, has suggested that by comparison "marketplaces with less demanding requirements seem to favour uptake of new varieties". However, none of these hybrids have succeeded in the export trade.

FHIA-02 as an organic banana for export

Both IDRC (17) and Dole have attempted to commercialize FHIA-02. Much effort was expended by IDRC to promote FHIA-02 as an organically produced banana for the North American market. However, their efforts were unsuccessful. Former Director of Sourcing and Development Organic and Exotics Program for Dole Fresh Fruit International, Frans Wielemaker, was a part owner in the farm Ecos del Agro in Costa Rica from which IDRC sourced fruit for their studies. Production of FHIA-02 was excellent under organic conditions and there was no black Sigatoka leaf disease to speak of. However there were major problems with finger drop, peel splitting and peel discolouration which was not tolerated by the market and which caused the project to be discontinued (Frans Wielemaker pers. comm. 2010). Bioversity International's Musa Program Regional Coordinator for Latin America, Luis Pocasangre (pers. comm. 2010), indicated that the main problems were FHIA-02's susceptibility to finger drop (on ripening) and insufficient shelflife. Susceptibility to Fusarium wilt may also have been a concern. Additionally Daniells (18) has made the assessment that "to try to sell any other variety *[other than Cavendish in the organic market]* is to severely limit the size of the potential consumer market – niche niche markets are all the more difficult to pursue (i.e. both a different variety and organic)". This is unfortunate as some varieties including bred hybrids are readily suited to organic production systems because of their pest/disease resistance and vigour on low nutrient inputs.

Interestingly, in the 1920s, Cavendish was initially determined an inferior replacement for Gros Michel by United Fruit (19). Eventually Cavendish was successful but it required major changes in marketing from whole bunches to hands in boxes. This suggests that new varietal success might be

realised through innovative marketing strategies. For instance, a few solutions might be available to overcome the finger drop problems of FHIA-02. These might be marketed as individual fingers or in prepacks and splitting can usually be overcome by adjusting ripening procedures including relative humidity. It may be naive to expect new varieties to follow the path of Cavendish. Novel methods of handling and marketing may be required.

The rise of Plantains for export

The relatively recent development of the world export trade in plantains [see earlier mentioned export figure of 600,000 tonnes] has been possible due to the "burgeoning immigrant population of chiefly African and Latin American origin" in Europe and the large Latin American populations in north America (20). In seeking to develop niche variety markets it has been Dole's approach to first target ethnic markets that are familiar with and are seeking non-Cavendish varieties (Frans Wielemaker pers. comm. 2007). Daniells (21) indicated that the prospects for sale of fruit for "traditional ethnic purposes rose greatly in Australia from 1976 to 1991 with migrants from selected Asian/Pacific countries [where bananas are prominent] increasing from 157,000 to 708,000. Ethnic markets are relatively easy markets to develop, yet this has been limited to date with only Ducasse and modest quantities of Sucrier and Pacific Plantain involved. The Table 1 updates Daniells (1994) (21) with 2001 and 2006 census information and shows growth of the ethnic community is still strong.

Table 1 Ethnic community census information 1976-2006

Country	Number June 1976	Of June 1991	Residents June 2001	June 2006
Vietnam	2,500	133,444	154,831	159,850
Malaysia	19,900	84,089	78,858	92,335
Philippines	5,800	74,328	103,942	120,540
Hong Kong & Macau	8,900	73,207	67,122	73,819
China	20,100	68,514	142,780	206,588
India	39,200	65,426	95,452	147,106
Sri Lanka	15,600	38,884	53,461	62,256
Indonesia	9,500	33,549	47,158	50,974
Fiji	5,900	29,630	44,261	48,142
Singapore	9,100	29,325	33,485	39,972
Papua New Guinea	15,400	24,303	23,616	24,021
Other Pacific Islands	4,700	22,124	30,744	34,061
Cambodia	500	18,667	22,979	24,528
Thailand	Not determined	12,313	23,600	30,554
TOTAL	157,100	707,803	922,289	1,114,746
% of Australian Population	1.1	4.1	4.9	5.6

Source – ABS

Note that there are now also about 30,000 Latin Americans and about 10,000 West African residents, both groups of which are familiar with Plantains.

Goldfinger in Australia

The benefits of establishing a market for Goldfinger were extolled at the First Australian Banana Industry Congress in 1995. One report author (JD) wrote at the time that "the Goldfinger banana variety launch was completely over the top - much market development work will be necessary in the years ahead for it to be a success." At the height of production the farmed area of Goldfinger reached about 120 ha (14). However, this reduced dramatically after Coles dropped the Goldfinger line from its stores in 2009. It is of the author's (JD) opinion that the release of Goldfinger was a reaction based on a growing concern in the southern industry for both a variety resistant to Fusarium wilt (both subtropical race 4 and race 1) and one that did not have to compete directly with Cavendish from Queensland's wet tropics. Goldfinger did not meet a strong need in the marketplace. Indeed Olsen stated that "Goldfinger is not seen to have major product advantages over current banana varieties" (22), and "it is likely that Goldfinger will be seen as a direct alternative to Cavendish in the mass market segment. The usual selection criteria would then apply in the purchase situation: - price, appearance and whether the purchaser was satisfied with the flavour of banana bought in previous weeks, will determine which variety is purchased." Olsen concluded by saying that "purchasers are likely to make choices based on price advantage if they find no other obvious differences between varieties". As the Goldfinger was usually sold at a price premium compared to Cavendish, this research predicted its fate. The market demand for Goldfinger through Coles supermarkets wasn't strong enough to warrant its continuation.

Bananza in Australia

FHIA-18, dubbed Bananza, is a full sister to Goldfinger and has been managed by ANFIC/BRI in Australia since the mid-late 90s. Less than 10 ha of the variety has been grown commercially. Some problems were experienced with peel splitting during ripening and some research was commenced on this subject before being aborted presumably due to funding problems. Unfortunately bananas are not ANFIC's primary market and have proved to require more effort than they wish to expend to successfully commercialise. Production of Bananza in Australia is now in limbo.

Challenges and opportunities

Several pests and diseases threaten the production of bananas around the globe including Fusarium wilt (tropical race 4 in particular), bacterial wilts, black Sigatoka and bunchy top. Successful production of niche banana varieties will require either resistance to these diseases or putting measures in place to prevent their entry or lessen their impact. Those regions that can remain free of important diseases will have a distinct advantage over those that cannot. The negative impacts can be due to both phytosanitary effects and the inability to profitably crop in the presence of disease. Australia's relative freedom from many serious banana disease problems, our world renowned ability to manage and eradicate disease and our stable government provide opportunity for the export of niche varieties. This might be particularly opportune when other export countries face adversities such as serious disease, natural disasters or political unrest.

The Australian industry has been fighting off the threat of imports from the Philippines. While the threat is over for the time being the industry must remain vigilant to ensure imports are not brought into Australia under the high quarantine bar that has been set and to ensure that our pest/disease-free status is not jeopardised by lapses in quarantine. Nevertheless there remains a need to investigate the prospects for developing niche banana varieties for export to offset the potentially large losses

that imports would cause should they occur. Daniells (31) has suggested taking Lady Finger to the world – a variety which we have particular expertise in growing.
In the Australian banana industry strategic review Clarke (2009) (29) noted mixed attitudes to the development of new varieties:

> Retail and supply chain opinion was mixed on the role of additional varieties, with some feeling that they were just a distraction from the main game of retail competition, quality control and promotion while others felt there was scope for more varieties. One comment was 'look at lettuce – it was 100% iceberg'. Now there are many types and the total category has grown. A greater number of banana varieties is not a problem at retail for specialist fruit shops. Look at subtropical varieties that do not compete with Cavendish.

Smith et al. in 1998 (23) commented on the advent of new variety production:

> Although Fusarium wilt may have been the catalyst for initiating selection programs in the cool subtropics of Australia, it is the inability to compete with Cavendish production from the wet tropics of north Queensland that has seen the subtropical industry embrace new non-Cavendish dessert bananas. Goldfinger is seen as the first in an era of man-made hybrids and already there are early indications that FHIA-02, FHIA-18, SH-3640.10 and SH-3641 from FHIA; IRFA 909, 910 and 914 from CIRAD-FHLOR and PC 12.05 from EMBRAPA-CNPMF may have potential in the Australian cool subtropics.

It would seem that despite a perceived need for alternative banana varieties, little progress has been made in the last 10 years and much market development work remains to be done.

The Australian banana industry does not appear to have been caught up in the rush to secure Plant Breeders Rights (PBR) protected varieties and the marketing of these through 'closed loop systems' that have been a feature of other Australian fruit industries. The move to market the variety 'Bananza' (FHIA-18) for the subtropics using 'closed loop systems' began in the 1990s but it failed due to poor supply chain management.

A further example of a 'new market' might be found in the promotion of health benefits of new varieties. Heasman has concluded that "the strategic goal of rural industries would be to 'leapfrog' current market activity with a new consumer-led nutrition vision integrating human and environmental health" (30). There are specific banana opportunities including pro-vitamin A and riboflavin rich varieties.

Current per capita consumption of bananas in Australia is 13-15kg per annum. This is relatively high by world standards. At the Seventh Australian Banana Industry Congress Bill Morgan reported on the extra sales possible for bananas by tackling the snack food market. The banana industry has duly pursued this with major promotion in this direction. The snack food arena should be a good opportunity for utilising varietal diversity.

Commercialisation review and application of marketing theory

A specific analysis of other horticulture crop new variety commercialisation activities was undertaken. This was done to assist in identifying any desirable characteristics common to the various crops. Some salient market development points from these industries are outlined below and a brief application of relevant marketing theory to bananas is provided.

Mango

Hofman (2006) (25) described the challenges of improving the market performance of a new cultivar. With new cultivars, many aspects of the interaction of the product with commercial practices are unknown. However, accurate ideas of most important areas for improvement can be gained from current knowledge of similar cultivars and supply chains.

Hofman detailed three areas of targeted R&D that agencies, industry bodies and the supply chain should work together to improve the performance of the Calypso mango:

1. eating quality
2. skin damage
3. ripening and holding conditions.

Note that all three priority R&D areas identified are specifically "consumer" focussed ie aiming to meet the direct needs of the consumer.

According to the www.calypsomango.com.au website this new variety has "already been labelled 'the perfect mango' by industry and consumers alike, the Calypso™ mango's succulent sweet taste is one thing, but the fibre-free dense flesh of the Calypso™ makes it very versatile and perfect to enjoy any time, every time".

Campbell (2009) (26) states that the USA mango selection and breeding programs have been focussed on developing a robust group of cultivars uniquely suited for export and modern marketing. Cultivars with superior characteristics of production, disease resistance, handling and shipping, and external appearance were favoured.

At the consumer level in the USA mangoes are distinguished according to skin colour, grouping cultivars as red (Tommy Atkins, Haden), green (Keitt, Kent) and yellow skinned (Ataulfo) (26).

Westfalia Technological Services (WTS) tests mango selections for several companies, research institutes and private individuals (26). WTS manages Plant Breeders Rights both locally and in select foreign countries for certain promising mango cultivars. WTS uses the following criteria in comparing cultivars:

- fruit mass
- TSS °brix
- fruit fibre level
- average yield / tree
- harvesting season.

Melon

Traditionally the domestic watermelon market has been supplied with large fruit, often weighing upwards of 10kg. Such large fruit pose a number of handling, storage and wastage problems for retailers and consumers. Many retailers now sell cut watermelon portions. These cut portions are particularly popular with households comprised of 2-3 members and older consumers. Barnes et al. (1994) (27) suggested that commercialisation of smaller watermelon cultivars in the weight range 2-4kg had potential on both the domestic and export markets. It was suggested that smaller fruit would alleviate problems consumers had with storage, refrigeration and wastage. A smaller fruit size while maintaining the light green – grey / green rind colour and 10+ °brix of the traditional varieties was identified as ideal.

Melon variety screening was also undertaken by Rogers (2010) (28). The aim of the study was to determine the best current seedless watermelon, rockmelon, and honeydew lines for both whole and fresh cut (processing) markets.

Throughout the 1990s the Commonwealth Scientific and Industrial Research Organisation (CSIRO) conducted a melon breeding program aiming to produce new melons which combine the best characteristics of sweetness, colour, size, small cavity size, rind texture and resistance to disease.

Tomato

In Biggs (2003) (29) report on consumer requirement for fresh tomatoes he states that the key attributes desired by tomato buyers were firmness, lack of blemishes, bruises or imperfection, red colour, and flavour / taste.

While there was considerable consumer dissatisfaction with the quality of fresh tomatoes throughout the 1980s and1990s, the situation is very different today. Olsen (1999) (30) suggests that the wider range of tomato types available (gourmet, Roma, cherry, greenhouse etc as well as traditional rounds) now allow consumers to choose fruit which suited their particular palate.

In 2009 SP Exports, a Bundaberg tomato producer, launched the leak free, no mess Intense variety to the Australian market. The 500gram pre-packs are sold by both Coles and Woolworths. SP Exports has exclusive growing and marketing rights to the Intense variety in Australia. http://www.spexports.com.au/intense/

Perfection Fresh (National Wholesaler / exporter) is another company engaged in marketing numerous tomato varieties. Most of the new smaller varieties are targeted towards consumption in salad dishes and antipasto platters.

Common themes amongst various horticulture crops

All the industries above perceived that there was some sort of need for diversity of product offering in the marketplace.

Harrison (2003) (31) lists genetic improvements as one of the forces driving consumer demand in horticulture products. The steady and accelerating process of new cultivar development has been a major factor in the expansion of fresh produce trade. She states that development of seedless varieties of grapes and melons has dramatically stimulated demand in the US and Europe. Other examples cited are low-chill stone fruit, tastier strawberries and easy peel citrus cultivars.

Generally new varieties / cultivars have been pitched to fill various market gaps:

- seasonality (early or late season varieties introduced to extend production season / continuity of supply)
- product use (fresh consumption vs cooking vs fresh cut / processed)
- product attributes (size, texture, seedless, TSS °brix, shelf life, colour).

Marketing theory

The following provides a brief overview of market segmentation and marketing mix theory (32) and applies it to the development of a new banana variety market. The two primary elements of a marketing strategy are the selection of a target market and the development of a marketing mix.

Prior to target selection, the market must first be segmented. Market segmentation is the process of dividing a heterogeneous group of buyers or potential buyers into more homogenous groups with relatively similar product needs. In the above examples there appears to be a common theme of demand for smaller fruit being used for different purposes i.e. fresh cut, prepared rather than the traditional fruit snack.The current study provides segmentation in the form of taste preferences. The outcome of this is provided in the consumer and sensory analysis sections of this report. Once the target market has been determined, the marketing mix should be established.

Marketing mix theory posits success in the market is due to a mix of four components: product, price, promotion and place. These marketing elements must be balanced appropriately to achieve the maximum response from the target market. However, any decisions regarding the make up of the marketing mix must be done with a thorough understanding of the external environments of the organisation. The external environment are those factors that have a direct impact on the success of an organisation and the decision making processes of management. These include:

- competitive environment
- social environment
- economic environment
- technological environment
- physical environment
- legal environment
- ethical environment

External environments are dynamic and outside of direct control. Thus, strategising and planning must be complimentary and adaptable. The following provides an application of the marketing mix to the Australian banana market.

Product

As discussed above the number of horticultural varieties or product lines at retail level varies depending on the type of crop. A current snapshot of a cross-section of crops reveals:

- two main varieties of banana
- more than eight varieties of apples
- four varieties of mango
- and six varieties of tomato.

This suggests that, in comparison to other fruits, the variety of banana product available to consumers is limited. In terms of horticultural product, Industry members need first identify the alternative or niche variety. The consumer and sensory section of this report endeavours to ascertain banana cultivars with desirable characteristics from a consumer perspective.

Price

Within marketing theory, pricing structures are developed as part of the overall marketing strategy. For instance, new market entrants may adopt a premium, economy or penetration type strategy to ensure the best possible advantage against current products in the category. Furthermore, with almost all food and fibre products the price paid to growers or producers is determined by the market. The marketer needs to identify the $/kg required for growers for a long-term, financially viable operation. Additionally, some form of information on consumer willingness to pay within the category is advantageous. For example, in the banana market it would be necessary to understand the value that consumers place on Cavendish as opposed to Lady Finger and Ducasse.

Promotion
Generic banana industry promotion is administered by the Australian Banana Growers Council (ABGC) using industry funds from levies. Specific promotions of alternative and exotic varieties will more than likely be funded by business in the supply chain in the form of a partnership or other relationship between growers, wholesalers and retailers. Marketing theory would suggest that an effective promotion strategy is a niche "push" strategy focussed at specific retailers in the supply chain (p 382 McColl-Kennedy). The alternative, a "pull" strategy targeting consumers directly, would appear to be prohibitive with the costs of such a promotion likely to outweigh the benefits.

Place – distribution
The three main options for distributing niche banana varieties are those available to current commercial varieties:

- local direct via farmers markets, roadside stalls and so on
- domestic via the wholesale market system
- direct to supermarket chain

However, as alluded to in the challenges and opportunities section, export markets might be a further avenue of distribution.

Additional general information from the literature on marketing of new varieties is included in Appendix 1.

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Survey of Alternative Banana Variety Supply Chain in Australia

Introduction

The project team chose to survey the niche variety supply chain with the aim of determining the current situation regarding alternative banana varieties in the Australian marketplace. The specific objectives of this phase of the research were to determine:

- what varieties were available
- in what areas and retail format were they available
- information on the likely target market
- the price distribution
- and information on preferences.

This information is intended to provide a better understanding of the issues facing the commercialisation of alternative banana varieties. A series of photographs of available bananas are shown in Figure 1.

Figure 1 Snapshot of niche banana varieties currently available

<table>
<tr><td> 
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<tr><td>Niche varieties ‘Ducasse’ and ‘Senorita’ are prominent along with Cavendish in Cabramatta retail outlets.</td><td>Pacific Plantain – retail Sydney</td></tr>
<tr><td> 
</td><td> 
</td></tr>
<tr><td>Ducasse – retail Brisbane</td><td>Sucrier – retail Sydney</td></tr>
</table>

Sucrier at Safeway Supermarket, Box Hill

Methods

The metropolitan markets of Brisbane, Sydney and Melbourne were visited over a week-long period in May 2010. An itinerary of meetings with central market wholesalers and visits to known ethnic retail precincts was developed. During face to face interviews wholesalers were asked about their experiences, both positive and negative, with handling niche varieties. Wholesalers were asked if they saw any opportunities for growth in this particular market and if they anticipated any issues that may stifle the development of the market. Retail precincts were visited in the same metropolitan markets to determine retail pricing and view the various product display approaches to consumers.

In December 2010 a cross section of banana growers were interviewed by telephone concerning niche banana varieties. The growers chosen were selected to represent farms of varying size, location, including north Queensland, New South Wales and Western Australia, and those that currently grew niche varieties, had grown or had never grown them. Growers were asked why they had or had not chosen to grow varieties other than Cavendish and to elaborate where possible on the issues involved.

Banana transport companies were also interviewed by telephone. They were asked to detail why they did or did not transport varieties other than Cavendish and asked to elaborate on the issues involved.

Results - Key supply chain findings (opportunities and issues)

Banana promotion

The 2009 annual ABGC promotion budget collected via the 1.7cents / kg banana levy was $2.6million / annum. This figure is based on production of 22 million cartons per year.

Banana promotion effort and funds are geared towards establishing the generic banana brand, specifically targeting 18-35 year olds and positioning bananas as "the first choice snack food". No promotion of varieties other than Cavendish and Lady Finger currently takes place. Further limited promotion of geographical production areas is occurring in WA and northern NSW.

It is interesting to note that bananas sold by a producer by retail sale (i.e. direct to the consumer via roadside stalls, shed sales, farm gate, etc.) are exempt from levy if the total amount of levy that the producer would be liable to pay in the levy year would be less than $100. It is reasonable to assume that a significant amount of niche variety sales are currently taking place this way with no levy paid.

Post cyclone Yasi it will be difficult to lobby for the limited levy funds available post 2011 to be directed toward promoting alternative banana varieties.

Handling / ripening

Many transporters are reluctant to handle mixed loads of different varieties. Many agents / ripeners are not able to ripen exotic banana varieties for retailers. There is a general lack of understanding of requirements and an unwillingness to tie up ripening rooms with niche varieties.

Market Supply

There is only patchy information in the market place about current supply volumes and distribution channels for alternative varieties. Small volumes of Sucrier bananas were observed being sold in independent fruit retailers in selected ethnic suburbs of the 3 cities visited. Large chains are reluctant to provide shelf space without a guarantee of continuity of supply. However, members of the project team did observe Sucrier banana being sold through one of the chain-stores. This would suggest that in this isolated case, an obvious need has been identified by one of the larger retailers. Banana wholesalers indicate that volumes of alternative varieties in excess of 15 pallets per week would currently flood the market.

Prices

Detailed wholesale price information on Cavendish and Lady Finger is available for all markets i.e. high, low, and average carton price. Price information on Ducasse, Sucrier, Goldfinger, Red Dacca is also available, albeit in limited capacity. It is important to note that Brisbane is the only market that records wholesale market throughput information. The 2010 wholesale price ranges as supplied by MIS were:

- Cavendish from $2 - 40 (13kg Carton)
- Lady Finger from $2 - 60 (13kg Carton)
- Sucrier from $30 - 50 (13kg Carton)
- Red Dacca from $40 - 45 (13kg Carton)
- Ducasse from $30 - 50 (13kg Carton).

Generally prices for alternative varieties track similar to Cavendish. As Cavendish drop in price so will Lady Finger, Ducasse and the others.2010 range of differences in wholesale carton prices between Cavendish and other varieties.

- Lady Finger ($5 - 20 above)
- Goldfinger ($2 - 6 above)
- Ducasse ($15 - 25 above) in Melbourne.

A 2002 study of the markets for niche banana varieties identified retail prices for Sucrier in the range of $8 - 10 per kg. This 2010 study observed prices ranging from $4 - 5.50 per kg.

Issues identified by growers and transporters

As a result of the interviews, several issues were identified by growers and transporters. Niche varieties were thought to be better suited to smaller growers for a number of reasons. First and foremost, the shorter lines of product are better suited to the scale of operation of small business. Furthermore, the demanding requirements in the field and packhouse to deliver the quality fruit needed to obtain profitable market prices necessitates an experienced, skilled workforce rather than the backpacker labour typical of larger farms. Smaller operations are also better able to exploit local markets and provide the necessary sales pitch at point of sale and avoid conventional supply chain bottlenecks brought about by noneconomies of scale.

Additional issues relate to the supply of niche varieties. The lack of supply control and quality control is a major problem for the sustainability and potential growth of niche variety market. Moreover, the low yields of niche varieties and the associated relatively low market demand brought about by premiums in excess of 50% severely caps prospects for expanding the market. Another issue pertinent to growers are the major retail outlets eroding of the profitability of Lady Finger from smaller growers supplying central markets. This is due to the 'bigger growers longer lines of product' requirement of supermarkets.

Consumer Panel Analysis and Sensory Preference Mapping

Summary

The purpose of the consumer panel and sensory preference mapping aspect of project BA09041 "Banana varieties for market growth" was to investigate consumer attitudes and sensory preferences toward alternative banana varieties. The successful introduction of novel horticultural products is dependent upon the market appeal of the product. The objective of this facet of the research was to understand if selected banana varieties were acceptable to consumers and to evaluate these preferences against currently available banana varieties in the market place.

A series of activities were performed. Preliminary sensory evaluation was performed for over 16 varieties of banana. Quality testing of banana samples was performed via chemical analysis. Acceptability testing of banana samples Gros Michel, High Noon, Pisang Ceylan and FHIA-18, and market samples Cavendish and Lady Finger were undertaken. Two hundred and twenty-eight consumers evaluated the samples on general characteristics and completed a brief survey measuring consumer behaviours and attitudes. A sensory panel study was also performed to provide a rigorous understanding of the distinct sensory attributes of each banana sample. A ten member panel evaluated each sample on a number of detailed descriptive sensory features including flavour, astringency, aroma, texture and external features such as skin-feel, size and girth.

Analysis of the blind taste testing found that distinct clusters of consumers exist with diverse preferences for banana varieties. The three consumer clusters were named according to their profile: *Banana Lovers*, *Traditionalists* and *Banana Snobs*. *Banana Lovers* scored all bananas as acceptable, but revealed a clear preference for High Noon and Cavendish bananas. *Traditionalists* favoured only Cavendish and Lady Finger. *Banana Snobs* found the High Noon to be superior to all others. Cluster analysis found that 80 per cent of consumers had a preference for High Noon. The results from preference mapping reveal that High Noon, while similar in some sensory aspects to Cavendish, displayed other features dissimilar to the market dominant variety. This indicates that the sensory needs for the majority of consumers are not being entirely met by industry.

Preference mapping of the consumer clusters onto sensory descriptive information identified that all consumer groups preferred a firmer textured banana and disliked astringency and sappy/resinous aromas. *Banana Lovers* and *Banana Snobs* had similar taste preferences and these groups had a distinct preference for bananas with lower overall flavour intensity. These groups did not mind bananas that were either sweeter with more fruity flavour characteristics, or bananas that were more tart with lemon sherbet flavours. *Traditionalists* much preferred sweeter flavoured bananas with high aroma intensity and fruity, tropical, lolly and perfumed characteristics. *Traditionalists* did not like tart or sappy flavours, musty or lemon sherbet aromas and did not like long flavour persistence.

These results based on consumer needs and wants suggest that a gap in the general market exists for an alternative banana variety. An opportunity may exist for market expansion by developing a market for High Noon bananas.

Considering the current avenue for alternative bananas is niche markets targeted at Asian or Islander communities, a limitation of this study is the consumer samples reliance on a general population. Further research might sample only consumers from more defined communities.

Introduction

Cavendish bananas currently represent 95% of Australian production in comparison to 45% of worldwide production/consumption of banana. Through many parts of the world, Cavendish bananas are less preferred by consumers to alternative varieties and the same is likely to be true for certain segments of the Australian population.

Queensland Government has an integral role in the introduction of new banana varieties and currently has an excess of 200 varieties in field and in-vitro collections. Some varieties may provide novel attraction to consumers as potential cooking varieties, alternative dessert types or nutrient-rich varieties.

A recent Australian market survey (2007), involving 1600 consumers, found that 60-65% of banana consumers "would like to buy more bananas" [1]. The research suggested that consumers were primarily not buying more bananas because they believed that "choice of fruit at point of sale…is limited". Consumers would prefer more choice in banana types, particularly in terms of variation in fruit size and ripeness level. These findings are supported by earlier market research (1999) which found that "consumers were looking for a full flavoured, good tasting, firm banana which is available in a range of sizes" [2].

The results of market research identify the opportunity to grow the Australian banana industry by diversification. The introduction of new varieties which meet consumer demand for full flavoured bananas that not only varies in size but also in flavour, shape, colour and texture may be considered

a rational strategy for diversification. The present project BA09041 "Banana varieties for market growth" aims to investigate and provide advice on alternative banana varieties with the objective of selecting new candidates with a strong chance for success in the Australian market. As part of this study, consumer quality investigations will be conducted together with a survey of the supply chain to understand the potential for the banana industry to adopt new varieties and expand market diversity. The economics will be evaluated and a road map will be developed setting out the way forward to grow the market for alternative varieties.

This report details the work conducted for banana quality testing where selected varieties were assessed by sensory descriptive analysis and consumer acceptability testing. Segmentation of consumers based on preferences informed the development of a consumer preference map. The preference map allowed for the identification of consumer groups that prefer different banana varieties and different sensory characteristics in banana from size, shape and colour, to flavour, astringency and texture.

Before designing the quality evaluation component of the present project, a literature search was undertaken to identify other work that had been completed in the banana consumer and sensory area which may benefit the design of the present study.

While numerous studies have investigated the sensory qualities or consumer acceptance of various banana varieties and processed banana fruit [3-16], only one study was located (published in Thai) that mapped sensory characteristics of banana to consumer taste preferences [3].

Typical banana sensory characteristics that have been measured previously in banana include: overall acceptance, flavour / taste (green, grassy, woody, vegetable flavour), sweetness, sourness / acidity, bitterness, off-odours, astringency, skin colour (green, yellow colour intensity, brown), skin thickness, pulp texture (softness, firmness, sliminess, lumpiness, stickiness, pastiness), pulp colour (uniformity, yellowness), peeling quality, shelf life, pulp spots, overripe zones and central fibrosity. These terms will help to form a lexicon for the descriptive panel to source for describing bananas in the present study.

A relevant issue for the current project was a concern that comparing the well-known Cavendish fruit to other lesser-know banana varieties in a taste test will result in biased results. Food neophobia, that is, a reluctance to ingest novel foods, is an understood phenomena in humans [17]. While the consumers for this study are not unfamiliar with the product category of banana, their lack of experience with the more unusual varieties of banana may result in reduced acceptability scores for those varieties.

One study of banana reported that the consumers' unfamiliarity with one particular variety of banana together with the unexpected central fibrosity resulted in very low consumer acceptability scores [13]. Other studies of cheese and sheep-meat also report that high familiarity with a product or product category may explain the high scores for consumer liking [18].

To overcome familiarity bias in the present study, external and internal banana characteristics were assessed separately to avoid participants linking visual cues of external attributes with internal flesh flavour and aroma qualities.

Method and activities

Samples

Samples of banana were sourced from South Johnstone Research Station (north Qld), from surrounding north Qld local banana growers, or from local fruit shops in Brisbane and transported

by road to Brisbane. A summary of the fruit received for chemical analysis, preliminary or formal sensory and consumer evaluation is provided in Table 2.

For preliminary assessments, typical 2 - 4 hands of fruit (~8-16 fingers/hand), were delivered at hard green stage for storage, ripening and subsequent evaluation. Fruit received for panel training in May and consumer assessment in June consisted of 4 – 7 hands per variety (~8-14 fingers/hand). Fruit received for the formal sensory and consumer evaluation in September/October consisted of 8-10 hands per variety, at hard green stage (~15 fingers/hand).

Fruit for informal assessments were ripened on-site at 17°C at normal atmosphere. Fruits for formal trained panel and consumer assessments were ripened by a commercial pack-house. Synchronisation of ripening was achieved by ripening at 17°C followed by holding at 12°C, where necessary. Fruit were then held at 23°C for at least 16 hours prior to the formal evaluation.

Table 2 Summary of banana varieties received from north Qld and assessed in Brisbane (date received, date assessed)

Variety	Preliminary sensory assessment	Sensory panel training	Preliminary consumer assessment	Formal sensory assessment	Formal consumer assessment
Ducasse	27/11/09 (1/12/09)	7/5/10 (18/5/10)			
FHIA-02	23/10/09 (2/11/02)	7/5/10 (18/5/10)		24/9/10 (not assessed)	24/9/10 (not assessed)
FHIA-18	23/10/09 (6/11/09)		25/6/10 (12/7/10)	24/9/10 (5/10/10)	24/9/10 (5/10/10)
FHIA-26		7/5/10 (18/5/10)	25/6/10 (12/7/10)		
Gros Michel	27/11/09 (4/12/09)		25/6/10 (12/7/10)	24/9/10 (5/10/10)	24/9/10 (5/10/10)
High Noon	23/10/09 (4/11/09)		25/6/10 (12/7/10)	24/9/10 (5/10/10)	24/9/10 (5/10/10)
High Noon variant		7/5/10 (18/5/10)			
Inarnibal		7/5/10 (18/5/10)			
J.D.Yangambi	27/11/09 (4/12/09)				
Kluai Hom		7/5/10 (18/5/10)			
Kluai Khai Bonng	8/1/10 (not assessed)		25/6/10 (12/7/10)	24/9/10 (not assessed)	24/9/10 (not assessed)
Kluai Khai Bonng		7/5/10 (18/5/10)			
Lakatan	27/11/09 (24/12/09)				
Ney Poovan			25/6/10 (12/7/10)		
Pisang Ceylan	8/1/10 (13/1/10)			24/9/10 (5/10/10)	24/9/10 (5/10/10)
Pisang Raja	27/11/09 (4/12/09)				
Pisang Susu		7/5/10 (18/5/10)			
Yenai (AA, Sucrier)			25/6/10 (12/7/10)		
Goldfinger			25/6/10 (12/7/10)		
Lady Finger		7/5/10 (18/5/10)	25/6/10 (12/7/10)	sourced locally (5/10/10)	sourced locally (5/10/10)
Cavendish		sourced locally (18/5/10)	sourced locally (12/7/10)	sourced locally (5/10/10)	sourced locally (5/10/10)

Sample preparation for consumer and sensory panel evaluation

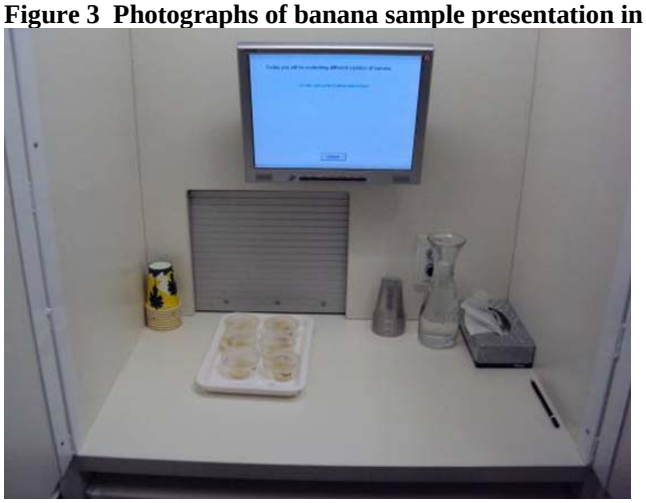
For preliminary assessment, whole fruit samples of each variety were presented to the panel on white trays labelled with unique sample codes.

Samples were prepared in an identical fashion for both the consumer evaluations and the formal trained panel assessments. Each taste session required up to 12 sets of sample for assessment and samples sets were prepared no more than 10 minutes prior to the commencement of a taste session.

Figure 2 Photographs of preparation of banana samples for sensory assessment

Samples of banana fruit were selected by appearance of ripeness level for inclusion in the taste session. A composite sample of 2-4 fruits of each variety were selected according to ripeness level, peeled, and sliced cross-wise into ~6-12 mm thick pieces. The fruit pieces were mixed and 2-3 slices were portioned into a 70 ml clear plastic cup labelled with a unique 3-digit sample code. Cups were sealed with a plastic lid and a sample of each variety was distributed across individual white trays in sets according to the experimental design Figure 2. No more than 6 varieties were presented for tasting per session.

Figure 3 Photographs of banana sample presentation in sensory booth area



Additional samples of fruit of each variety were presented as un-peeled whole fruit on white trays labelled with the corresponding 3-digit code.

Sample trays were presented to both consumers and sensory panellists in isolated sensory booths equipped with a computer to record responses and filtered water for palate cleansing. Booths were

light controlled (day-light equivalent lighting), temperature controlled (22°C) and were free from extraneous noise and odour. An example of the sensory booth set-up is given in Figure 3. Whole-fruit samples were presented to panellists on a small shelf directly behind or adjacent to participants in the booth area.

Preliminary sensory assessments

Preliminary sensory assessments were conducted informally in a discussion room where a panel of 5-6 judges assessed fruit individually. Judges were asked to record attributes that described their experience of the sensory properties including external appearance and feel, internal appearance, aroma, flavour, texture and mouthfeel. Individual assessments were followed by a discussion where a summary of the major sensory properties for each variety was developed and recorded.

Preliminary consumer taste evaluation sessions were conducted two months prior to the final, larger consumer preference mapping study. These sessions involved 93 consumers from on-site (the Health and Food Sciences Precinct, Coopers Plains) tasting bananas and completing an electronic questionnaire. The results of these tastings assisted with selection of varieties for the final preference mapping study (results not shown in this report).

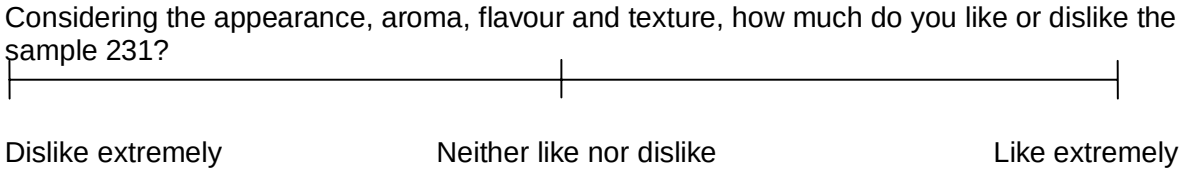
Consumer acceptability testing

Two hundred and twenty-eight respondents participated in the consumer acceptability testing sessions. Participants were primarily recruited by a professional recruitment agency, with some government employees recruited on site via prior email. Consumers were recruited according to their responses to a brief screening questionnaire about allergies to fruit and banana consumption. Recruiters were instructed to provide a sample with an even spread of banana consumption ie. weekly, fortnightly and monthly consumption. Participation from government employees was entirely voluntary and participants received no monetary payment. Participants sourced via the recruitment agency were paid a fee of $55.

Questionnaires included acceptance scales (overall acceptability of appearance aroma, flavour and texture; ripeness; and external appearance, aroma and feel), demographic information (gender, age, marital status, household income, education), and consumer behaviour items (banana consumption, shopping behaviours).

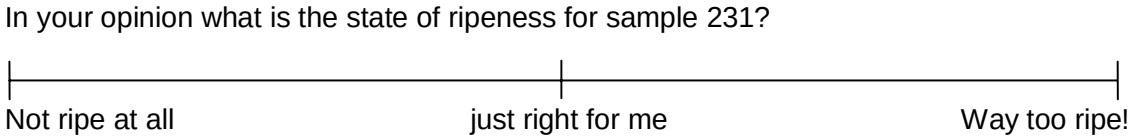
The consumer acceptability parameters were assessed using hedonic scales for overall acceptance of appearance, aroma, flavour and texture. Hedonic scales were also used to asses overall external appearance and smell of whole unpeeled fruit. These scales were anchored from ‘dislike extremely’ to ‘like extremely’ as shown in figure 4.

Figure 4 Example of the hedonic scale used for overall assessment



A ‘Just Right’ scale was used to examine consumer perceptions of ripeness of fruit as shown in Figure 5. Samples with scores accumulating at or around the mid-point can be considered ideal in ripeness.

Figure 5 Example of the 'Just Right' used for assessing ripeness



Consumers were also given the opportunity to provide comment on what they liked or disliked about the samples. An example of the pencil and paper version of the questionnaire is given in Appendix 3A.

Sensory descriptive analysis

Conventional quantitative sensory descriptive analysis was employed for the analysis of the banana fruit [19]. A 10-membered panel of judges were selected, comprising five male and five female panellists, aged 25 – 51 years (average age 37), all of whom were staff of Innovative Food Technologies (DEEDI) with previous experience in sensory studies of horticultural products.

Training sessions were conducted during May and again in Sept-Oct (11 sessions in total) and involved discussion sessions and practice sessions using the computers in the booths. During training, the judges generated a set of descriptive terms using the study bananas. By consensus six aroma and six in-mouth flavour terms were selected to rate during formal sessions. In addition, attributes were selected for assessing the size, visual appearance and feel of the whole unpeeled banana fruit, the visual appearance of the internal (sliced) fruit and the in-mouth texture of the banana. A summary of the attributes selected by the panel to rate during the formal assessments is given in Table 3.

Table 3 Summary of sensory attributes selected for descriptive analysis of banana samples

Attribute	scale used / variable type	Attribute type
External appearance		
thickness	category scale (thin, medium, fat)	external
length	category scale (short, medium, long)	external
colour	category scale (pale yellow, yellow, rosy yellow, bronzed)	external
shape (bend)	category scale (pronounced bend, slight bend, straight)	external
angularity	category scale (rounded, slight ridges, very angular ridges)	external
pronounced nipple	nominal	external
no nipple	nominal	external
external marks spotty pin stripes dark rub marks	 nominal nominal nominal	external
External feel		**external**
feel grippy (waxy) powdery	 nominal nominal	external
roughness	Unstructured line scale anchored from very smooth to very rough. (0-10)	external
Aroma		**internal**
aroma intensity	Unstructured line scale anchored from none to high (0-10)	internal
perfumed aroma (floral)	Unstructured line scale anchored from none to	internal

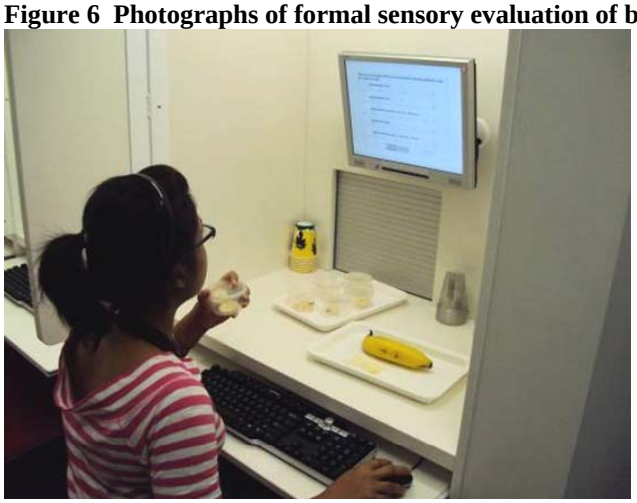
Attribute	scale used / variable type	Attribute type
	high (0-10)	
lolly fruit aroma (ester fruity confectionery)	Unstructured line scale anchored from none to high (0-10)	internal
tropical fruity aroma	Unstructured line scale anchored from none to high (0-10)	internal
sappy / resin aroma (grassy, 'unripe')	Unstructured line scale anchored from none to high (0-10)	internal
musty aroma (dank)	Unstructured line scale anchored from none to high (0-10)	internal
Internal appearance		
colour	category scale (white, cream, golden)	internal
uniformity	category scale (even colour, patchy, defined centre star)	internal
features moist dry prominent dark seeds	 nominal nominal nominal	internal
Texture		
features gooey consistent gritty lumpy chalky	 nominal nominal nominal nominal nominal	internal
firmness	Unstructured line scale anchored from soft to hard (0-10)	internal
astringency	Unstructured line scale anchored from none to high (0-10)	internal
Flavour		
sweetness	Unstructured line scale anchored from low to high (0-10)	internal
tartness	Unstructured line scale anchored from low to high (0-10)	internal
overall flavour intensity	Unstructured line scale anchored from low to high (0-10)	internal
fruity flavour	Unstructured line scale anchored from low to high (0-10)	internal
lemon sherbet lolly	Unstructured line scale anchored from low to high (0-10)	internal
sappy flavour (resin)	Unstructured line scale anchored from low to high (0-10)	internal
Aftertaste		**internal**
flavour persistence	Unstructured line scale anchored from very short to very long (0-10)	internal

Definitions were developed for each aroma and flavour attributes and an 'other' aroma and 'other' flavour attribute was included for panellists to use if they could detect a character that was not covered by the attribute list. All banana varieties included for formal evaluation were presented to the panel at least once during training, they included: Cavendish, Lady Finger, Gros Michel, High Noon, Pisang Ceylan and FHIA-18.

Formal rating sessions were held over three days (5th -7th Oct) concurrently with the consumer evaluations. The six varieties were presented in a single session for each of the three replicates in a random order according to the presentation design. Panellists were asked to first assess the whole fruit samples for external appearance and feel, followed by assessment of the cut fruit portions provided in closed sample cups for appearance, aroma, texture and flavour figure 6. Depending on the question, panellists were asked to score attributes on a line scale (anchored from none to high), check a box on a category scale, or check a box for the presence or absence of other features.

The software used to collect data was Compusense five (Release 5.0, 2008, Compusense Inc., Guelph, Ontario, Canada).

Figure 6 Photographs of formal sensory evaluation of banana fruit



Chemical analysis of banana fruit

Representative samples of fruit were taken on each day of the consumer sessions for measurement of brix, pH and titratable acidity. Water (90 g) was added to banana (30 g) and homogenised. The mixture was filtered, the pH measured using a pH meter, brix was determined using a refractometer, and titratable acidity was measured by automated titration (using 702 SM Titrino).

Data analysis and preference mapping

Consumer acceptability scales and descriptive analysis attribute scales were electronically presented to participants via sensory software *Compusense®5.* Participants were asked to rate each sample according to defined attributes or acceptability on hedonic unstructured 15 cm line scales. Consumer and trained panel scores were linearly converted to a score out of 100, and then reduced to a score out of ten and entered into statistical software SPSS or JMP (SAS, version 6.0.0). Qualitative comments from the consumer data were collated and subjected to content analysis to determine underlying themes. Responses to consumer demographic and behavioural multi-choice style questions were entered into statistical software SPSS.

Cross tabs were performed on acceptability, demographic and behavioural data using SPSS to provide descriptive data. Consumer acceptability data was scrutinised for outliers, and distributions checked for normality. Where data conformed to assumptions, a repeated measures analysis of variance (ANOVA) was performed using SPSS. Non-normal distributions were analysed using non-parametric tests. Where a significant ($p<0.05$) sample F-ratio was found using ANOVA, post hoc pair-wise comparisons were completed using a Bonferroni adjustment. A Spearman's rank-order correlation was performed for each banana sample to examine the relationship between ripeness and internal assessment. Hierarchical cluster analysis was performed using internal

assessment as the classification variable. Cross tabs were performed on resultant groups to understand trends in the data. A further repeated measures ANOVA was performed on resultant groups.

Analysis of variance (ANOVA) was performed on the raw descriptive analysis data set (10 judges x three replicates x 6 bananas) for each attribute to determine if there were significant differences among bananas, judges or replicates ($p<0.05$) using a mixed model treating judge as a random effect. Where a significant ($p<0.05$) sample F-ratio was found using ANOVA, pair-wise comparisons were completed using a student's t-test. Interactions between effects, including (banana x judge), (banana x replicate) and (replicate x judge), were assessed using least squares fit. For each continuous attribute the mean, minimum, maximum, standard deviation (SD), standard error of the mean (SEM) and the coefficient of variation (CV as a %) was calculated from the raw data set. Pearson's correlations between attributes were also calculated. For each quantitative attribute scored using a line scale, means were calculated for each variety and were compared using a student's t- test. For each category or nominal attribute scored, frequencies (as a % of the total) were determined for each banana variety for each attribute.

For multivariate data analysis both JMP and The Unscrambler X (version 10.1, CAMO Software, Oslo, Norway) were used. The data were structured so that the banana varieties were in rows and the variables (both sensory scores and consumer cluster preference scores) in columns. Prior to PCA or PLS analysis, all variables were autoscaled by dividing each value of each variable for each banana by that variables standard deviation, such that all variables had a standard deviation of 1.

PCA was performed before PLS models were developed to examine any relevant and interpretable structure in the data. PLS2 was used for external preference mapping where sensory scores were used to predict consumer cluster preference scores. The optimum number of components in the PLS calibration models was determined in cross validation as indicated by the lowest number of components that gave the minimum value of the PRESS (prediction residual error sum of squares) function in order to avoid overfitting of the models.

Results and discussion

Consumer acceptability and segmentation

The raw data file was visually inspected for missing data and data entry errors. One participant's response was deleted from the file due an excessive number of missing data (no. 207). Random missing data was then replaced with the mean for interval or ratio data or excluded from relevant analysis.

Demographics, stated preference, behaviours

Seventy-five percent of respondents were between the ages of 31 and 50 years of age and 69 per cent were female. Respondents were primarily Australian and married or living with a partner. Over half of participants had received some form of training or had attained a bachelor degree.

The sample was fairly representative of the Brisbane population geographically, considering all tests were undertaken in Coopers Plains, a mid-suburban area in the southern area of Brisbane. As can be expected, more than 50 per cent of participants lived in the Southern suburbs of Brisbane, stretching from the inner Southern suburbs to those in the outer South West through to the Gold Coast corridor. However, a sizable percentage of respondents were also sourced from Brisbane and

inner North and Northern Brisbane suburbs (33%). Household income levels were relatively well spread, although a slightly higher representation of a higher income bracket is noted.

Respondents were frequent banana consumers with almost half of respondents (47.4%) purporting to eat bananas everyday. Almost 80 per cent of respondents were the sole purchaser of bananas for the household. Participants were asked to recall the names of banana varieties. Lady Finger bananas were marginally spontaneously recalled ahead of Cavendish bananas. There was little awareness of other varieties. When asked about preference, over 50 per cent of people preferred Cavendish bananas, with 26 per cent preferring Lady Finger. The remaining participants largely did not have a preference.

Seventy-five per cent of respondents were solely responsible for grocery shopping in their household. Median spend on groceries was $100, fresh fruit and vegetables was $30, and frozen fruit and vegetables was $10. Over half of the respondents were the primary shopper for fruit and vegetables at supermarkets. A full presentation of demographic and behavioural statistics is available in table form in Appendix 3B.

Consumer acceptability of banana varieties

Internal assessment

The consumer acceptability parameters were assessed using hedonic scales for overall acceptance of appearance, aroma, flavour and texture. These scales were anchored from 'dislike extremely' (0), through 'neither like nor dislike' (50), to 'like extremely' (100). Scores were transformed into a percentage and then reduced to a score out of ten. For the hedonic scales, samples that score over 5, towards 10, are interpreted as acceptable for the consumer for those parameters. Samples with scores close to 10 may be said to be desirable. Conversely, samples rated below 5, toward 0, may be interpreted as unacceptable to consumers.

Data was checked for outliers, normality and skew and kurtosis. A complete description of the procedures is provided in Appendix 3C. Central tendencies and dispersion were calculated and inspected. These are presented in Table 4.

Table 4 Central tendencies for overall assessment of banana varieties

Sample	Mean (St.d)	Median
253 (Gros Michel)	5.45 (2.29)	5.3
328 (High Noon)	6.06 (2.42)	6
490 (Pisang Ceylan)	5.63 (2.44)	5.7
826 (FHIA-18)	4.75 (2.57)	4.6
545 (Cavendish)	6.59 (2.24)	6.9
930 (Lady Finger)	5.22(2.5)	5.3

A one-way repeated measures analysis of variance was conducted examining scores on internal assessment of banana varieties 253 (Gros Michel), 328 (High Noon) 490 (Pisang Ceylan) and 545 (Cavendish). A Friedmans test was conducted with samples not conforming to normal distributions (a complete description of procedure and results is provided in Appendix 3C). The change in values for internal assessment of banana varieties was significant F (4.57, 1022.81) = 18.191, p<.05.

Qualitative data shows over 50 per cent of the participants professed to prefer Cavendish. Results from overall acceptability testing however, show the sample 328 (High Noon) to be congruent with Cavendish with no significant difference found for internal acceptance between these two samples.

The only variety to have scored below the acceptability level of five, was the experimental variety FHIA-18. It is worth noting that there was no significant difference in internal assessment between this variety and sample 930 (Lady Finger) using non-parametric tests. This suggests that for this consumer panel - and despite 26 per cent of consumers admitting to favouring Lady Finger - it was also not well received in blind taste testing.

External assessment

The consumer acceptability parameters were assessed using hedonic scales for overall acceptance of appearance, aroma, flavour and texture. These scales were anchored from 'dislike extremely' (0), through 'neither like nor dislike' (50), to 'like extremely' (100). Scores were transformed into a percentage and then reduced to a score out of ten. For the hedonic scales, samples that score over 5, towards 10, are interpreted as acceptable for the consumer for those parameters. Samples with scores close to 10 may be said to be desirable. Conversely, samples rated below 5, toward 0, may be interpreted as unacceptable to consumers.

Data was checked for outliers, normality and skew and kurtosis. One consumer case was removed for external assessment only. Skew for external assessment was apparent for some samples. Non-parametric tests were employed here (a complete description of procedure and results is provided in Appendix 3C). Central tendencies were first inspected and are presented in Table 5.

Table 5 Central tendencies for the external assessment of banana samples

Sample	Mean (St.d)	Median
253 (Gros Michel)	4.7 (2.37)	4.95
328 (High Noon)	5.35 (2.06)	5.15
490 (Pisang Ceylan)	6 (2.17)	6
826 (FHIA – 18)	4.35 (2.21)	4.6
545 (Cavendish)	7.43 (2.06)	7.75
930 (Lady Finger)	6.1 (2.18)	5.9

When interpreting these results it is necessary to take into account that samples 545 (Cavendish) and 930 (Lady Finger) were grown commercially. All other samples were not produced for market, with many sourced from non-commercial farms. This variable may have influenced the outcomes of the external assessment.

Two varieties, 253 (Gros Michel) and 826 (FHIA-18), fell below the acceptability parameter of a score of five for external assessment. The two commercially sourced varieties, 545 and 930 received the highest ratings for external appearance, with significant differences between Cavendish and all other varieties. This and the high mean score of 7.43 suggests that for external appearance, the qualities of Cavendish bananas have superior appeal for these consumers. There was no significant difference found between sample 930 (Lady Finger) and 490 (Pisang Ceylan) suggesting that this sample may be equally acceptable in external ratings as the Lady Finger variety.

Ripeness assessment

A 'Just Right' scale was used to examine consumer perceptions of ripeness of fruit. Scores were transformed into a percentage and then reduced to a score out of ten.
Samples with scores accumulating at or around 5 can be considered ideal in ripeness. Scores collecting toward the 0 mark may be considered under ripe, and those collecting toward a score of 10 may be interpreted as overripe.

Data was checked for outliers, normality and skew and kurtosis. A complete description of the procedures is provided in Appendix 3C. One consumer case was removed for external assessment only. Skew for external assessment was apparent for some samples. Non-parametric tests were employed here. As was expected, perceived ripeness is associated with scores of acceptability for internal assessment. The ripeness of all bananas was considered acceptable.

Qualitative comments

Consumers were given the opportunity to provide comment about their banana consumption during blind taste testing. These comments were collated and subjected to content analysis.

Positive comments on fruit flesh focused on taste, aroma and visual appearance. Consumers reported that the internal look of a banana is important, with sample 328 (High Noon) selected as the most visually appealing. A banana that smells fresh and 'sweet' is highly considered when selecting a banana, with samples 328 (High Noon) and 545 (Cavendish) being popular choices. People enjoy a good flavour and a sweet tasting banana. Sample 490 (FHIA-18) received the most comments in sweetness of taste followed by sample 328 (High Noon). The best overall texture was found in sample 545 (Cavendish) following closely by samples 253 (Gros Michel) and 328 (High Noon). Consumers found sample 545 (Cavendish) to have a smooth texture and sample 328 (High Noon) to have a firm one.

Consumers were asked to comment on what they disliked about the products. Overall the sample 826 (FHIA-18) received the most negative comments on aroma, with many describing it as sour. This sample, as well as sample 253 (Gros Michel) received negative comments about an aftertaste. More negative comments on texture for sample 930 (Lady Finger) were apparent. A 'slimy' texture was found in samples 490 (Pisang Ceylan) and 545 (Cavendish). Texture was said to be too soft in samples 490 (Pisang Ceylan) and 930 (Lady Finger). Sample 545 (Cavendish) was found to be too firm in texture by some.

Consumers were asked if they had positive comments on the whole fruit. Many liked the smell of sample 490 (Pisang Ceylan) followed closely by sample 545 (Cavendish). The size, shape and colour are considered important in a banana, with sample 545 (Cavendish) receiving the most comments in all three cases.

When asked to describe an ideal banana, comments from consumers included 'It needs to look like a banana', and have a good yellow colour. Sample 490 (Pisang Ceylan) received the most positive comments on colour. Sample 930 (Lady Finger) seemed to be the most pleasant when touched. The banana that was most appealing to look at was sample 545 (Cavendish). This may be a function of familiarity with the variety. As previously discussed, Cavendish and Lady Finger were grown commercially whilst the others were not. It was apparent that the difference in growing conditions influenced qualitative assessment of external appearance.

Consumers were asked if any negative comments were warranted for the whole fruit samples. Smell overall was most disliked in sample 930 (Lady Finger). Shape is important, as it needs to 'look' like a banana with the most unusual shape being sample 826 (FHIA-18). Comments on size varied. Most people reported sample 253 (Gros Michel) as being too small and sample 545 (Cavendish) being too big. A general outcome may be that sizing should suit different needs. Sample 826 (FHIA-18) was least liked for its colour. Any green colouring is not considered a good feature, with sample 253 (Gros Michel) receiving comments about being too green. Levels of ripeness are important, with samples 328 (High Noon) and 826 (FHIA-18) found to be overripe by many. For

others, sample 253 (Gros Michel) was not ripe enough. Markings and blemishes on bananas are off putting for some, with sample 826 (FHIA-18) receiving the most comments on markings.

Participants were asked to spontaneously name the variety of banana they preferred. The most popular banana was Cavendish following by Lady Finger. Some people said they were unsure and others noted attributes that they liked about bananas such as organic, the price, colour and size.

Consumers were also asked to describe their ideal banana. Most people were attracted to a banana for its yellow colour and absence of markings and blemishes. The shape of the banana is important because it is purchased for various reasons with a smaller size preferred for children's lunch boxes and medium or large size for adults. Many consumers described the ideal banana as being firm to touch easy to open. They are enjoyed most when the taste has a smooth texture. A few people enjoy an aftertaste while others prefer no aftertaste. Consumer's used appearance and a fresh smell in the purchase decision process. Price was a major determinate for many with these participants motivated by cut-price promotions. Some consumers would like bananas to have a longer shelf life. Appendix 3D provides a count of different comments.

Segmentation of sample

Considering the small sample size and the scale nature of the acceptance data, a hierarchical cluster analysis was performed in order to investigate if natural sub-groups exist within the population sample with distinct preferences for banana attributes (see Appendix 3E, for full statistical analysis). Product samples 545 (Cavendish) and sample 930 (Lady Finger) were sourced commercially for assessment, and all other samples were sourced from a variety of farms using different processes. The difference in growing conditions was apparent in the external assessment for banana samples (see External assessment, page 44), and was therefore thought to provide a flawed basis for classification of subgroups. For this reason cluster analysis was performed using internal assessment only as the classification variable.

Cluster analysis was performed using Ward's method with a squared Euclidean distance as suggested by McEwan for use in preference map studies (1998) [21]. Inspection of the agglomeration schedule revealed several clusters with the largest co-efficient differences of around 6.3. This provides little direction for reducing clusters. To the author's (KG) knowledge no definitive approach is used for estimating the number of clusters (for an extensive review see Dolnicar, 2002 [22]; McEwan, 1998 [21]). However, Dolnicar (2002) revealed a concentration of clustering studies using, three, four and five cluster solutions. Considering the co-efficient approach provided little clarification, it was decided to 'road test' both a three, four and five cluster solution. Inspection of ANOVA with Post Hoc Tukey's HSD revealed a three cluster solution with significantly different acceptability patterns.

These three groups can be labelled *Banana Lovers* (Group one), *Traditionalists* (Group two), and *Banana Snobs* (Group three). Table 6 shows group central tendencies for both internal and external assessment as well as ripeness. All groups were well represented in terms of gender, and country of origin when compared to the overall sample population (refer to Table 7). However, *Traditionalists* were over-represented in the 18-25 years age group, and the *Banana Snobs* were over-represented in the 41-50 age group. This may be a function of the smaller size of these two clusters and should be interpreted with caution. Table 7 provides a behaviour profile for the three consumer segments identified.

Table 6 Cluster group central tendencies for internal and external assessment, and ripeness

		Internal Assessment		External Assessment		Ripeness	
Group 1		*M* (*st.d*)	*Mdn*	*M* (*st.d*)	*Mdn*	*M* (*st.d*)	*Med*
n = 124	253	6.05 (2.08) [a,b]	5.8	5.32 (2.42) [a,b]	5.1	5.07 (1.35) [a]	5
	328	7.02 (2.09) [d,e]	7.2	5.8 (2.1) [c,d]	5.65	5.2 (1.23) [b]	5
	490	6.6 (2.12) [g,h]	6.7	6.6 (1.96) [e,f]	6.4	5.51 (1.47) [d]	5
	826	6.15 (2.33) [j,k]	6.45	5 (2.1) [g,h]	5	4.95 (1.17) [e,f]	5
	545	6.87 (2.04) [l,m]	7.1	7.7 (1.85) [i]	7.85	5.57 (1.43)	5.1
	930	5.17 (2.43) [n,o]	5	6.28 (2.03)	6.2	5.38 (1.87)	5.1
Group 2							
n= 45	253	4.94 (2.26) [a]	5	4.19 (2.19) [a]	4.7	4.42 (1.49) [a]	4.7
	328	3.72 (1.86) [d,f]	3.8	4.54 (2.04) [c]	4.9	4.09 (2.3) [b c]	4.2
	490	5.1 (2.46) [g,i]	5.2	5.39 (2.33) [e]	5.4	4.36 (2.15) [d]	5
	826	2.9 (1.47) [j]	3.2	3.85 (2.13) [g]	4.1	3.53 (2.06) [e]	3.5
	545	7.94 (1.45) [l,m]	8	7.9 (1.73) [j]	7.9	5.15 (.82)	5
	930	7.4 (1.32) [n,p]	7.2	6.2 (2.47)	5.8	5.27 (.9)	5
Group 3							
n=55	253	4.45 (2.31) [b]	4.6	3.72 (1.98) [b]	3.1	4.62 (1.92)	4.9
	328	5.93 (2.07) [e,f]	5.4	5.03 (1.74) [d]	5.1	4.92 (1.92) [c]	5
	490	3.98 (1.96) [h,i]	3.9	5.06 (2.03) [f]	4.9	4.87 (1.98)	5
	826	3.2 (1.76) [k]	3.3	3.31 (2.09) [h]	3.3	4.04 (1.85) [f]	4.2
	545	4.76 (2.07) [l,m]	4.8	6.35 (2.31) [I,j]	7.1	5.51 (1.95)	5.1
	930	3.45 (1.87) [o,p]	3.2	5.72 (2.28)	5.4	5.39 (2.33)	5

[a, b, c] etc., denotes significant differences of a particular sample between groups.

Table 7 Demographic profile for consumer segments

		Banana Lovers	Traditionalists	Banana Snobs
		A (B) [C]		
Gender	Male	37 (30) [16.6]	15 (33.3) [6.7]	18(32.7) [8.1]
	Female	86 (70) [38.6]	30 (66.6) [13.5]	37 (67.3) [16.6]
Age	18-25	11 (9) [5]	9 (20) [4.0]	4 (7.2) [1.8]
	26-30	17(13.8) [7.6]	3 (6.7) [1.3]	6 (11) [2.7]
	31-40	44 (35.8) [19.7]	11 (24.4) [4.9]	14 (25.5) [6.3]
	41-50	49 (39.8) [22]	20 (44.4) [8.9]	30 (54.5) [13.5]
	>50	2 (1.6) [.9]	2 (4.4) [.9]	1 (1.8) [.4]
Country	Australia	91	30	41
	NZ	7	5	4
	N America	4	1	0
	Asia	7	4	5
	S Africa	2	2	0
	Europe	8	3	4
	S Pacific	2		1
	Middle E	1		
	S/Central America	1		
Marital status	Married/partner	72	35	38
	Single	45	9	14
	Other	6	1	3
Education	Some high	11	7	5
	High-school	25	4	8
	Training	34	15	17
	Undergrad	35	8	15
	Postgrad	18	11	10
Income	$10000	6	2	3
	$10001-20000	8	0	1
	$20001-30000	8	4	2
	$30001-40000	12	9	4
	$40001-60000	29	5	9
	$60001-80000	18	9	7
	$80001-100000	18	4	12
	$100001-150000	19	7	11
	$150001 plus	5	4	6

No.224
A = no. of respondents
(B) = percentage of cluster
[C]= percentage of total population

Table 7 Behaviour profile for consumer segments

		Banana Lovers	Traditionalists	Banana Snobs
Shopping responsibility	Me	99	33	37
	My partner	18	12	14
	Somebody else	3		1
	Shared	4		3
Grocery Spend	<$50	15	6	2
	$50-75	15	6	6
	$76-99	12	4	1
	$100-149	28	6	12
	$150-199	17	8	8
	$200-249	12	4	6
	>250	6	2	4
Fresh fruit and vegetable spend	$0	1	0	0
	$1-10	8	2	2
	$11-20	31	8	9
	$21-30	27	13	17
	$31-50	38	14	19
	$51-100	18	7	5
	>100	1	1	3
Frozen fruit and vegetable spend	$0	11	5	4
	$1-5	34	12	10
	$6-10	34	12	15
	$11-20	19	6	8
	$21-50	5	1	2
	>$51	2	0	0
Place of purchase	Supermarket	68	25	34
	Green Grocer	41	15	15
	Public Market	13	4	6
	Other	2	1	0
Banana form	Fresh	All	All	All
	Dried	25	13	13
	Smoothy	79	23	27
	Cooked	19	8	10
	Bake	63	27	23
	Other	6	4	4
Banana recall	Lady Finger	108	39	45
	Cavendish	92	32	40
	Eco red	17	4	5
	Goldfinger	5	2	0
	Plantain	5	1	1
	Other	15	6	3
Banana Preference	Lady Finger	33	11	14
	Cavendish	64	26	33
	Eco/Organic	3	0	1
	Small	4	2	1
	No preference	10	2	5
	Other/don't know	20	7	4
		134	48	58

No. 224

Group one – *Banana Lovers*

Banana Lovers were the largest group with over 50 per cent of participants falling into this category. A greater percentage of *Banana Lovers* were single than in any other group. This group was evenly represented by education and income.

Overall internal assessment

With all banana samples scoring over 5, this group of participants is distinguished in that all bananas are acceptable to them. 24 per cent of respondents falling into this group professed to prefer Lady Finger, (M = 5.17) yet this was the least acceptable banana variety for this group with scores significantly lower than all other varieties. Forty-eight per cent of participants in this group said they preferred Cavendish bananas, yet overall internal acceptability testing reveals High Noon was the highest scoring banana variety. However this variety was not significantly higher in scores than Cavendish or Pisang Ceylan. This suggests that based on overall internal assessment *Banana Lovers* find these three varieties equally as pleasing. A write up of analysis can be found in Appendix 3E.

Overall external assessment

The general outcome of overall external assessment of varieties for this group was not different to that of the whole sample. Cavendish (M=7.7) received a significantly higher ranking than all other varieties; Pisang Ceylan (M=6.6) and Lady Finger (M=6.2) were not significantly different in rankings but were more acceptable to consumers than Gros Michel (M=5.3), High Noon (M=5.8) and FHIA-18 (M=5); FHIA-18 was significantly lower in scores than all other varieties except Gros Michel. These scores suggest that for cluster one Cavendish is the preferred banana variety in terms of external attributes. The least acceptable are the FHIA-18 and Gros Michel varieties. A write up of analysis can be found in Appendix 3E.

Group two - *Traditionalists*

As previously discussed, when inspecting descriptive trends, the 18-25 years age group is slightly over represented within the *Traditionalists* cluster. However, given the small size of the group this should be interpreted with caution.

Overall internal assessment

This group is distinguished in their definitive preference for both Cavendish and Lady Finger. Qualitative data reveals more than 50 per cent of this group stated a preference for Cavendish, and 23 per cent for Lady Finger. This correlates well with acceptability data where both Cavendish (M = 7.9), and Lady Finger (M = 7.4) were the clearly preferred varieties for this group as depicted by the small variances experienced in the sample acceptability data. No significant difference was found between these two samples. Unambiguously, the least acceptable variety for this group is sample 826 (FHIA-18), M = 2.9 with significant differences in overall internal acceptability between this variety and all others.

Overall external assessment

Assessment of external features of banana varieties shows little difference between this group and the outcomes from the population sample with Cavendish the preferred banana sample. Like the overall participant population, no significant difference was found between Lady Finger and Pisang Ceylan. Based on external attributes, three varieties were scored as unacceptable to this group: 253 (Gros Michel), 328 (High Noon) and 826 (FHIA-18).

Group three – *Banana Snobs*
Visual inspection of the data reveals that this group was quite well represented in the Griffith electorate, which takes in the inner city Southern suburbs, and was representative of a higher socio-economic status.

Overall internal assessment

This group is characterised by the apparent low mean scores in relation to the other two clusters, with sample 328 (High Noon) the only banana variety to achieve acceptable scores (>5) for internal assessment. This is in contrast to qualitative stated preferences for this group which, similar to *Tradionalists* were dominated by first Cavendish followed by Lady Finger. Considering the authors' (KG, HS & KF) past experience with the fruit, those samples with the lowest scores for internal assessment amongst *Banana Snobs* ostensibly may have been a result of ripeness levels. In order to understand if a moderating effect from ripeness was apparent, ripeness data was inspected and a between groups ANOVA with *post hoc* Tukey's was performed. However, those varieties with the lowest internal acceptability scores; 490, 826 and 930, were largely not significant for ripeness between groups. The only sample to be significant was that of 826, which was perceived to be significantly riper for group three than for group one, for which it received a higher internal acceptability score. Therefore, the low internal assessment scores for group three can confidently be interpreted as characteristic of *Banana Snobs* and unrelated to the ripeness levels of fruit. It would seem that for the *Banana Snobs*, High Noon is the superior variety above all others.

Overall external assessment

Scores on external assessment did not differ in tendency to that of the overall sample.

Descriptive panel sensory evaluation

From a preliminary sensory screening of 16 varieties of banana, and after preliminary consumer assessments of 10 varieties, a total of six varieties were chosen to conduct formal sensory evaluation and consumer taste testing for the purpose of preference mapping.

The varieties chosen for preference mapping included FHIA-18, Gros Michel, High Noon, Pisang Ceylan (which was not available for preliminary consumer assessments) together with comparator varieties Lady Finger and Cavendish. The four 'new' varieties were chosen because of the good eating qualities, their promising performance in the preliminary consumer taste testing or preliminary assessments and desirable agronomic qualities including pest and disease resistance, fair yield and transportability.

Samples were presented to the panel and to consumers in two formats. Fruit were presented as whole unpeeled single bananas so that external parameters could be assessed and scored. Fruit were presented separately as cut internal fruit flesh (2-3 pieces) for assessment of internal fruit attributes. It was important to separate the external appearance from internal eating qualities as the 'new' varieties differed significantly in terms of skin blemishes and rub marks in comparison to the commercially grown Cavendish and Lady Finger. As discussed in the previous section, the external blemishes significantly affected consumer acceptability scores and may have affected scored for internal fruit acceptability if the two presentation formats had not been separated.

Table 8 Summary of the descriptive analysis line scale (0 - 10) scores for external and internal attributes of 6 banana varieties (n = 6 varieties x 3 replicates x 10 panellists = 180).

Attribute	mean	minimum	maximum	SD	CV(%)[i]	SEM
External feel						
roughness	2.1	0	8.8	2.1	100	0.15
Aroma						
aroma intensity	5.7	0	9.8	2.0	35	0.15
perfumed aroma (floral)	2.2	0	9.9	2.6	120	0.19
lolly fruit aroma (ester fruity confectionery)	3.5	0	9.5	2.8	80	0.21
tropical fruity aroma	2.8	0	9.4	2.7	96	0.20
sappy / resin aroma (grassy, 'unripe')	4.1	0	10	3.5	85	0.26
musty aroma (dank)	2.3	0	9.9	2.7	120	0.20
Texture						
firmness	3.5	0	8.2	2.1	60	1.6
astringency	3.2	0	10	2.7	84	0.20
Flavour						
sweetness	4.1	0	9.2	2.2	54	0.20
tartness	4.2	0	10	2.8	67	0.20
overall flavour intensity	5.0	0	8.9	2.0	40	0.15
fruity flavour	4.1	0	9.6	2.4	59	0.18
lemon sherbet lolly	3.1	0	10	3.1	100	0.23
sappy flavour (resin)	2.3	0	9.8	2.6	110	0.19
Aftertaste						
flavour persistence	3.7	0	10	2.3	62	0.17

SD : standard deviation; CV : coefficient of variation; SEM : standard error of the mean.

For the six banana varieties assessed, a total of 10 external attributes and 19 internal attributes were assessed and scored by the trained sensory panel using conventional descriptive analysis techniques. These included a range of quantitative variables scores on line scales (from 0 - 10) and a range of attributes rated on category scales or collected as nominal variables. A summary of the scale type used for all attributes rated is provided in Table 2, and a summary of the results for quantitative variables including mean, minimum and maximum, standard deviation (SD), coefficient of variation (CV) and standard error of the mean (SEM) is given in Table 8. Mean results for each individual variety for all attributes are summarised in Appendix 3G, Table 20 to Table 26.

A summary of the analysis of variance (ANOVA) for each quantitative attribute for each of the effects tested, as well as the least squares fit for each of the interactions tested, is given in Table 9. Many of the attributes tested were significantly different between the bananas including roughness, aroma intensity, perfumed aroma, lolly fruit aroma, firmness, astringency, tartness and lemon sherbet lolly. There were significant differences between judges for most attributes which is usual of descriptive analysis data.

Interestingly there were significant differences between replicates for attributes lolly fruity aroma, astringency, tartness, fruity flavour and sappy flavour. Fruit were presented in triplicate with each replicate presented in a single taste testing session. Given these attributes are likely to relate to sugar and acid content of the fruit, together with presumably 'ripe' flavours and aromas, this may indicate a slight ripening effect of the bananas over the 3 days of formal evaluation.

[i] Coefficient of variation (CV) is the ratio of the standard deviation to the mean, presented as a percentage.

Table 9 F ratios and significance for effects of banana, judge, repetition and interactions for each sensory attribute

sensory attribute	banana	judge	replicate	banana x judge	judge x replicate	replicate x banana
roughness	3.4^{**}	5.6^{**}	0.02^{ns}	5.5^{**}	4.5^{**}	2.4^{*}
aroma intensity	7.6^{**}	2.4^{*}	0.6^{ns}	4.9^{**}	2.1^{*}	5.6^{**}
perfumed aroma	4.0^{**}	9.0^{**}	0.02^{ns}	8.8^{**}	7.3^{**}	2.8^{**}
lolly fruit aroma	6.8^{**}	1.6^{ns}	4.3^{*}	3.8^{**}	2.2^{*}	6.5^{**}
tropical fruity aroma	2.0^{ns}	3.8^{**}	0.6^{ns}	3.4^{ns}	3.2^{**}	1.6^{ns}
sappy / resin aroma	2.2^{ns}	6.1^{**}	0.9^{ns}	5.1^{**}	5.2^{**}	1.9^{ns}
musty aroma	0.6^{ns}	10.5^{**}	1.0^{ns}	7.0^{**}	8.9^{**}	0.3*
firmness	4.0^{**}	8.2^{**}	1.6^{ns}	0.8^{**}	7.2^{**}	1.7^{ns}
astringency	2.4^{*}	10.1^{**}	9.5^{**}	8.3^{**}	12.2^{**}	4.8^{**}
sweetness	0.7^{ns}	12.9^{**}	1.9^{ns}	8.8^{**}	11.4^{**}	2.8^{**}
tartness	9.7^{**}	6.9^{**}	3.2^{*}	11.1^{**}	6.7^{**}	8.3^{**}
overall flavour intensity	1.8^{ns}	5.0^{**}	0.8^{ns}	4.1^{**}	4.1^{**}	1.3^{ns}
fruity flavour	1.5^{ns}	5.3^{**}	6.1^{**}	4.2^{**}	6.1^{**}	2.9^{**}
lemon sherbet lolly	7.1^{**}	6.3^{**}	1.8^{ns}	8.5^{**}	5.6^{**}	5.7^{**}
sappy flavour	1.9^{ns}	6.1^{**}	6.1^{**}	4.9^{ns}	6.8^{**}	3.2^{**}
flavour persistence	0.6^{ns}	18.4^{**}	0.7^{ns}	12.2^{**}	15.4^{**}	0.6^{ns}

[a] values from analysis of variance; [b] values from least squares fit effect tests; significance indicated by ** ($p < 0.01$), * ($p< 0.05$), ^{ns} not significant.

Significant differences were observed for the interaction of banana x judge for all attributes with the exception of tropical fruity aroma and sappy flavour. This indicates that panellists rated the bananas in different ways for almost all of the quantitative sensory attributes in the study. This is common of sensory studies where variability between judges in unavoidable.

The interaction of judge x replicate also showed significant differences for the majority of attributes. This indicates judges rated the bananas differently across the replicates indicating that the panel may not have been sufficiently trained or that the banana were indeed ripening and changing over the 3 days of testing.

The interaction of replicate x banana showed significant differences for several of the attributes, including those relating to sugar and acid content and 'ripe' aromas and flavours, indicating again that there may have been some changes in banana ripening across the replicates.

Pearson correlations (pair-wise) were assessed for the sensory data and the results of this analysis are shown in Table 19 (Appendix 3F). High collinearity (correlation) was observed between attributes which is common for analyses where many variables are measured, including sensory data sets [23].

High positive correlations were observed between aroma intensity and lolly fruit aroma (r=0.91), perfumed aroma and tropical fruity aroma (r=0.83), tartness and lemon sherbet lolly (r=0.99), sappy resin aroma and flavour persistence (r=0.93) and between sappy flavour and flavour persistence (r=0.78).

Strong negative correlations were observed between perfumed aroma and sappy resin (r=-0.91), perfumed aroma and flavour persistence (r=-0.91), lolly fruit aroma and flavour persistence (r=-0.90), tartness and fruity flavour (r=-0.94), fruity flavour and lemon sherbet lolly (r=-0.91).

Results of sensory attribute scores for external attributes of six varieties of banana

External appearance attributes were scores by the panel from assessment of a whole single unpeeled banana fruit. Fruit presented were carefully selected to be representative of the banana varieties shape, colour and size, and fruit that were as blemish-free as possible were chosen. In this study, the 'non-commercial' growing conditions and handling of the 'new' varieties meant that all fruit had significantly more blemishes on the skin than the commercial Lady Finger and Cavendish. Nevertheless these blemishes did not affect internal fruit quality.

Appendix 3G (Tables 23 & 24), provides summary tables for the descriptive analysis results for the external banana attributes rated.

Compared to the other fruit, Cavendish presented with a medium thickness and length with a rosy yellow colour. More than any of the other varieties, it received most scores for having a pronounced bend, for not having a pronounced 'nipple' shape on the end of the fruit. Cavendish also was frequently scored for being very grippy which may relate more to commercial handling of the fruit and was significantly more rough to touch.

Lady Finger presented as a much thicker variety than the others, with a consistent medium length, very angular ridges and a pronounced 'nipple'. It was also significantly more smooth to touch (least rough) than all the other varieties with the exception of FHIA-18.

Similar to the Cavendish, the variety FHIA-18 was commonly rated as medium in thickness and length, although was more yellow in appearance and was most frequently scored as the straightest variety. It also had a pronounced nipple although was frequently scored as having dark rub marks on the skin.

Gros Michel was more frequently scored as a thin and short fruit compared to the other varieties. Fruit ranged in scores for colour from yellow to rosy yellow, and from straight, slight bend to having a pronounced bend. This indicates some inconsistencies in its colour and shape from fruit to fruit. It was frequently scored as being angular, having a pronounced nipple, dark rub marks and was powdery to touch.

High Noon was typically scored for being of medium thickness although ranged in length, colour and bend between individual fruit assessed. Similar to FHIA-18 it was frequently scored for having a pronounced nipple, dark rub marks and for being powdery to touch.

The variety Pisang Ceylan presented as medium – thick but was most frequently rated as short compared to the other varieties and with a slight bend and slight ridges. In colour it was frequently rated as rosy yellow. Compared to the other varieties it was most frequently rated as having pin stripes on the skin.

Results of sensory attribute scores for internal attributes of six varieties of banana

Internal assessments were conducted on freshly sliced pieces of banana presented in clear plastic pots with lids. Panellists were asked to open the lid of each sample, smell the headspace above the banana slices and rate each aroma attribute on the scales provided.

Appendix 3F (Tables 22-26), provides summary tables for the descriptive analysis results for the internal flesh banana attributes rated by the panel. The results will also be explored using multivariate data analysis (Figure 7 and Figure 8).

Cavendish presented as a white / cream flesh colour with a non-uniform appearance both being patchy and having a defined centre star. Cavendish was neither predominantly moist nor dry looking and was almost equally scored for being lumpy and consistent in texture. Cavendish was typically the firmest in texture and was significantly lower in astringency that all the other varieties. The major differences observed in the scores for aroma was that Cavendish scored significantly higher in aroma intensity than all of the other varieties (with the exception of FHIA-18). Cavendish also scored significantly higher for fruity flavour, perfumed aroma and lolly fruit aroma than the other varieties.

FHIA-18 was scored more frequently as being a white fleshed fruit, and ranged in terms of colour uniformity. It was clear that the uniformity scores were affected by length of exposure of the cut surface to the air, and this may have influenced appearance scores. FHIA-18 received a high frequency of scores for moist looking and was scored frequently for consistency in texture. FHIA-18 (and Pisang Ceylan) were scored highest for tartness and lemon sherbet lolly flavours. FHIA-18 was mid-range in terms of aroma intensity, and was rated high for sappy / resin aroma.

Variety Gros Michel received a spread of scores for colour and uniformity although was scored frequently for being moist looking. In terms of texture, Gros Michel was not significantly different in firmness or astringency to most of the other 'new' varieties. Gros Michel was scored higher for sappy flavour than the other varieties, and was scored low for aroma intensity.

High Noon was also scored very frequently for moist looking, and received a fairly equal spread of scores across the colour and uniformity categories. High Noon was scored frequently for consistency in texture. High Noon was scored high for overall flavour intensity and low for aroma intensity.

Lady Finger presented typically as a white coloured flesh compared to the other varieties, although was frequently scored for having prominent dark seeds and being dry looking. Again, scores allocated for uniformity in colour was spread between the categories. Lady Finger received the most scores for consistency in texture but was not different to the 'new' varieties for firmness or astringency. Similar to High Noon, Lady Finger was also scored high for overall flavour intensity. Lady Finger was scored high in aroma intensity and for sappy / resin aroma.

Similar to FHIA-18 and High Noon, Pisang Ceylan received frequent scores for being moist looking. It presented as a white/cream coloured flesh, and was rated as patchy and with a defined centre star similar to Cavendish. Pisang Ceylan received some scores for texture consistency, but was not much different to other varieties in terms of firmness and astringency. Similar to FHIA-18, Pisang Ceylan also scored high for tartness and lemon sherbet lolly flavours. Pisang Ceylan was scored low for aroma intensity.

There were no significant differences found between banana varieties for musty aroma, sweetness or for flavour persistence. It may be that differences between replicates due to ripening of the fruit over the 3 days of testing may have resulted in too broad a distribution of scores for sweetness within a variety.

Although no differences were observed in perception of sweetness, the perception of acidity (tartness) was found to relate to chemical determination of brix: titratable acidity (brix: TA) ratios. Two main types of banana emerged with Cavendish, Lady Finger and Gros Michel scoring lower for tartness while FHIA-18, High Noon and Pisang Ceylan were scored significantly higher for tartness. This agreed with the brix: TA ratio data (refer to Table 15, Appendix 3H) where the same two groups were observed. Those varieties with higher brix: TA ratios of ~54 corresponded to those varieties with lower acidity, while the three varieties with higher brix: TA ratios of ~30 corresponded to those varieties scoring higher for perceived acidity (tartness).

A principal component analysis (PCA) bi-plot of the quantitative aroma, texture and flavour scores for each replicate of each banana variety is shown in Figure 7 (PC1 versus PC2) and Figure 8 (PC 1 versus PC3). A total of 72 % of variation in the data set was explained within the first three principal components (PCs).

The PCA plot demonstrates clearly that in many cases, differences between replicate bananas of the same variety were scored quite differently. This may be attributed to changing ripeness levels between fruit, or simply individually fruit to fruit variation which is typical of horticultural products.

Every attempt was made to ensure the consistency of the fruit over the course of testing. As described in the methods section on page 30 and 33, fruit bunches were synchronised for ripening by a commercial banana pack-house and were sorted and selected for presentation during testing sessions to ensure similar levels of ripeness. This is obviously one of the biggest challenges in undertaking sensory and consumer analysis of different banana varieties. The results from the chemical analysis for °Brix, pH and titratable acidity (Tables 27 & 28) demonstrate a reasonable level of ripeness for the fruit. There was some variation between samples of the same variety, which was not unexpected.

Differences between replicates may also be attributes to panel drift over the formal assessments indicating the panel were not sufficiently trained. Practice sessions in the booths prior to the formal evaluations demonstrated the panel were sufficiently reproducible for replicates of the banana same sample and therefore were thought to be ready to conduct formal evaluations.

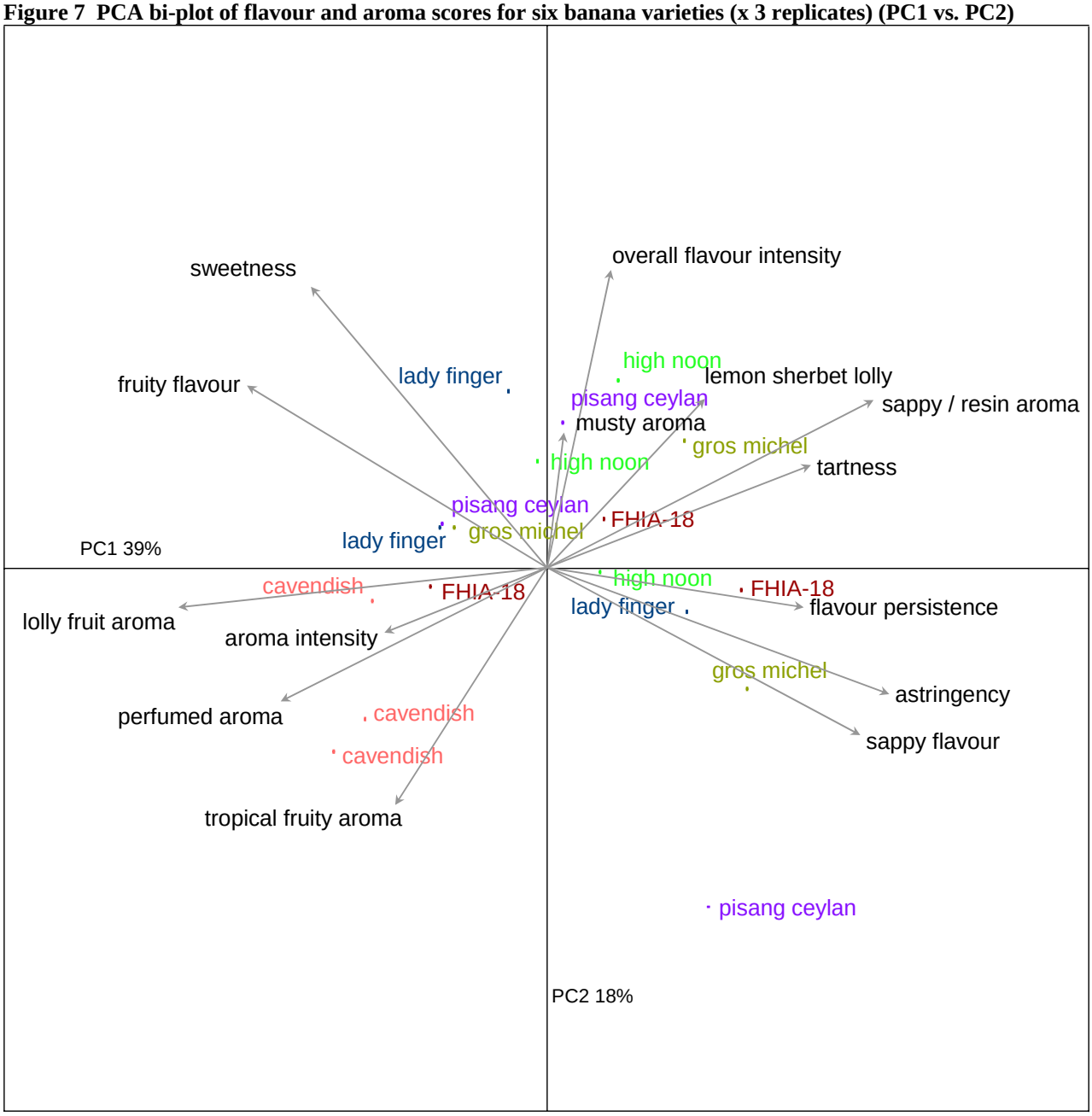
Overall, replicate samples of the Cavendish variety was found to be the most tightly clustered of all the varieties. Some separation and clustering was observed between replicates of the other varieties; however, in most cases one particular replicate of each variety was separate from the other two resulting in overlap between varieties (certainly in the case of Pisang Ceylan). There was no pattern by which one replicate from all varieties was consistently an outlier.

From visual observations of the PC scores, the first PC (39%) separated the samples according to fruit that were scored higher for sweetness, fruity flavour, lolly fruity aroma, aroma intensity, perfumed aroma and tropical fruity aroma (Cavendish) from those that were higher in sappy / resin aroma, tartness, flavour persistence, astringency and sappy flavour (Gros Michel).

In the second PC (18%), fruit were separated according to bananas that were higher in sweetness and overall flavour intensity from those that were low in these attributes and higher in tropical fruity aroma. Typically this was not driven by varietal differences, rather by individual fruit differences

across the replicates as shown clearly by separation of one replicate from within the Pisang Ceylan variety.

Figure 7 PCA bi-plot of flavour and aroma scores for six banana varieties (x 3 replicates) (PC1 vs. PC2)

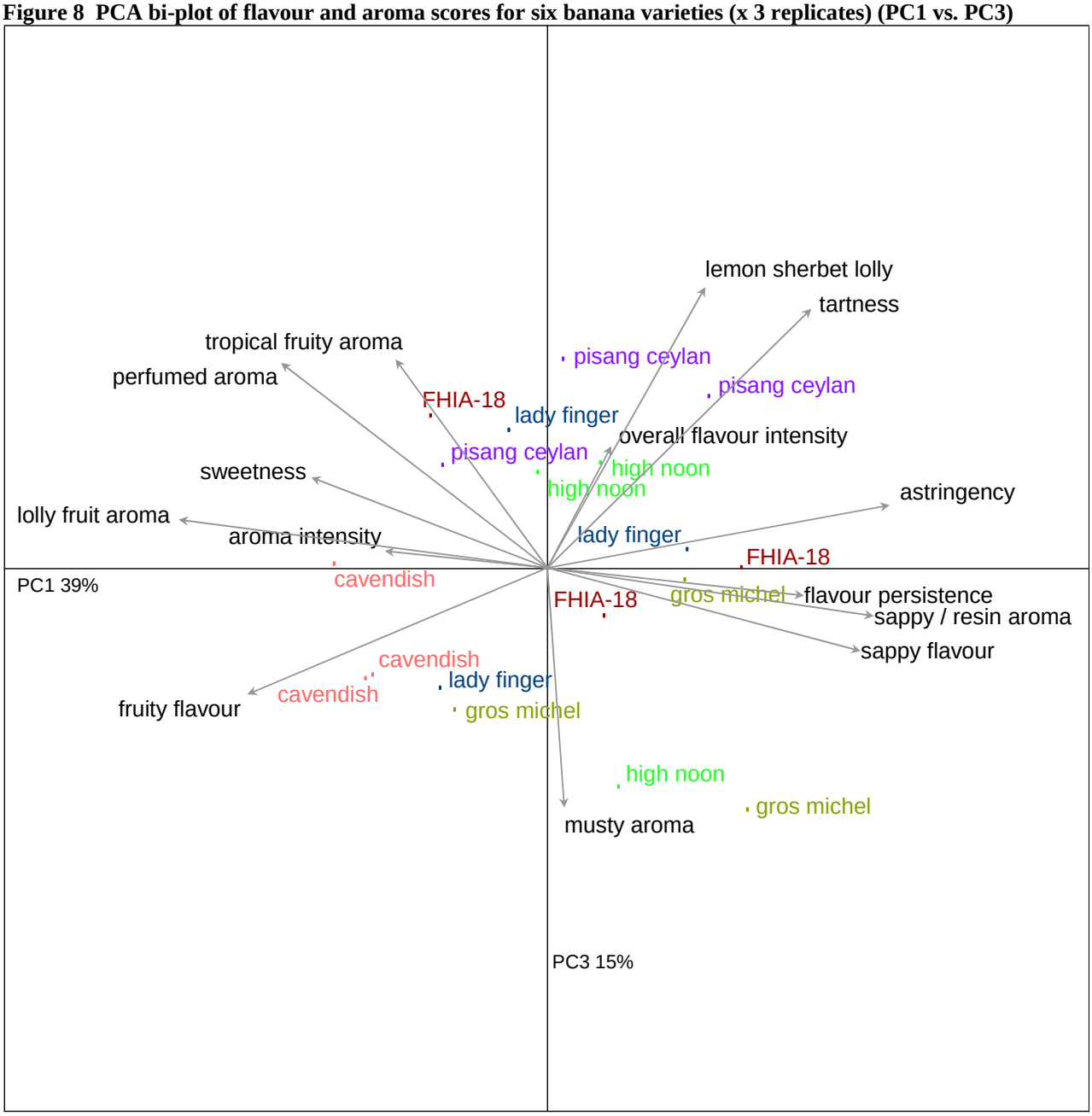


The third PC (15%) separated fruit according the attribute musty aroma. Typically Gros Michel bananas were higher in musty aroma compared to Pisang Ceylan fruit which were low in musty aroma.

For preference mapping purposes it would have been ideal to include the fruit samples as separate replicates due to the marked difference observed for certain replicate fruit within each variety. As the consumers only tasted one example of each variety this is not possible. Furthermore, the samples tasted by each consumer were not identical pieces of fruit or composite samples of fruit due to large number of consumers involved. Therefore the consumer data itself would encompass the variations observed within any one variety. As mentioned previously, this is a challenge of working

with naturally variable horticultural products where there is a balance between what is practically and logistically possible and what is ideal.

Figure 8 PCA bi-plot of flavour and aroma scores for six banana varieties (x 3 replicates) (PC1 vs. PC3)



Preference mapping for banana varieties

Preference mapping was used to map acceptability data for each consumer group (cluster) onto both banana varieties and a sensory profile of the banana varieties obtained from the trained sensory panel assessments.

The advantage of preference mapping is that it helps identify new markets, provides direction for future breeding programs and information on market segmentation, with respect to sensory preferences.

Two variations of preference mapping techniques have been developed and typically used by researchers when investigating consumer sensory preferences for a product type. These include internal and external preference mapping [24, 25].

Internal preference mapping uses a multivariate technique known as principal component analysis (PCA) to summarise the consumer preference data. The summarised data can be used to identify which bananas individual consumers prefer. Hierarchical cluster analysis may also be carried out on consumer preference scores to identify clusters of consumers with similar preference patterns. If the consumer clusters relate to particular socioeconomic variables, these patterns may also be defined.

External preference mapping uses a multivariate technique known as partial least squares regression (PLS). This technique may be used to relate sensory properties of the product with the acceptability data of individual consumers or clusters of consumers.

Internal preference mapping of consumers to preferred banana varieties

An internal preference map was produced (shown in Figure 9) for the three consumer segments identified by hierarchical cluster analysis (segments described in pages 42-47).

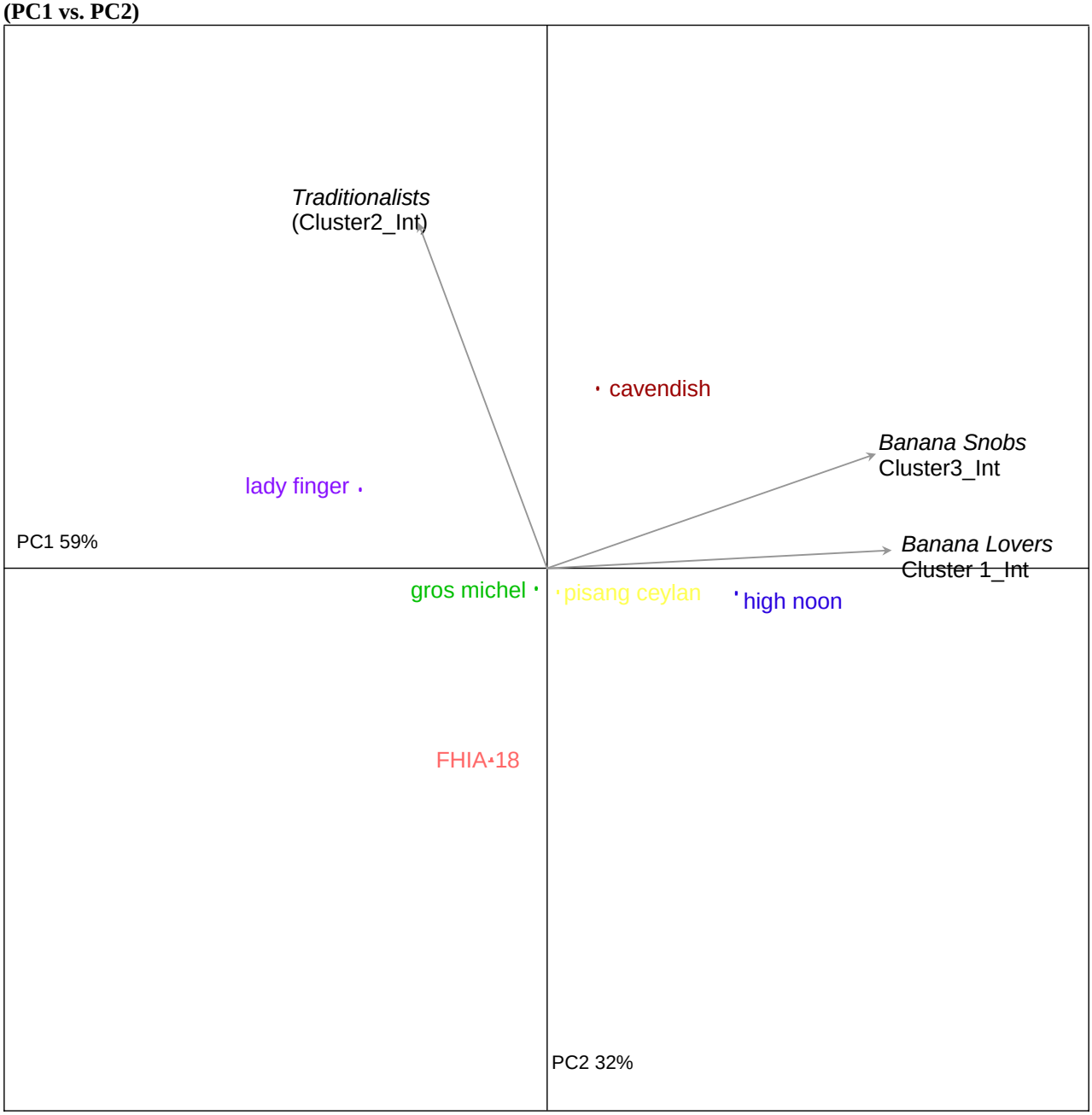
The first two principle components explained 91 per cent of variation within the data set. As a result, only the first two components were explored for relevant interpretation.

According to the preference map shown in Figure 9, both the *Banana Lovers* (cluster one) and the *Banana Snobs* (cluster two) had a preference for High Noon and for the *Banana Snobs* also for Cavendish. The least preferred varieties of these two groups were FHIA-18 and Lady Finger. *Banana Lovers* (cluster one) and *Banana Snobs* (cluster two) had the most similar preference patterns of the three groups identified.

The *Traditionalists* (cluster three) demonstrated a distinctly different preference pattern to the two other consumer groups. They much preferred commercial varieties Lady Finger and Cavendish and were not fond of either FHIA-18 or High Noon.

As expected, these results neatly summarise the findings already described in detail for these groups in the consumer data analysis (pages 42-45).

Figure 9 PCA bi-plot of consumer clusters according to preference for internal sensory attributes of banana (PC1 vs. PC2)

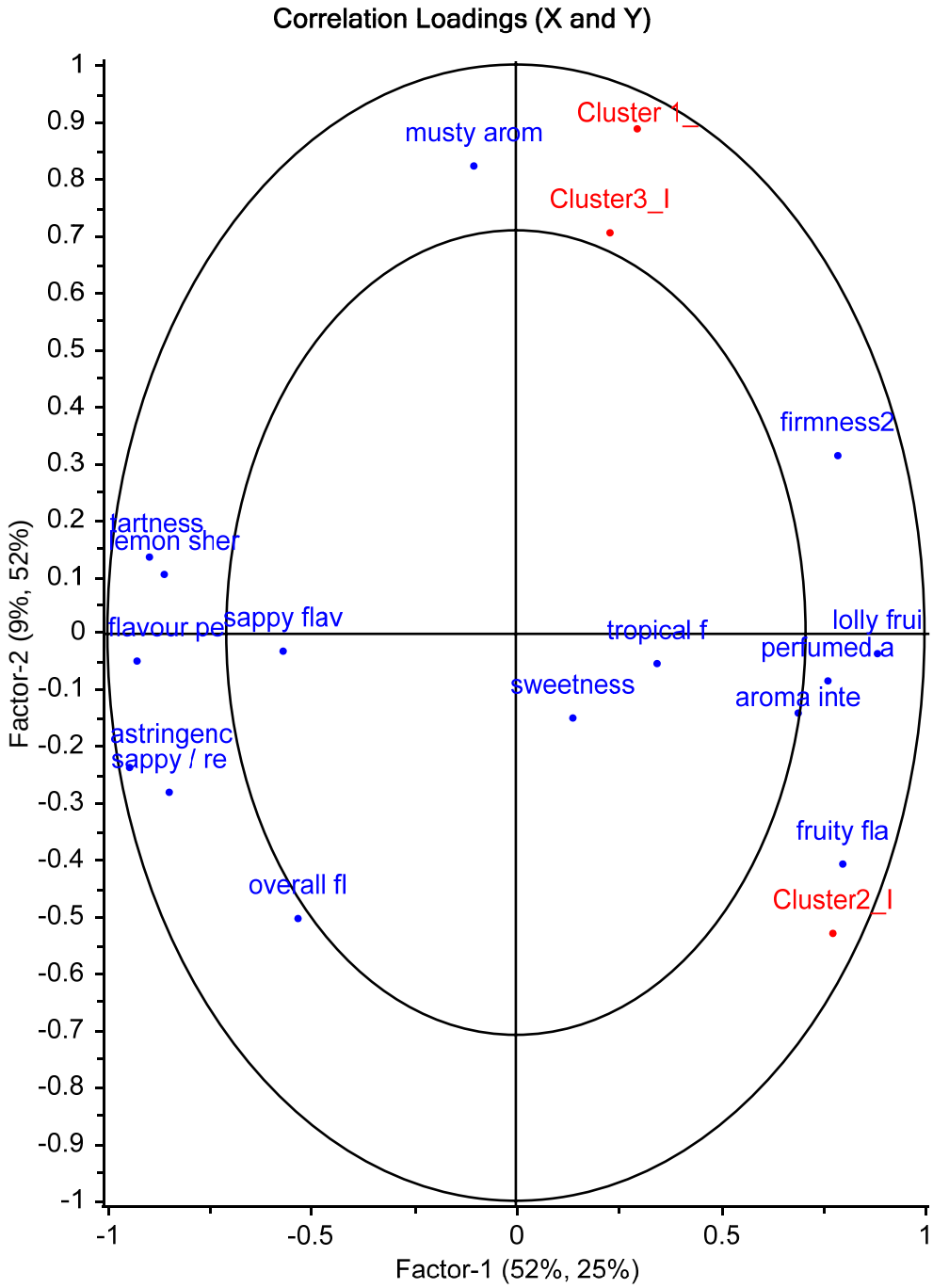


A preference map was also produced for the three consumer groups which were identified according to external assessments of the fruit; however, as this was heavily influenced by the commercially grown blemish-free appearance of Cavendish and Lady Finger, this was disregarded.

External preference mapping for banana

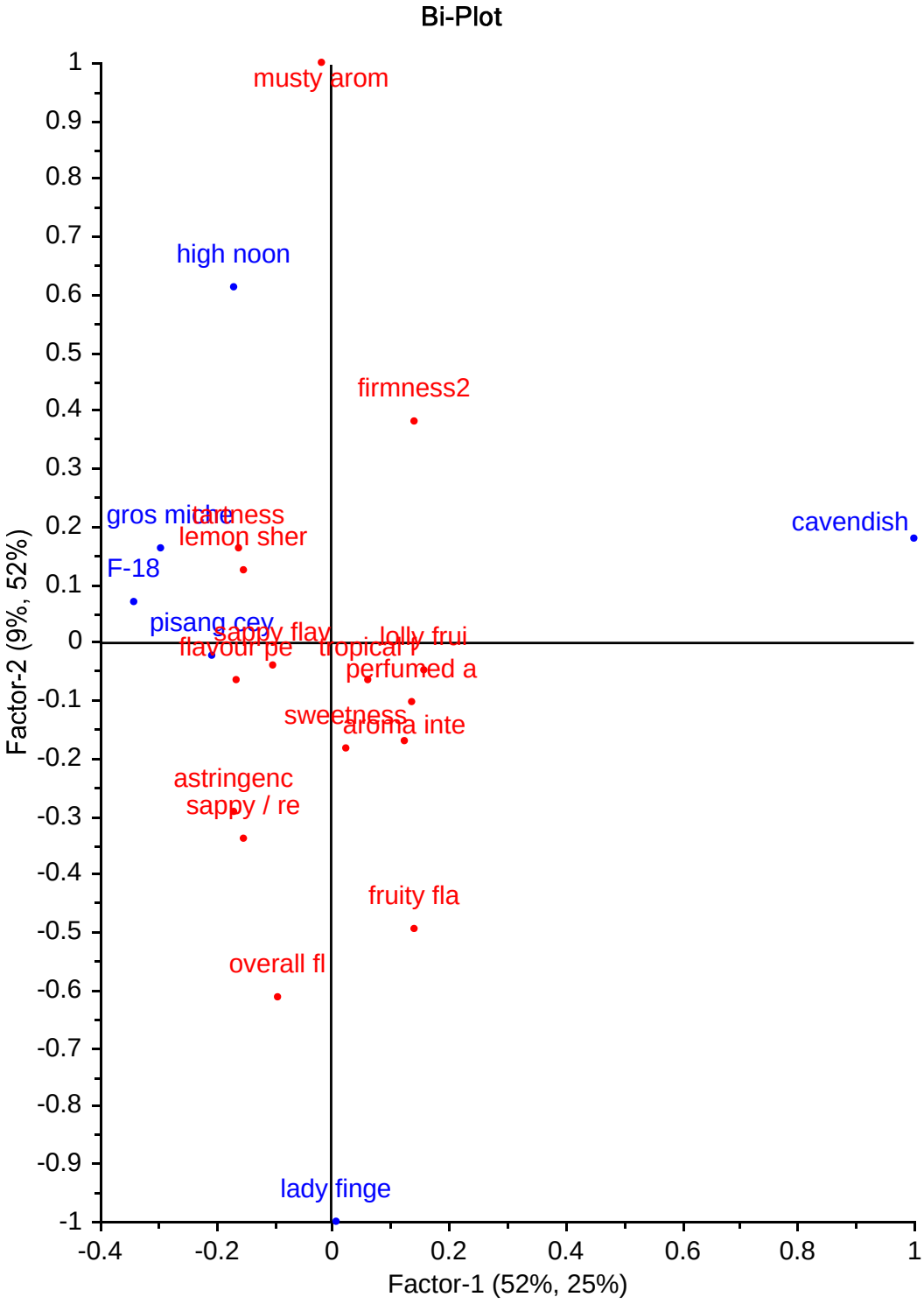
External preference mapping was performed where a model was developed (using PLS2) to predict consumer preferences based on sensory attribute scores for the six bananas assessed. The external preference map is shown in Figure 10 and the corresponding bi-plot in Figure 11.

Figure 10 PLS2 X and Y loadings plot of flavour, aroma and texture attributes and 3 consumer clusters for six banana varieties (average of 3 replicates for each variety) (Factor 1 vs. Factor 2)



The groups *Banana Lovers* (cluster one) and *Banana Snobs* (cluster three) appeared to prefer varieties that had a firmer texture and it appears from the plot that they may prefer higher musty aromas. This should be viewed with caution however as the scoring of the musty aroma attribute by the sensory panel was not statistically significant between the varieties and is unlikely to be contributing relevant information to the model. *Banana Lovers* (cluster one) and *Banana Snobs* (cluster three) did not like bananas that were softer in texture with higher overall flavour intensities, sappy / resin aromas and astringency. These groups had no distinct preference either way for bananas that were either more tart with a lemon sherbet aroma with low aroma intensity or bananas that were sweeter with lolly, fruity, tropical and perfumed characteristics with high aroma intensity.

Figure 11 PLS2 scores and loadings bi-plot of flavour and aroma attributes for six banana varieties (average of 3 replicates for each variety) (Factor 1 vs. Factor 2)



Traditionalists (cluster 2) preferred sweeter bananas with a high overall aroma intensities, fruity flavours and tropical, lolly fruit and perfumed aromas. They also preferred a firmer textured banana. This group did not like musty, lemon sherbet or sappy/resinous aromas for banana, tartness, astringency, sappy flavour nor long flavour persistence.

Implications and recommendations

Based on the results from the study, it can be said that consumer involvement in purchase and consumption of bananas is relatively high for a horticultural product. This implies that consumer attitudes and preferences for bananas affect not only the purchase process but also satisfaction and loyalty with the product.

Overall the results indicate that for the bananas included in this research, High Noon has high acceptability amongst the majority of participants. This banana was, in general, equal in acceptability ratings with Cavendish. However, when consumers were clustered into groups defined by preferences, High Noon was the preferred banana variety for 80 per cent of respondents. The results from preference mapping reveal that High Noon, while similar in some sensory aspects to Cavendish, displayed other features dissimilar to the market dominant variety. This indicates that the sensory needs for the majority of consumers are not being entirely met by industry.

The characteristics identified which all consumers clearly disliked in banana were astringency, soft in texture and sappy/resinous aromas with long flavour persistence. It is recommended that a new variety selected for diversification of the Australian market avoid these characteristics.

These results based on consumer needs and wants suggest that a gap in the general market exists for an alternative banana variety. Based on these results, an opportunity may exist for market expansion by developing a market for High Noon bananas in Australia.

Considering the current avenue for alternative bananas is niche markets targeted at Asian or Islander communities, a limitation of this study is the consumer samples reliance on a general population. Further research might sample only consumers from more defined communities.

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Comparative gross margin analysis for Cavendish and Ducasse banana enterprises in north Queensland

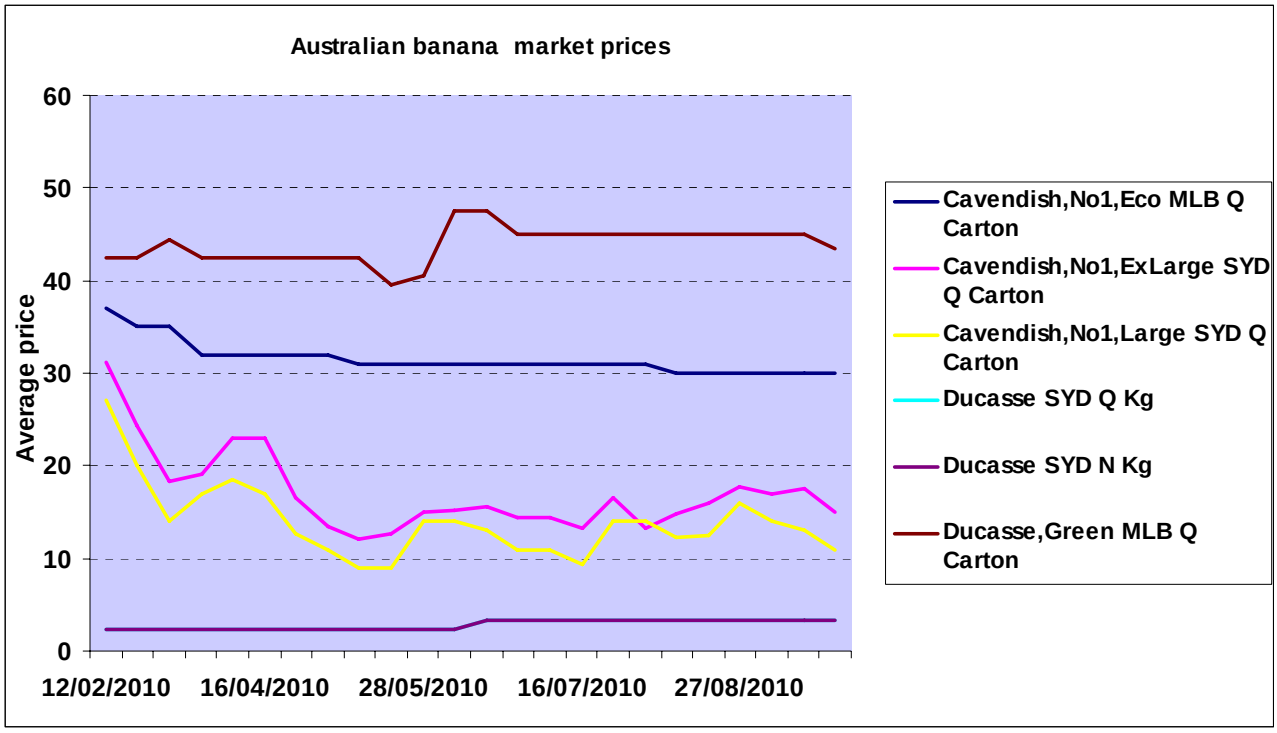
Introduction

The analysis estimates average gross margins to examine the numerical economic benefits and costs of growing alternative banana varieties in the region. The Ducasse - a sweet banana popular in Thailand - is chosen as the alternative variety. Cavendish, as the largest banana crop grown in the region (around 95%), is used as the base case. Interviews from banana growers and research also identified the major incentives and disincentives for this diversification.

A comparison of Cavendish and Ducasse banana prices

In the short-term Cavendish market prices tend to fluctuate more than Ducasse market prices. This can be an advantage or disadvantage for growers, depending on their business strategy and risk psychology. It is important to note that data over a longer period will show a clearer picture of any seasonal price movements. Figure 12 provides a snapshot of 2010 market prices for Cavendish and Ducasse.

Figure 12 2010 market prices Cavendish and Ducasse



Source: Australian Weekly Banana Report; Australian Banana Growers Council

Methods

Gross margin is simply operating revenue minus operating variable costs. Variable costs are unit costs that move in proportion to unit revenue. Gross margin analysis is a partial analysis and is only effective when fixed assets do not change much with a change in production. Also gross margin estimates are based on average market prices and costs per production year, and assume production at normal capacity. The gross margin is therefore a static comparative analysis.
However gross margins are rarely static, therefore a sensitivity analysis is done to demonstrate how changes in prices and yields affect gross margin.

The economics research and analysis work summarised the significant points of the production benefits and costs of growing alternative banana types. Ducasse was chosen as the alternative because there was sufficient economic information - making it a more accurate and meaningful analysis.

The data were obtained from interviews with growers and also research papers. Banana market prices were obtained from growers and markets. Average yields and input costs are also measured in carton per hectare. Input costs include:

- land preparation and planting cost
- machinery costs (fuel, oil, repairs and maintenance)
- fertiliser
- weed, pest and disease control
- harvest and post-harvest activities
- packaging
- marketing
- labour
- freight to market.

Input cost structures may vary substantially from business to business and are influenced by size of operation, climate, and access to resources and distance to market.

Other economic aspects should be considered with changes in banana production such as cost escalation, efficiencies over time, substitution of resources – land, labour and capital, returns to scale, cost of capital, and regulations.

Also gross margin does not include capital costs and other start up costs, for example the purchases of an extended ended boom to harvest bananas from higher plants.

Results

Gross margin

The Cavendish gross margin in north Queensland is estimated at $9,458 per hectare, and the Ducasse gross margin is almost the same, estimated at $9,478 per ha. The plant cost for Ducasse is slightly higher due to the material planting costs. These are presented in Tables 8 and 9.

Table 8 Cavendish summary

	$/Carton	$/Ha
Plant cost first year	$2.43	$7,732
TOTAL VARIABLE COSTS - ongoing average	$17.03	$54,262
GROSS MARGIN - ongoing average	**$2.97**	**$9,458**

Table 9 Ducasse summary

	$/Carton	$/Ha
Plant cost first year	$3.76	$8,378
TOTAL VARIABLE COSTS - Plant	$25.00	$55,750
GROSS MARGIN – Ongoing average	$4.25	**$9,478**

Sensitivity (prices and yields)

The price sensitivity tables 10 - 13, and figures 13 and 14 show how changes in prices and yields affect gross margin. The base price and yield is $20 and 3186 cartons/ha respectively for Cavendish and $29.25 and 2230 cartons/ha for Ducasse.

Table 10 Cavendish price sensitivity

$/Carton	Gross Income	Variable Costs	Gross Margin
$13.00	$41,418	$54,262	($12,844)
$20.00	$63,720	$54,262	$9,458
$25.00	$79,650	$54,262	$25,388
$30.00	$95,580	$54,262	$41,318
$50.00	$159,300	$54,262	$105,038

Table 11 Ducasse price sensitivity

$/Carton	Gross Income	Variable Costs	Gross Margin
$20.00	$44,600	$55,750	($11,150)
$25.00	$55,750	$55,750	$0
$29.25	$65,228	$55,750	$9,478
$40.00	$89,200	$55,750	$33,450
$50.00	$111,500	$55,750	$55,750

Figure 13 Cavendish sensitivity of return to sale price and yield

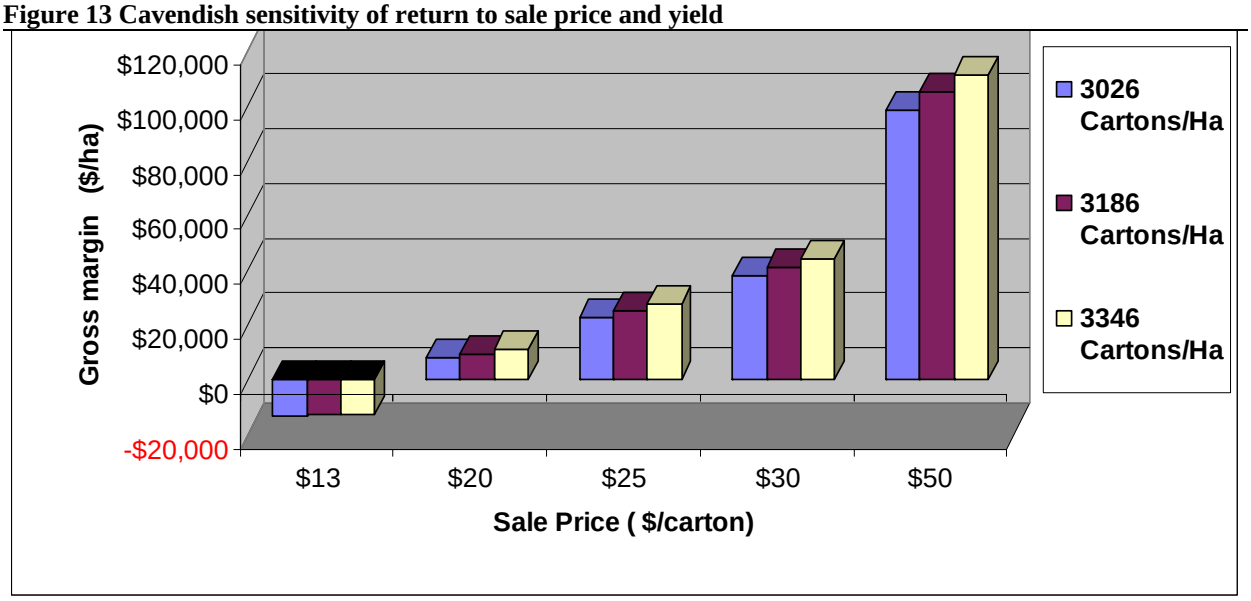


Table 12 Cavendish sensitivity of return to sale price and yield

% change	Yield (Cartons/Ha)	Sale Price ($/carton)				
		$13	$20	$25	$30	$50
5%	**3026**	-$13,216.50	$7,965.50	23,095.50	38,225.50	98,745.50
0	**3186**	-$12,843.94	$9,458.06	25,388.06	41,318.06	105,038.06
5%	**3346**	-$12,471.38	$10,950.62	27,680.62	44,410.62	111,330.62

Figure 14 Ducasse sensitivity of return to sale price and yield

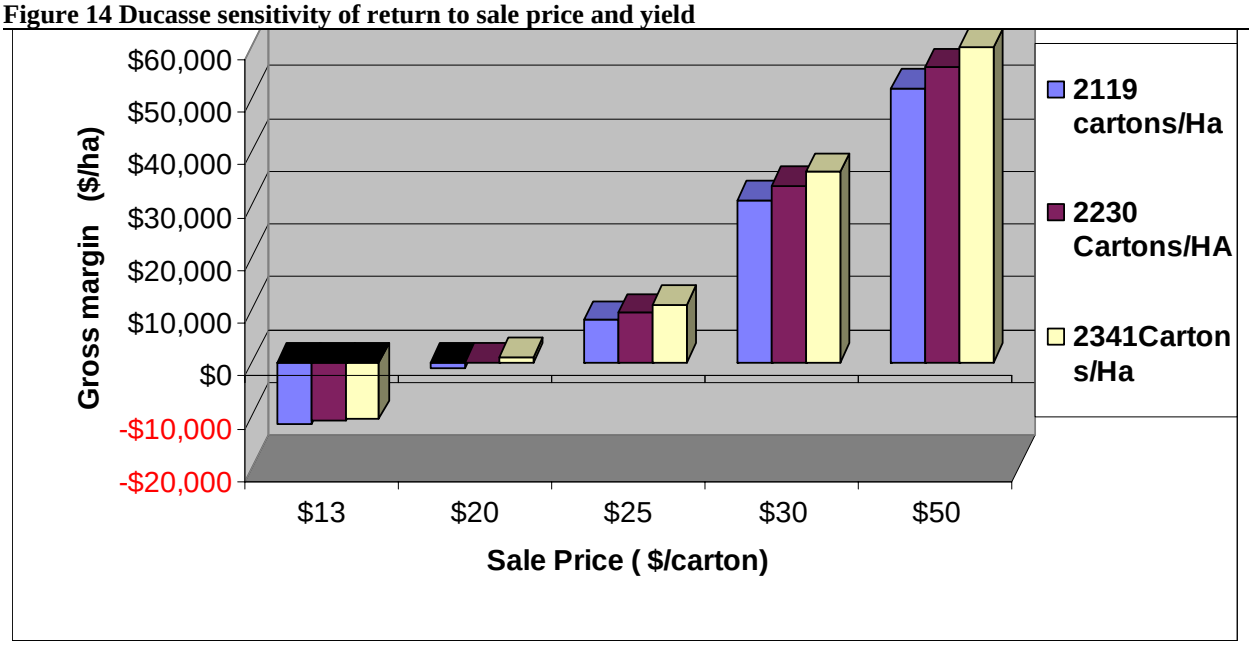


Table 13 Ducasse sensitivity of return to sale price and yield.

% change	Yield (Cartons/Ha)	Sale Price ($/carton)				
		$20	$25	$29	$40	$50
5%	**2119**	-$11,614.71	-$1,019.71	7,986.04	30,765.29	51,955.29
0	**2,230**	-$11,149.51	$0.49	9,477.99	33,450.49	55,750.49
5%	**2341**	-$10,684.31	$1,020.69	10,969.94	36,135.69	59,545.69

Incentives and disincentives for growers to diversify into Ducasse production

This study revealed several market and production elements that may act as incentives and disincentives for Australian growers of Ducasse. Motivation for diversification into Ducasse include the higher and more stable prices compared to other varieties, as well as the potential to provide higher revenue as 6-7 bells (male buds) may be sold at around $50- 60 per carton. Ducasse may also present as a desirable organic product due to its general resistance to leaf spot disease. Furthermore, the variety would seem to have a consumer advantage, as consumers prefer the sweet taste.

Various deterrents to Ducasse production are apparent. A principal disincentive to producing the variety is its susceptibility to Panama disease. Other growing obstacles to uptake include lower yields leading to greater sensitivity to changes in market prices, and the shorter plant life. Furthermore too many hectares devoted to Ducasse may saturate the market, bringing a significant

drop in banana prices. Harvesting problems are also evident. Ducasse may be difficult to pick and plants and ratoons are tall compared to Cavendish. This extrapolates into increasing labour and capital costs as new harvesting booms are required. Ducasse ripen quickly, potentially causing supply chain problems and higher costs, particularly when there are long distances to market. This also means the variety has a shorter shelf life. From a consumer perspective awareness of Ducasse must be generated and some education undertaken. For the main Asian target, availability must coincide with particular moon phases as per their custom.

Other considerations for banana production (Cavendish and others)

Several other considerations for general banana production were revealed during the course of this study. Production costs and other input costs have been rising faster than the general rate of inflation. Since banana growers trade in a competitive market they cannot pass on cost increases up the supply chain. Product perishability is also an issue. Growers are price takers and cannot hold or re-direct consignments if prices are unsatisfactory. Market volatility is a concern as oversupply of a market results in a high degree of price volatility.

Growers are also at a high degree of risk exposure. Banana crops are susceptible to damage and this can reduce the quality of the product and attractiveness to potential buyers and consumers. These risks include exposure to weather, sunlight, high temperatures and disease amongst others. Further risk comes from potential market threats. This includes unpredictable changes in trade policy by overseas countries.

Industry Road Map

As previously stated, the overwhelming majority (95%) of bananas produced in Australia are Cavendish. A mere 4 % are Lady Finger whilst the remainder is mostly Ducasse, Sucrier and Pacific Plantain (this is where we are now). Despite much effort by researchers and growers alike this situation has not changed remarkably over the last 20 years (this is where we've been for a while now). If significant market growth of alternative varieties is to occur (if this is where we want to get to) we need to have a good understanding of the forces that have got us to where we are now and which strongly influence our ability to get to this other destination (significant market growth of alternative varieties) and then do things differently than we've done in the past. It would seem to be unproductive to repeat past behaviours and expect a different outcome

Our literature review and survey of the supply chain have revealed the following **major forces and issues** at play:-

1. The Australian domestic banana industry is characterised by mass marketing of its product. Mass marketing refers to a broad-brush, unfocussed attempt to appeal to an entire market with one basic marketing strategy utilising mass distribution and mass media. It is also called undifferentiated marketing. It is this mass marketing which has contributed to the narrow variety focus in the banana industry. Having just one variety, in what is a complex supply chain, has facilitated very successful mass marketing of bananas. This contributes to point 2.
2. There is not a great deal of room for niche varieties in such a system – particularly if their ripening or other requirements in the supply chain differ from that of Cavendish. Varieties other than Cavendish and Lady Finger currently exist in the Australian market largely without controlled ripening. This promotes quality issues. Fruit quality is adversely affected

particularly at the extremes such as chilling damage and associated poor fruit colour development at low temperatures, and poor shelflife at high temperatures.

Non-Cavendish varieties are low yielding (one quarter to three quarters of Cavendish). This means alternative varieties are unable to compete with Cavendish in the mass market because they need to sell at premiums of between about 20 to 200 per cent to be profitable (worth growing). An example is Lady Finger which requires roughly a 100 per cent premium to be a worthwhile crop. Thus they are not well suited to mass marketing, a character of which is "high volume sales at low prices". To ensure market success, non-Cavendish varieties must provide value for the consumer to compensate for the high premium. This value might be in the form of such attributes that Cavendish cannot replicate such as taste, size, shelflife, environmental credentials and so on. If this value is not apparent then sales of the alternative variety will suffer adversely at the hands of the mass marketing phenomenon as the crop cannot compete with Cavendish on price.

3. Thus non-Cavendish varieties really need a different system. In the Australian market Cavendish and non-Cavendish bananas are generally considered a commodity product (a good for which there is demand but which is supplied without qualitative differentiation across a market i.e. equivalent regardless of who produces it, like milk) rather than a premium product. A premium product will tend to have points of differentiation including brand, packaging, reliable eating quality and so on. The successful marketing of niche varieties will require high quality standards, marketing company support and marketing activities that lift the product from commodity to premium. (note by author JD: an example might be a blue tipped Lady Finger marketed as "when only the best will do" or "it's the ones which blue tips rejects that makes blue tips the best!"). To ensure success a premium product must be perceived as more desirable by consumers (note by author JD: "the sweeter banana which always delivers"). Supply control is required so that prices are kept up strongly positioning the product as something of value and so support development of the category. The product must tick all the boxes where possible such as appearance, taste, distinguishably different, environmental credentials, availability and so forth. To grow the size of such a category requires good control on supply and quality so that consumers begin to associate price with quality. Currently such associations are poor on a week to week basis.
4. There are questions over the real commitment by the supermarkets to new varieties. A regular turnover of both policy managers and store managers often means inconsistent decision-making with regard to alternative varieties. This suggests investments by growers in new varieties are a risky proposition. Supermarkets also need to be convinced that there will be continuity of supply of product lines. This is an area that many small / niche industries struggle with.
5. However, under current circumstances if supermarkets are not part of the equation then the suppliers are limiting themselves to 20% or less of the overall market such is the dominance of supermarkets. Larger players may have better prospects of developing niche varieties into supermarkets than smaller growers because of existing relationships with them. There is evidence of this occurring already. But they will first need to overcome the following difficulties identified by growers in the supply chain survey:-
    a. Short lines of product are better suited to scale of operation of small business
    b. Demanding requirements in field/packhouse to deliver quality fruit needed to get the profitable market prices necessitates experienced/skilled workers not a backpacker workforce typical of larger farms

c. Small businesses are better able to exploit local markets and provide the necessary sales pitch at point of sale and avoid conventional supply chain bottlenecks brought about by noneconomies of scale.

6. Marketing companies such as OneHarvest already have strong relationships with the supermarkets. Their management of the supply chain includes branding of product, quality management and other activites directed at lifting a commodity to a premium product. This may be beneficial for growers of alternative varieties but it will probably require 21st Century growers to make this work.
7. The market for non-Cavendish is largely 'ethnic' based. This is particularly true of Ducasse, Sucrier and Pacific Plantain which are mostly retailed in ethnic enclaves. This may also be true to some extent with Lady Finger whose 'ethnic' group are SE Queenslanders and northern New South Welshman who have traditionally had access to the variety from backyards and local commercial producers for over a century. Notably Lady Finger in the Brisbane market has 10 times the per capita consumption of the Melbourne market. Internationally the non-Cavendish export trade is also largely ethnic market based- with Plantains the most important category. Catering to the ethnic market is catering to a [market] need which is why it is successful. Thus further growth may be possible using this thread.
8. Diversity has been embraced in the Australian marketplace for a range of fruit species. Often however, diversity is favoured by different production windows for seasonal fruits. But bananas are not really seasonal – Cavendish fruit can be independently supplied fresh the year round from several locations in Australia. Comparisons are probably better made with tomatoes which can be made available to the marketplace year-round albeit from a range of locations. The market needs tapped for tomatoes have been variations in size, texture, colour and purpose and marketing companies have been critical players in the successful development of niche varieties. The banana industry needs more up-to-date information from consumers as to what needs they have in a banana / and opportunities that might be created that are not currently being catered for and determine if they can meet such needs profitably.
9. Find a need and meet it - variety diversification can work as a strategy to grow the market if the benefits created by the new variety are convincingly communicated to the consumer. It is not enough to develop a variety just for the production ease of producers. Such was the case which led to the demise of Goldfinger.
10. The need for artificial ripening of bananas to ensure orderly marketing of quality product is seen as one of the obstacles to diversification. However, artificial ripening of product in Australia is not peculiar to bananas with significant quantities [~50%] of papaws and mangoes being treated to this process. For papaws and mangoes artificial ripening is undertaken largely at the grower end. This is less suited to bananas because many markets have a mandatory requirement to arrive in the wholesale market in a hard green condition to ensure freedom from quarantined fruit flies. Also bananas are much more subject to bruising once ripening has begun. Thus growers of niche varieties may need to organise artificial ripening in the market place themselves. This is another reason for being connected to a marketing company who could coordinate such requirements for a group of niche variety producers.

Market Opportunities for Niche Varieties

Several opportunities for niche varieties were revealed:

1. Significant supermarket sales will require support of a marketing company which can coordinate and control supplies and essentially 'manage the category' reinventing niche bananas as a premium product. This would be to the advantage of suppliers because the retail buying dynamic within a premium category places much more control and power in the hands of the supplier, not the buyer.
2. Direct sales to the public at fruit stalls, farmers markets, door to door sales etc better suits the adoption of new varieties as the grower is better able to manage quality , provide consumer advice and get the required consumer feedback. However, the current major production region is distant from most of the larger markets. Subtropical producers in southern Queensland and NSW have an obvious opportunity to exploit this further, but its development is partly stifled by Fusarium wilt affecting both Cavendish and Lady Finger in the subtropics. In recent years the subtropical industry has increased proportionally away from Cavendish and towards Lady Finger but this has been at the expense of Cavendish and not as a result of increased production of Lady Finger. However, we estimate that sales through these channels would not exceed 3-4% of total banana sales – small but not insignificant.
3. Further development of existing ethnic markets and identification of new ones e.g. Horn Plantain for African and Latin American ethnic communities.
4. The banana industry is currently pursuing the snack market with its general banana promotional efforts. An opportunity may exist to exploit this strategy to promote varietal diversity. Varieties would give useful diversity but it may complicate matters. One author (JD) suggests the slogan "Banana varieties – the healthy energy snack with choices for on the go".
5. An opportunity may also exist for exporting niche varieties. An example may be an Eco-Lady Finger for upmarket Asia. If there are to be opportunities for Australia to export bananas it will come from premium products including varieties.

Market / Supply Chain Development Recommendations

The following recommendations are based on information obtained from numerous industry (wholesalers, retailers, food service) interviews during the course of the project. Interview notes are attached as Appendix 2

Recommendations are in order of priority.

1. **Short term** the banana industry focus any generic "diversity of product" promotion effort toward market development of the Lady Finger variety. Lady Finger can be seen as a testing ground and vehicle for change – if industry growth can be achieved with Lady Finger the results could then be extrapolated to other niche varieties. For Lady Finger there may be issues of capacity to supply a larger market because of its susceptibility to Fusarium wilt. But perhaps further new plantings in north Queensland or elsewhere with proper attention to quarantine may be able to get around this issue.

2. **Medium term**, pursue opportunities for other varieties such as African Plantains in targeted city suburbs with significant ethnic populations. Growth suburbs with migrant populations,

particularly in Sydney (Cabramatta, Ashfield, Bankstown, Blacktown) and Melbourne (Footscray, Box Hill, Springvale, Newmarket, City, The Glen).

3. **In the longer term**, position / promote other banana varieties as an anchor product (available year round) in an "exotic fruit" category. The category would include seasonal products such as rambutan, longan, durian, mangosteen etc. This strategy has been recommended to the exotic fruit industry on a number of occasions. Successful examples of this approach include 'international' food and 'organic' food sections on retailer's shelves.

Note : Significant development of the niche banana variety market will require the involvement of a marketing group/company responsible for managing the category, promoting the value proposition of a premium brand. Ideally this would work best for a private variety, not a public one like Lady Finger, but with appropriate branding and focus on quality (not just external appearance) progress should be possible. Recommendation three will be difficult to achieve / coordinate post Cyclone Yasi with many complementary exotic fruit industries suffering a drop in production.

Research & Development Recommendations

- In the consumer analyses High Noon was the preferred variety for 80% of respondents. The results from the sensory analysis indicated that High Noon had some sensory aspects similar to Cavendish but some that were not indicating that the sensory needs for the majority of consumers are not being entirely met by industry. An opportunity may exist for market expansion by developing a market for High Noon in Australia. Next steps for consumer research for High Noon would be focus groups:-
    a. Targeting consumers from the 'general banana-eating market' from Melbourne, Sydney and Brisbane (a broader base).
    b. Identify if the 'High Noon' variety meets other needs of the consumer for size, shape, convenience. Determine other attributes that would be ideal to incorporate with the banana to identify the High Noon as identifiably distinct for consumers (cf. Cavendish or Lady Finger).
    c. Identify consumer willingness to pay. How much *more* would consumer pay for High Noon if it was marketed and presented in a unique way that met their perceived needs. Determine the potential value for the industry.
    d. Use information to develop a marketing strategy for the industry (e.g. different name, other unique identifiable markers such as product presentation, packaging, location of sale, and other marketing/branding messages).

- A limitation of the current consumer analysis was the focus on the general population. Considering that alternative varieties are currently targeted at Asian and Islander communities, further research might sample only consumers from more defined communities to better understand their needs. However, this would be a very costly exercise, and would need a significant amount of assistance from ethnic / cultural support groups in the major metropolitan cities.
- Varietal research and development needs to continue given the disease threats facing the industry but such efforts need to be closely linked with market research into consumer behaviour conducted by expert agencies to allow matching of varieties to the preferences of different groups of consumers to maximise their adoption prospects.

- In a longer term context of varietal change in response to disease incursions and market opportunities, if we wish to talk beyond the small niche markets, then yields have to be there otherwise growers would be wasting their time for the scale they would need to operate at. Thus a suggestion is to modify Cavendish [which has the yield feature] in ways that are an advantage to consumers and growers. Points of differentiation might be sweeter/better taste, health features [orange flesh perhaps] or some aspect of convenience [e.g. shelflife]. This product would ideally be distinguishably different both for the customer and the checkout. It is suggested that differentiation occur in more than one attribute. This is the domain of genetic engineers and outside the scope of this report.

Technology transfer

Staff extension activities

DEEDI had a press release in July regarding the consumer and sensory analyses aspects of the project which generated a lot of publicity and led to articles in several newspapers, including a feature in Brisbane's Courier Mail, several radio interviews as well as a segment on ABC TV News.

Publications 2009-2011

Reports and Technical Publications

Daniells, J.W., O'Keefe, V., Fanning, K., Smyth, H. and Telford, P. (2010) Roadmap for development of niche variety markets. *BAPNET Bulletin* **14**(1):3. [brief article describing the project underway for R&D audience in Asia/Pacific also seeking input from readers on their experiences on the subject]

Daniells, J.W., O'Keefe, V., Fanning, K., Smyth, H. and Telford, P. (2010) Niche varieties – what are their prospects and the way forward?' *Australian Bananas* **30:**41. [brief article describing the project to the Australian banana industry]

Daniells, J.W. and O'Keefe, V. (2010) Banana production challenges in the subtropics – are banana varieties part of the solution? Paper presented at 28th International Horticultural Congress in Lisbon, Portugal in August 2010 [eventually to be published in *Acta Horticulturae*] [discusses some of the issues confronting the adoption of new varieties and the further challenge of doing so as a subtropical producer].

Daniells, J.W., O'Keefe, V., Fanning, K., Smyth, H. and Telford, P. (2010) Expanding varieties may increase sales. Banana industry annual report 2009/2010, page 3. HAL. [project overview for HAL Annual Report]

Appendix 1 Literature Gleanings – Salient points and their implications

Other banana industry development reports as well as new crop industry development experiences shed additional light on issues and factors important in the development of the non-Cavendish banana industry which are now covered.

The 1999 Banana Consumer Research Report (Wilson, 1999) indicated the following opportunities for possible market expansion by better meeting consumer needs.

- Australian consumers require "the availability of a mix of banana sizes". Varieties can broaden the range available to meet virtually all possible requirements.
- Consumers have a range of expectations for fruit shelflife which could be satisfied by a range of varieties.
- "Over a third of consumers believed the taste of bananas generally available in stores required improvement" – taste requires attention. Growers of niche varieties could capitalize on this but need to know how to optimize taste attributes with their growing environment (climate & crop management) and ripening protocol.
- "Cycles of oversupply and undersupply places profitability pressure on all parties in the supply chain" - the perennial problem in banana industry. Crop forecasting and staggered production is desirable. Do banana varieties offer supply control options? Yes for some but the remainder are in public domain. Production coordinated from several regions (geographic diversification) would be particularly desirable in the event of a severe cyclone so that supply disruption is lessened.

The subtropical banana industry has shown far more interest in non-Cavendish bananas than growers in the wet tropics mostly because they have difficulty competing directly with the Cavendish type. The recent report by Brian Ramsay on market development for the subtropical banana industry (Ramsay 2009) while not giving any attention to varieties, does have well considered recommendations with relevance to niche variety market development which include:-

- "Profitable niches are possible if **quality**, **consistency** and volume of supply [can be improved] and combined with **effective marketing** and **supply chain partnerships [*read strong relationships*]**"
- "The key opportunity for growth in short to medium term is in expanding supply to **premium independent food and produce retailers** in capital city markets…these retailers are actively looking for ways to differentiate their product". The message here is that supermarkets are less supportive of niche market development and that significant sales of niche bananas are in the capital cities where the vast majority of people are and that direct connection [fruit ripening could be an obstacle to overcome and one that does not facilitate diversity] and possible partnership (rather than via merchants/agents in central market) with those desperate to differentiate is desirable.
- "Consumers in these stores are also likely to be more open to new products and may be less price sensitive than regional and major supermarket shoppers. These consumers may be more engaged in product purchase and open to differentiation." If this is not certain then some study should be instigated to verify this.
- Ramsay asks the question "Who in the supply chain shares their interest in market development and may be willing to collaborate commercially?" Frieda Caplan, best known as the pioneer of kiwifruit, was for many years the only one in the US market place promoting the cause of new industries. More about her steps to success later.

- Ramsay also asks "How can subtropical growers leverage product attributes in the market" i.e. what are the attributes of [*varieties*] that you can promote to your advantage in the market? Daniells [21] has listed these previously for bananas as
  - better suited for cooking
  - longer shelflife
  - traditional ethnic purposes
  - curiosity value for displays
  - ease of supply as organic/pesticide-free
  - better/sweeter/different flavour
  - different appearance/size & more lately
  - ease of digestion
  - vitamin/mineral content
- Ramsay indicates that "premium pricing …would require high product standards to build and maintain". Niche varieties are not about cutting corners. Premium prices are paid for premium product.
- Ramsay also says that "if the value proposition of the Lady Finger variety [*and presumably any other*] can be better understood and communicated to consumers further market development and expansion may be possible". The value proposition is what the customer gets for his money. A value proposition can assist in a firm's marketing strategy and may guide a business to target a particular market segment - Convince who? that what? because why? Is the product aligned properly with the target?
- Product presentation /packaging was considered very important. "bags achieve good in-store impact and would be recommended for consideration by any commercial initiative which was seeking to attract a retail premium price" and also assists check-out operators to distinguish between different banana products where there is different pricing.
- "The banana industry as a whole invests in a mass marketing campaign to promote increased consumption…Within the category, individual commercial businesses have the further responsibility to support their own marketing initiatives." Market development goes beyond promotion! "a cost effective strategy...support product/point of sale activity in-store ..to…differentiate offerings from competitors and communicate the individual benefits of each product".
- Ramsay says that industry has a clear interest in [*niche*] market development but a limited role in its achievement – the responsibility of which rests with individual businesses. He lists 3 strategies at industry level for catalysing market development. The list is in order of increasing commitment, investment and risk.
  - (i) Develop Awareness – communications driven and low cost
  - (ii) Inform Decision Making – stimulating the development process by providing new information
  - (iii) Facilitate Action – active role in development of product quality and supply chain collaborations

The project report by Broadley (2003) on 'Enhancing market penetration of Lady Finger bananas' reported that consumers indicated they would buy more Lady Finger bananas if they were more readily available and at a cheaper price. Retailers said increased sales would require education, promotion, advertising, taste testing and price reduction. Broadley noted that historically most Lady Finger bananas were sold through the independent stores and not through the major supermarkets.

Fletcher (2002) has some perspectives on new crop development which have relevance to commercialization of new banana varieties.

- "New industries must have **sufficient capital** to finance infrastructure, systems and research and development"
- "Selling outside the system results in the undermining of prices"
- "The economy of distribution is heavily driven by volume. A strategic alliance is recommended with organizations which distribute complementary but not non-competitive products to same customer base"
- "Innovations …will only be commercially successful if they are marketed as applications that satisfy the needs of the consumer"
- "new crop products have usually been developed by relatively small companies with limited resources"
- "The challenge for new crop participants is to demonstrate the viability of their new crop products through active partnerships with all other components in the supply chain."
- "New crop participants often cannot accept that a commercially successful new crop product takes time to develop and the risks are high."

Key elements in developing a new industry that have been distilled by the Australian government's Rural Industries Research & Development Corporation (RIRDC 2009) and which are also relevant to new varieties include:

(i) Planning strategically
(ii) Setting goals
(iii) Researching market
(iv) Develop market strategy
(v) Supply chains and value adding
(vi) Overcoming production challenges
(vii) Managing R&D
(viii) Industry organization
(ix) Establishing effective communication and support structures
(x) Developing quality standards and codes of practice

The experience of Frieda Caplan in the United States in developing the market for new crops holds interesting insights. Frieda is best known as the pioneer of kiwifruit. For many years she was about the only one in the US market place promoting the cause of ne industries. Some important keys from Freida Caplan's experience in developing new industries (Caplan 1996) were

- Create consumer awareness and interest and encourage trial e.g. supplying complimentary samples of new banana product lines to food conscious innovators with money and a lifestyle of entertaining others that needs a supply of things new as well as the food service sector.
- Building of strong relationships with the supply chain (producers, transporters, retailers and customers).
- Real money is made from repeat sales – not once off transactions. Therefore guarantee your product to the customer (money back).
- Develop the customer's appreciation of your product – recipes/advice on how to best enjoy the product. Many crops are going nowhere because of customers lack of knowledge of what it is, its taste and how to use it in their lifestyle as well as how to thoroughly enjoy the product. The banana variety industry needs to be a passionate font of knowledge.
- Need to be innovative in the development of new products (varieties and manufactured products) or methods of presentation – continual improvement in all that you do.
- Connectedness/feedback from your supply chain and end-users of your product is vital to such an improvement process so that appropriate action can be taken.

- Staged development of market segments, supported by consistent supply and satisfying of quality requirements.

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Appendix 2A Wholesale/retail markets visit notes 17-20 May 2010

BRISBANE

Wholesaler 1
Sells 32-40 Cartons per week of Sucrier (8kg/carton)
Buyers from independent fruit stores (Inala, Sunnybank) are in market Mondays
Has had same grower supply for 4 years.
Prefer natural ripening to ethylene (ripens too quick)
Hold fruit for 3-4 days of natural ripening before selling.

Wholesaler 2
Cavendish and Lady Finger are the main lines sold. Have tried Red Dacca and Plantain in the past but can't move volumes because they don't sell.
Goldfingers find it difficult to get the premium required for the grower, often sell at around ½ price of Lady Fingers. There is a real issue with taste in comparison to Lady Finger. The oldies know the difference.

Ausmarket - MIS (Market Information Service) Jon Brewer
www.ausmarket.com.au
Service available to industry / growers to track daily / weekly / monthly prices for all the major fruit and vegetable lines traded in the markets (Brisbane, Sydney, Melbourne)
There is capacity to monitor and report on niche banana varieties on a fee for service basis.

Wholesaler 3
Not currently stocking niche banana varieties.
Has stocked Plantain, Red Dacca in the past
Plantains for cooking are sold to Islander communities for approx $30/13kg
Red Dacca grower currently not sending, there are ongoing issues with consistency / continuity $25-30/13kg.
$$$ promotion push is the key to development.
Loyalty from growers is an issue. Many growers don't understand how the market operates.
Growers need to be aware of the importance of Monday markets. Need fruit to be in the market ready for Monday trade. All buyers in the market on a Monday, this can influence buying patterns later in the week (top ups). "Monkey see – Monkey buy"
Standardised 13kg/carton is best for all banana varieties.
Sells to both retail and food service sectors (approx 50:50 split)
Transportation of small volumes is an issue and will be difficult to overcome. Many transporters require pallet minimum.
Handling, there is a lot of misinformation and a lack of knowledge about the correct storage and handling of exotic lines.
Volumes – has handled up to 4 pallets / week of each (Red Dacca & Plantain)
Global financial crisis has impacted on purchase patterns of consumers, has noticed a drop off in sales of exotic / niche lines. It's very difficult to get people to experiment.

Wholesaler 4
Was interested in exotic category for supply to Coles. After initial investigations deemed that the diversity of the industry was an issue. Difficult to coordinate and schedule production and be able to

market / promote effectively. The whole rare fruits industry looks quite disjointed, there are some growers in the industry who have never visited the markets. Small volume lines need to be handled professionally.
De Luca supply Coles in Queensland with Cavendish and Lady Finger
Wholesaler moving into supplying banana to Woolworths in Qld in June 2010.

Brisbane Markets Limited – Amy Kearns
www.brisbanemarkets.com.au/cms/
Questioned are alternative varieties that much different to what was already on offer with Cavendish, Lady Finger?
There has been solid growth in the Brisbanes immigrant population a real diversity of cultures and culinary experiences. African, Sudanese population around Moorooka and Annerly may be an opportunity for cooking varieties.
Brisbane Markets retail program only works with independent operators.
Suggests demonstrations to ensure repeat purchase. Retailers often try once but will drop a new line if there is no ongoing support for follow up purchase.
Cited an example of Perfection Fresh promotion / launch of:

- Mini lines – capsicum
- Mini Pines – Sweeter
- Broccolini
- Grape Tomato

Support point of sale material is important
450 registered buyers at Brisbane Markets, 150 participate in the Fresh Tastes Retail Development Program.
BML is willing to assist with any activity that would mean increased sales for retailers. Opportunity to use existing email and SMS database of Brisbane retailers to get feedback / determine level of interest in new product lines.
Recommend a partnership, co promotion with a Masterclass or even Masterchef with a dessert or cooking type variety. Supermarkets may not be the best entry point for niche product lines.
David Fussal is the contact person at (MMA) Melbourne Market Authority for promotions.

Retail Visits
Inala – 4 Asian stores in Inala Plaza stocked Cavendish, Lady Finger, Ducasse, Sucrier bananas in various stages of ripeness. (insert photos) retailing for $1.99-$3.99/kg
Plantain retailing for $4.99-$5.50/kg

Sunnybank – no niche varieties sighted.

SYDNEY

Wholesaler 5
Has wholesaled Red Dacca, Sucrier (Senorita, Monkey banana), Goldfinger, Ducasse (90% dessert fresh use, 10% cooked)
Black skinned Ducasse variety was popular.
Has had Lakatan but buyer went back to Ducasse
Not impressed with Red Dacca.
Goldfinger has no taste. Looked beautiful but taste is not there.

Commercialisation of niche varieties has been attempted in the past. Coles tried a few years ago. Believes that didn't continue because Aussies only know 2 types of bananas.
Sydney suburbs of Cabramatta and Bankstown is where you will see Sucrier sold.
Plantain for Islanders has been sold $25-30/ 12kg carton, but often out of their price range.
Niche varieties will take a fair bit of promotional push. Anglo Saxons don't know the fruit.
It is a small market that is very easily saturated even for Asians. Probably best not to encourage new growers to get into production. How many bananas can we eat? The kids get sick of them. It is difficult for consumers to embrace a new line.
Handling – heat is an issue for Ducasse due to the thin skin, need to pre cool and sell green and intact. Plantain is required green.
There are no demands from retailers for this wholesaler to source other varieties. Belief is that they have their hands full with the lines that they currently stock. Cavendish taste best. Consumers don't have knowledge of other varieties.
Ducasse – perfect hands required.
Sydney Cavendish price at retail was $1.49kg
This wholesaler has been selling

- Sucrier for $32 for 11kg carton (wholesale)
- Ducasse $22-30 carton (majority at $22)

In the early days (15years ago) sold Ducasse (Gaia's) for $40 / carton. Consistently sold 5 pallets / week green. Over time other growers entered market and saturated resulting in depressed prices and a glut.

Black Ducasse variety vs White variety?
Asians prefer the black variety, black sooty mould look, creaminess
They will buy white when no black is available.

Wholesaler 6
Sees a future for small volumes of niche varieties (but not Red Dacca and Goldfinger) Blue Java – no cash in it, there's not a chance in the world.
Difficult to quantify the volume required to meet the market without saturating. At the moment very much a small segment of Asian consumers.
Price points at which demand drops off

- Sucrier $4/kg
- Plantain $2.50kg
- Ducasse $3/kg

Prices follow Cavendish somewhat
Commercialising niche varieties will be a challenge. There is no cash in it for anyone for exotic varieties. Particularly during the current tough economic times. Limiting supply is the obvious solution but impractical. Nature of the industry is that it is easy for others to jump on board a good thing.
During tight economic times the niche varieties go by the wayside.
Questioned who is going to pay for the promotion required to grow the market? industry or individual business. This wholesaler has experience in promotions of exotic fruit and vegetable lines to retail and food service clients.
Introduction of exotic lines to supermarkets is nearly mission impossible.
It is a "volume gig', management of volumes is needed for the development of the category. Very difficult to get a group of exotic products bundled together. This wholesaler had a go at labelling and packaging longan, mangosteen and rambutan.
Sees some potential in Sucrier (small banana) similar to what the tomato industry did with (grape & cherry varieties)

Information is needed on new ways to break ground. i.e. how to use it, how to eat it.
Lakatan – Fillipinos know what it is, it may be an option to target specific suburbs although not convinced that they will be prepared to pay a premium for it.
There is a finite amount of growth in the Asian community for exotics.
The Vietnamese have a great attitude toward food, very adventurous and willing to pay with an emphasis on fresh.
Goldfinger makes it (the market) crowded. It confuses the consumer.
Need to establish a "connection" via advertising / promotion. Not sure what that would be though.
Cooking show could be the avenue.

Wholesaler 7
Questioned what constituted an alternative variety? Recognised the issue of yields of niche varieties.
Taste is a major consideration, Goldfinger example 90% of people didn't like the taste. There is confusion in the marketplace around the names of particular varieties monkey / senorita etc.
Coles had issues with Goldfinger variety and ended up pulling the line from shelves.

This wholesaler is currently involved in a new variety development project that will be rolled out with one of the chain stores over the next few months (Coles?) it's a very expensive process. Buyer approached wholesaler to investigate options for introduction of a new line. Chains analyse scan data and approach with estimated volume required, no indication / commitment on price though.
Variety is currently in the ground now, plan to sell product green. Understand that consumers are unwilling to pay $5-6kg for product. It has been a difficult exercise getting from concept to viable exercise stage
There is also a major issue with identification of Cavendish vs other varieties at supermarket check out. Shrinkage with Lady Fingers being sold as Cavendish.
60% of all Lady Finger sales occur in Brisbane. 50-50 split volume of sales supermarket vs independents.
Cavendish have improved the taste over the years, with a breakeven price of $18 carton. The difference in taste between Cavendish and Lady Finger is no longer "significantly" different.
Pre packaging is the way to go to get around issue of identification. Lady Fingers should be packaged random weight labelling incorporating barcodes.
Wholesaler clients – Woolworths, Coles, Harris Farms, Duffy Brothers

HAL - David Chenu
www.horticulture.com.au
HAL undertaking / commissioning some research work Nutritional Panels, regional branding.
Much of the promotional focus is on the 18-39 year old segment of the market.
No-nos vs Na-nas campaign
Also rolling out a program of advertising in office building lifts and on buses.
Lunch bars, 7-11 store program where singles are sold in 6kg boxes instead of hands in 13kg boxes
Banana varieties don't generally have a seasonality advantage as is the case for many other fruit.

Wholesaler 8
The project team observed the following banana varieties on the wholesale floor
¾ pallet of Sucrier
Ducasse
Plantain

Wholesaler 9
Sydney branch doesn't have contacts with Asian retailers so don't carry lines of exotic bananas
Lady Finger market has dropped off due to poor quality from Coffs Harbour region
Norton Street Leichardt
Lankester Lady Fingers and Ecos, wholesaler currently running in store promotions. Wholesaler funding Lady Fingers. Pacific Coast (Sciaccas) funding Eco activity.
Woolworths are currently looking for diversity in bananas, Des Rackley investigating options.
$200k promotion budget for Lady Finger nations wide. Utilising services of Star*Dem Promotions and National Talent Pool.
The organic banana has held up strong in comparison to Lady Finger
Marrickville may be a suburb to look for exotic stores with different lines of bananas.
Some growers of dwarf Lady Fingers are affecting quality in the markets and impact on prices received.

Wholesaler 10
Sees an opportunity for "African Plantain" (e.g. Horn Plantain) 4 to 5 pallets / week sold to Indian community around Newtown. Could sell for $60/carton
Likes Lakatan variety, has gone to Cabramatta in the past. Up to a pallet / week. No longer sold there though.
Has handled all types of niche varieties in the past.
Older Australians buy Lady Finger
Has a Chinese buyer that will only buy NSW fruit, will not buy Qld fruit.
There is limited scope outside of the Asian suburbs. 10 pallets a week will flood the current market.
Tried to put Ducasse in Woolworths years ago at Cabramatta store but chains wouldn't take up.
Need to promote as an industry, shop front promotion in inner city to increase awareness.
Cited Dole as an example of a multinational company attempting to broaden range of products without much success.
Potential to reduce the size of the carton from 13kg to 6kg for exotics which may be more manageable price and volume wise for buyers.
Sucrier sold in 10kg boxes approx
Major issue with differentiation of bananas – how can this be done? appearance? taste?, stickers?

Retail Visits
The project team visited retail stores in Ashfield, Cabramatta, Manly, Bondi.
We observed Cavendish, Lady Finger, Ducasse, Sucrier, Eco and Organic bananas on sale. Prices ranged from $1.29/kg for Cavendish at Cabramatta to $5.99/kg for Lady Finger and Organic bananas at Bondi.

MELBOURNE

Wholesaler 11
Footscray, Box Hill, Springvale are Melbourne suburbs with ethnic Asian population.
Woolworths – currently stocking Sucrier, sold as "Monkey Banana"
Wholesaler has sold 48-72 cartons over 2 week period to Woolworths for $20/ 8kg carton.

Currently not a strong pull / demand from chains, wholesaler pushes the variety when it comes into market. During Chinese New Year there is a spike in demand and prices.
"Cross sales" of supplementary products is one of the reasons this wholesaler stocks non Cavendish varieties. It draws attention to the whole category. Staff are very conscious of needs of retailer to make a return on shelf space.

Sucrier are sold in a mix of green and ripened, depending on customers needs.
Maybe scope to roll out some in store taste testing or use bunches as a visual display. (issue of who pays for bunches as promos, how do consumers purchase?)

There are challenges for the industry / supply chain in promoting Lady Fingers in Victoria. Another variety may confuse an already confused market. We have a tough enough time to get Lady Finger happening. There is definitely a need to better educate checkout operators in identification of different varieties.

Wholesaler 12
Had top quality Lady Finger bananas from Kennedy on floor at $20/carton. Unable to move them due to the current glut in the market. Melbourne has a difficult enough time with Lady Fingers, people tend to know the difference but not how to store or when to eat them. Suggested that industry effort / resources / $$$ be spent on the established Lady Finger variety.

Supermarket Chain
Officer we met with has a background (9 years) in UK fresh produce market. (Tesco)
In Europe Cavendish are the only variety. There are 3 segments 1st grade, Organic and budget Cavs.
There was an attempt to introduce other varieties (small pinkish skin) by Tescos. It was a 2 year process without much success. Also had issues with ethnic consumers unwilling to pay for Plantain, they knew what it was but were unwilling to pay market prices for the product.
Identification of the variety by store check out operators is an issue, packaging to identify new varieties.
Types of information required from supermarket chain to progress new variety concept :

- Identification card for each variety
- Product description for each when available, size & shape, brix / flavour, colour, internal external, intended purpose, ripening requirements, storage requirements,
- Shelf life (harvest – ripening – storage – DC – sale)
- Exclusivity options
- QA program – food safety
- Projected timeframe for commercial volume roll out

Retail visits
The project team visited retail stores in Queen Victoria Market, Footscray Market, Box Hill, Richmond, Prahan Market, 7/11 stores. We observed Cavendish, Lady Finger, Ducasse, Sucrier, Plantain, Eco and Organic bananas on sale. Prices ranged from $1.33/kg for Cavendish at Box Hill to $6.99/kg for Lady Finger and Sucrier bananas at Prahan Market.

Appendix 2B Banana Grower and Fruit Transporter Survey Notes

As part of survey of supply chain for our 'Banana varieties for market growth' growers were contacted in December 2010 to find out why they grow or don't grow niche varieties to understand the issues from their perspectives. This group was selected to provide a cross section of the industry in terms of varieties grown, size of operation and geographical location.

Grower 1 - Atherton Tablelands, large grower, has attended niche varieties fieldwalk, has grown some Lady Finger

Grower 2 - Liverpool Ck, delegate, medium grower, has grown niche varieties along with Cavs

Grower 3 - Murray Upper, small grower of Cavs and niche varieties including Lady Finger - mostly direct sales to 'fleamarkets'

Grower 4 - South Johnstone, small grower of just niche varieties to southern markets

Grower 5 - Nerada, large grower, only ever grown Cavendish

Grower 6 - Innisfail, medium / large grower, interested in niche varieties

Grower 7 - Atherton Tablelands, medium/large grower, has grown Lady Finger and Goldfinger in past

Grower 8 - NSW, delegate, small/medium grower of Lady Fingers. Previously grew Cavendish and Goldfinger

Grower 9 - NSW, delegate, Cavendish and some Rossi Dwarf Lady Finger

Grower 10 - Carnarvon, WA, delegate, small grower of Cavs

Two transporters from Innisfail were also interviewed .Dot point notes from phone conversations follow.

Grower 1

- Previously grew 30 ac Lady Finger and 95 ac Cavs, now only Cavs
- For Lady Finger need so much time to do it well in paddock and shed. Lady Finger take longer to harvest because tall and difficulty judging fruit fullness
- Could pick and pack about 600-1000 cartons of Lady Finger per day compared with about 2900 cartons of Cavendish!
- Therefore need very good returns for Lady Finger to be profitable. Need at least $30/carton.
- Went out of Lady Finger because of increased plantings occurring which would force prices down further and did have Fusarium wilt commencing on property.

Grower 2

- Once grew Ducasse, Sucrier [and a few Dwarf Red Dacca and Lakatan] and Cavs but now only Cavs.

- Started with both Ducasse and Sucrier because at outset prices were very good
- Fusarium wilt took out Ducasse and low prices took out Sucrier. Disinterest of market took out Lakatan and Dwarf Red Dacca
- Niche varieties are often taller (Lady Finger/Sucrier/Lakatan) which makes harvest assessment more difficult and ability to meet market size specifications [Sucrier can fill so quickly in warmer weather that just about need to go through plantation twice a week to harvest!]. They also requires more desuckering and are more difficult to bag and in the case of Sucrier are more sensitive to heat/wind and cold.
- To deliver quality from field and packing need whole hands [Sucrier and Ducasse] and therefore experienced staff to do the work to ensure get the good price that is required to be profitable.
- But market is not prepared to pay the money required for it to be profitable for growers. "Asians in marketplace have a mindset on what they want to sell fruit for [and thus the price they must buy at] but is not enough for growers for it to be worthwhile.
- "Takes nothing to flood market for niche varieties"

Grower 3

- Originally grew Ducasse [~30 years ago] when small Asian demand in central markets and price was good
- Changed to Lady Finger [central markets] when demand declined
- In more recent years switched to local markets [Townsville] and diversified to suit meeting special needs. This suits his style and the control possible with direct marketing
- 2.5-3 ha
- But 95% of population still like Cavs so he must grow them also for the customer!
- Santa Catarina Prata better flavour than Lady Finger

Grower 4

- Grows Sucrier and Pacific Plantain for southern markets
- Ducasse was wiped out by Fusarium wilt
- Started with niche varieties initially because of threat of imports
- Has only 2 ha which is not large enough to be profitable for Cavendish supermarket supply chain
- Threat of large plantings of niche varieties causing gluts and ruining market prices
- Send fruit in Lifespan ® bags [ICI product] to promote transport life and appearance. Transporter requires these bags if sending with load of Cavendish to prevent ripening of Cavendish consignment
- Fusarium wilt causing some problems also for Pacific Plantain but manageable
- No market promotion of niche varieties. Therefore market growth is limited.
- Niche varieties suited to smaller grower because of short lines of product required by market

Grower 5

- Cavendish only
- Too much effort to go into another variety
- Can't do another variety on the scale required for their operation
- Very difficult to put low volumes through the shed as require minimum of 3 tubs in operation at once with 14 people required per tub
- ICA issues could be a nightmare – ensuring have varieties in correct boxes etc

Grower 6

- Have grown Dwarf Lady Finger in past, Cav grower currently experimenting with Lakatan/Pisang Ceylan .
- Looking at niche varieties because his nature is to try new things, to keep ahead of the pack and locate something with improved profitability
- Lakatan has its own set of problems and is too similar in appearance to Cavs
- For new varieties so little is known about the best way to manage all the way through to customer. So takes a major commitment to break the required ground
- Commitment required from individual/group to really analyse how to market profitably and a very good associate to push the product at market end
- Lady Finger is changing [for the worse due to supermarket involvement – they don't understand why Lady Finger needs to be so much more expensive or treated differently as the case may be] *{Reflection – Supermarkets may not be the place for premium banana varieties as need to be able to separate them away from commodity Cavendish which makes them look too expensive?}*
- For wholesalers it's about moving volumes. Can't afford to mess with half pallets and tying up a coolroom with small volumes having special requirements

Grower 7

- Currently only Cavs; 17 ac Lady Fingers pre cyclone Larry and 1000 plants Goldfinger during 1990s
- Cyclone Larry was a convenient time to take out Lady Finger block which was badly damaged thene. Had only been doing half a job on them
- Goldfinger had marketing troubles and the fingers were too big [fat]
- Not able to put the extra management into Lady Finger/other varieties that would be required to do them well and quality/yields/returns suffered as a result
- Is a believer that if you had volumes of good eating other variety to supply supermarkets they would be interested

Grower 8

- Once 30 ac Cavs; then added 2-6 ac Goldfinger
- Now 30 ac Lady Finger [by necessity], no Cavs, no Lady Fingers
- NQ competition has destroyed Cavs to wholesale market for southern growers
- Got into Goldfinger as alternative to Cavs which were already suffering from low prices in 1990's
- Goldfinger had too short a shelflife [eating life]
- Lady Finger also gets glutted to some extent at times. Some targeted marketing is required
- Got Fusarium wilt in about 2000 [3 years after planting Lady Finger] which is an increasing problem on his property

Grower 9

- 13 ha Cavs; 3 ac Rossi Dwarf Lady Finger [last 3 years]
- Dwarf Lady Finger has own set of problems [compact hands etc]
- Got into Lady Finger to possibly make more money [higher density of dwarf possible?] but Lady Finger price has fallen away [maybe issues over price for Dwarf Lady Finger fruit, quality etc with new growers entering production]
- Sells only 2 pallets Cavs locally, rest is central market
- Poor returns this year so thinking about getting out!
- Coff's Harbour has 3 Woolworths and most of their fruit is sourced from NQ!

- Indian community are main banana growers there of which 70% are also getting into blueberries which are more profitable
- No Fusarium wilt

Grower 10

- Just Cavs; never grown Lady Finger
- One Carnarvon grower grew 7 ac Lady Finger [which grew well] and promptly flooded the Perth market. So not really much opportunity at all
- Careful marketing would be required

Transporter 1

- Transport Cavs, Ducasse, Lady Finger, Pacific Plantain and Sucrier
- Success with Ducasse and other niche varieties depends on **precooling** and **not mixing loads** with Cavs e.g. use either A or B trailer in B-double
- Does not require Lifespan® bags because doesn't mix
- Other transporters do freight other than Cavs. Some have had problems while others haven't
- Experience is important – do it properly

Transporter 2

- Transport [from Tully & Innisfail] about half of NQ crop [of Cavs]
- Only transport Cavs and Lady Fingers
- Have sent Ducasse in past [in shipments with Cavs] but every 3-4 months there would be a claim for ripening of Cav load [due to ethylene given off by ripening Ducasse] so decided it was not worth it for the small volumes relatively that were being sent
- Don't accept Ducasse now
- No issue with Lady Finger so long as precooled
- "Not enough Ducasse to fill a load as 20 pallets would flood the market [on a particular day]"

Appendix 3A - Pencil and paper version of consumer panel questionnaire

Innovative Food Technologies -a sub-group of Agri-Science Queensland- is currently researching alternative banana varieties. The following questions will help us to achieve our goals.

Information provided by you will only be used for the purposes of research and will remain strictly confidential. Data will be de-identified and secured after final tastings. We appreciate your participation and encourage you to contact Katrina Gething on (07) 3276 6014 if have any queries or concerns.

Section 1 – Aroma, flavour and texture assessment

Please find sample 545 and taste it

Considering the appearance, aroma, flavour and texture, how much do you like or dislike sample 545 overall?

dislike extremely | neither like nor dislike | like extremely

In your opinion what is the state of ripeness for sample 545?

Not ripe at all | just right for me | Way too ripe!

What, if anything, did you like about sample 545?

……

……

What, if anything, did you dislike about sample 545?

……

……

[repeated for 5 more samples]

Section 2 – Whole unpeeled fruit assessment

Please find and assess sample 545
Considering the external appearance, aroma and feel, how much do you like or dislike sample 545 overall?

dislike extremely | neither like nor dislike | like extremely

What, if anything, did you <u>like</u> about sample 545?

……

……

What, if anything, did you <u>dislike</u> about sample 545?

……

……

[repeated for 5 more samples]

Section 3 – About your banana and other food consumption

1. How often do you eat bananas?

□ At least once a week
□ Around once a fortnight
□ I would probably eat a banana each month
□ I rarely eat a banana
□ I don't eat bananas

2. Do you buy the bananas in your household?

□ Yes all the time □ Yes some of the time □ No

3. In what format do you eat bananas (tick as many as apply)

□ Fresh □ Dried □ In a smoothy □ I cook them □ I bake with them

□ Other (please specify) _____

4. What varieties of banana can you recall? _____

5. What variety of banana do you prefer to eat? _____

6. In your household, who is responsible for shopping for groceries?

□ 1. Me
□ 2. My partner
□ 3. Somebody else other than partner

□ 4. Shared activity

7. On average how much would your household usually spend each week on?

1. Fruit and vegetables,_____

8. From where did you last buy whole fruit?

□ 1. Supermarket

□ 2. Greengrocer

□ 3. Public market

□ 4. Other

Section 4 – About you

1. What is your age? _____ (in years)

2. Which of the following describes you? □ Male □ Female

3. In which country were you born? _____

4. What is your marital status?

□ 1. Married/ living with a partner
□ 2. Not married/ not living with a partner
□ 3. Other

5. What is the highest level of education you have completed?

□ 1. Primary school
□ 2. Some secondary school
□ 3. Completed high school
□ 4. Some additional training (apprenticeship, TAFE courses etc.)
□ 5. Undergraduate university
□ 6. Postgraduate university
□ 7. Other _____

6. What is the postcode of where you live? _____

7. What is your **household** income?
(If share-housing with people other than family just **your** income).

□ Up to $10 000
□ $10 001 - $20 000
□ $20 001 - $30 000
□ $30 001 - $40 000
□ $40 001- $60 000
□ $60 001- $80 000
□ $80 001- $100 000
□ $100-001-$150 000
□ $150 001 plus

Appendix 3B - Demographic and behavioural data

Table 10 Demographic frequencies and percentages

Demographic Item		Frequency	Percentage %
Age	18-25	24	10.5
	26-30	26	11.5
	31-40	71	31.4
	41-50	100	44.2
	>51	5	
Gender	Male	70	31
	Female	156	69
Marital status	Married/living with partner	147	65
	Single	69	30.5
	Other	10	
Education	Some highschool education	23	10.2
	Completed highschool	37	16.4
	Some training (TAFE, app/ship)	67	29.6
	Undergraduate university	58	25.7
	Postgraduate University	41	18.1
Country of Origin	Australia	164	72.6
	New Zealand	16	7.1
	USA/Canada	5	
	Asia	17	7.5
	South Africa	4	
	Europe	15	6.6
	South Pacific	3	
	Middle East	1	
	South/Central America	1	
Brisbane district	Brisbane and Inner North	35	15.6
	North East	8	
	North & North West & West	22	9.8
	Outer North	9	
	Inner South	30	13..3
	Inner South West	31	13.8
	South West	26	11.6
	Outer South West & West	31	13.8
	Logan City/Beaudesert/Northern Gold Coast	19	8.5
	East Bay area and Logan	13	5.8
Income	Up tp $10 000	12	5.3
	$10 001 – 20 000	9	
	$20 001-30 000	14	6.2
	$30 001-40 000	25	11.1
	$40 001-60 000	44	19.6
	$60 001-80 000	34	15.1
	$80 001-100 000	34	15.1
	$100 001-150 000	38	16.9
	$150 000 plus	15	6.7

* Only percentages 5 and over a recorded

Table 11 Banana behavioural frequencies and percentages

Behaviour		Frequency	Percentage
Banana consumption	Everyday	108	47.4%
	Weekly	98	43
	Monthly	21	9.2
	< Monthly	0	
Do you buy the bananas in your household?	Yes – all the time	180	79.3
	Yes- it's a shared activity	46	20.3
	No	1	
Format	Fresh	226	99.6
	Dried	52	22.9
	In a smoothy	132	58.1
	In cooking	38	16.7
	In baking	114	50.2

	Other	15	6.6
Banana variety recall	Lady Finger	195	85.9
	Cavendish	165	72.7
	Eco red	27	11.9
	Goldfinger	7	
	Plantain	7	
	Other	24	10.6
Banana variety preference	Lady Finger	59	26
	Cavendish	124	54.5
	Eco/Organic	4	
	Small	7	
	No preference	18	7.9
	Other/don't know/unsure	31	13.7

* Only percentages 5 and over a recorded

Table 12 Shopping behaviour frequencies and percentages

Behaviour		Frequency	Percentage
Shopping responsibility	Me	172	75.8
	My partner	44	19.4
	Somebody else	4	
	Shared	7	
Grocery Spend No. 181	<$50	23	12.7
	$50-75	27	14.9
	$76-99	17	9.4
	$100-149	47	26
	$150-199	33	18.2
	$200-249	22	12.2
	>250	12	6.6
Fresh fruit and vegetable spend	$0	1	
	$1-10	13	5.7
	$11-20	48	21.1
	$21-30	58	25.6
	$31-50	71	31.3
	$51-100	31	13.7
	>100	5	
Frozen fruit and vegetable spend	$0	21	
	$1-5	56	11.6
	$6-10	61	30.9
	$11-20	33	33.7
	$21-50	8	18.2
	>$51	2	
Place of purchase	Supermarket	129	56.8
	Green Grocer	72	31.7
	Public Market	23	10.1
	Other	3	

Only percentages 5 and over a recorded

Appendix 3C – Statistical outcomes consumer acceptability

Internal assessment.

For those samples with normal distributions, a series of paired samples t-tests with a Bonferroni adjustment to p< .017 were conducted examining scores of internal assessment for banana varieties 253, 328 and 490. A significant difference in values was found between samples 253 (M =5.47) and 328 (M= 6.08), t (226)= -3.197., p<.017.

A Friedman test was conducted examining scores for internal assessment of samples 545, 826 and 930 and all other samples. This analysis found a significant difference in internal assessment of samples X^2 (DF 5, n = 225) = 80.903, p < .05. Post hoc comparisons using the Wilcoxson signed-rank test with a Bonferroni adjustment of alpha to p < .003 were conducted on samples 545, 826 and 930 and all other samples. A significant difference in internal assessment was found between sample 826, *Mdn* = 4.63, and:

1. sample 253, *Mdn* = 5.3 and, z = -3.11 , p<.003,
2. sample 328, *Mdn* = 6 and, z = -6.12 , p<.003,
3. sample 490, *Mdn* = 5.7 and, z = -4.18 , p<.003,
4. sample 545, *Mdn* = 6.9 and, z = -7.44 , p<.003,

A significant difference in internal assessment was found between sample 545, *Mdn* = 6.9, and:

5. sample 253, *Mdn* = 5.3 and, z = -5.00 , p<.003,
6. sample 490, *Mdn* = 5.7 and, z = -4.57 , p<.003,
7. sample 930, *Mdn* = 5.3 and, z = -6.37 , p<.003,

A significant difference in internal assessment was found between sample 930, *Mdn* = 6.9, and:

8. sample 490, *Mdn* = 5.7 and, z = -1.95 , p<.003.

External assessment

A one-way repeated measures analysis of variance was conducted examining scores on external assessment of banana varieties 253 (Gros Michel), 328 (High Noon) 490 (Pisang Ceylan), 930 (Lady Finger) and 826 (FHIA-18). The change in values for internal assessment of banana varieties was significant F(3.8, 846.96) = 10.89, p<.05.

A series of paired samples t-tests with a Bonferoni adjustment were conducted examining scores of internal assessment for banana varieties 253, 328, 490, 930 and 826 using a significance value of p = .005. A significant difference in values was found between samples 253 (M =4.71) and:

1. sample 328, M = 5.35 , t (225) = -3.8, p<.005
2. sample 490, M = 6.0, t (225) = -7.14 , p<.005
3. sample 930, M = 6.1, t (225) = -6.5, p<.005

A significant difference in values was found between samples 328 (M = 5.35) and:

4. sample 490, M = 6.0, t (225) = -3.54 , p<.005
5. sample 826, M = 4.35, t (225) = 6.68 , p<.005

6. sample 930, M = 6.1, t (225) = -3.78, p<.005

A significant difference in values was found between samples 490 (M = 6.0) and:

7. sample 826, M = 4.35, t (225) = 9.23 , p<.005
8. sample 930, M = 6.1, t (225) = -.61, p<.005

A significant difference in values was found between samples 826 (M = 4.35) and:

9. sample 930, M = 6.1, t (225) = -9.14, p<.005

A Friedman test was conducted examining scores for External Assessment of sample 545 and all other samples. This analysis found a significant difference in External Assessment of samples X^2 (DF 5, n = 226) = 257.83, p < .05. Post hoc comparisons using the Wilcoxson signed-rank test with a Bonferroni adjustment of alpha to p < .01 were conducted on samples 545 and all other samples. A significant difference in internal assessment was found between sample 545, Mdn = 7.75, and

1. sample 253, Mdn = 4.95 , z = -10.57, p<.01
2. sample 328, Mdn = 5.15, z = -9.13, p<.01
3. sample 490, Mdn = 6.0, z = -7.29, p<.01
4. sample 826, Mdn = 4.6, z = -10.89, p<.01
5. sample 930, Mdn = 5.9, z = -6.56, p<.01

Ripeness assessment

Ripeness and correlation with internal acceptance
A Friedman test was conducted examining scores for ripeness of all samples. This analysis found a significant difference in internal assessment of samples, X^2 (DF 5, n = 219) = 83.1, p < .05. Post hoc comparisons using the Wilcoxson signed-rank test with a Bonferroni adjustment of alpha to p < .003 were conducted on all samples. A pattern of significant difference was found for sample 826, Mdn = 4.9 and all other samples. A slight pattern of significant difference was found for sample 545, Mdn = 5.1. However, as the Median scores can still be considered to be clustered around the ideal ripeness score of 5 it is not felt that the significant difference between these scores is of consequence and so z-scores are not reported.

A Spearman's rank-order correlation was performed on each sample for Internal Assessment and Ripeness in order to examine whether there is a significant relationship between them, as would be expected. A significant positive correlation was found between all samples and their ripeness values, except:

1. Sample 545 (Cavendish), r_s = -.10, p > .05
2. Sample 930 (Lady Finger), r_s = -.03, p > .05

Appendix 3D – Results from comment questions

Table 13 Question 3 – What, if anything, did you like about the look, smell, taste and texture?

	1-253 Gros Michel	2-328 High Noon	3-490 Pisang Ceylan	4-826 FHIA – 18	5-545 Cavendish	6-930 Lady Finger
Look						
Overall	43	54	41	17	41	31
Colour	21	30	14	52	25	12
Size	25	9	17	24	7	10
Smell						
Overall	56	53	46	53	79	58
Sweet	9	10	6	4	10	9
Fresh	2	6	2	2	0	5
Taste						
Overall	68	51	35	37	63	36
Smooth	11	1	0	0	0	0
Sweet	13	24	30	15	21	17
Flavour	8	17	11	12	12	10
Aftertaste	2	6	5	1	7	3
Texture						
Overall	44	42	31	33	46	28
Moist	4	7	4	3	4	0
Soft	2	10	6	4	11	4
Smooth	0	8	12	14	18	14
Firm	11	20	16	17	10	10

Table 14 Question 4 – What, if anything, did you dislike about the look, smell, taste and texture?

	1-253 Gros Michel	2-328 High Noon	3-490 Pisang Ceylan	4-826 FHIA – 18	5-545 Cavendish	6-930 Lady Finger
Look						
Overall	5	3	16	6	7	26
Colour	9	2	25	9	12	34
Size	18	2	5	2	2	6
Smell						
Overall	49	41	52	85	31	42
Musty	2	1	2	0	0	0
Taste						
Overall	32	33	33	58	21	37
Gritty	1	0	0	1	0	1
Sour	17	38	25	45	7	9
Chalky	4	0	0	1	3	5
Flavour	9	5	5	13	10	13
Aftertaste	22	16	18	23	7	21
Texture						
Overall	9	5	9	8	19	27
Slimy	1	11	10	7	10	2
Soft	3	5	11	2	6	10
Firm	2	1	2	4	10	2

Table 15 Question 6 – What did you like about the whole fruit?

	1-253 Gros Michel	2-328 High Noon	3-490 Pisang Ceylan	4-826 FHIA – 18	5-545 Cavendish	6-930 Lady Finger
Look						
Overall	18	17	29	7	46	26
Colour	23	29	54	19	68	61
Yellow	10	9	26	4	16	17
Green	4	2	1	1	0	0
Size	80	80	58	74	85	66
Shape	9	39	39	20	60	33
Ripe	9	8	20	6	19	13
Smell						
Overall	16	17	21	18	19	13
Taste						

	1-253 Gros Michel	2-328 High Noon	3-490 Pisang Ceylan	4-826 FHIA – 18	5-545 Cavendish	6-930 Lady Finger
Overall	3	4	9	1	10	4
Sweet	1	0	0	2	1	2
Texture						
Overall	4	8	6	4	11	4
Soft	1	2	1	2	3	1
Moist	1	0	0	0	1	0
Feel						
Good	5	0	4	6	19	22
Firm	25	23	27	14	34	20

Table 16 Question 7 – What, if anything, did you dislike about the whole fruit?

Q.7	1-253 Gros Michel	2-328 High Noon	3-490 Pisang Ceylan	4-826 FHIA – 18	5-545 Cavendish	6-930 Lady Finger
Look						
Overall	8	15	4	30	3	4
Colour	6	7	1	20	5	5
Green	28	21	3	5	0	0
Shape	12	29	28	36	9	51
Small Size	80	9	58	26	4	31
Large Size	0	7	1	0	15	5
Over Ripe	4	15	5	15	6	7
Not Ripe	20	16	6	5	0	4
Markings	16	25	8	43	7	15
Smell						
Overall	29	22	14	25	19	27
Taste						
Overall	5	1	5	4	0	4
Flavour	1	1	0	2	0	0
Sour	3	0	3	4	2	0
Mouth Feel	0	0	1	0	0	1
Aftertaste	0	0	0	2	0	1
Texture						
Overall	2	5	2	3	1	1
Too Soft	4	20	20	10	8	6
Moist						
Feel						
Feel	5	14	6	12	4	8

Table 17 Question 13 – What variety of banana do you prefer?

	5-545 Cavendish	6-930 Lady Finger
	107	65

Table 18 Question 16 – Please describe your idea of a banana?

Yellow	**68**
Green	1
Markings	46
Feels Firm	64
Feels Soft	16
Ripe	48
Not too ripe	32
Shape	34
Small	20
Medium	29
Large	24
Colour	25
Opens easily	8
Smooth Texture	34
Taste Sweet	28
Taste Good	13
Flavour	18

Not Floury Taste	10
Aftertaste	3
No Aftertaste	17
Smell Fresh	43
Smooth Skin	1
No Marks Inside	1
Looks Appealing	10
Long Shelf Life	7
Organic	2

Appendix 3E – Statistical analysis cluster preferences

Cluster one: Banana Lovers

Internal assessment

Central tendencies were inspected for relevant comparisons. A post-hoc paired sample t-test with a Bonferroni adjustment to $p < .01$ was conducted examining scores of Cluster one internal assessment for banana samples 328 (High Noon) $M = 7.02$, and 545 (Cavendish) $M = 6.87$, and 490 (Pisang Ceylan)) $M = 6.6$. No significant difference was found between High Noon and Cavendish $t(123) = .522$ $p > .01$; High Noon and Pisang Ceylan $t(123) = -1.7$ $p > .01$, and Cavendish and Pisang Ceylan $t(123) = -.99$ $p > .01$.

A post-hoc paired sample t-test with a Bonferroni adjustment to $p < .01$ was conducted examining scores of Cluster one internal assessment for banana sample 930 (Lady Finger) $M = 5.17$, and all other varieties. Significant differences were found for this variety and all other varieties:

253 (Gros Michel) $M = 6.05$, $t(123) = .3.14$, $p < .01$
328 (High Noon) $M = 7.02$, $t(123) = -6.71$, $p < .01$
490 (Pisang Ceylan) $M = 6.6$, $t(123) = -5.21$, $p < .01$
826 (FHIA-18) $M = 6.15$, $t(123) = -3.56$, $p < .01$
545 (Cavendish) $M = 6.87$, $t(123) = -6.01$, $p < .01$

External assessment

A post-hoc paired sample t-test with a Bonferroni adjustment to $p < .01$ was conducted examining scores of Cluster one external assessment for banana sample 826 (FHIA-18) $M = 5$, and all other varieties. Significant differences were found for this variety and varieties:

328 (High Noon) $M = 5.8$, $t(123) = -3.96$, $p < .01$
490 (Pisang Ceylan) $M = 6.6$, $t(123) = -6.94$, $p < .01$
545 (Cavendish) $M = 7.7$, $t(123) = -10.52$, $p < .01$
930 (Lady Finger) $M = 6.2$, $t(123) = -5.25$, $p < .01$

A post-hoc paired sample t-test with a Bonferroni adjustment to $p < .01$ was conducted examining scores of Cluster one external assessment for banana sample 545 (FHIA-18) $M = 7.7$, and all other varieties. Significant differences were found for this variety and all other varieties:

253 (Gros Michel) $M = 5.3$, $t(123) = 9.20$, $p < .01$
328 (High Noon) $M = 5.8$, $t(123) = 8.02$, $p < .01$
490 (Pisang Ceylan) $M = 6.6$, $t(123) = -4.96$, $p < .01$
930 (Lady Finger) $M = 6.2$, $t(123) = -5.12$, $p < .01$

A post-hoc paired sample t-test with a Bonferroni adjustment to $p < .01$ was conducted examining scores of Cluster one external assessment for banana sample 930 (Lady Finger) $M = 6.2$, and sample 490 (Pisang Ceylan) $M = 6.6$. No significant difference was found $t(123) = -1.45$, $p > .01$

Cluster two: Traditionalists

Internal assessment

Central tendencies were inspected for relevant comparisons. A post-hoc paired sample t-test with a Bonferroni adjustment to $p < .01$ was conducted examining scores of Cluster one internal assessment for banana samples 328 (High Noon) $M = 7.02$, and 545 (Cavendish) $M = 6.87$, and 490 (Pisang Ceylan)) $M = 6.6$. No significant difference was found between High Noon and Cavendish $t(123) = .522$ $p > .01$; High Noon and Pisang Ceylan $t(123) = -1.7$ $p > .01$, and Cavendish and Pisang Ceylan $t(123) = -.99$ $p > .01$.

A post-hoc paired sample t-test with a Bonferroni adjustment to $p < .01$ was conducted examining scores of Cluster one internal assessment for banana sample 930 (Lady Finger) $M = 5.17$, and all other varieties. Significant differences were found for this variety and all other varieties:

253 (Gros Michel) $M = 6.05$, $t(123) = .3.14$, $p < .01$
328 (High Noon) $M = 7.02$, $t(123) = -6.71$, $p < .01$
490 (Pisang Ceylan) $M = 6.6$, $t(123) = -5.21$, $p < .01$
826 (FHIA-18) $M = 6.15$, $t(123) = -3.56$, $p < .01$
545 (Cavendish) $M = 6.87$, $t(123) = -6.01$, $p < .01$

External assessment

A post-hoc paired sample t-test with a Bonferroni adjustment to $p < .01$ was conducted examining scores of Cluster one external assessment for banana sample 826 (FHIA-18) $M = 5$, and all other varieties. Significant differences were found for this variety and varieties:

328 (High Noon) $M = 5.8$, $t(123) = -3.96$, $p < .01$
490 (Pisang Ceylan) $M = 6.6$, $t(123) = -6.94$, $p < .01$
545 (Cavendish) $M = 7.7$, $t(123) = -10.52$, $p < .01$
930 (Lady Finger) $M = 6.2$, $t(123) = -5.25$, $p < .01$

A post-hoc paired sample t-test with a Bonferroni adjustment to $p < .01$ was conducted examining scores of Cluster one external assessment for banana sample 545 (FHIA-18) $M = 7.7$, and all other varieties. Significant differences were found for this variety and all other varieties:

253 (Gros Michel) $M = 5.3$, $t(123) = 9.20$, $p < .01$
328 (High Noon) $M = 5.8$, $t(123) = 8.02$, $p < .01$
490 (Pisang Ceylan) $M = 6.6$, $t(123) = -4.96$, $p < .01$
930 (Lady Finger) $M = 6.2$, $t(123) = -5.12$, $p < .01$

A post-hoc paired sample t-test with a Bonferroni adjustment to $p < .01$ was conducted examining scores of Cluster one external assessment for banana sample 930 (Lady Finger) $M = 6.2$, and sample 490 (Pisang Ceylan) $M = 6.6$. No significant difference was found $t(123) = -1.45$, $p > .01$

Appendix 3F – Data analysis of sensory descriptive analysis results

Table 19 Pearson correlation coefficient matrix (r) of selected banana sensory attributes

	roughness	aroma intensity	perfumed aroma	lolly fruit aroma	tropical fruity aroma	sappy / resin aroma	musty aroma	firmness	astringency	sweetness	tartness	overall flavour intensity	fruity flavour	lemon sherbet lolly	sappy flavour	flavour persistence
roughness	**1.00**															
aroma intensity	0.08	**1.00**														
perfumed aroma	0.31	0.58	**1.00**													
lolly fruit aroma	0.17	**0.91**	**0.78**	**1.00**												
tropical fruity aroma	0.40	0.30	**0.83**	0.37	**1.00**											
sappy / resin aroma	-0.61	-0.55	**-0.91**	**-0.78**	-0.68	**1.00**										
musty aroma	0.55	-0.03	-0.45	-0.11	-0.45	0.07	**1.00**									
firmness	0.52	-0.04	0.29	0.18	0.11	-0.48	0.04	**1.00**								
astringency	0.02	**-0.76**	-0.14	-0.59	0.05	0.18	-0.35	0.52	**1.00**							
sweetness	-0.29	-0.47	-0.10	-0.15	-0.39	0.07	-0.25	0.47	0.59	**1.00**						
tartness	-0.24	-0.58	-0.44	-0.69	-0.02	0.55	0.00	-0.73	0.09	-0.24	**1.00**					
overall flavour intensity	-0.72	-0.65	-0.27	-0.55	-0.17	0.53	-0.62	-0.28	0.55	0.55	0.51	**1.00**				
fruity flavour	-0.09	0.54	0.36	0.63	-0.10	-0.36	-0.22	0.60	-0.05	0.37	**-0.94**	-0.25	**1.00**			
lemon sherbet lolly	-0.31	-0.47	-0.39	-0.59	-0.01	0.52	-0.02	**-0.82**	-0.04	-0.28	**0.99**	0.50	**-0.91**	**1.00**		
sappy flavour	0.09	-0.31	-0.66	-0.64	-0.26	0.62	0.34	-0.07	0.20	-0.40	0.26	-0.11	-0.30	0.18	**1.00**	
flavour persistence	-0.32	-0.66	**-0.91**	**-0.90**	-0.54	**0.93**	0.23	-0.42	0.26	-0.09	0.67	0.40	-0.58	0.60	**0.78**	**1.00**

Appendix 3G – Summary tables of descriptive analysis results

Table 20 Frequency summary of banana external appearance sensory attributes scores (% of total)

sensory attribute		Cavendish	FHIA-18	Gros Michel	High Noon	Lady Finger	Pisang Ceylan
thickness	thin	7	17	**60**	37	0	3
	medium	**77**	**63**	40	**60**	27	50
	thick	17	20	0	3	**73**	47
length	short	0	33	**57**	33	0	**63**
	medium	**67**	**67**	43	23	**90**	13
	long	33	0	0	43	10	23
colour depth	pale yellow	0	3	0	3	0	0
	yellow	13	**57**	50	23	17	23
	rosy yellow	**63**	33	43	53	47	**63**
	bronzed	23	7	7	20	37	13
bend	straight	3	**67**	27	33	50	37
	slight bend	23	27	33	56	30	57
	pronounced bend	**73**	7	40	13	20	7
angularity	round	7	13	27	20	0	20
	slight ridges	**80**	57	**70**	53	0	**73**
	very angular ridges	13	30	3	27	**100**	7
pronounced nipple		23	**97**	**80**	**83**	**83**	26
no nipple		**67**	0	13	10	10	10
spotty		37	37	33	10	3	20
pin stripes		20	20	13	20	13	40
dark rub marks		20	**63**	57	**63**	20	30
grippy (waxy)		**93**	17	43	27	40	47
powdery		7	**83**	57	**73**	60	53

Table 21 Summary of banana external feel attribute scores (average on a scale of 0-10)

sensory attribute	Cavendish	FHIA-18	Gros Michel	High Noon	Lady Finger	Pisang Ceylan
roughness	**3a**	2bc	3ab	2ab	1c	3ab

[abc] Different letters within a column indicate a significant difference between samples by means comparisons for each pair using Student's t test

Table 22 Summary of banana flesh aroma attribute scores (average on a scale of 0-10)

sensory attribute	Cavendish	FHIA-18	Gros Michel	High Noon	Lady Finger	Pisang Ceylan
aroma intensity	7a	6ab	5cd	5d	6bc	5cd
perfumed aroma	4a	2bc	1c	2bc	2bc	3ab
lolly fruit aroma	6a	4b	2c	3bc	3bc	3bc
tropical fruity aroma	3ab	3ab	2b	2b	2b	4a
sappy / resin aroma	2b	5a	5a	4a	5a	4ab
musty aroma	2	2	3	3	2	2
'other' aroma	0.7ab	0.1b	0.1b	0.2b	0.4ab	1a

[abc] Different letters within a column indicate a significant difference between samples by means comparisons for each pair using Student's t test

Table 23 Frequency summary of banana internal appearance sensory attributes scores (% of total)

sensory attribute		Cavendish	FHIA-18	Gros Michel	High Noon	Lady Finger	Pisang Ceylan
colour	white	43	**60**	37	37	**80**	53
	cream	53	37	27	47	20	33
	golden	3	3	37	17	0	13
uniformity	even colour	7	17	30	30	17	17
	patchy	43	37	27	30	50	47
	defined centre star	50	47	43	30	33	37
moist looking		53	**90**	70	**90**	40	**87**
dry looking		47	10	30	10	**60**	10
prominent dark seeds		47	20	40	40	**70**	53

Table 24 Frequency summary of banana in-mouth texture sensory attributes scores (% of total)

sensory attribute	Cavendish	FHIA-18	Gros Michel	High Noon	Lady Finger	Pisang Ceylan
gooey	3	37	17	17	20	50
consistent	57	**73**	60	70	**77**	60
gritty	20	3	13	13	13	10
lumpy	47	17	43	30	23	17
chalky	13	7	27	3	23	3

Table 25 Summary of banana in-mouth texture sensory attribute scores (average on a scale of 0-10)

sensory attribute	Cavendish	FHIA-18	Gros Michel	High Noon	Lady Finger	Pisang Ceylan
firmness	5a	3bc	4ab	3bc	3bc	3c
astringency	2b	4a	3a	3a	3a	4a

[abc] Different letters within a column indicate a significant difference between samples by means comparisons for each pair using Student's t test

Table 26 Summary of banana flavour and aftertaste attribute scores (average on a scale of 0-10)

sensory attribute	Cavendish	FHIA-18	Gros Michel	High Noon	Lady Finger	Pisang Ceylan
sweetness	4	4	4	5	5	4

sensory attribute	Cavendish	FHIA-18	Gros Michel	High Noon	Lady Finger	Pisang Ceylan
tartness	2c	5a	4b	5ab	4b	6a
overall flavour intensity	4b	5ab	5ab	5a	6a	5ab
fruity flavour	5a	4ab	4ab	4ab	5ab	3b
lemon sherbet lolly	0.8c	5a	3b	4ab	3b	4a
sappy flavour	2b	2ab	4a	2b	2b	2ab
'other' flavour	0.2	0.2	0.7	0.3	0.5	0.2
flavour persistence	3	4	4	4	4	4

[abc] Different letters within a column indicate a significant difference between samples by means comparisons for each pair using Student's t test

Appendix 3H - Results of chemical analysis for fruit ripeness level

Table 14 : Results of chemical analysis for each day of consumer tasting

Sample	Brix (˚)	pH	Titratable acidity (TA, % malic acid)	Brix:TA
Gros Michel 5/10	15.0	4.6	0.38	40
Gros Michel 6/10	15.7	4.7	0.34	46
Gros Michel 7/10	17.1	4.9	0.27	63
Gros Michel 8/10	16.6	5.0	0.26	63
High Noon 5/10	14.3	4.2	0.52	28
High Noon 6/10	14.9	4.4	0.47	32
High Noon 7/10	15.5	4.5	0.46	34
High Noon 8/10	15.9	4.5	0.42	38
Pisang Ceylan 5/10	11.5	4.6	0.44	26
Pisang Ceylan 6/10	14.8	4.4	0.52	29
Pisang Ceylan 7/10	15.0	4.5	0.63	24
Pisang Ceylan 8/10	14.6	4.6	0.43	34
FHIA-18 5/10	13.4	4.2	0.57	24
FHIA-18 6/10	15.0	4.4	0.52	29
FHIA-18 7/10	17.1	4.4	0.52	33
FHIA-18 8/10	14.2	4.4	0.44	32
Cavendish 5/10	14.6	4.8	0.32	46
Cavendish 6/10	15.5	4.9	0.29	54
Cavendish 7/10	15.4	4.9	0.30	52
Cavendish 8/10	15.1	5.1	0.24	63
Lady Finger 5/10	13.8	4.7	0.29	47
Lady Finger 6/10	15.8	4.9	0.25	64
Lady Finger 7/10	15.6	4.7	0.33	48
Lady Finger 8/10	18.4	4.8	0.33	56

Table 15 : Average results of chemical analysis of banana fruit (range; mean (SD))

Fruit	Brix (˚)	pH	Titratable acidity (TA, % malic acid)	Brix:TA
Gros Michel	16.1 (0.9)	4.8 (0.2)	0.31 (0.06)	53 (12)
High Noon	15.2 (0.7)	4.4 (0.1)	0.47 (0.04)	33 (4)
Pisang Ceylan	14.0 (1.7)	4.5 (0.1)	0.51 (0.09)	28 (4)
FHIA-18	14.9 (1.6)	4.4 (0.1)	0.51 (0.05)	29 (4)
Cavendish	15.1 (0.4)	4.9 (0.1)	0.29 (0.03)	54 (7)
Lady Finger	15.9 (1.9)	4.8 (0.1)	0.30 (0.04)	54 (8)

Values are represented as range followed by mean (n=4) with standard deviation shown in brackets.

Appendix 4 Detailed Gross Margins

Gross margin/operating profit estimates per hectare for Cavendish bananas in north Queensland

…….. plants per hectare - 1 plant crop and 5 ratoons

(1) GROSS INCOME per ha		Yield (Cartons/Ha)		$/Carton
	Plant	3,186		$20.00
	Ratoon			
	Total hectares	1		

(2) PRE HARVEST COSTS per ha			Operations	labour hours	fuel , oil, lubricants, repairs and maintenance $ per hour
Machinery Costs (Fuel, oil,)	**Plant**	Discing	8	8.0	$89.20
		Slashing	0	0.0	
		Ripper	5	5.0	$60.00
		Rotary Hoe	1	1.0	
		V' plough	2	2.0	$221.64
		Planting	1	10.0	$183.36
		Deleafing	0	0.0	
	Plant & Ratoon	Fertiliser Application (Foliar)	0	0.0	
		Fertiliser Application	5	5.0	$22.80
		Fertiliser spreader	12	12.0	$77.32
		Spray Application (Mites)	0	0.0	
		Spray Application (Herbicide)	5	0.0	
		Spray Application (Fungicide)	0	0.0	
		Spray Application (Rust and Flower Thrips)	0	0.0	
		Spray Application	0	0.0	

		(Bell Injection)			
		Aerial Spraying	26	0.0	$28.00
		banana transporter	1.29	0.0	$3,359.53
	Ratoon	Deleafing	0	0.0	

			Applications	**units /Ha**	**$/unit**
Planting		Material (Bits)			
-		imidacloprid	1	41.00	$136.50
-		chlorpyrifos	1	$2.50	$10.75
-					
-					
-					

			Applications	**L or Kg/Ha**	**$/Kg or L**
Fertiliser	**Plant**	CK7	0	800.0	$0.75
-		compost	0	0.0	$0.11
-		N20,P1.8,K25.5	1	4,446.0	$0.80
-		Dolomite	1	2,000.0	$0.22
-		Superphosphate	0	750.0	$0.14
	Plant & Ratoon	CK77	0	500.0	$0.70
		KNO3	0	130.0	$1.15
		Zinc Sulphate	0	10.0	$1.25
	Ratoon	Dolomite	0	2,500.0	$0.15
		Superphosphate	0	25.0	$0.50

			Applications	**L or Kg/Ha**	**$/Kg or L**
Sprays	**Plant**	Torque	0	0.370	$110.00
-		Dithane	26	2.200	$11.00
-		Confidor guard	1	34.000	$160.00
-		Strike-out 500WP	1	5.190	$59.60
-		Folimat	1.29	1.750	$55.00
-		DC Tron	0	5.000	$3.20
-		Tilt	0	0.400	$113.00
-		Surflan	0	4.000	$40.00
-		Basta	6	3.000	$22.75
-		Cabrio	2	0.350	$70.00
-		Biopest	2	5.000	$5.60
-		Flint	2	0.150	$3.13
-		Folicur	6	0.200	$41.65
-		Supercharge	26	5.000	$5.60
	Plant & Ratoon	Lorsban	0	0.144	$25.00
		Lorsban 1% Dust	0	9.500	$2.40
	Ratoon	Torque	0	0.370	$110.00
-		Dithane	0	2.500	$9.50
-		DC Tron	0	5.000	$3.20
-					

-	Tilt	0	0.400	$113.20
-	Apollo	0	0.250	$230.50
-	Benlate	0	2.500	$72.90
-	Nemacur 400	0	8.000	$57.60
-	Lorsban	0	1.500	$24.80
-	Basta	0	4.000	$22.60
-				

		ML/Ha	$/ML
Water Charges	Plant	0	$0.00
-	Ratoon	0	$0.00
-			
-			

		Hours/ha	$/Hour
pre harvest Labour	desuckering	20	$18.00
	average labour cost		$18.00
-			

		$/ha	Hours/ha
Bagging and Bunch Pruning	……. Plants	$170.00	80
-			

		$/Ha
Crop Monitoring	Soil Analysis	$90.00
	Land management	

		Operations	$/Hectare	labour hours
Crop Removal (Last Ratoon)	Tractor Cutting	1	$89.20	
-	Discing	1		
-	2,4-D (1.25l/ha)	1	$10.00	
-	Spray Application	1	$48.60	
-				
-				

(3) HARVEST AND MARKETING COSTS per ha

		$/Carton
Plant Crop	Cartons	$2.80
	Liners	$0.12
	Taping	$0.05
	Tractor	$0.20
	Cutting labour	$0.55
	Packers Labour	$0.30
	Levies	$0.25
	Agent's commission	$0.00
	Freight	$3.40
	other	$3.00

	total	**$10.67**	$33,999.40
Ratoon Crop	Cartons	$2.80	
	Liners	$0.12	
	Taping	$0.05	
	Tractor	$0.20	
	Cutting labour	$0.55	
	Packers	$0.30	
	Levies	$0.25	
	Agent's commission	$0.00	
	Freight	$3.40	
	other		

Gross margin /operating profit estimates per hectare for Ducasse bananas in north Queensland

…….. plants per hectare - 1 plant crop and 5 ratoons

(1) GROSS INCOME per ha			**Yield (Cartons/Ha)**		**$/Carton**
		Plant	2,230	y	$29.25
		Ratoon			
		Total hectares	140		

(2) PRE HARVEST COSTS per ha					
			Operations	**labour hours**	**fuel , oil, lubricants, repairs and maintenance $ per hour**
Machinery Costs (Fuel, oil,)	**Plant**	Discing	8	8.0	$89.20
		Slashing	0	0.0	
		Ripper	5	5.0	$60.00

		Rotary Hoe	1	1.0	
		V' plough	2	2.0	$221.64
		Planting	1	7.0	$183.36
		Deleafing	0	0.0	
		Fertiliser Application (Foliar)	0	0.0	
		Fertiliser Application	5	5.0	$22.80
		Fertiliser spreader	12	12.0	$77.32
		Spray Application (Mites)	0	0.0	
		Spray Application (Herbicide)	5	0.0	
		Spray Application (Fungicide)	0	0.0	
		Spray Application (Rust and Flower Thrips)	0	0.0	
		Spray Application (Bell Injection)	0	0.0	
		Aerial Spraying	26	0.0	$28.00
		banana transporter	1.29	0.0	$3,359.53
	Both				
	Ratoon	Deleafing	0	0.0	

			Applications	**units /Ha**	**$/unit**
Planting		Material (Bits)	1	700	$1.00
-		imidacloprid	1	41.00	$136.50
-		chlorpyrifos	1	$2.50	$10.75
-					
-					

			Applications	**L or Kg/Ha**	**$/Kg or L**
Fertiliser	**Plant**	CK7	0	800.0	$0.75
-		compost	0	0.0	$0.11
-		N20,P1.8,K25.5	1	4,446.0	$0.80
-		Dolomite	1	2,000.0	$0.22
		Superphosphate	0	750.0	$0.14
	Both	CK77	0	500.0	$0.70
		KNO3	0	130.0	$1.15
		Zinc Sulphate	0	10.0	$1.25
	Ratoon	Dolomite	0	2,500.0	$0.15
		Superphosphate	0	25.0	$0.50

			Applications	**L or Kg/Ha**	**$/Kg or L**
Sprays	**Plant**	Torque	0	0.370	$110.00
-		Dithane	13	2.200	$11.00
-		Confidor guard	1	34.000	$160.00
-		Strike-out 500WP	1	5.190	$59.60
-		Flimat	1.29	1.750	$55.00

		DC Tron	0	5.000	$3.20
		Tilt	0	0.400	$113.00
		Surflan	0	4.000	$40.00
		Basta	6	3.000	$22.75
		Cabrio	2	0.350	$70.00
		Biopest	2	5.000	$5.60
		Flint	2	0.150	$3.13
		Folicur	6	0.230	$41.65
		Supercharge	26	5.000	$5.60
	Both	Lorsban	0	0.144	$25.00
		Lorsban 1% Dust	0	9.500	$2.40
	Ratoon	Torque	0	0.370	$110.00
		Diothane	0	2.500	$9.50
		DC Tron	0	5.000	$3.20
		Tilt	0	0.400	$113.20
		Apollo	0	0.250	$230.50
		Benlate	0	2.500	$72.90
		Nemacur 400	0	8.000	$0.00
		Lorsban	0	1.500	$24.80
		Basta	0	4.000	$22.60

		ML/Ha	$/ML
Water Charges	Plant	0	$0.00
	Ratoon	0	$0.00

		Hours	$/Hour
pre harvest Labour	desuckering	30	$18.00
	average labour cost		$18.00

		$/ha	Hours/ha
Bagging and Bunch Pruning	……. Plants	$170.00	100

		$/Ha
Crop Monitoring	Soil Analysis	$90.00
	Land management	

		Operations	$/Hectare	labour hours
Crop Removal (Last Ratoon)	Tractor Cutting	1		
	Discing	1		
	24-D (1.25l/ha)	1	$10.00	
	Spray Application	1	$48.60	

(3) HARVEST AND MARKETING COSTS per ha

		$/Carton	
Plant Crop	Cartons	$2.80	
	Liners	$0.12	
	Taping	$0.05	
	Tractor	$0.20	
	Cutting labour	$0.70	
	Packers Labour	$0.30	
	Levies	$0.25	
	Agent's commission (15%)	$4.39	
	Freight	$4.00	
	other	$3.00	
	total	**$15.81**	$35,254.07
Ratoon Crop	Cartons	$2.80	
	Liners	$0.12	
	Taping	$0.05	
	Tractor	$0.20	
	Cutting labour	$0.55	
	Packers	$0.30	
	Levies	$0.25	
	Agent's commission	$0.00	
	Freight	$3.40	
	other		

Appendix 5 Banana Variety Selection Criteria

	Synonyms	Classification	Yield/time**	Ethnic Opportunity	Taste
Best Prospects					
Lakatan	Pisang Berangan	AAA (AA*), Lakatan	48%	Filipinos; Indonesians	*****
Gros Michel	Pisang Ambon	AAA, Gros Michel	44%	Various[LA; Indonesians]	****
Pisang Ceylan		AAB, Mysore	62%	Indians; Samoans; Fijians	****
High Noon	SH-3640.10	AAAB, Pome Hybrid	71%		****
Kluai Khai Bonng		AAA	33%		**
Inarnibal		AA, Pisang Lemak Manis	32%	Indonesians	***
FHIA-18	SH-3480, Bananza	AAAB, Pome Hybrid	65%		****
FHIA-02	Mona Lisa	AAAA, Williams? Hybrid	80%		***
Commercial					
Red Dacca		AAA, Red	60%	Various	***
Dwarf Red Dacca		AAA, Red	62%	Various	***
Sugar	Latundan, Apple, Pisang Raja Sereh	AAB, Silk	39%	Various	****
Sucrier	Pisang Mas, Monkey Banana, Kluai Khai, Senorita	AA, Sucrier	27%	Vietnamese; Various	****
Ducasse		ABB, Pisang Awak	46%	Vietnamese; Thai	***
Kluai Namwa Khom	Dwarf Ducasse	ABB, Pisang Awak	~45%	Vietnamese; Thai	***
Goldfinger	FHIA-01, SH-3481	AAAB, Pome Hybrid	71%		***
Santa Catarina Prata	Prata Ana	AAB, Pome	37%		*****
Lady Finger		AAB, Pome	36%		*****
Williams [Cavendish]		AAA, Cavendish	100%		***
Less prospects					
Yangambi Km5		AAA, Ibota	~55%		***
SH-3656		AAAB, Pome Hybrid	~70%		***
FHIA-03	SH-3565	AABB	~70%		***
Kluai Hom		AA	~40%		***
Pisang Susu		AAA	~40%		***
Cooking & commercial					
Pacific Plantain		AAB, Maoli/Popoulu	64%	Pacific Islanders	####
Mangaro Torotea		AAB, Maoli/Popoulu	~80%	Pacific Islanders	####
Horn Plantain	Tanduk, Pisang Tandok	AAB, Plantain	37%	LA; WA; Asian	#####
Dwarf French Plantain		AAB, Plantain	42%	LA; WA; Asian	#####
Pisang Gajih Merah	Saba	ABB, Saba	39%	Filipinos; Indonesians	#####
Bluggoe	Square Cooker	ABB, Bluggoe	~30%	Islanders	##
Blue Java	Blue Lubin	ABB, Ney Mannan	~35%	Islanders	##
Pisang Raja		AAB, Pisang Raja	32%	Indonesians	###
* Literature reports as	** If breakeven for	LA = Latin Americans			*****
diploid but flow cytometry	Williams is	WA = West Africans		[5] Banana Streak Virus	Subjective 5-star
shows our material is	$17/carton then		[1] benefits from bunch support	[2] race1; subtropical race 4; tropical race 4	[3] some ratoon resistance
triploid	0.33 yield -> $34				
	0.5 -> $26				
	0.67 -> $21	If all things =			

	Greenlife	Wind Sus	Stature	Black Sigatoka	Yellow Sigatoka	*Foc* R1[2]	*Foc* SR4	*Foc* TR4	Other comments
Best Prospects									
Lakatan	*****	Sus	Intermediate	Vsus	Vsus	Res	Sus	Sus	
Gros Michel	*****	Vsus	Tall	Vsus	Sus	Sus	Sus	Sus	Fruit less prone to mechanical damage in transport
Pisang Ceylan	?	Sus	Tall	Res	Res	Sus[3]	Sus[3]	Sus	
High Noon	?	Sus	Intermediate	Sus	Sus	Res	Res	Sus	
Kluai Khai Bonng	?	VSus	Intermediate	Res?	Res	Res	Sus	Sus?	Very attractive fruit
Inarnibal	?	ParRes	Dwarf	Sus?	Res	Res	Sus	Sus?	
FHIA-18		ParRes	Intermediate	Vres	Sus	Res	Res	Res	Finger drop; fruit splitting
FHIA-02		ParRes	Intermediate	Vres	Res	Sus	Sus	Sus?	
Commercial									
Red Dacca	?	Vsus	Tall	Sus	Sus	Sus	Sus	Sus	Some choke throat
Dwarf Red Dacca	?	Res[1]	Dwarf	Sus	Sus	Sus	Sus	Sus	
Sugar	?	ParRes	Intermediate	Sus	Sus	Sus	Sus	Sus	
Sucrier	?	ParRes	Intermediate	Res	Sus	Res	Sus	Sus	
Ducasse	*	ParRes	Tall	Res	Res	Sus	Sus	Sus	
Kluai Namwa Khom	*	Res[1]	Dwarf	Res	Res	Sus	Sus	Sus	Bacterial finger tip rot
Goldfinger		ParRes	Intermediate	Vres	Sus	Res	Res	Res	Fruit non-browning
Santa Catarina Prata	**	Vres	Intermediate	Vsus	Vsus	Sus	Sus	Sus	Fruit non-browning; Some choke throat
Lady Finger	****	Res	Tall	Vsus	Vsus	Sus	Sus	Sus	Fruit non-browning
Williams [Cavendish]	*****	Sus	Dwarf	Vsus	Vsus	Res	Sus	Sus	
Less prospects									
Yangambi Km5	?	ParRes	Intermediate	Vres	Vres	Res	Sus	Sus	
SH-3656	?	ParRes	Intermediate	Res?	Sus	Res?	Res	Sus?	
FHIA-03	?	ParRes	Intermediate	Res	Res	Sus	Sus	Res?	
Kluai Hom	?	Res	Intermediate	Sus?	Res	Res?	Sus?	Sus?	
Pisang Susu	?	ParRes	Tall	Sus?	Sus	Sus?	Sus	Sus?	
Cooking & commercial									
Pacific Plantain	*****	Res	Dwarf	Sus	Sus	Sus	Sus	Sus?	
Mangaro Torotea	?	ParRes	Intermediate	Sus	Sus	Sus	Sus	Sus?	
Horn Plantain	?	Sus	Intermediate	Sus	Res	Res	Sus	Sus?	BSV[5] issues
Dwarf French Plantain	?	Res[1]	Dwarf	Sus	Res	Res	Sus	Sus?	BSV issues
Pisang Gajih Merah	?	ParRes	Tall	Res	Vres	Sus	Sus	Sus	
Bluggoe	?	ParRes	Intermediate	Res	Vres	Res	Sus	Sus	
Blue Java	?	ParRes	Intermediate	Res	Vres	Res	Sus	Sus	
Pisang Raja	?	Sus	Tall	Sus	Sus	Res	Sus	Sus	