Horticulture Innovation Australia

Final Report

Australian Citrus Quality Standards Program – Stage 2

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Citrus Australia Limited

Project Number: CT12004

CT12004

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Contents

Summary

The citrus industry is one of Australia's largest horticulture industries, producing on average 600,000 tonnes per year, for the past ten years. Each year around 225,000 tonnes of citrus is consumed by the domestic market, the remainder is exported (160,000 tonnes on average) or processed by the juice industry. The domestic market is the citrus industry's largest market, it is competitive and often quickly over supplied at the commencement of the season. Previously quality standards for taste and appearance were held by each state, but have since been deregulated (with the exception of Western Australia). Supplying citrus as early as possible became a strategy to improve grower returns at the beginning of the season. However, citrus is a non-climacteric fruit, meaning it does not continue to ripen after picking, and fruit that is harvested prior to maturity is typically either bland or sour, neither of which encourage repeat purchase behaviour in most Australian citrus consumers.

Citrus is part of the fresh food industry, regardless of the transactions between grower, marketer and retailer, the consumer is the customer, a fact often forgotten by some in industry. Fresh citrus such as mandarins and oranges are peeled and eaten as snack food and compete with a plethora of quality controlled, consistently flavoured, manufactured snack foods. The citrus industry could not continue its trajectory of poor quality control and inconsistent taste without creating consumer mistrust and destroying demand, as has been the case in other industries.

The key activity in CT12004 was completing a large-scale consumer sensory evaluation exercise to provide a scientific basis to the Australian Citrus Quality Standards. Taste panels were conducted in Perth and Melbourne, and included six navel orange taste panels with 720 test subjects tasting 2,160 fruit samples, and four Afourer mandarin taste panels with 480 test subjects tasting 1,440 fruit samples, across a spread of age, ethnicity, gender and income demographics.

This exercise is the largest ever undertaken in Australia on citrus and gave us the confidence to adopt the BrimA method of expressing fruit maturity, and to set consumer acceptance thresholds based on this method. These new Australian Citrus Standards for oranges and mandarins (which adopt BrimA as the predictor of citrus likability) are now widely adopted by the entire supply-chain.

Other highlights of the project include:

- National industry adoption of BrimA maturity standard
- 2,384 citrus maturity tests performed
- 102 Australian Citrus Quality Standards market reports sent to industry
- Imperial granulation trained panel and consumer sensory analysis survey completed

Recommendations from the project include:

- Hort Innovation continue funding of the quality standards project, specifically a project that:

    1. Provides industry with independent testing and transparent reporting of fruit maturity results at market.

    2. Develops and implements a maximum granulation standard for Imperial mandarin.

    3. Strengthens linkages with the national supply chain, with the goal of achieving greater adoption of quality improvement practices.

4. Develops a standard operating procedure for starting harvest, in consultation with industry stakeholders, to reduce the likelihood that immature fruit will enter the supply chain.

5. Introduces ACQS pre harvest field testing and reporting to provide industry with maturity results of key varieties in a range of representative growing regions, prior to harvest.

6. Strengthens our linkages with national and international researchers working on citrus quality improvement.

- Hort Innovation seeks to implement other fruit eating quality related research and development projects as raised in the Sweeter Citrus workshop, such as:

    1. Developing and evaluating non-destructive testing equipment for accurately assessing Brix, acidity and granulation of Imperial mandarins.

    2. Understanding variation in fruit maturity, within the tree and orchard, and between orchards within a district.

    3. Developing on-farm cultural practices to improve fruit quality, in particular reduced deficit irrigation monitored by remote sensing of tree stress.

    4. Protecting Australia's taste advantage in export markets – ensuring Australian growers and marketers can continue to demand high prices for fruit through gaining a better understanding of consumer requirements in export destinations.

    5. Developing a digital library of fruit external defect images to assist the supply chain with quality assurance specifications.

Keywords

Citrus maturity; BrimA; Brix; acid; sensory analysis; consumer preference; trained panel; granulation; citrus taste; citrus flavour

Introduction

Project CT12004 is the continuation of the work commenced in the CT09055 *Co-ordinating a market development program for the Australian citrus value chain* project. In 2010, Citrus Australia's Domestic Market Committee recommended a program for establishing national standards for citrus maturity (based on sugar levels, acidity and juice content) and recommended that compliance by industry to these standards should be monitored. With strong and widespread support from industry, Citrus Australia established the Australian Citrus Quality Standards Program (ACQS), and began applying it in the 2011 citrus season.

The *Australian Citrus Strategic R&D Plan 2012-17* (Horticulture Australia Limited, Citrus Australia Limited, 2011) identified four key Objectives and Key Strategy Areas.

> *Objective 1: Develop and Maintain Market Opportunities*
>
> *Objective 2: Increase Product Value*
>
> *Objective 3: Improve Efficiency and Sustainability*
>
> *Objective 4: Provide a Supportive Operating Environment*

The industry identified the ACQS program as a strategy in Key Objective 2:

> *Objective 2.1.1 Implement a national quality standards program to improve eating quality*

CT12004 resourced a Manager of Market Information and Quality (0.5FTE) that worked with the Manager of Market Development (CT13022) to drive cultural change in the industry, influencing stakeholders along the value chain to adopt a quality first approach to supplying citrus. This report will explain the methods used to affect this change, but to summarise we:

- Produced evidence of market failure
- Raised awareness, educated the value chain
- Provided scientific evidence for change
- Supported and communicated with stakeholders along the value chain

CT12004 operated between 1 July 2012 and 31 December 2015.

Methodology

1. Awareness and education

From the commencement of the Australian Citrus Quality Standards in CT09055, it became clear that stakeholders in the citrus industry had a poor understanding of fruit maturity. As such, a large part of the project has focused on educating the value chain, from growers to retailers. This has included raising awareness of:

- Terminology, units of measure
- Equipment available and its use
- Methods of maturity assessment
- Calculating maturity result (Brix acid ratio, BrimA)
- Poor quality in the market place
- Variation in fruit maturity

2. Consultation

Throughout the life of the CT12004 project, the Manager of Market Information and Quality reported to the Domestic Market Committee (DMC); a skills based steering committee made up of growers, packers and marketers. The DMC met face to face twice per year and on other occasions via teleconference or by email. The DMC provided practical guidance and feedback to the market development team as they sought to ensure commercial relevance to the research and development they conducted.

The market development team sought feedback at national and regional grower meetings and through calls for feedback by email and post. This information was presented at meetings of the DMC for their input.

To raise awareness of the citrus industries commitment to improving the taste, quality and consistency of citrus the Manager of Market Information and Quality consulted with the business and quality teams of:

- Woolworths
- Coles
- IGA (Metcash)
- ALDI
- many wholesale marketers across Australia.

The Manager of Market Development built networks with personnel at the following research institutions:

- University of California, Riverside
- United States Department of Agriculture
- New Zealand Plant and Food
- Curtin University
- Central University of Queensland
- University of Queensland
- New South Wales Department of Industry
- Department of Agriculture and Food Western Australia

Information gathered through these networks was provided in verbal progress reports the DMC to inform them of advances in citrus maturity research and development and the varying attitudes toward citrus maturity by the

retailer's and wholesale marketers.

Notes of the DMC meetings including recommendations to the board were provided to the Board of Citrus Australia to further extend the consultation process.

3. National standards

An outcome of the CT09055 project was the introduction of agreed national citrus maturity standards. These were standards that came from various sources, but none based in scientific fact. Between the 2011 and 2013 citrus seasons the ACQS used Brix, Brix acid ratio and juice percentage to express the minimum maturity standards. However, there was evidence from international sources that a better method for measuring maturity of citrus, BrimA, (Brix – (4xAcid)) had been developed. The Manager of Market Information and Quality travelled to California in November 2012 to meet researchers at University of California, the United States Department of Agriculture and citrus industry representatives (a copy of the travel report is attached as Appendix 1. California study trip_BrimA 2012).

Encouraged by the strong support for the change to BrimA in California, the market development team conducted a consumer sensory evaluation exercise to provide a scientific basis to the Australian Citrus Quality Standards. Taste panels were conducted in Perth and Melbourne, and included six navel orange taste panels with 720 test subjects tasting 2,160 fruit samples, and four Afourer mandarin taste panels with 480 test subjects tasting 1,440 fruit samples, across a spread of age, ethnicity, gender and income demographics (a copy of the report is attached as Appendix 2. Navel orange and mandarin consumer preference study).

The consumer survey was designed to determine:

- Which maturity parameter (Brix, acid, Brix acid ratio or BrimA) correlated with consumer preference
- What the minimum maturity standard should be to encourage consumption

Results of the consumer study showed that only BrimA correlated with consumer preference, and that BrimA could be used to predict consumer preference. BrimA is a mathematical equation that reflects the importance of acid in the balance of flavour in citrus fruit. Acid is present in small amounts in citrus (typically between 0.5 Brix and 1.4 Brix in mature fruit) yet it plays a large part in the perception of flavour.

Results of the survey were reported to industry at national and regional citrus grower meetings and through magazine articles. At the National Issues Forum held in October 2013 industry voted to drop the previous standards of Brix and or Brix acid ratio and to implement the new standard now known as the Australian Citrus Standard.

4. Market reporting

The Manager of Market Information and Quality facilitated testing of citrus fruit samples from five wholesale markets: Brisbane, Sydney, Melbourne, Adelaide and Perth. The testing was conducted to the specified protocol (based on best practice) by fruit maturity assessors that were trained and audited by the Manager of Market Information and Quality.

Fruit was sampled at random from fruit marketers stalls and tested within 24 hours of collection (this was to allow accumulation of samples over 1-2 market days). Results of the maturity tests were recorded in a spreadsheet provided by the Manager of Market Information and Quality and emailed to him on a weekly basis. The data from the five markets was collated into a report, checked for errors and inconsistencies. In the case of a failed result the grower/ received an email prior to the release of the report, detailing the results of the test and all of the data collected about the sample. This allowed them to trace back and determine why the failure

occurred. This would include:

- grower number
- packed on date
- batch number
- wholesale market
- market agent
- photographs of labels and fruit (if requested)

If the grower/packer challenged the result, the Manager of Market Information and Quality would investigate any perceived inconsistencies. At no time was a result withdrawn, most challenges resulted in:

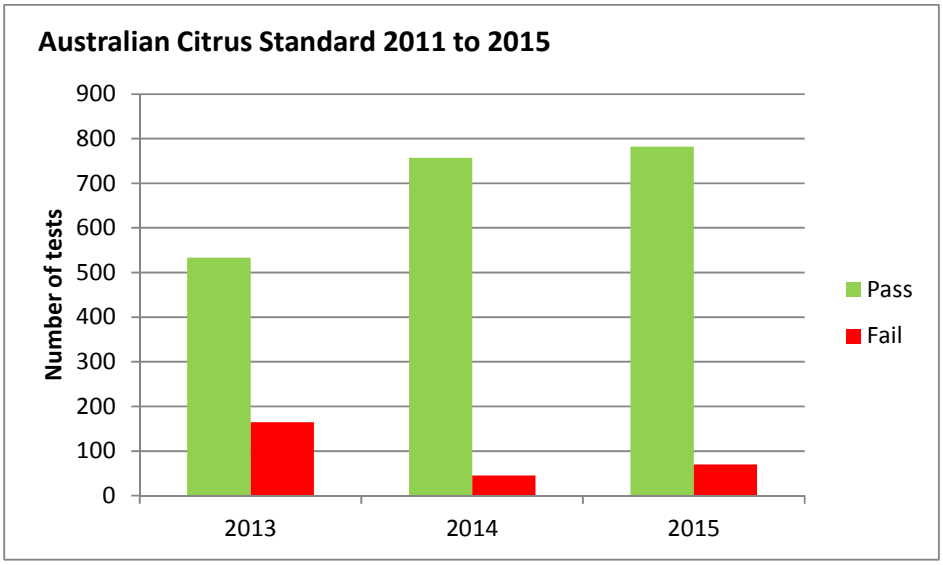
- The grower or packer finding that there had been a break down in their quality procedures.
- An admission of a poor understanding of maturity standards or methods of measuring maturity standards.
- Correction of minor details such as grade or variety name.

All results of the weekly testing were sent to an email list whose members had direct links to the citrus industry as growers, packers, marketers or retailers.

Over the three years of CT12004 the project:

- Conducted 2,384 citrus maturity tests
- Delivered 102 Australian Citrus Quality Standards market reports to industry

The market development team acknowledges contributing factors such as seasonal conditions, however there is evidence that the quality of citrus tested in the market place has improved over the three years of the project. Using the ACS as a comparison, the failure rate for citrus in the markets decreased from 24% in 2013 to 6% and 8% in 2014 and 2015 respectively.



5. Imperial mandarin granulation

The Imperial mandarin is almost exclusively grown in Australia and is one of the industry's most important varieties with 1,700ha planted nationally. It is the first mandarin available in the domestic market and each

season its quality and market performance is considered a barometer for the success of the season. Granulation, also referred to as dryness, is a physiological phenomenon that affects the available juice content of the fruit. Juice sacs in the fruit develop a gel and become flavourless as the intensity of granulation increases. Research into the cause of granulation has found some likely contributing factors but no management practices have been developed that consistently reduce the incidence of granulation.

During the life of CT12004 the issue of Imperial mandarin granulation grew worse. Measuring granulation is difficult in the orchard and can only be done by destroying the fruit. Visual assessment is being conducted by retailers and marketers without evidence to support the assessment. The market development team felt that a key element missing from the research was to understand how granulation affected consumption. A research project was developed with by Dr. Sangeeta Prakash from Queensland University and facilitated by the Manager of Market Information and Quality (a copy of the report is attached as Appendix 3. Dry fruit or granulation in Imperial Mandarin).

The project first established a lexicon to describe granulation in laymen terms and then conducted a consumer preference study to determine what percentage of granulation consumers found unacceptable. The study found that:

1. Imperial mandarins with 35% granulation are acceptable by consumers on all parameters tested.
2. Imperial mandarins with 45% granulation are acceptable but not always preferred by consumers.
3. Imperial mandarins with 55% granulation are not preferred by consumers.
4. Consumers expressed an intention to purchase Imperial mandarins with 35% and 45% granulation, but on average would not purchase mandarins with 55% granulation.

This data provides the first plank in the determination of a maximum allowable granulation threshold per sample. Further work to develop a visual guide is required. Researchers at the Central University of Queensland are developing equipment that could potentially sort fruit on the packing line. Whilst this will help reduce the amount of poor quality fruit on the market it does not help growers to grow better fruit. Research into that area must continue.

Outputs

Reports

Reports of the two consumer studies conducted during CT12004

- Investigating consumer taste preferences of Australian navel oranges and rich flavoured mandarins, 2014, Dr. C. Storer, G. McAlpine, N. Hancock, A. Harty, B. Walsh and K. Lacey
- *Sensory evaluation of Imperial mandarins by trained and consumer panel*, 2015, Dr. S. Prakash, Sensory Evaluation Services, School of Agriculture & Food Sciences, The University of Queensland.

Presentations

The following presentations were delivered by the Manager of Market Information and Quality:

- *All in good* taste, Produce Marketing Association, July 2012
- *Internal Quality,* Maturity, Post conference technical forum, Yanco, NSW October 2012
- *Australian Citrus Quality Standards*, Sunraysia Citrus Growers Annual General Meeting, November 2012
- *Citrus Quality Standards - Sensory Evaluation 2013*, National Issues Forum, Melbourne, October 2013
- *Queensland Growers Post season meeting 2013*, Gayndah Qld, October 2013
- *Improving consumer satisfaction - ACQS*, Regional Forums – Western Australia, Queensland, Riverland, Riverina, Murray Valley February – April 2014
- *Improving consumer satisfaction ACQS – Citrus Outlook 2014*, National Outlook Forum, Sydney March 2014
- *Developing a minimum standard for granulation in Imperial mandarins*, Citrus Technical, March 2015
- *ACQS regional forum presentation*, Queensland, Riverina, Sunraysia, Riverland, Western Australia, March to April 2015
- *Australian Citrus Quality Standards – 2015 score card*, 2015 National Issues Forum, Melbourne November 2015
- *Australian Citrus Quality Standards – 2015 score card*, Queensland post season meeting, December 2015

Workshops

The market development team organised and facilitated a workshop in Dareton, NSW, in April 2014 called *The Sweeter Citrus Workshop*, which brought together researchers and industry personnel to discuss citrus quality. Topics covered in the workshop included:

- Citrus germplasm & nutrition
- Reduced deficit irrigation
- Maturity sampling & grading
- Project Development

From this workshop a project concept was developed that reflected the strategic research and development needs of industry to continue improving the quality of citrus for Australia's domestic and export markets.

Other workshops conducted by the market development team include:

- Produce Marketing Association citrus maturity testing workshop
- Training ALDI quality assurance staff to conduct maturity assessments of citrus (6 workshops)
- Post-harvest quality assessment of citrus – ALDI staff training
- Tasting the difference – two workshops held in Western Australia to demonstrate maturity testing and the difference in flavour, using Brix acid ratio and BrimA results.

Articles

During the life of the project the following articles were published:

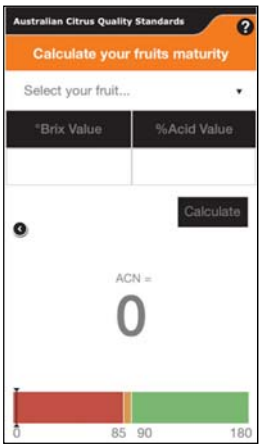
- *Global eating quality standards prove sweet fruit sells*, Australian Citrus News article June/July 2012

Volume 89 pp11.

- *Orchard management practices critical in reducing granulation*, Australian Citrus News article Aug/Sept 2012 Volume 89 pp10-12.
- *Setting the standard on taste to grow citrus sales*, Media release 31 October 2012
- *California visit kick starts Australian taste research*, Industry newsletter 8 December 2012
- *Quality standards report card: progressing well but needs improvement…*, Australian Citrus News Vol 89, Feb/Mar/Apr 2013 pp 14-15
- *BrimA - offering a 'sweeter' option for testing Aussie citrus*, Australian Citrus News Vol 89, Feb/Mar/Apr 2013 pp 16 - 19
- *Quality standards 2013 - adjustments made to balance flavour*, Australian Citrus News Vol 89 Apr/May pp 21
- *Navel taste panels launched in Perth*, Australian Citrus News Vol 89 June/July 2013 pp 22
- *Consumer preferences to provide clear direction for industry*, Australian Citrus News Vol 89 September 2013 pp 6
- *Australian Citrus Quality Standards: 2013 season report card*, Australian Citrus News Vol 89 December 2013 pp 30
- *Taste panels show a better way to measure consumer preferences*, Australian Citrus News Vol 89, December 2013 pp 24-29
- *Growers highlight management techniques at Queensland Imperial field day*, Australian Citrus News Vol 89 March 2014 pp 20-22
- *Workshop seeks to identify secrets to test sweeter citrus in the orchard*, Australian Citrus News Vol 89 June 2014 pp 24-25
- *Rind issue testing for mandarin growers*, Australian Citrus News Vol 89 June 2014 pp 26-27
- *Internal quality trumps season woes*, Australian Citrus News Vol 89 June 2014 pp 25
- *Quality standards program gains respect from leading Australia retailers*, Australian Citrus News Vol 89 September 2014 pp 19
- *WA growers get taste of maturity*, Australian Citrus News Vol 89 December 2014 pp 10
- *Three years on and industry is embracing ACQS*, Australian Citrus News Vol 89 December 2014 pp 12
- *Better taste to boost consumption*, Australian Citrus News Vol 89 Summer 2015/16 pp 12
- *Consumers accept 35% granulation*, Australian Citrus News Vol 89 Summer 2015/16 pp 12

Apps

The Manager of Market information and Quality developed an App for iPhone and Android users; search 'Citrus Maturity Calculator' in App Stores and Google Play.



Webpage

Citrus Australia's website contains resources for industry stakeholders under the tab *Citrus Quality and Maturity.* The information was available without login requirements. The webpage holds information such as:

- The Australian citrus quality manual
- The Australian citrus quality standards
- Australian Citrus Quality Standards - Calculating citrus fruit maturity guide
- Australian Citrus Quality Standards - calculations spread sheet
- Citrus maturity testing equipment list
- A link to the Australian Citrus Quality Standards guide video
- Australian Citrus Quality Standard calculator

Market development team reports to Board of Citrus Australia

Detailing the activities of CT12004 on a bi-monthly basis

- July-December 2012: 4 reports
- January-December 2013: 6 reports
- January-December 2014: 6 reports
- January-December 2015: 6 reports.

Advisory committee minutes – domestic market

Capturing the debate and decisions of the Domestic Market Committee chaired and coordinated by the market development team

- July – December 2012 – 1 meeting
- January – December 2013 - 2 meetings
- January – December 2014 - 3 meetings
- January – December 2015 - 2 meetings.

Retail and Wholesale Market visits

On average the Manager of Market Information and Quality visited the wholesale markets and met with the wholesale marketers that buy and sell citrus twice per season.

Meetings with retailers such as Woolworths, Coles and ALDI were conducted pre and post season and on a needs basis when quality issues arose. Initial meetings with Metcash were positive, but stalled for some time. The

Metcash business model does not have the same influence on purchasing decisions as its contemporaries, therefore more effort was put into building networks with the other retailers with the intention to revisit Metcash on a less frequent basis.

Outcomes

CT12004 has been the driver of cultural change across the value chain.

The outcomes of the project can be summarised as:

1. An industry with minimum quality parameters that reflect its consumers preferences
2. An industry with an increased awareness of the importance of meeting consumer expectation
3. An industry that is conversant in the terminology and methodology of assessing citrus fruit maturity
4. An industry that can make informed decisions about the level of maturity at which fruit is harvested and the likely impact on demand the fruit will have on consumers
5. A retail sector that is aware of the citrus industry's efforts to improve quality
6. A retail sector that is confident in the long term strategy of the citrus industry

Evaluation and Discussion

This report has already covered many of the positives of the project. There are some areas that the project did not perform as well in and some issues that arose during the project that could not be covered due to time or financial restraints which will be mentioned here.

As the project developed it became apparent that the issue of maturity variation was not well understood by industry. CT12004 and other research has shown there is significant differences in fruit maturity between fruit on the same tree, as well as differences between trees in different soil types, rootstocks, topography and growing regions to name a few variables.

This leads into a second point, the industry needs a rapid method for testing acid levels; titration is slow and uses chemicals and glassware that is not practical in busy distribution centres for example. If a rapid, non-destructive acid test could be developed it would allow more frequent, individual fruit samples to be taken, thus improving accuracy and understanding of fruit maturity and variation. Currently industry best practice is to combine ten fruit in a sample, which saves time and provides an average of the ten fruit tested. However current test results are simply an average of a very small sample of a potentially very large volume because testing is slow and destructive

In a similar vein and as previously mentioned, assessing of granulation of Imperial mandarins is difficult. Whilst creating a visual guide based on consumer preference is a positive step forward for industry, it is a subjective measure. Ultimately it would benefit industry to have a non-destructive tool for measuring fruit either in the orchard or on the packing line. Even more importantly, the lack of a management solution for Imperial granulation is a threat, because marketers, retailers and consumers could lose confidence in Imperial mandarins if granulation goes on unabated; it will spell the end for the variety.

Collaboration with the national supply chain, in particular major retailers has largely been positive. Having retailers adopt the ACQS is seen as the only viable method of enforcing the standards; legislation is unpopular with growers and government alike. To date only ALDI have adopted the ACQS as their minimum standards for citrus, the other major retailers acknowledge the standards and have stated intentions to adopt, but there are hurdles in their businesses which have so far prevented this. A contributing factor is the staff turnover in these businesses and the loss of corporate knowledge as each staff member moves to a new position. Changing maturity specifications is not taken lightly and needs the confidence of someone who understands the business, this can be hard to do if the tenure is not long enough.

A significant factor in poor product reaching the market place is the lack of procedure around the commencement of harvest. As mentioned above this is compounded by the inconvenience of titrating acid levels. Aside from that issue, the supply chain would benefit from a standard operating procedure for commencing harvest. If this became a requirement of the retailers it would further regulate adherence to the minimum maturity standards and would put less pressure on quality assurance staff in the distribution centres as they could rely on a documented best practice process for harvest being conducted. Without doubt it is growers and packers that harvest early that most impacts consumer confidence; the consumer pays a relatively high price for a product they did not enjoy and do not want to purchase again. Improving the protocol by adopting best practice techniques and standardising procedures will benefit the industry long term.

CT12004 reported that due to the high cost of labour the only practical on-farm cultural practices to improve fruit quality in the Australian citrus industry are deficit irrigation and nutrition programs. The market development team were limited in their ability to progress this further, however these ideas were raised at the Sweeter Citrus

workshop, in particular reduced deficit irrigation monitored by remote sensing of tree stress. This is the sort of research and development that could set Australian citrus apart from its competitors and maintain the quality advantage we currently trade on.

On average 160,000 tonne of citrus per year has been exported, for the past ten years. In the past two seasons export volume has set new records. The Australian industry leverages higher prices from premium markets because of its reputation for taste and safe growing practices. To protect these premiums, industry must gain a better understanding of consumer requirements in export destinations so they can make informed decisions about minimum maturity levels in their shipments.

CT12004's primary focus has been on internal quality, maturity and taste. However, the Manager of Market Information and Quality has received requests for information about a wide range of quality issues, including external defects. The topic of external fruit standards and grading comes up regularly and is passionately argued. To this point there has been no appetite by larger players in the industry to go down that path. Regardless, CT12004 identified the need for a digital library of fruit external defect images; this will assist the supply chain with identifying issues and could be used by stakeholders to develop training materials that suit their specific needs.

Recommendations

Recommendations from the project include:

- Hort Innovation continue funding of the quality standards project, specifically a project that:

    1. Provides industry with independent testing and transparent reporting of fruit maturity results at market.

    2. Develops and implements a maximum granulation standard for Imperial mandarin.

    3. Strengthens linkages with the national supply chain, with the goal of achieving greater adoption of quality improvement practices.

    4. Develops a standard operating procedure for starting harvest, in consultation with industry stakeholders, to reduce the likelihood that immature fruit will enter the supply chain.

    5. Introduces ACQS pre harvest field testing and reporting to provide industry with maturity results of key varieties in a range of representative growing regions, prior to harvest.

    6. Strengthens our linkages with national and international researchers working on citrus quality improvement.

- Hort Innovation seeks to implement other fruit eating quality related research and development projects as raised in the Sweeter Citrus workshop, such as:

    1. Developing and evaluating non-destructive testing equipment for accurately assessing Brix, acidity and granulation of Imperial mandarins.

    2. Understanding variation in fruit maturity, within the tree and orchard, and between orchards within a district.

    3. Developing on-farm cultural practices to improve fruit quality, in particular reduced deficit irrigation monitored by remote sensing of tree stress.

    4. Protecting Australia's taste advantage in export markets – ensuring Australian growers and marketers can continue to demand high prices for fruit through gaining a better understanding of consumer requirements in export destinations.

    5. Developing a digital library of fruit external defect images to assist the supply chain with quality assurance specifications.

Citrus Australia has the expertise and motivation to provide overall coordination for such a program, and would ensure that uptake of R&D outcomes by the value chain and benefit to industry were maximised.

Intellectual Property/Commercialisation

No commercial IP generated.

Appendices

Appendix 1. California study trip_BrimA 2012
Appendix 2. Navel orange and mandarin consumer preference study
Appendix 3. Dry fruit or granulation in Imperial Mandarin

Appendix 1

Study trip to investigate Californian citrus maturity standards

1 - 9 December 2012
Nathan Hancock
Manager Market Information & Quality
Citrus Australia

Background

In 2010, Citrus Australia's Domestic Market Committee focussed on minimum maturity standards as a primary objective in the development of the domestic market. In its role as custodian of the Australian Citrus Quality Standards (ACQS), Citrus Australia is seeking to find minimum standards that will have a positive impact on consumer purchasing. In 2013, Citrus Australia will commission a sensory analysis project to more accurately determine Australian consumer preferences for citrus fruits.

In June 2001 a paper was published by researchers in New Zealand which outlined BrimA - a proposed new index to replace Brix:acid ratio as a measure of consumer preference for citrus (Jordan et.al, 2001). In May 2011, an article in the Citrograph by Dr Mary Lu Arpaia and Dr David Obenland (University of California) showed a strong correlation between BrimA and US citrus consumer preference. They proposed that a new standard - the California Standard, which incorporates BrimA - should be adopted by the Californian citrus industry (Arpaia et al 2011).

In October 2012, the Californian citrus industry, after much industry consultation and debate, adopted the California Standard for navel oranges. The driver for change after 100 years of using the same maturity parameters was recognition by industry that they were losing orange consumers due to poor eating experience.

Having introduced voluntary minimum standards based on Brix level, Brix:acid ratio and juice content, Citrus Australia felt it necessary to investigate the new California Standard, its impact on growers, the science behind the change and how maturity standards in California are enforced. I therefore travelled to California in early November 2012, at the start of the Californian citrus harvest season, where I met with growers, nurserymen, packers, industry service bodies, inspectors and researchers. The excellent cooperation I received from my hosts was very much appreciated.

Californian citrus industry overview

- According to the 2012 California Citrus Acreage Report the Californian industry consists of 107,683ha of citrus (266,090ac), however Californian Citrus Mutual estimates it is closer to 115,335ha (285,000ac).
- Navel plantings have declined by 3% in the past two years to 52,600ha, of which 3,400ha are non-bearing.
- Late navel area of production is 7,330ha, of which 300ha are non-bearing.

- According to several contacts the lateness of the 2011/12 crop was considered a failure - the fruit that was in the US, Japan and other markets into August (and which negatively affected Australian navel sales in those markets) was a financial loss and packers will in future attempt to exit the market by mid-July.
- The California industry is not happy with yields of the current suite of late varieties (predominantly Australian) and is investigating new varieties from South Africa, as well as improved nutrition programs to set and carry larger crop volumes.
- The area planted to mandarins has risen from 7,400ha in 2006 to 14,900ha in 2012, of which 2,300ha are non-bearing.
- The main varieties of mandarin grown are Clementine 4,317ha and W.Murcott (Afourer) 3,950ha. Tango (a seedless Afourer) is also increasing in production area with 2,340ha planted, of which 1,040ha are non-bearing.
- Mandarin growers have found that to set a crop under inland Californian growing conditions it is necessary to cincture Clementine varieties. Traditionally this has been a trunk cincture, however trials are being conducted on branch cincturing too. (Cincturing involves cutting the bark in a ring around the circumference of the trunk or branch, but not removing any of the bark as in girdling.)
- Whilst there is a large market for mandarins in the US, naturally some volume will be exported to places such as Australia - there are implications for our growers who may find themselves competing with Californian Afourers in the traditional Imperial window of late April/May, particularly if dryness of our Imperials continues to turn off consumers.
- Clementine harvest had commenced during my visit (early November) and fruit quality was generally very good. Dryness is an issue in the Clementine variety and I witnessed some dry fruit at several orchards.
- The 2012/13 navel crop appears to have a large volume of small fruit with a low acid level early in the season.
- The cold winter period of December- February, where maximum daily temperatures are as low as 3 - 5°C, extends the life of the fruit.
- The industry is under pressure from 'environmental politics' for air quality issues as well as access to water - much of the San Joaquin Valley is on 10-15% water allocation due to an endangered fresh water fish.

Study tour overview

California Citrus Mutual Annual Dinner - I was hosted by California Citrus Mutual (CCM) at their 36th annual dinner. The guest speaker Rebecca Bech (Deputy Minister of APHIS Plant Protection and Quarantine program) was scheduled to speak on the HLB funding/program however she was replaced due to flooding in her home state. Instead, local state and national politicians (I was there during the US Elections) spoke on their intentions to support agriculture in California.

Despite the size of the Californian agricultural industries in the San Joaquin Valley the industry is essentially politically powerless due to the relatively small population. Approximately 3.9 million people live in the 8 counties that make up the San Joaquin Valley, a percentage of them are employed/involved in agriculture. In comparison the population of California is estimated to be in excess of 38 million people.

I had discussions with growers and packers at the dinner about the Californian Standard, US supply, length of season, supply shoulders, mandarin production. All seemed willing to collaborate and expressed an interest in us working together.

I also met with Joel Nelson and Bob Blakely at the CCM office in Tulare County. We discussed the similarities in the purposes of Citrus Australia and CCM and some of the issues that the two countries had with market access to common markets.

The CCM website has the following consumer page promoting the California Standard: http://thecaliforniastandard.com/

Meetings with Tree Source nursery, Griffith Farms and Suntreat Pack-house.
I visited the Tree Source nursery, one of the largest commercial citrus nurseries in the US. This nursery is transitioning from a field nursery to a potted nursery and is just months from completing that change. Roger Smith and his team have developed and patented an air prune pot (see photo) and have made large advances in reducing the time to produce a tree. He sees the next advances will come in implementing a form of hydroponics.

Griffith Farms is the parent company of Tree Source and Suntreat and is the farming arm of the business. Griffith Farms has properties across the San Joaquin Valley - 930ha in total. I visited the farm in Tulare County near the Tree Source nursery with Mike George, president of Suntreat. I tasted some Fukumoto navels here which weren't particularly sweet but weren't acidic either. Colour in the bin varied widely (see photo).

Griffith Farms are the company behind Sumo mandarin in the US. I saw a grove of Sumo trees, they'd set a reasonable crop and some trees had their branches staked for support (see photo). Griffith Farms sees great potential in the variety and hold the trademark to the name Sumo in the US.

Suntreat Packing packs for around 150 growers (3,600ha) each year, there are three separate packing lines for oranges, mandarins and Sumo mandarins. Every piece of fruit that enters the shed is sold - there are markets for 1st, 2nd, 3rd grade, juice grade and cattle feed.

I tasted Beck and Fukomoto navels here also, the fruit was sweet but not particularly flavoursome, but not acidic. I brought this up with Randy Scheer, Director of Operations at Suntreat. His comment (and it was echoed through the rest of the trip) was that early navel varieties such as Thomson Improved, Beck, Fukumoto and Bonanza are all marginal quality varieties; they never develop particularly high Brix and the acid drops out fairly quickly.

These varieties are being removed by many growers, some of them replaced with M7 early navel but others with Tango and Afourer. The California Standard is partly responsible for this trend as achieving a pass of 90 is difficult with varieties that are known to produce low sugar-low acid fruit. Varieties such as Beck and Bonanza were already out of favour with supermarkets and many growers have simply sped up their plans to remove them.

Don Rorke, citrus grower and advocate for the Californian Standard
Don by his own admission was originally against the change in standards when the discussion was simply to raise the Brix:acid ratio. His change in approach came when he became involved with the BrimA work and could see the difference in consumer responses.

He and many other growers have said that if you are a grower who doesn't try to push the boundaries too much then the standard won't affect you at all.

Don has been a strong advocate of the change and many of the industry feel his support of the change is what changed many other growers' minds.

University of California and USDA - Dr Mary Lu Arpaia and Dr Dave Obenland
My meetings with the two researchers were extremely productive. We discussed the methods that they had used over their many years of consumer surveys and preparations of the samples. Most importantly they agreed to share their raw data with me and I have copies of all of their spread-sheets used to determine correlations of consumer responses to maturity parameters.

Whilst there, I discussed my concern about the seemingly high levels of acid that fruit can have and yet still pass the BrimA. We looked for correlations with a dislike in acid, but anything we looked at was not as strong as correlations for BrimA with consumer preference (most of the samples with high acid also had high sugar).

Both researchers agreed to work with Citrus Australia as we develop our sensory analysis project and provide comment on the research methods and results if asked.

Another area of research that Dr Obenland is now involved in is the study of off flavour development in mandarins - a study which has some parallels with the work being carried out by Helen Hofman in Queensland. Dr Obenland's work has gone so far as to identify mandarin varieties by their tendency to develop off flavours. I have linked Dr Obenland with Helen Hofman from QDAFF and hopefully some collaboration can be achieved.

California Department of Food and Agriculture (CDFA)
I met with Andrew Valero, Program Supervisor, Standardisation Program, at CDFA to get an understanding of the legislation that underpins the maturity standards in California.

- The Director of the California Department of Food and Agriculture is responsible for the legislation and receives advice from the California Citrus Advisory Committee. California Citrus Advisory Committee's role among others is to advise the Director of recommendations on the inspection program including the

maturity parameters. The committee is comprised of 12 voting members who are handlers and producers of citrus in California.
- The program was entirely government funded up until 1992, now it is entirely industry funded, but regulated by government.
- More detail is provided in the section of this report that covers the California Standard procedures.

Paramount Citrus

Paramount Citrus is a privately owned fully integrated horticulture business with just over 19,000ha of citrus - navels, Valencias, Clementines/Afourers, lemons, limes and grapefruit - predominantly in the San Joaquin valley but also in Texas (6,000ha mixed citrus predominantly red grapefruit - including an acquisition on the 13/12/2012) and Mexico (4,600ha of limes, 2,500ha lemons).

I spent a day with Dr Etienne Rabe, Vice President of Horticulture, in the south of Kern County and Bakersfield area, tasting oranges and mandarins. Etienne is a major supporter of the shift to the California Standard.

Etienne felt that the testing Paramount Citrus was carrying out showed that it would be a low acid year as acid levels were already low by comparison with other years (the average of tests I saw was about 1.5% acid).

We discussed the issue of dry Clementines, which has dogged the industry since its move to the variety. Etienne has a number of irrigation trials running to see the effect on dryness and I have put Helen Hofman and Etienne in contact and shared Helen's final report with him.

Interestingly, Etienne told me that they found it very difficult to set a Clementine crop for many years. After many spray and irrigation trials it was discovered that due to the conditions in the San Joaquin Valley it was necessary to cincture each tree every year.

Size in both the mandarin and the navel crops was down, however overall estimations are that production will be higher than 2011.

We discussed the late navel category, Etienne is not happy with the yields of the current late navel varieties and is looking for other varieties in South Africa and around the world. He said that supply into August had been expensive for many packers and that in future the aim would be to finish their programs by mid-July at the latest.

Etienne felt that Paramount Citrus would be against the introduction of a BrimA/California Standard for mandarins as their company uses quality as a point of differentiation to other smaller packers and brands. Internally they have assessed BrimA and mandarins and would set the pass at around 110 on the California Standard index.

Packing sheds

Although it was still under construction the new mandarin packing shed was in operation when I was there.

Some key facts are:

- The shed is 60,000m^2 under roof.
- 40 lane pre-sorting, 5 bagging and palletising units.
- There is room for another 20 lanes and 5 bagging and palletising units.
- Capable of processing 10,000t a day (20hr day) of bagged mandarins.
- Cool store facilities could hold 14,000 tonnes of packed fruit.
- The sorting table has a remote sampling system which quality control personnel can program to deliver fruit to a quality control station for testing - currently checking seed counts and dryness.

I also had a tour of the navel and lemon packing shed next door. Some key facts:

- 41,000 m^2 under roof.
- Packing lines capable of 100 tons of citrus per hour.
- NIR technology grading for Brix.

Sunkist, Golden Valley Citrus, Strathmore CA

I spoke with Gerald Denni, General Manager of Golden Valley Citrus.Sunkist Growers is the oldest continually operating citrus cooperative in the US.
In 2011/12 they packed in excess of 400,000 tonnes.

Sunkist is cautious in the approach to the California Standard because of the political nature of the industry and their position as a cooperative. Being a cooperative they have a wide range of growers and grower crop profiles, some of which will be more affected by the change than others.

Gerald said that some varieties once considered early will be removed because of the marginal ability to meet the standard year in year out due to their characteristics of low sugar and low acid.

Sunkist carries out extensive testing and Gerald's team has gone back over the historical records and reviewed them from many angles. He and many others I spoke to felt that the positives of the change will far outweigh the perceived negatives.

He said the results from the field tasters and the maturity tests this season 'definitely can be seen as a validation of the California Standard as a very useful tool in determining not only the internal maturity but also as an indicator of taste.'

Packing shed

I toured the Golden Valley Citrus packing shed with Gerald. The shed packs a mixture of citrus and has bagging and carton facilities. An organic fruit packing line has recently been developed but we did not visit it.

After the fruit enters the line from a four bin rotating dump it floats through a tank. The fruit does not come in contact with brushes until the fruit have been treated for moulds to reduce spore build up and resistance.

The brushes in the high pressure washer section do the job of removing the sooty mould, however a surfactant can be added to the water dump and flume that loosens and helps release the sooty mould from the fruit. The surfactant used is an extract from the yucca plant and is USDA approved organic.

Black light (UV) rooms are spaced into two sections, one before the high pressure washer and one after. The one before is used to remove the obvious mould, the one following the pressure washer is useful because the pressure washer should break open any decay thus making it more obvious if missed in the first room.

A third black light area is used during heavy clear rot periods. These rooms are considered essential in packing sheds of the San Joaquin Valley. A tank following the pressure washer contains a solution of 3.0% sodium bicarbonate and 100ppm chlorine to heal up any grazes and nicks from harvest and handling. I've discussed these ideas with Peter Taverner (SARDI) and he is invstigating the black light concept. Apparently they may be considered an occupational health hazard in Australia.

Californian citrus fruit maturity parameters and protocols

Due to the manner which the Californian industry has evolved, being predominantly a navel and Valencia orange production area, the focus of quality standards have been on those commodities, with less attention given to mandarins, grapefruit, lemon and limes.

California maturity parameters for oranges focus on two aspects - peel colour (external) and the relationship of sugar to acid. There are no standards for juice percentage or Brix.

Regulation of colour development is universal across all varieties, 90% of fruit (in a sample) must achieve a 25% colour break before harvest can commence. Internal quality requirements differ between navel and Valencia oranges. Navels are tested using the Brim A calculation known as the California Standard and Valencias are tested against the Brix:acid ratio.

The regulation of the standards is conducted by County Weights and Measures inspectors, coordinated by the CDAF and funded by a grower levy (0.007cents per case of Valencias and 0.012 cents per case of navels).

Inspectors conduct cursory and official tests in the field and in pack houses across all the citrus producing counties.

Unofficial protocol

Growers and packers can contact the County inspectors and arrange to have 'cursory' tests for colour and California Standard performed. Often a packer will ask an inspector to provide feedback on colour samples to get a feel for the interpretation. By law, all the pack houses must have a prescribed juice press and many of the packers also have pick-up (ute) () mounted testing equipment, so they are already well aware of the internal maturity through their own program of pre-season testing.

Harvest can begin on any block at any time, however the risk to the grower is that harvest may be stopped and fruit destroyed if it does not meet both the colour and California Standard.

Inspectors operate in the field and at pack houses to cover as much of the crop as is possible. Inspectors operate in their own specific counties. At times, fruit grown in one county may be packed in another county and paper work must be provided for movement of the fruit.

Growers and packers can make an appointment or inspectors will 'cold call' by driving through the regions looking for evidence of picking - bins, ladders, vehicles. The inspector begins with a cursory sample for colour and the California Standard. This consists of 30 pieces of fruit randomly selected from bins. If the fruit passes both the colour and California Standard no further testing is required.

If the grower or field manager request a certificate to say the fruit has passed the cursory test, one is provided (also applies for transport permit). If the fruit fails the cursory test an official test is conducted (discussed below).

Official protocol
The detail of the protocol is in the attachment, however below I have outlined a few key points which aren't clearly defined and some differences between their and our methods of determining the soluble solid soncentration (Brix) and titratable acidity.

- When fruit fails Test 1 - either colour or the California Standard - a disposal notice (see attached examples) is attached and can only be removed by the inspector who placed the notice.
- All bins of fruit that have a disposal notice attached must be re-tested within 4 days.
- Generally the packer/grower will make a decision to 1) recondition the fruit or 2) resize the fruit.
- Reconditioning means to grade out the greenest fruit before re-presenting it to the inspector.
- Alternatively the fruit can be graded into counts and presented by size. Each count size will be considered a single lot and will be allowed to be tested separately, increasing the chance that some fruit will pass the Test 2 process.
- Fruit in the field must be reconditioned or sized in the field.
- Fruit in the packing shed cannot be accelerated or sweated (de-greened) once a disposal notice has been placed on it.
- Off-run fruit sold to market stall holders must have passed the maturity tests and any individual with more than 25lbs (11kg) must have a proof of ownership - failure to meet these regulations will result in confiscation and destruction.
- Soluble solid concentration (Brix, TSS) is measured using a temperature compensating hydrometer - this is to test more of the volume of the sample. I think this may have merit because we often have slight differences in the digital refractometer reading - could it be due to the small amount of the sample taken from the overall volume collected?
- The California protocol suggests 25ml of juice be used in the titration with 20 drops of phenolphthalein and 100ml of water, again using a larger proportion of the sample.
- The juice collection method is obviously different given they press the fruit rather than reaming it - the benefit being the process is extremely quick.
- In an average year the budget for the entire inspection program is US$500,000.
- These inspectors are also used to inspect for freeze damage - in 2007 the cost for the inspection of maturity and freeze compliance was US$1.7 million.

Legislation specifies inspection programs are to be conducted in nine counties by county agricultural commissioners. The nine counties are: Fresno, Kern, Madera, Orange, Riverside, San Bernardino, Santa Clara, Tulare, and Ventura. The counties combined have approximately 25 inspectors performing citrus inspections depending on the season.

What are BrimA and the California Standard?
According to Jordan et al (2001) BrimA is a maturity model which indexes Brix and acid readings. BrimA more effectively accounts for the sweetness reducing effect of the acid than a ratio of Brix and acid. The human tongue is more sensitive to changes in acidity

and this index allows small changes in the level of acid to make large effects on the score - more closely mimicking the effects of acid on the tongue.

The BrimA calculation determines if the sugar level in the sample is high enough to compensate for the high acid. The subtraction of acid times the cofactor (in the California Standard the cofactor is 4) allows for the 'de-sweetening' effect of the acid.

Essentially BrimA is a calculation using the Brix (total soluble sugars) and the titratable acid and a cofactor:

BrimA = Brix - *k* X total acid.

The California Standard uses the cofactor of four (4) which was determined through the correlation with the sensory analysis conducted by Arpaia and Obenland over a seven year period. The sum of the BrimA formula is generally a low number, so to minimise confusion with the existing Brix:acid ratio, researchers Arpaia and Obenland added a multiplier to the BrimA formula when they proposed the California Standard:

California Standard = (Brix - (4 X total acid) X 16.5)

The pass level of the California Standard is 90.

For example, a fruit with a Brix of 10.0 and an acid percentage of 1.10 has a California Standard score of:

(10-(4 x 1.1) x 16.5)= 92.4 (pass in California)

The same fruit has a Brix:acid ratio of 9.0 to 1 (pass in Australia)

However a fruit with a Brix of 11 and a percentage acid of 1.3 has a California Standard score of -

(11(4 x 1.3) x 16.5) = 95.7 (pass in California)

The same fruit has a Brix:acid ratio of 8.5 to 1 (fail in Australia)

The same procedures as currently performed in the ACQS are required to determine the Brix and the percentage acid - the formula is the main difference, so new techniques or equipment will not be required if this scale is adopted.

Advantages of using BrimA in the ACQS

The aim of the ACQS is to guide industry to produce fruit of an eating quality that encourage increased consumption of citrus. The current ACQS use Brix:acid ratio as one of the main parameters.

Researchers in California have amassed over 2,600 consumer responses over a number of years. They have plotted consumer responses against various maturity parameters such as acid percentage and Brix levels as well as Brix:acid ratio. Using a hedonic scale

the researchers attempted to determine any correlations in these levels. The nine point hedonic scale used is as follows:

1) Dislike extremely
2) Dislike very much
3) Dislike moderately
4) Dislike slightly
5) Neither like nor dislike
6) Like slightly
7) Like moderately
8) Like very much
9) Like extremely

Figure 1 shows the correlation with Brix:acid ratio and consumer preference is weak, with an R^2 value of just 0.38.

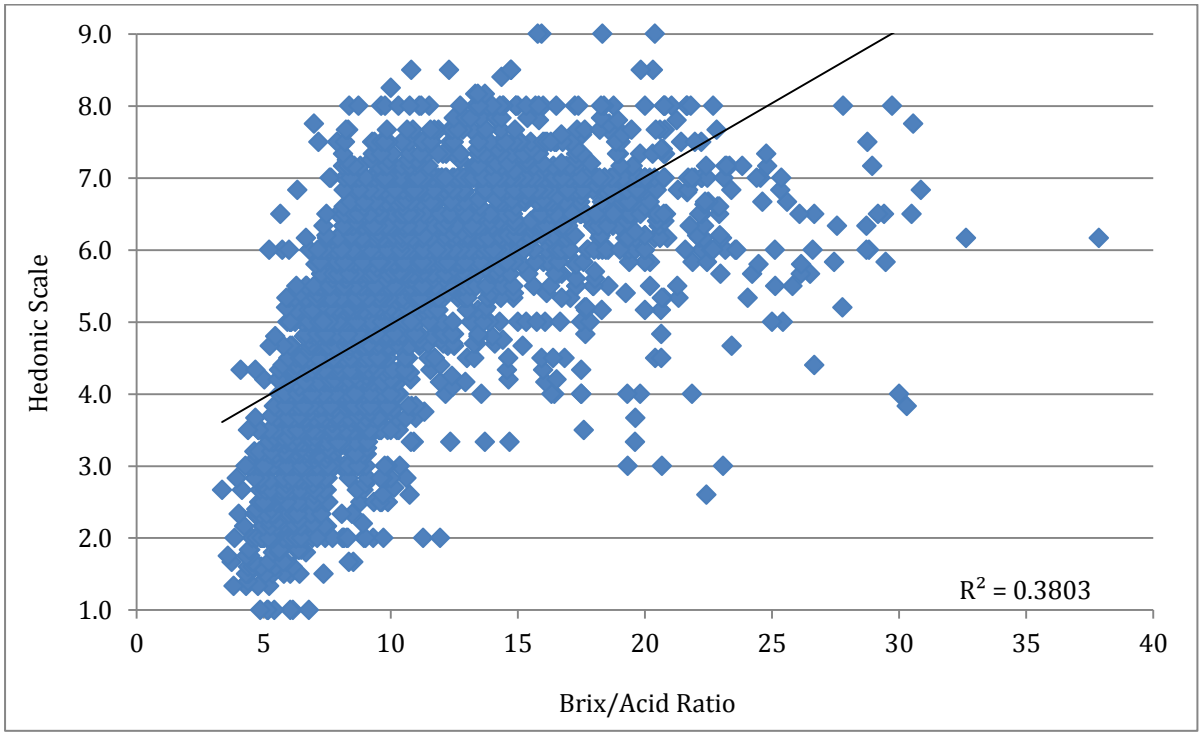


Figure 1: Consumer preference for 2,600 samples of navel oranges – hedonic scale versus Brix:acid ratio (source: University of California)

In contrast when consumer preference is plotted against BrimA the correlation is stronger and the R^2 value is higher at 0.6 (Figure 2).

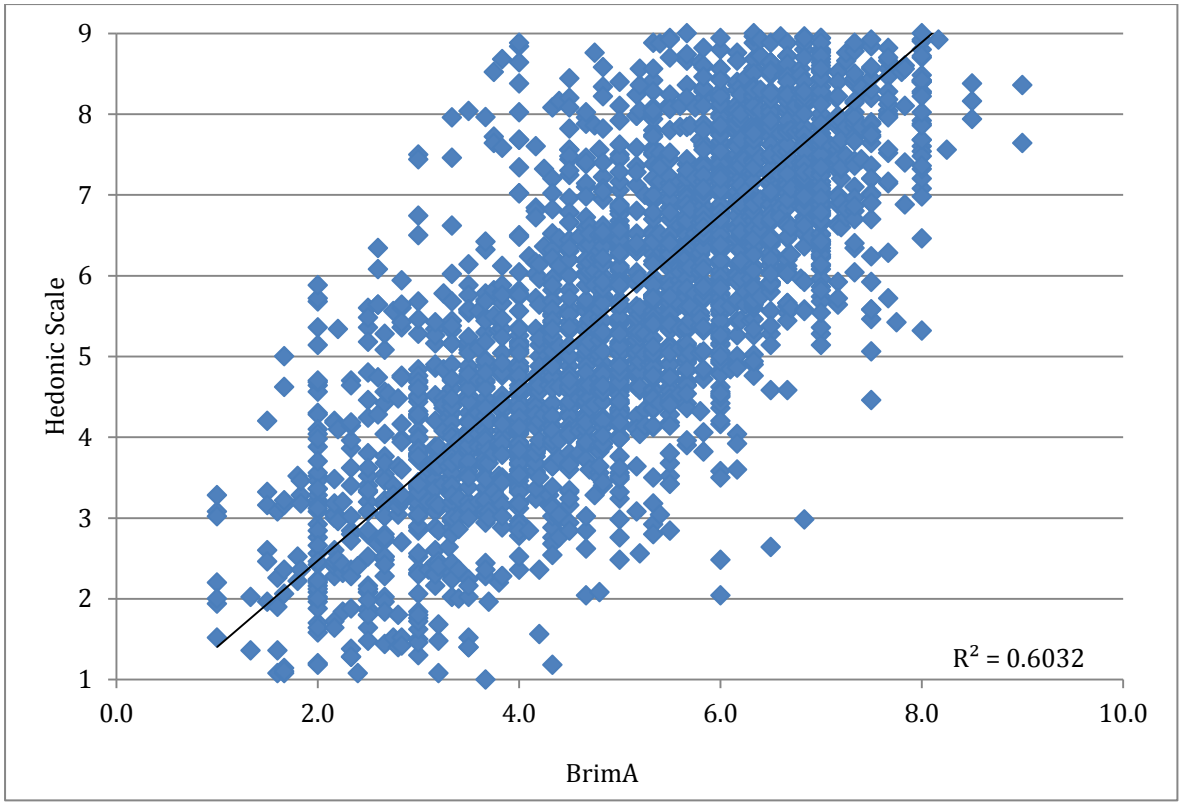


Figure 2: Consumer preference for 2,600 samples of navel oranges – hedonic scale versus BrimA (source: University of California)

According to the US studies, BrimA shows that consumers prefer a balanced fruit that has flavour. Consumers are tolerant of high acids if high sugars are also present. In fact this type of fruit correlates well with consumer preferences. In contrast, consumers do not like insipid fruit with low sugar and low acid, even when it meets the sugar acid ratio. Consumers do not prefer fruit with low sugar and high acid, the two must be balanced. Arpaia et al (2011) also went on to show an increased intention to purchase when the hedonic score was above 4.

Whilst it is unlikely to ever be made a regulation in California, it is understood that many large mandarin sheds will have a Californian Standard of 110. The current regulated standard in California for mandarins is 6.5 : 1 Brix:acid ratio, clearly far too low and widely ignored by industry.

Colour standard

The Californian industry also has a fruit colour standard which helps to delay harvest - in many instances internal maturity parameters have been met before colour has developed. Oranges may be picked when 90 % or more of the oranges in any lot have attained on 25% of the fruit surface at least characteristic orange colour break.

The Australian industry could at times be accused of picking fruit too green, and in mandarins in particular gas burn and anthracnose is often a feature of early season shipments. In California it is common practice to gas oranges at 2.5-4.5ppm ethylene and mandarins at 1ppm ethylene for up to 96 hours early in the season.

Considerations for future ACQS

If the Australian industry was to adopt a BrimA index for all citrus it would negate the need for a minimum Brix level. It would be advisable to maintain a measure of percentage juice as we differ from California in that:

1) The Imperial mandarin suffers from an internal dryness issue
2) We do not have a minimum colour standard and are unlikely to achieve agreement or be able to enforce one in the near future.

The adoption of the California Standard has impacts for Australia's domestic and export markets - our product will be competing in these markets with Californian fruit that exceeds the ACQS specifications.

Recommendations

- The sensory analysis project to determine Australian consumer preferences for navels should include BrimA and compare correlations in responses with other maturity parameters. Results should be reported to industry.

- Industry should be encouraged to conduct more maturity tests on farm and at the pack house to reduce the amount of immature fruit entering the supply chain.

- An investigation into costs and feasibility of replacing reamer juicers with hydraulic or pneumatic citrus presses - particularly for larger sheds and quality assurance labs. Alternatively the development of a juice standard for mandarins (or all citrus) using centrifugal force juicers.

- An investigation into industry best practice use of de-greening rooms in Australia with the aim to set guidelines for de-greening of citrus fruit and maintain optimum internal and external quality.

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Investigating consumer taste preferences of Australian navel oranges and rich flavoured mandarins

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Contents

Table of Figures

Acknowledgements

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The research organisations Curtin University, TQAS and DAFWA provided laboratory, analysis and field skills for the tasting panels and fruit preparation.

The analysis team of Mark Loeffen and Bob Jordan at Delytics and Mark Loeffen and Associates who added great value to the process.

Executive Summary

Consumers of fresh produce have an ever increasing opportunity to choose from within and outside of the fresh produce category. Amongst other reasons, the fresh produce category is challenged to meet consumer expectation of uniformity in appearance and taste of fresh produce, when it is a product of nature not a mass produced factory food. Not meeting this expectation risks consumer dissatisfaction. Maturity standards exist in most established citrus growing regions throughout the world as a benchmark for providing uniformity.

However little emphasis has been placed on customer satisfaction when setting these standards - rather these standards were based on logistics of long sea voyages to export markets and resulting shelf life in these destinations. Whilst these considerations are of high importance many mature industries have recognised the importance of their own domestic markets and have begun investigations of domestic consumer satisfaction accordingly. The Australian citrus industry introduced voluntary minimum standards in 2010 and Citrus Australia, the industry peak body continue to develop these standards and the Australia citrus market to increase citrus consumption through improved eating experience. To achieve this objective Citrus Australia sought to determine the suitability of current industry maturity standards and their correlation with consumer preferences and to determine a standard that met consumer expectation.

This study compared the Australian industry standards of Brix and Brix acid ratio with a new formula called BrimA[1], developed in NZ and adapted by researchers in the USA to become the California Standard. Instead of a Brix acid ratio it considers a balance of Brix and acid that correlates with the perception of tanginess. The acid percentage in citrus has a large bearing on taste. Using a constant (k=4) BrimA increases the effect of acid in the equation and in the California Standard a multiplier is added to magnify the scale and avoid confusion with other standards.

The research objectives were to:

1. Investigate Australian consumer preferences for taste of Australian navels and mandarins.
2. Assess the effectiveness of current methods and parameters for determining 'maturity'.
3. Show consumer probability for increased purchase, and or increased frequency of purchase.
4. Recommend Australian minimum standards for internal quality that aligns to consumer preferences for navel orange and rich flavoured mandarins.

A multi-disciplinary fruit quality research team conducted the research. Navel oranges and rich flavoured mandarins were the citrus used for consumer feedback. Fruit for the research was picked from the beginning to the mid-season of each variety. Consumer based sensory panels were used to provide feedback on fruit samples of different Brix and acid levels. A broad cross section of demographics were included in the panels, including ethnicity, age, gender and socioeconomic.

Extensive comparative analyses of consumer responses to fruit characteristics and the existing Australian Citrus Quality Standard was done. Results were used to propose standards for navel oranges and mandarins, based on consumer preferences and their willingness to purchase. It also allowed for assessing the current method for expressing internal fruit quality.

Recommendations from the research are:

[1] BrimA calculation=Brix-(%Acidx4); California Standard calculation = (Brix-(%Acidx4))x16.5.

1. The Australian citrus industry moves from a Brix acid ratio to a BrimA formula for measuring internal quality of fruit. It is recommended that as in the California Standard a multiplier be used to increase the scale, i.e. the calculation will be

   Citrus Maturity Standard calculation (CMS) = (Brix-(%Acidx4))x16.5

   This method is a better predictor of consumer opinion and provides a better correlation with consumer taste preferences.

2. The citrus industry adopts new minimum standards using the above formula of:
   - CMS90 for oranges. Oranges include navels, Valencias and common orange. It excludes blood oranges.
   - CMS120 for rich flavoured mandarins. Rich flavoured mandarins include Afourer and Murcott types.

   The study determined that the natural variation within the orchard meant that the current method of sample taking - using an average of 10 fruit - meant that a wide range of fruit maturities could be found in the sample and the consignment the sample represented. For example if the oranges in a sample ranged from a Standard of 70 to 110 and averaged 90, then nearly 60% of consumers would like the lowest standard oranges and nearly 90% would like the best oranges in the consignment. Therefore setting a minimum standard of 90 would mean that on average 75% of consumers would like the fruit and purchase it again

3. An extensive communication, training and extension program be conducted throughout the citrus value chain to ensure adoption of these standards.

4. A consumer panel project be conducted to define additional standards for
   - Milder flavoured mandarins such as Imperials
   - Late season low acid oranges and
   - Maximum acceptable fruit dryness of Imperial mandarins.

5. A maturity variation project be conducted to develop decision support tools for industry and to review maturity testing protocols. This will improve grower and buyer confidence in fruit quality and will improve the growers' ability to deliver a consistent line of product having accounted for variability between individual fruit. Project activities would include:

   - Develop maturity curves for important citrus varieties. Results from weekly maturity testing of a large number of individual fruit from early in fruit development to after commercial harvest periods will provide a database of maturity curves for each variety. Growers will use the curves for their own data and predicting their own harvest time.

     This type of data collection has not been conducted in Australia, where industry protocol is to bulk fruit juice together for testing. Important citrus varieties to be included are Navelina, Washington and Lane Late navel orange, Imperial, Murcott and Afourer mandarins.

   - Develop improved methodology for maturity testing to account for variability between individual fruit from the same orchard block. New equipment or processes will provide a protocol that allows for individual fruit testing within practical time

frames and costs. This will increase grower confidence that maturity-testing results reflect the maturity level of the orchard block.

- Based on maturity curves and database above develop a computer model that helps growers determine the maturity rate in their orchard blocks, predict harvest times and the rate of maturity protocol compliance. Provide better grower decision tools based on new equipment and method that uses rapid fruit testing. This will be an improvement on current industry use of a titration method for internal fruit testing.

1. Introduction

Consumers of fresh fruit such as oranges and mandarins rely on visual perception of quality - brightness of the skin, no marks or deformities and physical attributes such as weight, firmness - to make their purchases. Often how they assess visually the maturity or taste of the fruit does not match their eating experience, that is its actual taste[2], which leads to disappointment and distrust of the fruit. This is particularly true at the start of the season for each variety.

Providing consumers with an improved eating experience can increase citrus consumption. This can be achieved by improving industry awareness and adherence to maturity parameters that match the consumer's perception of a good eating experience.

Examples of improved consumption of fresh produce due to improvements and adherence to quality standards exist in Australia. In Western Australia minimum maturity parameters based on consumer preference research were introduced to the table grape industry and have been shown to increase sales and value along the supply chain[3].

Citrus Australia, the industry peak body, seeks to increase citrus consumption through providing the consumer an improved eating experience by improving the industry awareness of maturity parameters. To this end Citrus Australia sought to determine the suitability of current industry maturity standards and their correlation with consumer preferences and to determine a standard that met consumer expectation.

This study compared the Australian industry standards of Brix and Brix acid ratio with a new formula called BrimA[4], developed in NZ and adapted by researchers in the USA to become the California Standard[5]. Instead of a Brix acid ratio it considers the balance of Brix and acid that correlates with consumer perception of 'tanginess' and 'balance of flavour'. Although acid percentage in citrus is typically in the range of 0.5% to 2.5% it has a large bearing on taste. Using a constant (k=4) BrimA increases the effect of acid in the equation and in the California Standard a multiplier is added to magnify the scale[6].

The research objectives were to:

1. Investigate Australian consumer preferences for taste of Australian navels and mandarins.
2. Assess the effectiveness of current methods and parameters for determining 'maturity'.
3. Show consumer probability for increased purchase, and or increased frequency of purchase.
4. Recommend Australian minimum standards for citrus quality to consumer preferences for navel oranges and rich flavoured mandarins.

[2] Bartlett 2004
[3] McAlpine
[4] Jordan et al 2001
[5] Blakely 2011
[6] BrimA calculation=Brix-(%Acidx4); California Standard calculation=(Brix-(%Acidx4))x16.5

2. Methodology

The methodology of the research is described under the following headings:

- Population and sampling
- Fruit samples
- Consumer panel data collection
- Data analysis
- Reporting
- Critical success factors and risks
- Resources

Photographs of various stages of the method are included in the appendices.

2.1. Population and Sampling

The population of interest for consumer panels were current and potential Australian citrus consumers. The consumer panel participants were selected from a population in Western Australia and Victoria. The sample of consumers in each jurisdiction provided statistical clarity and came from different locations to attract consumers from a range of different geographical locations and socio economic backgrounds (Table 1&2). At the completion of the first panel at Curtin University where only 102 consumers completed the survey a target of 120 consumers per panel was set to allow for outliers and incomplete surveys. The navel orange panels then achieved 120 consumers each and as did the mandarin panels except in Keilor Downs where 103 consumers completed surveys.

Table 1 Details of navel orange tasting panels held in 2013

Time of year	Total no. consumers	Total no. samples	Venues for panels	Date of event
Early-season	462	1386	• Curtin University, Bentley WA • Westfield Carousel, Cannington WA • RMIT University, Melbourne VIC • Prahan Markets, South Yarra VIC	8 May 10 May 23 May 24 May
Mid-season	240	720	• Innaloo Shopping Centre WA • Whitfords City Shopping Centre WA	12 July 13 July

Table 2 Details of mandarin tasting panels held in 2013

Time of year	Total no. consumers	Total no. samples	Venues for panels	Date of event
Early-season	222	666	• Keilor Downs Shopping Centre VIC • Northland Shopping Centre, Preston VIC	25 July 26 July
Mid-season	241	723	• RMIT University, Melbourne VIC	15 August 16 August

2.1.1 Venue

The consumer panels were run at locations where large numbers of people congregate and were expected to be willing to spend five to ten minutes participating in the tasting and survey. Also of consideration was proximity to commercial food preparation facilities in order to prepare samples as close to the venue as possible.

Curtin University and RMIT Melbourne were used as the first venues as they provided a semi-experienced group of people (students and staff) who were familiar with this type of research. To meet requirements of each site the use of registered commercial labs / kitchens was required as was following Good Hygiene Practice (GHP) in all sample preparation - staff wore hairnets, gloves and lab coats whilst preparing samples for example.

Other panels in WA and in Victoria were conducted at locations where a mix of demographics could be expected such as shopping centres and fresh food markets. By selecting venues in varied socio-economic areas (based on local knowledge) the research cohort was representative of consumer population in general.

During planning for each consumer panel, the relevant venue was engaged for permission and support. In some cases paperwork relating to food handling, insurance and safety were required. In some Shires a Temporary food premise permit was required with food safety risk mitigation having to be demonstrated. Negotiations were undertaken to be able to set up consumer panels near thoroughfares to assist with efficient recruiting.

At the universities, ethics required that tabletop privacy booths were used for each participant whereas at the shopping open tables were used to reduce impact on visibility of nearby vendors

2.1.2 Recruiting

Consumers self-selected to participate in the consumer panels after being approached by a citrus maturity team member (promoters). Promoters moved through the crowd and talked to people, explaining the purpose of the taste panel. Panel recruits were directed to the tasting area and were given verbal and written instructions. Where necessary staff would explain each question in the survey and help the participant to complete the survey, as they tasted the fruit.

At the conclusion of the first round of panels the validity of the panel selection was tested to confirm appropriate methodology (see Appendix 1). The characteristics of panel participants collected included their gender, age, the countries they have lived the longest, their ethnic origin and the years they have lived in Australia. It was concluded that the consumers participating in the panels had a wide range of demographic characteristics in terms of gender, age, ethnic origin and countries they had lived in the longest.

To determine if the consumers participating in the early season panels were different to those in the mid-season panels, the characteristics of the two panels were compared in terms of age, gender and ethnic origin. In conclusion, the differences in demographic characteristics of early season to mid-season orange panellists were as expected (early season younger, more males and more Asian descent). The selection of mid-season venues accounted for the early-season consumer panel demography. Panel operation in both Perth and Melbourne gave similar results further corroborating findings (see Appendix 1). As a result, the term ‘consumers’ is used in discussion of results and analyses to reflect the panellists responses to fruit samples.

2.1.3 Timing

Panels were run to cover the availability of early and mid season Navels with findings from these panels so conclusive that research was shifted to rich flavoured mandarins to optimise research effort. These panels covered the availability of early and mid-season Afourer mandarins.

The consumer panels run in each part of the season were a week apart to minimise the travel expense of the research team frequently travelling to Perth and Melbourne, reduce the expense in sourcing fruit and to allow learning from each panel to be used in planning the next panel.

2.2. Fruit Samples

2.2.1 Fruit selection

Navel oranges including M7, Navelina, Washington and Lanes Late were the navel orange varieties used and the Afourer variety was used as rich flavoured mandarin. Previous seasons maturity tests were used to identify suitable regions and orchards to source a wide range of maturities for the sample fruit. Fruit from the orchards were tested prior to harvest to confirm their suitability. Fruit was sourced from Western Australian orchards for the Perth taste panels and from Sunraysia orchards for the panels held in Melbourne.

A total of between 100-120 pieces of fruit was needed to get the 120 samples for each panel with an equal number of samples in each of the low, medium and high Brix acid ratio categories so each panellist sampled all three. Navel oranges harvested were of a uniform size 73-79mm minimum diameter and Afourer mandarins 50-57mm diameter, free of blemish and insect damage, splitting and sunburn.

2.2.2 Fruit Preparation

After picking the sample fruit was washed and waxed at one location for uniformity of treatment and to mimic commercial conditions. Facilities were in Bindoon (Western Australia) and Nangiloc (Victoria). On the morning the consumer panel was run the fruit was prepared no more than three hours prior to expected consumption.

For each navel orange, the fruit yielded 4 samples; the fruit was cut in half through the axis and then two pieces were cut on either side of the navel or of the stem end. The flesh was sliced from the peel of each sample piece and two pieces each were placed in sample containers, each with a unique identifier code on the lid and cup. The navel and stem ends from the fruit were squeezed through a sieve into a container with the corresponding identifier number to the fruit sample and were used to obtain the Brix and acid levels of the fruit sample.

The Afourer mandarins were peeled and segmented. Two segments were placed into each sample cup leaving 2-3 segments to obtain a juice sample and record of the Brix and acid percentages.

The identifier code included the classification of low, mid and high maturity levels using ‘R’, ‘Y’ and ‘G’ respectively and the panel number and sample number were also included e.g. R010001 would be a low maturity fruit from panel one. The maturity levels and groupings were decided on the day, after analysis of the fruit available.

As sample preparation was being done, entries were made into a spreadsheet in batches of ten of each fruit’s identification code number, acid and Brix level and a calculation made of the BrimA and Brix acid ratio. The entries were sorted by Brix acid ratio/BrimA during preparation to ensure there were sufficient samples in each of the low, medium and high categories to supply samples to at least one hundred consumers per panel. Any extreme outlier fruit was discarded.

An analysis of attributes verified that there were significant differences in the orange samples offered in the mid-season panels compared to the early season panels (see Appendix 2).

An analysis of attributes verified that the mandarin samples offered to the panellists had a wide range of attributes to enable consumers to evaluate which mandarin samples were more to their taste (see Appendix 2).

The fruit samples were packed into three (low, medium, high categories) eskies with ice bricks as part of the temperature food safety risk mitigation and transferred to the panel sampling areas.

2.3. Consumer panel data collection

2.3.1 Fruit Tasting

Tables were set up with or without privacy booths. When seated each consumer had in front of them three sample cups placed in a semi circle. Each cup sat on a label marked Sample 1 (2,3) as it corresponded to the survey and staff advised each consumer to taste and respond to each sample on the corresponding survey form. Consumers were asked to eat a plain cracker and sip some water cleanse their palette before and between samples to remove any residual mouth tastes and flavours. The order the consumer was offered fruit from each maturity category was at random to reduce potential order effects. The consumer was not made aware of the differences of each sample and could not have determined any difference through the look, number code or placement on the table of the sample.

After eating each sample, consumers were asked to complete a survey to rate the sample. The surveys had individual consumer numbers that identified the location and date of the taste panel as well as the identifier code of the sample fruit. Completed surveys were returned to one of the consumer panel research team who checked that it had been fully completed before the consumer left. Data from completed surveys were entered into the statistical package for social sciences (SPSS) by a professional data entry company to reduce the risk of errors.

2.3.2 Survey Instrument

Questions for the survey were developed by the project team and tested with a small group of consumers prior to being used in the consumer panel. Ethics approval was received from Curtin University before the surveys were administered. Fruit evaluation questions included ratings of juiciness, sweetness, acidity, as well as whether they like it and why and if they would buy fruit of this type again. Background questions on the characteristics of consumers included gender, age, country of origin, ethnicity, time living in Australia and frequency of buying citrus and fruit. The complete survey is provided in Appendix 3.

2.4. Data Analysis

A variety of analyses were used to interrogate the data (Table 3) including the use of the statistical package for social sciences (SPSS). Major results are presented in the following section while individual analyses results are provided in the Appendices.

Table 3 Statistical analyses used for interrogating data

Statistical analysis	Data
Independent t-tests	Pairs of metric variables such as fruit attributes and panel characteristics
ANOVA	Category comparisons

Regression	Consumer preferences and fruit qualities
Correlation	Consumer preferences and fruit qualities

The existing Australian Citrus Quality Standard[7] (ACQS) for navels and mandarins was compared against the range of consumer responses to range of the Brix, Brix acid ratio of samples to determine if the ACQS required changing to better reflect consumer preferences.

Similarly the Brix and acid levels were used in the BrimA and California Standard calculations to consider the 3 different methods of measuring fruit quality and the proportion of fruit that would be accepted by consumers (Table 4).

Table 4 Internal fruit quality measures and their calculations

Measure name	Calculation
ACQS 2013	Brix acid ratio
BrimA	(Brix – (Weighting 4 x %Acid)
California Standard	(Brix – (Weighting 4 x %Acid)) x 16.5

Navel Oranges: The weighting used in the Brim A / California Standard calculation was varied from 2.5 to 5.5 (at 0.5 increments) and a linear regression run to see which level of weighting resulted in the greatest explanation of variation measured as R^2. The R^2 for weightings 4 and 4.5 was 0.09 but less for other weightings.

A comparison of the predictive power of the California Standard compared to other standards was assessed based on the level of explanation of variation (R^2) in a linear regression and the correlation to consumer opinion (like/dislike). The California Standard had a higher correlation (R^2 =0.09) to predict opinion than Brix acid ratio (R^2= 0.077), Brix (R^2= 0.051) and Acid % (R^2= 0.024). The Californian Standard also returned a higher correlation to opinion (R^2=0.30) than Brix acid ratio (R^2= 0.28), Brix (R^2= 0.23) and Acid % (R^2= -0.16). Analysis of similar studies in citrus and kiwi fruit involving consumer opinion showed that the low R^2 recorded in this study was common to all studies of this type[8].

It was concluded that a proposed standard should be calculated using a weighting of 4 and that the California Standard calculation was a better predictor of consumers liking or disliking oranges than Brix acid ratio, Brix or acid percentage. Therefore, all further analysis of orange samples was based on comparison to the Californian Standard calculation. Comparisons to Brix acid ratio, Brix and acid percentage are in Appendices 5-7.

Afourer Mandarins: The weighting used in the California Standard calculation was varied from 2.5 to 5.5 (at 0.5 increments) and a linear regression run to see which level of weighting resulted in the greatest explanation of variation in consumer opinion, willingness to purchase and purchase more as measured by R^2. The R^2 for weightings 3.5 and 4 to explain opinion was 0.034 but less for other weightings. The R^2 for weightings 3.5, 4 and 4.5 was better to explain willingness to purchase. The R^2 for weighting 4 was better to explain willingness to purchase more.

A comparison of the predictive power of the Californian standard compared to other standards was assessed for Afourer mandarins based on the level of explanation of variation (R^2) in a linear regression and the correlation to consumer opinion (like/dislike). The California Standard higher R^2 (0.034) to predict opinion than Brix acid ratio = 0.015, Brix = 0.018 and Acid % = 0.001. The

[7] Australian Citrus Quality Standards 2013 Citrus Season www.citrusaustralia.com.au
[8] Loeffen and Jordan 2014

Californian Standard higher correlation to opinion (0.19) than Brix acid ratio = 0.12, Brix = 0.13 and Acid % = -0.02.

It was concluded that the Californian Standard should be calculated using a weighting of 4 and that it was a better predictor of consumer liking or disliking mandarins than Brix acid ratio, Brix or acid percentage. Therefore, all further analysis of mandarin samples was based on comparison to the Californian Standard. Comparisons to Brix acid ratio, Brix and acid percentage are in Appendices 9 to 11.

2.5. Reporting

Presentations of results were made to the Team Leader at intervals during panel events to allow for adjustments for the next consumer panel event. A further presentation was to a wider audience for feedback at the 2013 Citrus Australia National Issues Forum.

2.6. Critical Success Factors and Risks

Selection of fruit providing the range of variation needed and of a quality that was reflective of normal commercial practice was the first critical success factor. Secondly suitable venues with access to volumes of consumers that were also in reasonable proximity to commercial kitchens used for preparation was also essential.

2.7. Resources

Research activities were delivered at a total project cost of $77,690 (exclusive of CAL costs). An itemised budget is provided in the Appendices. Costs were shared between Citrus Australia, Fruit West and DAFWA. The project was run from April to October 2013. Resources were used for costs incurred by a multidisciplinary team of laboratory, social research, and management skills from Fruit West, DAFWA, Curtin and Citrus Australia (Appendix 4). New Zealand collaborators also provided valuable data analyses.

3. Results - Navel Orange

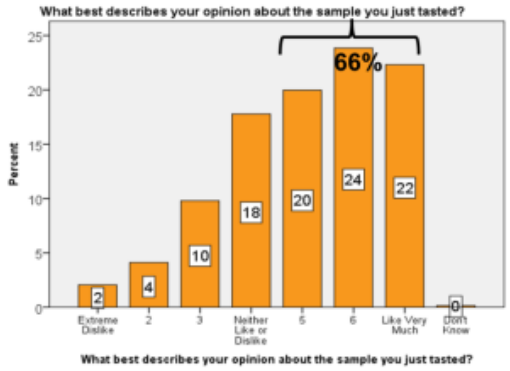
3.1 Orange Sample Assessments

The research focus was on responses to orange samples in terms of: an overall like/dislike opinion; the willingness to purchase oranges; and the willingness to purchase more oranges. The responses to the orange samples were compared to the current quality measure and the Californian standard to determine where the minimum standard should be set.

3.1.1 Opinion about Orange Sample

Two out of every three orange samples were liked by consumers (66% rated 5-7) (Figure 1). This shows that the range of samples were well suited to the panels taste preferences.

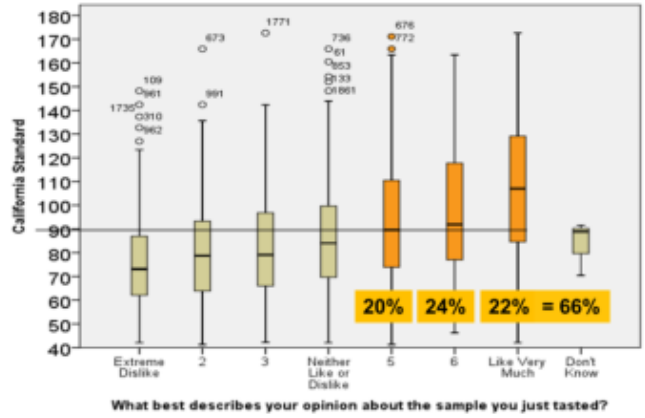
Figure 1 Opinion about Orange Sample



3.1.2 Opinion Like-Dislike Orange V. Californian Standard

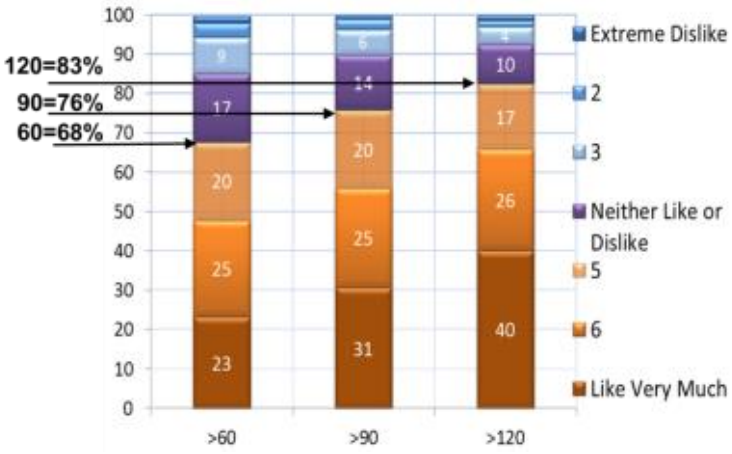
An assessment of the minimum standard that would satisfy orange consumers based on liking the fruit showed that using the California Standard calculation and setting it at a minimum of 90 would mean at least 50% of consumers would like the sample (opinion 5 & 6) (Figure 2).

Figure 2 Opinion Like-Dislike Orange V. Californian Standard



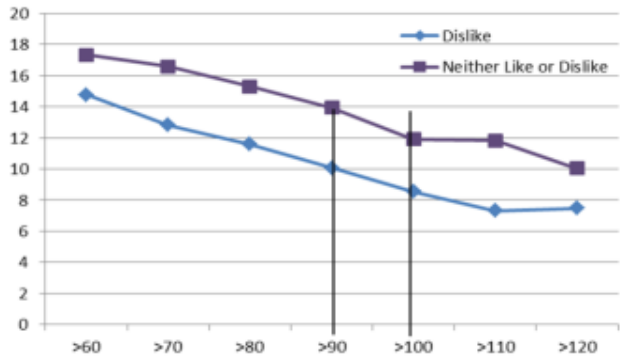
In looking at consumers' responses to orange samples, setting the minimum standard at 90 would result in 76% of all consumers liking the oranges (Figure 3).

Figure 3 Opinion Like-Dislike Orange V. Californian Standard >60, >90 & >120



In terms of a negative response, at a standard of 90, the percentage of consumers who dislike the orange sample reduces to 10% (Figure 4). The percentage of consumers who dislike the orange sample plateaus out at about 7-8% once the standard is 100 or greater.

Figure 4 Opinion Dislike Orange V. Californian Standard



3.1.3 Would Purchase Orange

Consumers said they would definitely purchase two of three orange samples (63%) if it was available for a reasonable price where they normally shopped (Figure 5), confirming the range of samples were well suited to the panels taste preferences.

Consumers' opinions about liking the sample tasted were closely related to their willingness to purchase those oranges (correlation 0.82) (Figure 6).

Figure 5 Opinion Would Purchase Oranges

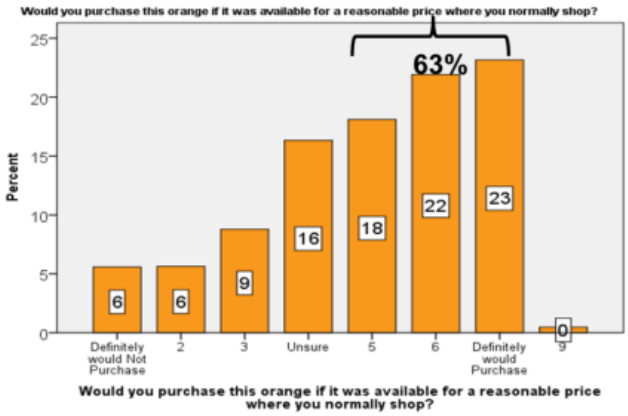
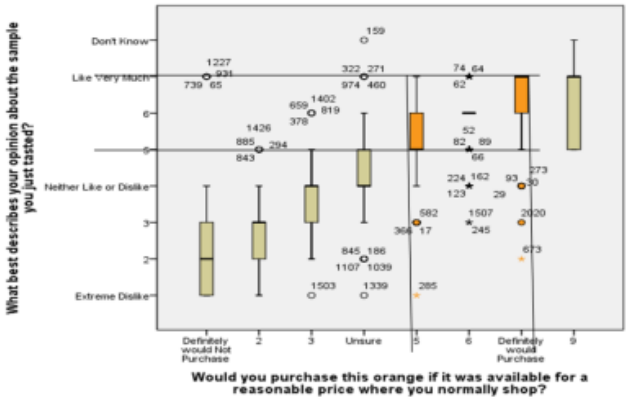


Figure 6 Opinion Like-Dislike Orange Sample V. Would Purchase Oranges



3.1.4 Opinion Would Purchase Oranges V. Californian Standard

An assessment of the minimum standard needed to satisfy orange consumers based on their willingness to purchase, showed that using the California Standard calculation would be and setting it at a minimum of 88 would get at least 50% of consumers to purchase the sample (opinion 5 & 6) (Figure 7).

In looking at consumers responses to all orange samples, setting the minimum standard at 90 would result in 73% of all consumers would purchase the oranges (Figure 8).

Figure 7 Opinion Would Purchase Oranges V. Californian Standard

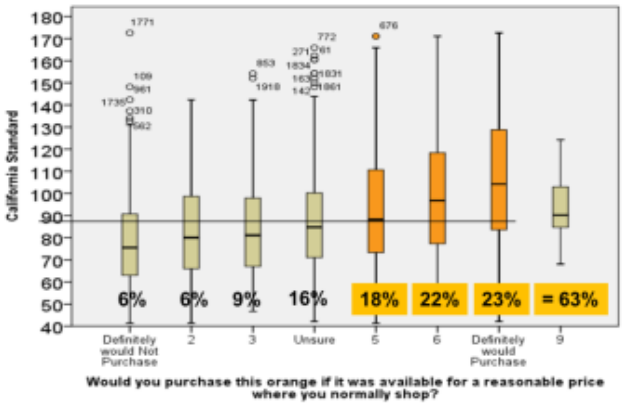
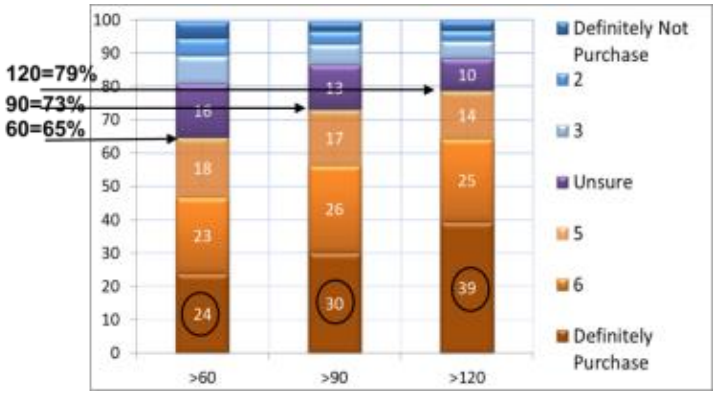
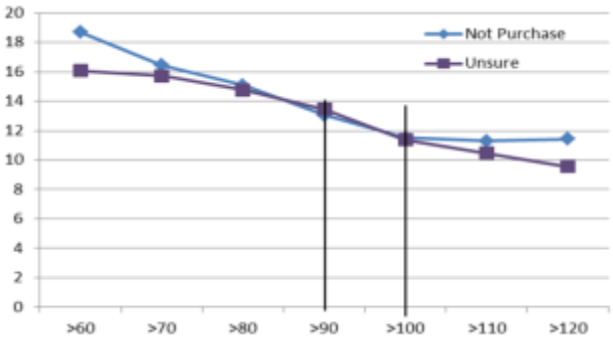


Figure 8 Opinion Would Purchase Orange V. Californian Standard >60, >90 & >120



In terms of a negative response, at a standard of 90, the percentage of consumers who would not purchase the orange sample reduces to 13% (Figure 9). The percentage of consumers who would not purchase the orange sample plateaus at about 11.5% once the standard is 100 or greater.

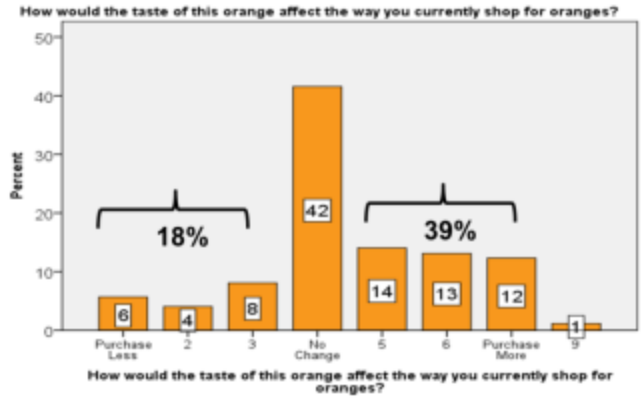
Figure 9 Opinion Dislike Orange V. Californian Standard



3.1.5 Would Purchase More Oranges

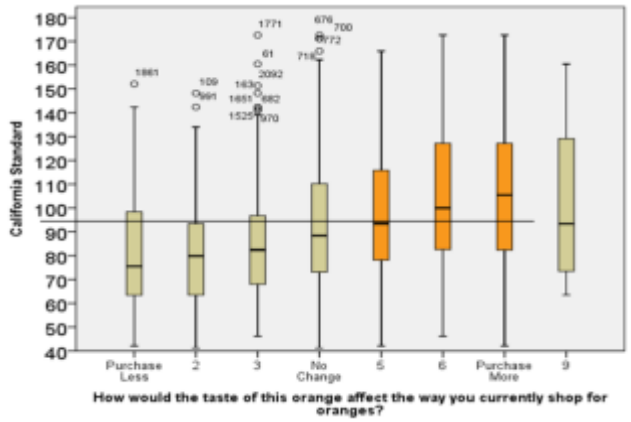
Over a third of consumers (39%) said they would purchase more oranges based on the taste of the sample (5-7) (Figure 10). This indicates that if oranges can be produced that meet the taste demands of consumers more oranges can be sold.

Figure 10 Opinion Would Purchase More Oranges



A preliminary assessment of the minimum standard needed to satisfy orange consumers based on willingness to purchase more oranges indicated it should be set at a minimum of 95 to get at least 50% of consumers to purchase more (opinion 5 & 6) (Figure 11)

Figure 11 Opinion Would Purchase Oranges V. Californian Standard



In looking at consumers' responses to orange samples, setting the minimum standard at 90 would result in 48% of all consumers willing to purchase more oranges (Figure 12).

In terms of a negative response, at a standard of 90, the percentage of consumers who would purchase fewer oranges reduces to 12.5% (Figure 13). The percentage of consumers who would not purchase the orange sample plateaus out at about 11.5% once the standard is 100 or greater.

Figure 12 Opinion Would Purchase Orange V. Californian Standard >60, >90 & >120

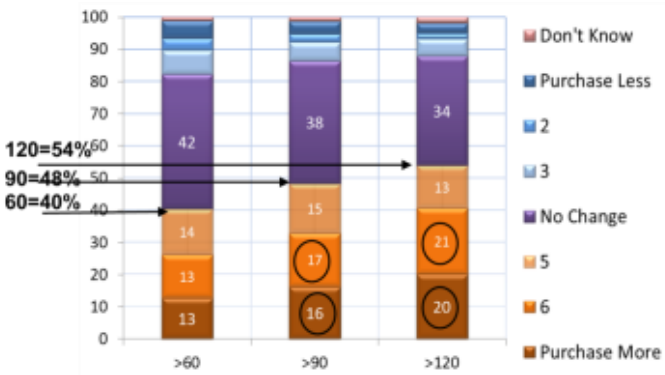
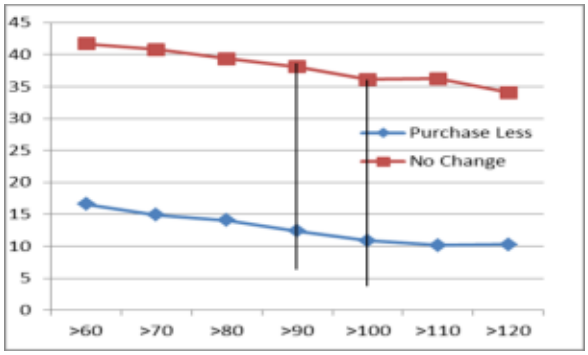
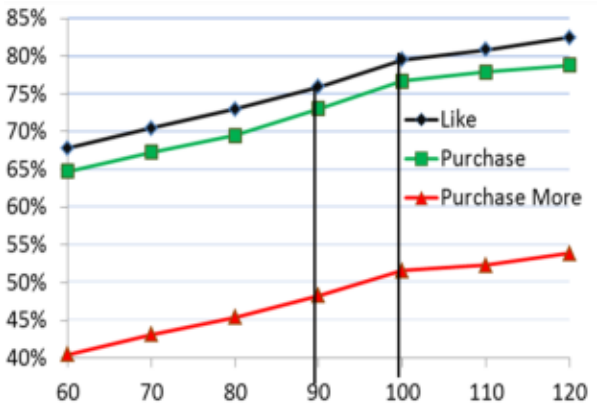


Figure 13 Opinion Dislike Orange V. Californian Standard



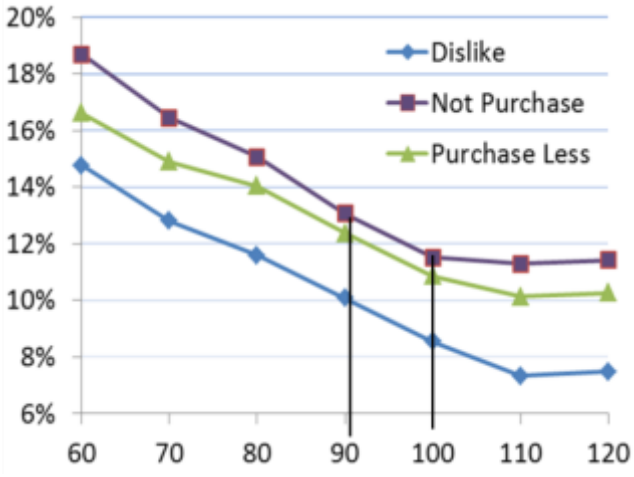
In assessing all the responses by consumers to the samples in terms of liking/disliking the orange sample, willingness to purchase the oranges and willingness to purchase more oranges the conclusion was to set the standard at 90. At a standard of 90, 76% of consumers like the oranges, 73% would purchase the oranges and 48% would be willing to purchase more oranges (Figure 14).

Figure 14 Orange Standard Conclusions - Positive



At a standard of 90 the negative responses reduce to 10% disliking the orange sample, 13% not purchasing the oranges and 12.5% purchasing less oranges (Figure 15).

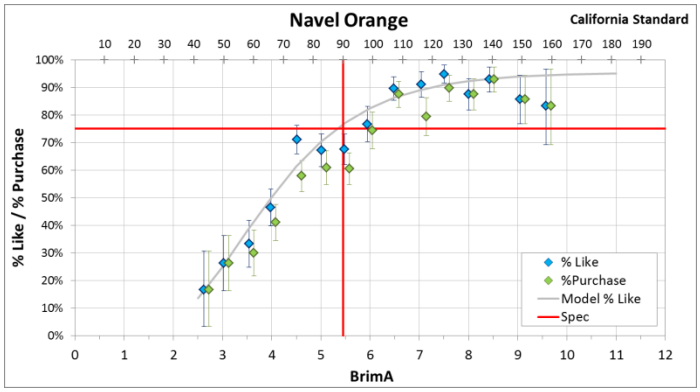
Figure 15 Orange Standard Conclusions - Negative



3.1.6 Analysis to determine standards

The effect of different standards on panellists' response to the orange sample is easiest to see when the rating of all consumers has been averaged. Averaging removes panellist biases such as any tendency to rank the samples and the consumers individual idiosyncrasies. This principle was used in research conducted by Arpaia and Obenland[9] when they developed the California Standard for navel oranges. Figure 16 shows the percentage of panellists who liked the orange sample or who would purchase it if they found it at a reasonable price compared to the Californian Standard. The grey trend line shows that orange samples greater than 130 on the Californian Standard do increase the number liking it or willing to purchase it much more than 90%. With most orange samples assessed by the panels being a Standard 60 to 140, there is greater confidence with results in this range.

Figure 16 Opinion Like & Would Purchase Orange V. Californian Standard[10]



The conclusion from the results in setting a standard for the industry is that a minimum standard of 90 would mean that on average 75% of consumers would like it and purchase it again. This gives some room for the natural variation in a harvest of oranges. For example if the oranges ranged from a Standard of 70 to 110 and averaged 90, then nearly 60% of consumers would like the lowest standard oranges and nearly 90% would like the best oranges in the harvest.

4. Results - Afourer Mandarin

4.1 Mandarin Sample Assessments

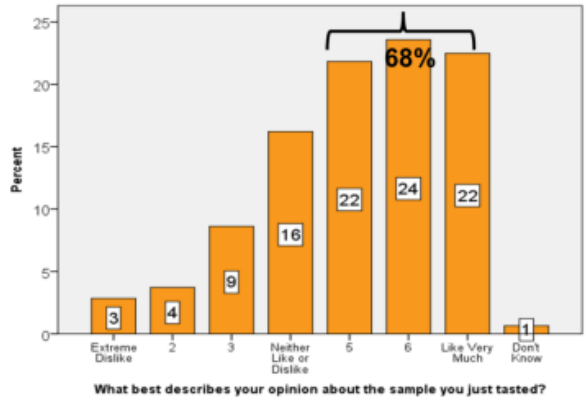
Responses to mandarin samples were sought in terms of: an overall like/dislike opinion; the willingness to purchase mandarins; and the willingness to purchase more mandarins. The responses to the mandarin samples were compared to the current quality measure and the Californian Standard to determine where the minimum standard should be set for mandarins. The results of the statistical analyses are presented in the following.

4.1.1 Opinion about Mandarin Sample

Two out of three mandarin samples were liked by consumers (68% rated 5-7) (Figure 17). This shows that the range of samples was well suited to the panels taste preferences.

Figure 17 Opinion about Mandarin Sample

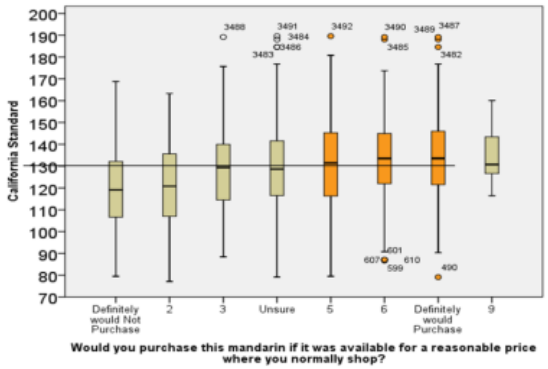
[9] Arpaia and Obenland pers com 2014
[10] Jordan & Loeffen 2013



4.1.2 Opinion Like-Dislike Mandarin V. Californian Standard

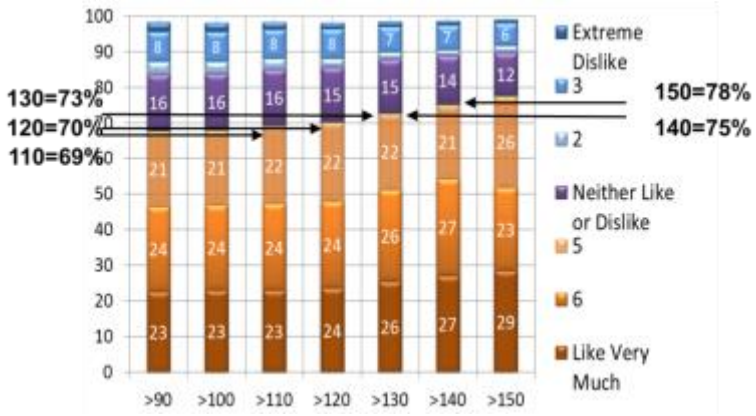
An assessment of the minimum standard that would satisfy mandarin consumers based on liking the fruit showed that using the California Standard calculation and setting it at a minimum of 130 would mean at least 50% of consumers would like the sample (opinion 5 & 6) (Figure 18).

Figure 18 Opinion Like-Dislike Mandarin V. Californian Standard



In looking at consumers responses to mandarin samples, setting the minimum standard at 130 would result in 73% of all consumers liking the mandarins compared to 70% at 120 (Figure 19).

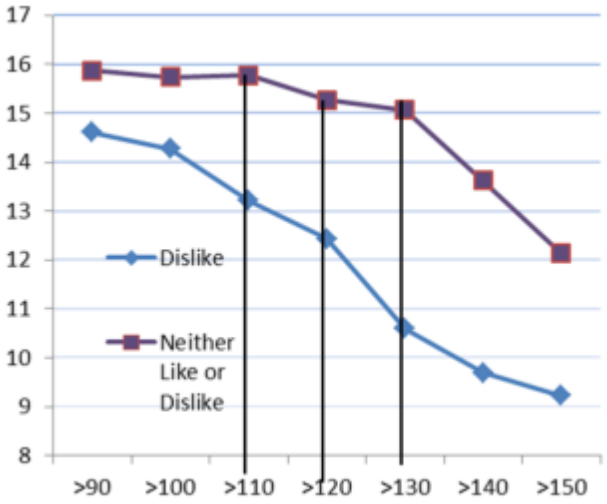
Figure 19 Opinion Like-Dislike Mandarin V. Californian Standard >60, >90 & >120



In terms of a negative response, at a standard of 130, the percentage of consumers who dislike the mandarin sample reduces to 10.5% compared to 13.1% at standard 120(

Figure 20). The percentage of consumers who dislike the mandarin sample plateaus out at about 9-10% once the standard is 130 or greater.

Figure 20 Opinion Dislike Mandarin V. Californian Standard



4.1.3 Would Purchase Mandarin

Consumers said they would definitely purchase two of three mandarin samples (66%) if it was available for a reasonable price where they normally shopped (

Figure **21**), confirming the range of samples was well suited to the panels taste preferences.

Consumers' opinions about liking the sample tasted were closely related to their willingness to purchase those mandarins (correlation 0.79) (

Figure 22).

Figure 21 Opinion Would Purchase Mandarins

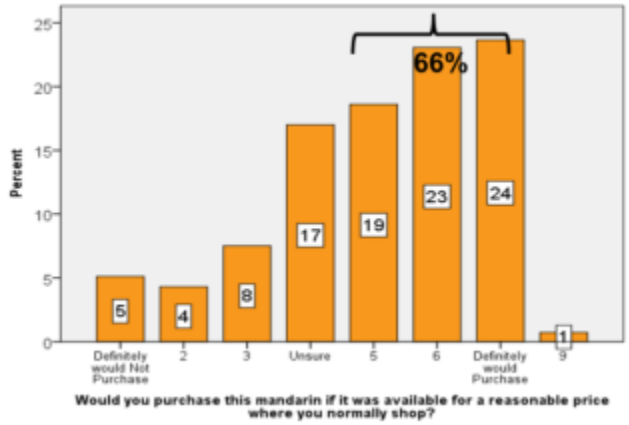
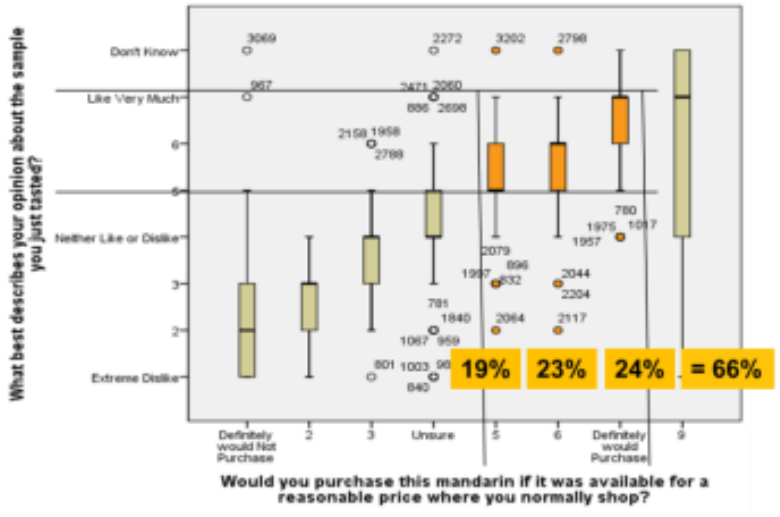


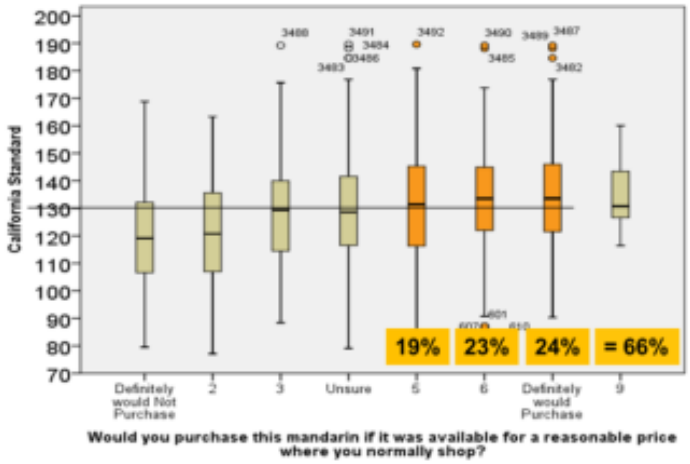
Figure 22 Opinion Like-Dislike Mandarin Sample V. Would Purchase Oranges



4.1.4 Opinion Would Purchase Mandarins V. Californian Standard

An assessment of the minimum standard needed to satisfy mandarin consumers based on the willingness to purchase using the California standard calculation would be set at a minimum of 130 to get at least 50% of consumers to purchase the sample (opinion 5 & 6) (Figure 23).

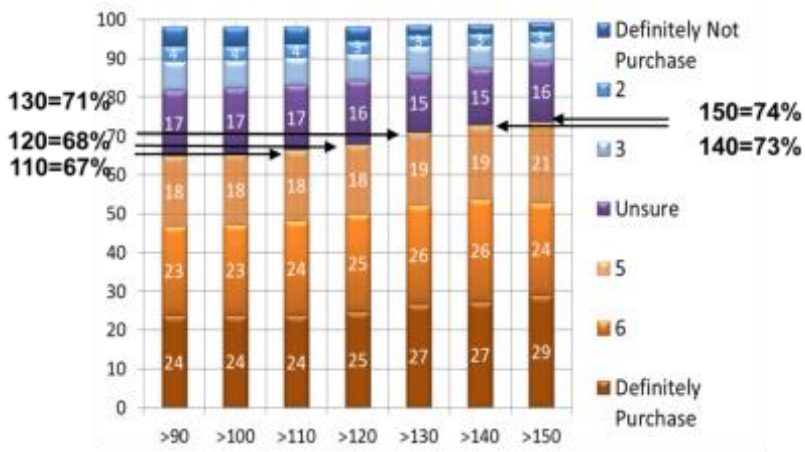
Figure 23 Opinion Would Purchase Oranges V. Californian Standard



In looking at consumer responses to mandarin samples, setting the minimum standard at 130 would result in 71% of all consumers purchasing the mandarins compared to 68% at 120 (

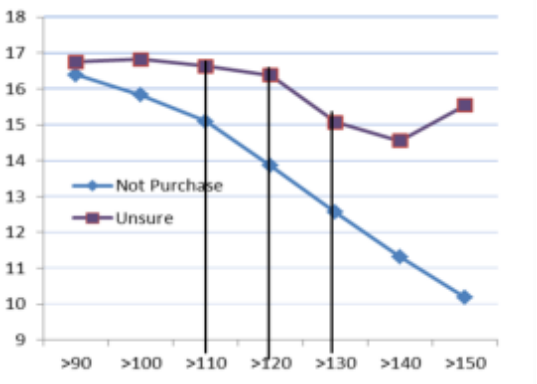
Figure 24).

Figure 24 Opinion Like-Dislike Mandarins V. Californian Standard >90, >100. >110, >120, >130, >140, >150



In terms of a negative response, at a standard of 130, the percentage of consumers who would not purchase the mandarin sample reduces to 12.5% compared to 13.9% at 120 (Figure 25).

Figure 25 Opinion Dislike Mandarin V. Californian Standard



4.1.5 Would Purchase More Mandarins

Close to half of consumers (45%) said they would purchase more mandarins based on the taste of the sample (5-7) (Figure 26). This indicates that if mandarins can be produced that meet the taste demands of consumers more mandarins can be sold.

An assessment of the minimum standard needed to satisfy mandarin consumers based on the characteristic 'willingness to purchase more mandarins' indicated it should be set at a minimum of 132 to get at least 50% of consumers to like the sample (opinion 5 & 6) (Figure 26).

Figure 26 Opinion Would Purchase More Mandarins

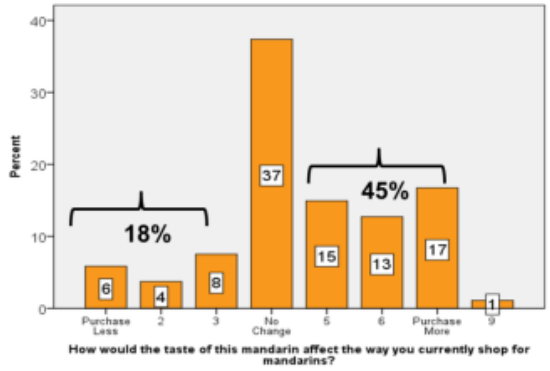
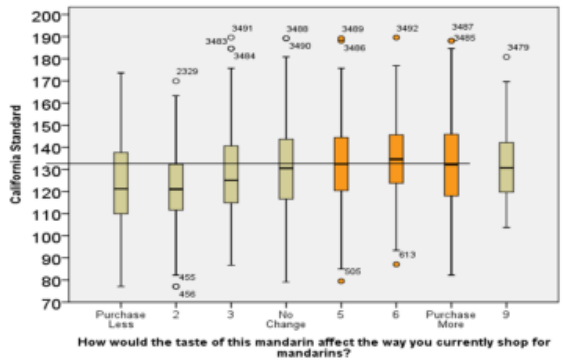
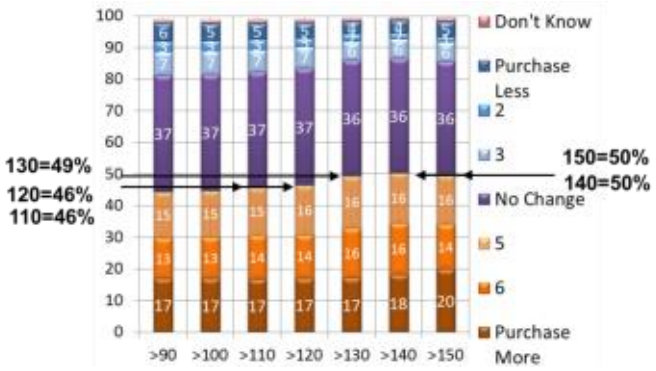


Figure 27 Opinion Would Purchase Mandarins V. Californian Standard



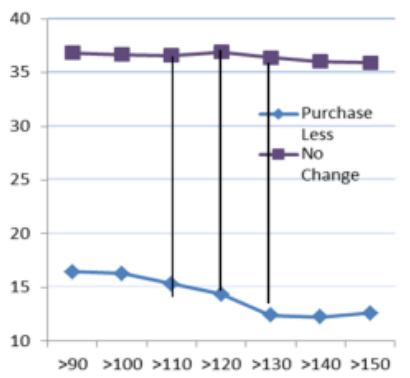
In looking at consumers' responses to mandarin samples, setting the minimum standard at 130 would result in 49% of all consumers willing to purchase more mandarins compared to 46% at 120 (Figure 28).

Figure 28 Opinion Like-Dislike Mandarins V. Californian Standard >90, >100. >110, >120, >130, >140, >150



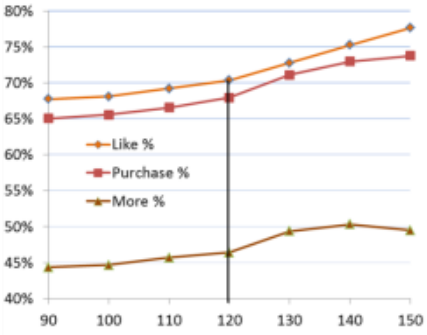
In terms of a negative response, at a standard of 130, the percentage of consumers who would purchase fewer mandarins reduces to 12% compared to 14.9% at 120 (Figure 29).

Figure 29 Opinion Dislike Mandarins V. Californian Standard



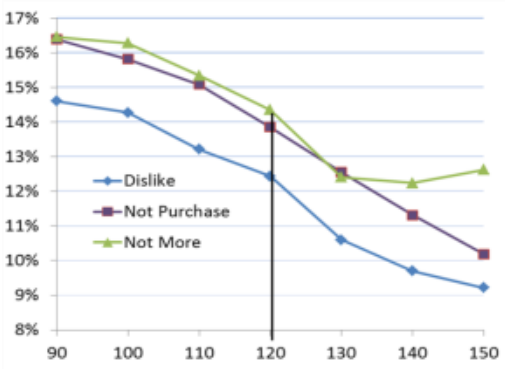
In assessing all the responses by consumers to the samples in terms of liking/disliking the mandarin sample, the willingness to purchase the mandarins and the willingness to purchase more mandarins the conclusion was to set the standard at 120. At a standard of 120, 70% of consumers like the mandarins, 68% would purchase the mandarins and 47% would be willing to purchase more mandarins (Figure 30).

Figure 30 Mandarin Standard Conclusions - Positive



At a standard of 120 the negative responses reduce to 12.5% disliking the mandarin sample, 13.9% not purchasing the mandarins and 14.1% purchasing fewer mandarins (Figure 31).

Figure 31 Mandarin Standard Conclusions - Negative



4.1.6 Analysis to determine standard

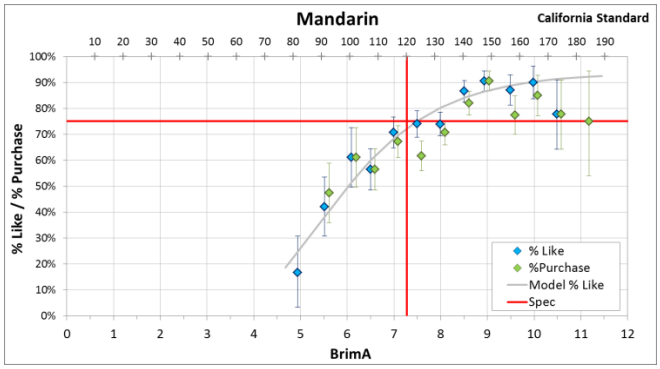
The effect of different standards on consumer response to the mandarin sample is easiest to see when the rating of all consumers has been averaged. Averaging removes consumer panels biases such as any tendency to rank the samples and their individual idiosyncrasies. This principle was used in research conducted by Arpaia and Obenland[11] when they developed the California Standard for navel oranges. Figure 16 shows the percentage of conumers who liked the mandarin sample or who would purchase it if they found it at a reasonable price compared to the Californian Standard. The grey trend line shows that mandarin samples greater than 150 on the Californian Standard do increase the number liking it or willing to purchase it much more than 90%. With most mandarin samples assessed by the panels being a Standard 100 to 150, there is greater confidence with results in this range.

The conclusion from the results in setting a standard for the industry is that a minimum standard of 120 would mean that on average 75% of consumers would like it and purchase it again. This gives some room for the natural variation in a harvest of mandarins. For example if the mandarins ranged from a Standard of 100 to 140 and averaged 120, then 50% of consumers would like the lowest standard mandarins and 85% would like the best mandarins in the harvest.

Figure 32 Opinion Like & Would Purchase Mandarin V. Californian Standard[12]

[11] Arpaia and Obenland pers com 2014

[12] Jordan & Loeffen (2013)



5. Conclusions and Recommendations

Recommendations from the research are:

1. The Australian citrus industry moves from a Brix acid ratio to a BrimA formula for measuring internal quality of fruit. It is recommended that as in the California Standard a multiplier be used to increase the scale, i.e. the calculation will be

   Citrus Maturity Standard calculation (CMS)= (Brix-(%Acidx4))x16.5

   This method is a better predictor of consumer opinion and provides a better correlation with consumer taste preferences.

2. The citrus industry adopts new minimum standards using the above formula of:
   - CMS90 for oranges. Oranges include navels, Valencias and common orange. It excludes blood oranges.
   - CMS120 for rich flavoured mandarins. Rich flavoured mandarins include Afourer and Murcott types.

   The study determined that the natural variation within the orchard meant that the current method of sample taking - using an average of 10 fruit - meant that a wide range of fruit maturities could be found in the sample and the consignment the sample represented. For example if the oranges in a sample ranged from a Standard of 70 to 110 and averaged 90, then nearly 60% of consumers would like the lowest standard oranges and nearly 90% would like the best oranges in the consignment. Therefore setting a minimum standard of 90 would mean that on average 75% of consumers would like the fruit and purchase it again

3. An extensive communication, training and extension program be conducted throughout the citrus value chain to ensure adoption of these standards.

4. A consumer panel project be conducted to define additional standards for
   - Milder flavoured mandarins such as Imperials
   - Late season low acid oranges and
   - Maximum acceptable fruit dryness of Imperial mandarins.

5. A maturity variation project be conducted to develop decision support tools for industry and to review maturity testing protocols. This will improve grower and buyer confidence in fruit quality and will improve the growers' ability to deliver a consistent line of product having accounted for variability between individual fruit. Project activities would include:

- Develop maturity curves for important citrus varieties. Results from weekly maturity testing of a large number of individual fruit from early in fruit development to after commercial harvest periods will provide a database of maturity curves for each variety. Growers will use the curves for their own data and predicting their own harvest time.

  This type of data collection has not been conducted in Australia, where industry protocol is to bulk fruit juice together for testing. Important citrus varieties to be included are Navelina, Washington and Lane Late navel orange, Imperial, Murcott and Afourer mandarins.

- Develop improved methodology for maturity testing to account for variability between individual fruit from the same orchard block. New equipment or processes will provide a protocol that allows for individual fruit testing within practical time frames and costs. This will increase grower confidence that maturity-testing results reflect the maturity level of the orchard block.
- Based on maturity curves and database above develop a computer model that helps growers determine the maturity rate in their orchard blocks, predict harvest times and the rate of maturity protocol compliance. Provide better grower decision tools based on new equipment and method that uses rapid fruit testing. This will be an improvement on current industry use of a titration method for internal fruit testing.

6. References

Arpaia and Obenland pers com 2014

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Loeffen and Jordan 2014

McAlpine

7. Appendices

Appendix 1 Consumer panel characteristics

The consumer panel characteristics include their gender, age, the countries they have lived the longest, their ethnic origin and the years they have lived in Australia.

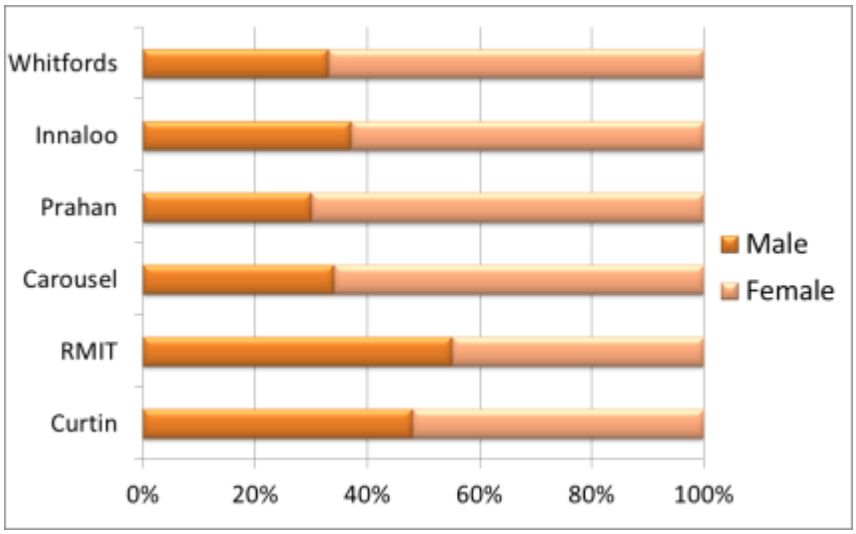
Navel orange consumer panels

The analysis of Navel orange consumer panel characteristics is presented in the following.

Gender

The balance of male (39%) and females (61%) in the panel was as expected (Figure 33). While fewer males joined the panels in the shopping centres, there were close to equal percentages at University panels (RMIT and Curtin).

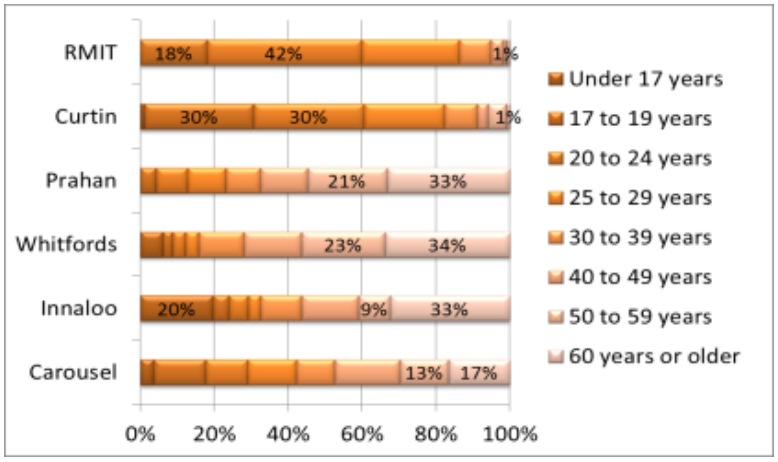
Figure 33 Gender - Navel Orange Panel



Age

A broad range of age categories participated in the panels (Figure 34). As expected mainly older people joined panels in shopping centres. This was balanced by sourcing younger consumers at the Universities (RMIT and Curtin).

Figure 34 Age - Navel Orange Panel



Countries lived the Longest

While most consumers in the panels lived the longest in Australia (68%), there was a wide range of other countries represented with more from China (4%), South Africa (2.4%), the United Kingdom (2.4%), India (2.1%) and Malaysia (2.1%) (Figure 35).

Figure 35 Countries lived the Longest - Navel Orange Panel

	Frequency	Percent
Australia	479	68.3
China	29	4.1
South Africa	17	2.4
United Kingdom	17	2.4
India	15	2.1
Malaysia	15	2.1
New Zealand	13	1.9
England	11	1.6
United States of America	10	1.4
Ireland	8	1.1
Singapore	8	1.1
Vietnam	6	0.9
Thailand	5	0.7
Hong Kong	4	0.6
Indonesia	4	0.6
Sri Lanka	4	0.6
Africa	3	0.4
Canada	3	0.4
Sweden	3	0.4
Tanzania	3	0.4

Ethnic Origin

Panellists were asked to describe their ethnic origin (unprompted open question). If the description was unclear (80 people) it was assessed based on the countries they lived the longest. The ethnic origin of some (16 people) could not be assessed. The descriptions were categorised into those of Caucasian descent (from Australia, New Zealand or Europe), Asia (India through to East Asia) or Other (Africa, Middle East, America etc.). Most people were categorised as of Caucasian descent (66%) - similar percentage to those who had lived the longest in Australia (Figure 36).

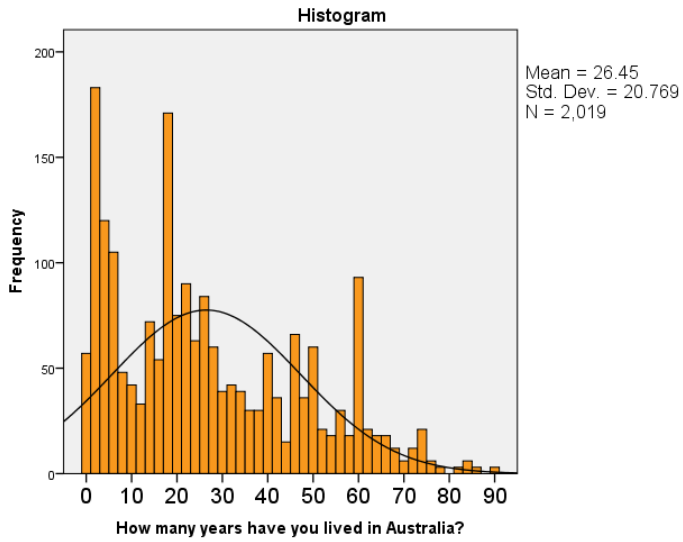
Figure 36 Ethnic Origin - Navel Orange Panel

Ethnic Origin	Consumers	Percent
Caucasian	466	66.5
Asian	154	22.0
Other	65	9.3
Total	685	97.7
Missing	16	2.3

Years in Australia

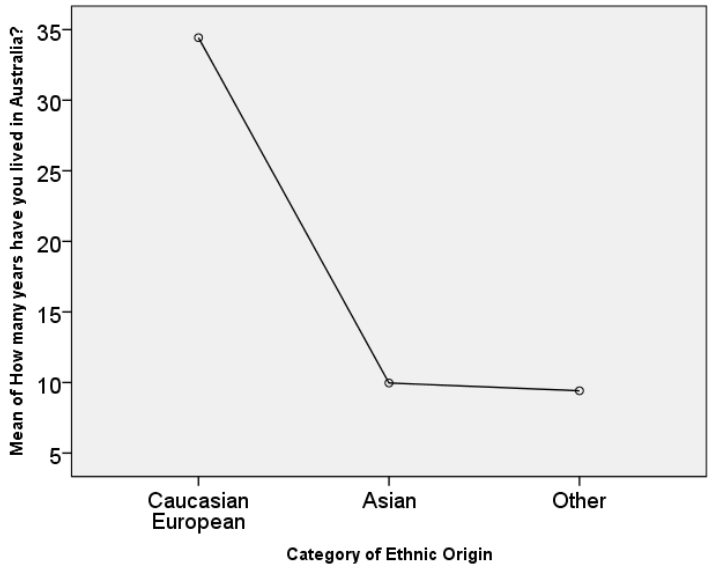
On average consumers had lived in Australia 26 years with most time ranging from 6 years to 46 years (Figure 37). Some had lived in Australia all of their lives – up to 90 years.

Figure 37 Years in Australia - Navel Orange Panel



When comparing the years lived in Australia to ethnic origin, most identifying as of Caucasian descent had lived the longest in Australia compared to those of Asian or Other descent (Figure 38).

Figure 38 Years in Australia V. Ethnic Origin - Navel Orange Panel



It was concluded that the consumers participating in the Navel orange panels had a wide range of demographic characteristics in terms of gender, age, ethnic origin and countries they had lived in the longest.

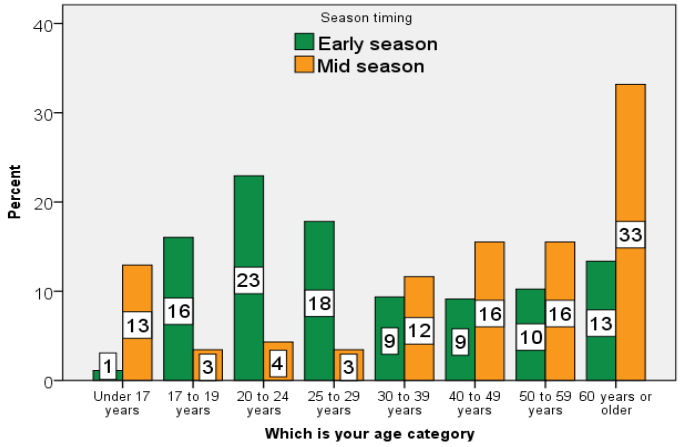
Comparisons - Early V. Mid-Season Orange Panels Consumer Characteristics

To determine if the consumers participating in the early season panels were different to those in the mid-season panels, the characteristics of the two panels were compared in terms of age, gender and ethnic origin.

Orange Season V. Age

In terms of age, the early season consumer panellists were younger than those in the mid-season panels (Figure 39). This difference reflected that half the consumers in the early season panels were from the younger University students whereas all the mid-season panels had older shopping centre panellists.

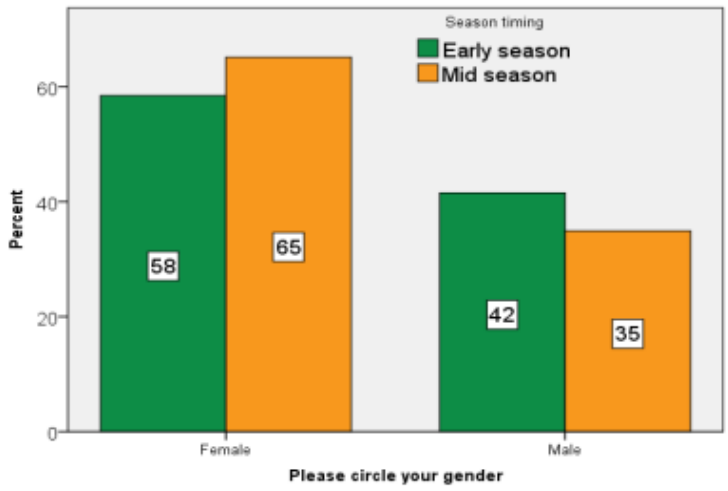
Figure 39 Orange Season V. Age - Navel Orange Panel



Orange Season V. Gender

In terms of gender, the early season consumer panellists had more males than those in the mid-season panels (Figure 40). This difference also reflected that half the consumers in the early season panels were from the University whereas all the mid-season panels were run in shopping centre where more panellists were female.

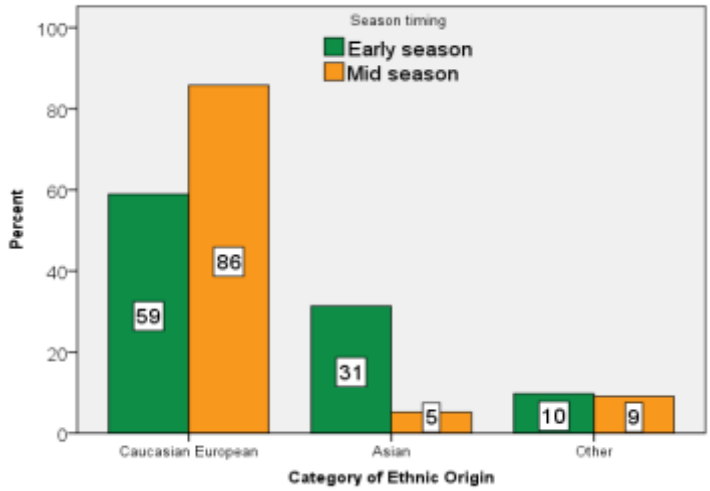
Figure 40 Orange Season V. Gender - Navel Orange Panel



Orange Season V. Ethnic Origin

In terms of ethnic origin, the early season consumer panellists had more identifying from Asia than those in the mid-season panels (Figure 41). This difference also reflected that half the consumers in the early season panels were from the more ethnic diverse Universities whereas all the mid-season panels were run in shopping centre where more panellists were Caucasians. There were more Asians in the early season testing at the Universities.

Figure 41 Orange Season V. Ethnic Origin - Navel Orange Panel



In conclusion, the differences in demographic characteristics of early season to mid-season orange panellists were not seen to be unexpected.

Comparisons Perth V. Melbourne Early Season Orange Panels

After running the early season consumer panels the question was whether there were significant differences between consumers in Melbourne and Perth. If there were no significant differences then the remaining panels could be run at either location without impacting on the results. The differences in responses were assessed in terms of demographic characteristics of consumers, orange eating and purchasing patterns as well as sample attributes and responses to samples.

Demographic Differences Perth V. Melbourne

The differences in terms of demographics that were statistically significant (95% confidence) were in terms of age and ethnic origin. There were no differences in terms of gender and number of years lived in Australia.

The consumers in the Perth orange panels were younger than those in Melbourne orange panels. The differences were primarily due to younger consumers recruited at the Carousel Shopping Centre in Perth compared to the older consumers at the Prahan Markets in Melbourne.

In terms of ethnic origin differences, there were more Middle East/African consumers in Perth than in Melbourne (13% Perth V. 4% Melbourne) but more Asians in Melbourne (26% Perth V. 37% Melbourne).

Orange Eating & Purchase Pattern Differences Perth V. Melbourne

There were no differences in terms of frequency eating oranges and eating other tangy fruit.

There were some significant differences in attributes important when shopping (scale 1 not at all important – 7 very important). Skin colour was more important to Perth shoppers (mean 5.3 V. 4.9)

as was being Blemish free (mean 5.3 V. 4.9). However, Tangy flavour less important to Perth shoppers (mean 5.3 V. 5.5). There were no significant differences in other attributes when shopping.

Orange Sample Differences Perth V. Melbourne

There were some statistically significant differences in the orange samples presented to the panels in Perth and Melbourne. In Perth the orange samples had lower sugar % (11.05 V. 11.5), lower acid % (1.40 V. 1.45), higher sugar/acid ratio (8.1 V. 7.9) and lower Californian Std. (90 V. 93). While Perth panellists were more likely to say the taste affects the way they currently shop for oranges (Mean 4.54 V. Melbourne 4.37), there were no significant differences in opinion, flavour, sweetness, sourness or tanginess.

Conclusions Perth V. Melbourne Early Season Orange Panels

In conclusion there were few differences between Melbourne and Perth early season panels. There were only differences in the sample taste affecting shopping (purchase more or less) and importance of orange skin colour, blemish free and tangy flavour.

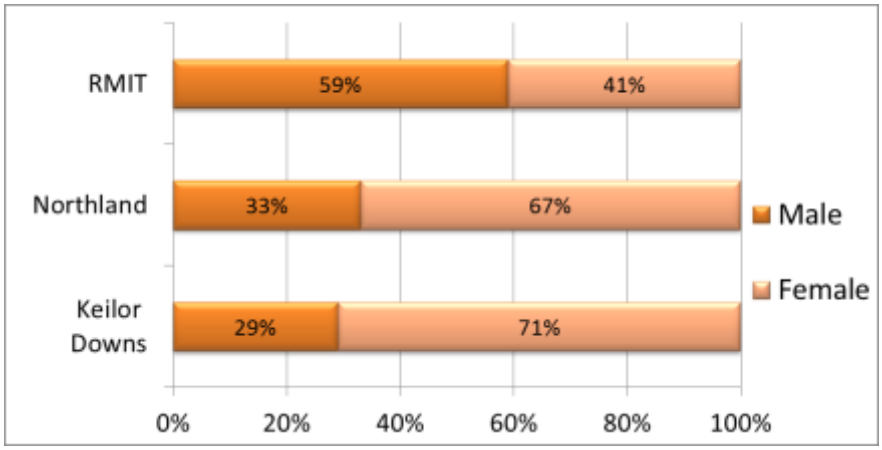
Mandarin consumer panels

The analysis of Afourer mandarin consumer panel characteristics are presented in the following.

Gender

The balance of male (46%) and females (54%) in the panel was as expected (Figure 42). While less males joined the panels in the shopping centres, this was made up for with more males at the University panels (RMIT).

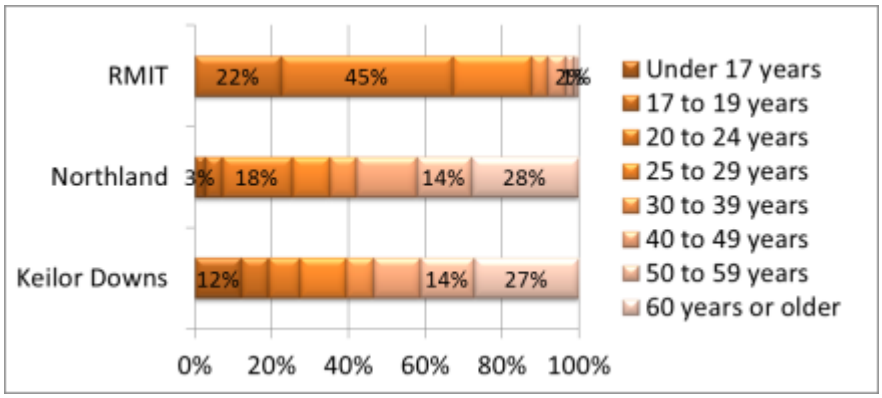
Figure 42 Gender – Afourer Mandarin Panels



Age

A broad range of age categories participated in the panels (Figure 43). As expected mainly older people joined panels in shopping centres. This was balanced by sourcing younger consumers at the Universities (RMIT and Curtin).

Figure 43 Age – Afourer Mandarin Panels



Country lived the Longest

While most consumers in the panels had lived the longest in Australia (57%), there was a wide range of other countries represented. The next most common country where had the lived the longest were China (7%), India (5%), Vietnam (3%), Sri Lanka (2.6%) and New Zealand (1.9%) (Figure 44).

Figure 44 Countries in which lived the Longest – Afourer Mandarin panellists

	Frequency	Percent
Australia	265	57.2
China	34	7.3
India	25	5.4
Vietnam	14	3.0
Sri Lanka	12	2.6
New Zealand	9	1.9
Malaysia	7	1.5
Indonesia	6	1.3
Taiwan	6	1.3
Hong Kong	4	0.9
Singapore	4	0.9
United States of America	4	0.9
No response	18	3.9

Ethnic Origin

Panellists were asked to describe their ethnic origin (where they and their family are from - unprompted open question). If the description was unclear it was assessed based on the countries they lived the longest. The ethnic origin of some (17 people) could not be assessed. The descriptions were categorised into those of Caucasian descent (from Australia, New Zealand or Europe), Asia (India through to East Asia) or Other (Africa, Middle East, America etc.). Most people identified themselves as of Caucasian descent (55%) - similar percentage to those who had lived the longest in Australia (Figure 45).

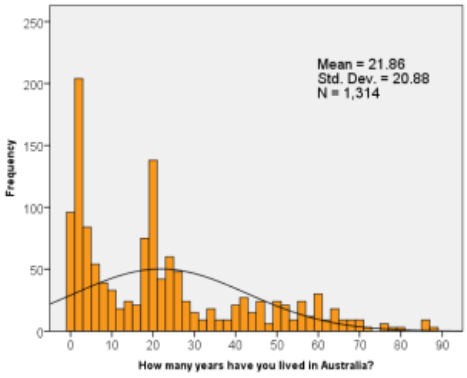
Figure 45 Ethnic Origin of panellists – Afourer Mandarin Panels

Ethnic Origin	Consumers	Percent
Caucasian	256	55
Asian	157	34
Other	33	7
Total	446	96
Missing	17	4

Years in Australia

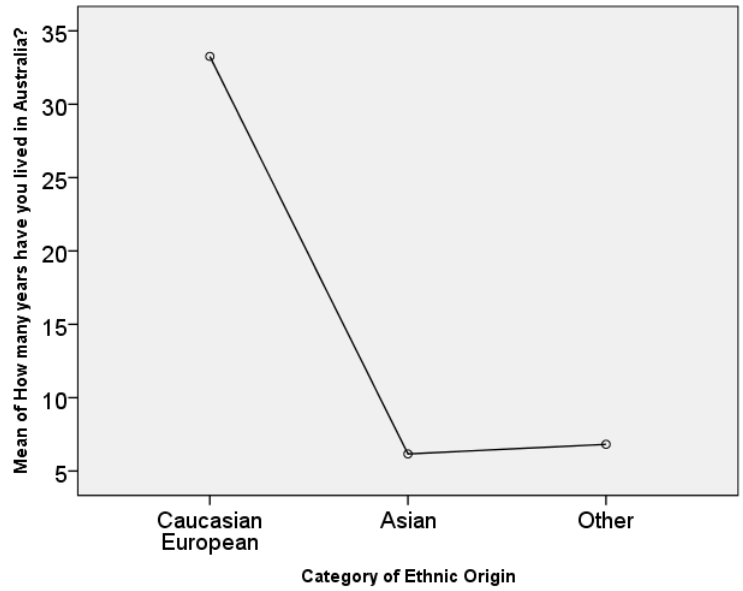
On average consumers had lived in Australia 22 years with most time ranging from 6 years to 43 years (Figure 46). Some had lived in Australia all of their lives – up to 90 years.

Figure 46 Years in Australia – Afourer Mandarin Panels



When comparing the years lived in Australia to ethnic origin, most identifying of Caucasian descent had lived the longest in Australia compared to those of Asian or Other descent (Figure 47).

Figure 47 Years in Australia V. Ethnic Origin – Afourer Mandarin Panels



It was concluded that the consumers participating in the Afourer mandarin panels had a wide range of demographic characteristics in terms of gender, age, ethnic origin and countries they had lived in the longest.

Appendix 2 Fruit Sample Characteristics

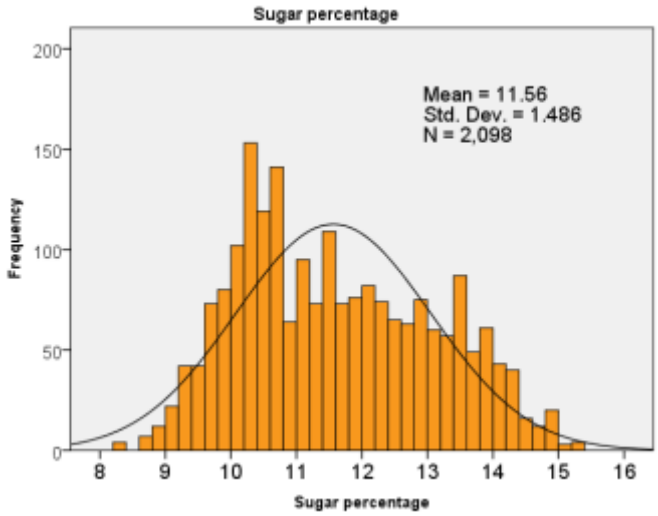
Navel samples

Orange samples were measured for level of Brix (total soluble solids), acid percentage, Brix acid ratio and their Californian Standard measurement.

Orange Brix (Total Soluble Solids TSS)

Orange samples averaged 12 Brix with most samples (68%) between 10.5˚ to 13.5˚ (mean 12 +/- standard deviation 1.5) indicating the samples offered had a wide range of Brix with a higher mean than 9.0 brix, current minimum standard, due seasonal conditions (Figure 48).

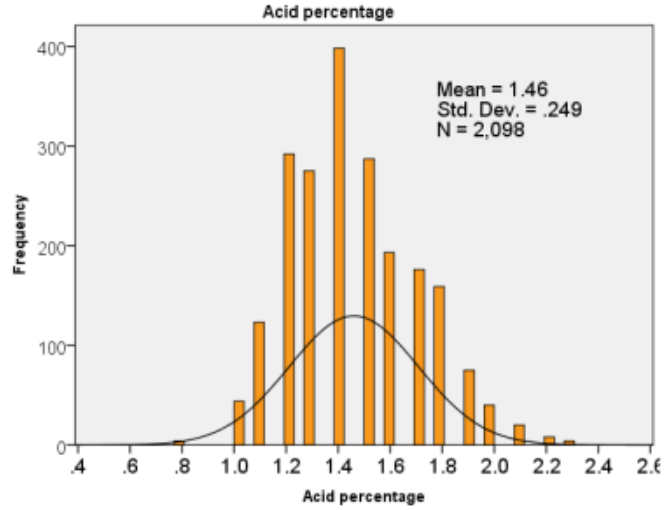
Figure 48 Orange Samples Brix (Total Soluble Solids TSS)



Orange Acid %

Orange samples averaged 1.5 percent acid with most samples (68%) between 1.2% - 1.7% (mean 1.46 +/- standard deviation 0.25) indicating the samples offered had a wide range of acid (Figure 49)

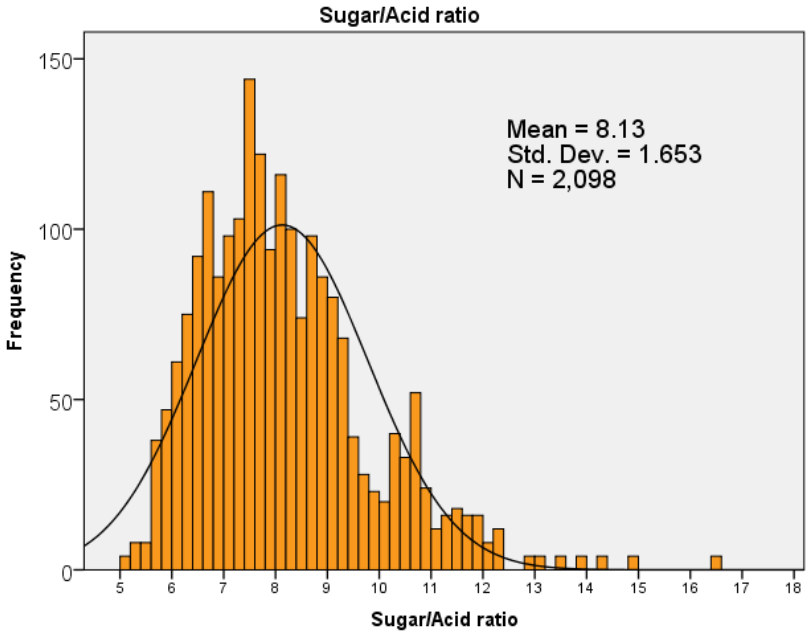
Figure 49 Orange Samples Acid %



Orange Brix acid ratio

Orange samples averaged 8.1: 1 Brix to acid ratio with most samples (68%) between 6.5 : 1 and 9.8 : 1 (+/- standard deviation 1.6) indicating the samples offered had a wide range of Brix to acid ratio (Figure 50).

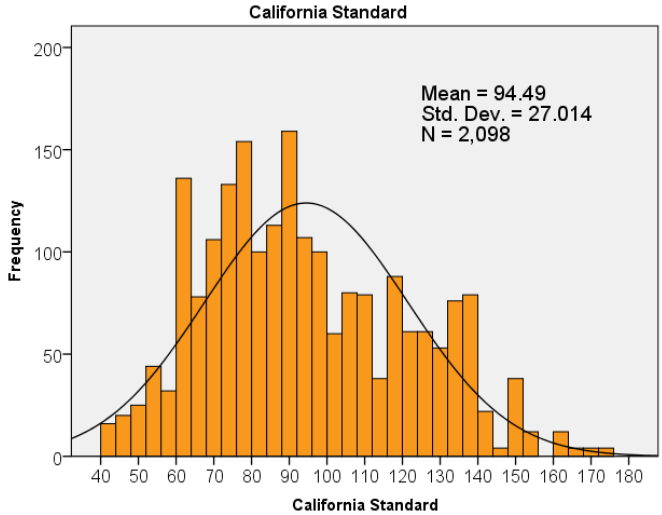
Figure 50 Orange Samples Brix acid ratio



Orange Californian Standard

Orange samples averaged a Californian standard of 95 with most samples (68%) between 67 to 122 (+/- standard deviation 27) indicating the samples offered had a wide range of standards (Figure 51).

Figure 51 Orange Samples Californian Standard



On assessing the characteristics of the samples, it was concluded the orange samples offered to the panellists had wide range of attributes to enable consumers to evaluate which orange samples were more to their taste.

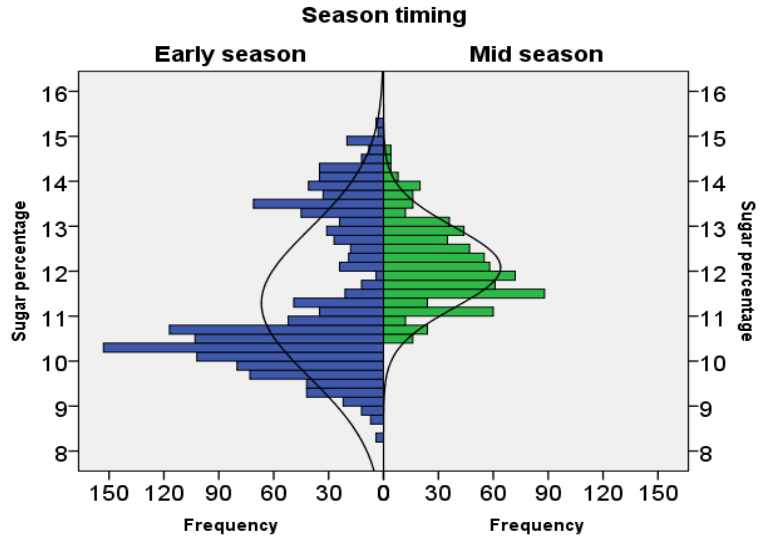
Comparisons - Early V. Mid-Season Orange Panel Samples

To determine how the orange samples provided in the early season panels were different to those in the mid-season panels, the characteristics of the orange samples were compared in terms of Brix (total soluble solids), acid %, brix acid ratio and Californian Standard. Differences were also assessed in terms of panellist's responses to orange sample perceived sweetness, flavour, sourness and sweet and sour balance.

Orange Brix (Total Soluble Solids TSS)

Mid-season orange samples had more consistent Brix levels with most between 11% to 13% (Early season Mean=11.3%, Standard Deviation=1.65; Mid-season Mean=12.1%, Standard Deviation=0.9) (Figure 52).

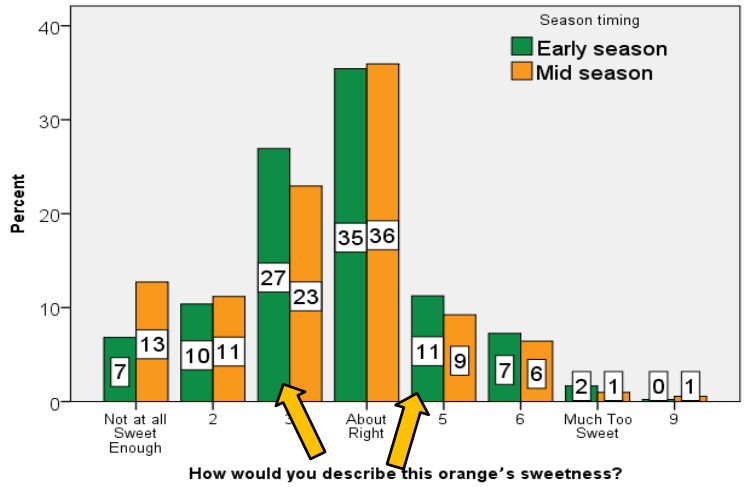
Figure 52 Orange Brix (Total Soluble Solids TSS) – Early V. Mid-Season



Orange Consumer Perceived Sweetness

Mid-season orange samples were perceived by consumers to be less sweet (mean 3.4 V. early 3.6/7) despite consistently higher Brix in the samples offered (Figure 53).

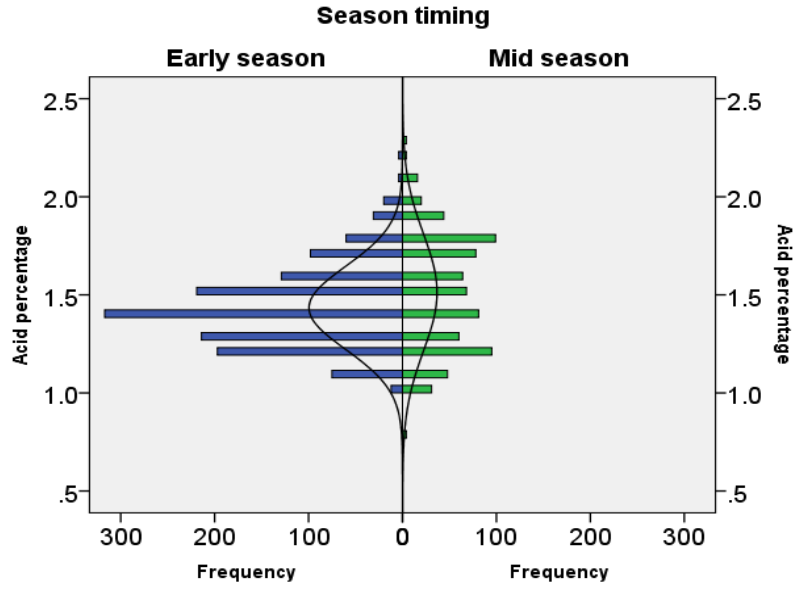
Figure 53 Orange Consumer Perceived Sweetness – Early V. Mid-Season



Orange Acid Percentage

Mid-season orange samples had a greater variation in acid percentage (Standard Deviation 0.3 not 0.2; mean 1.4% V. 1.5%) (Figure 54).

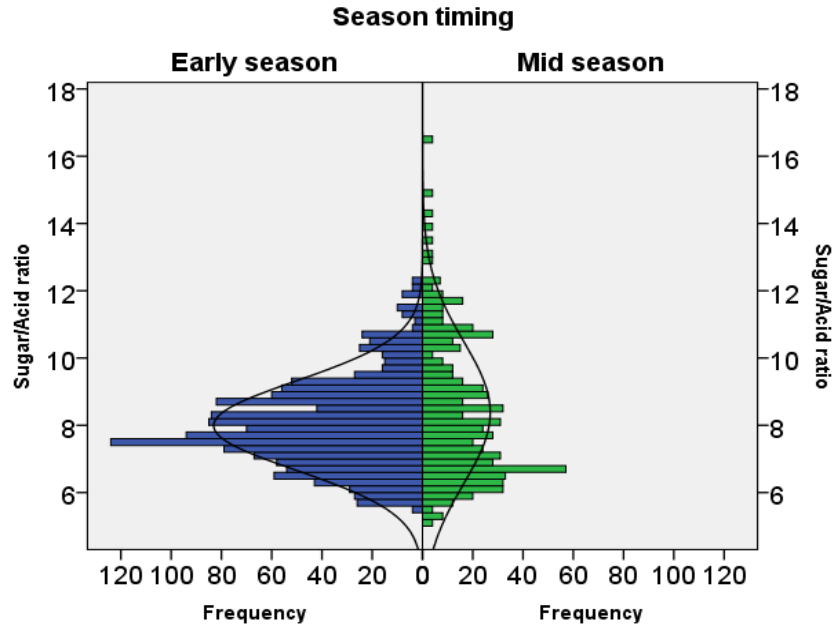
Figure 54 Orange Acid % – Early V. Mid-Season



Orange Brix acid ratio

Mid-season orange samples had a higher variation in the Brix acid ratio (standard deviation 2.1 V. 1.3; mean 7.9V. 8.4%) (Figure 55).

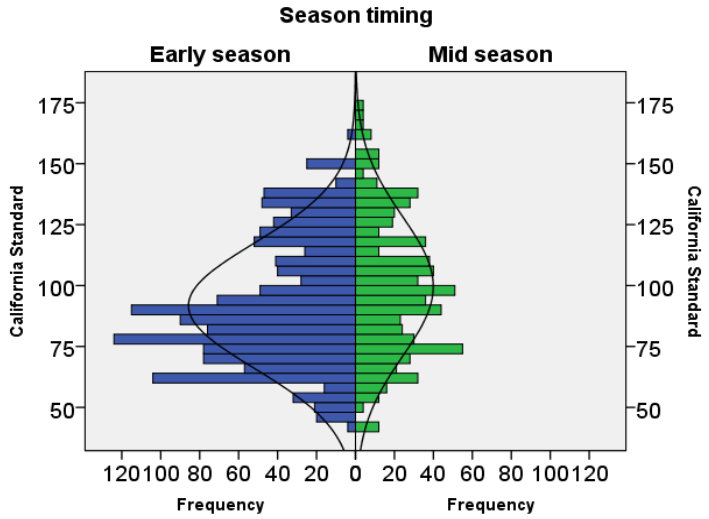
Figure 55 Orange Brix acid ratio – Early V. Mid-Season



Orange Californian Standard

Mid-season orange samples had a higher Californian Standard with more variation (Standard Deviation 29 V. 26) (Figure 56).

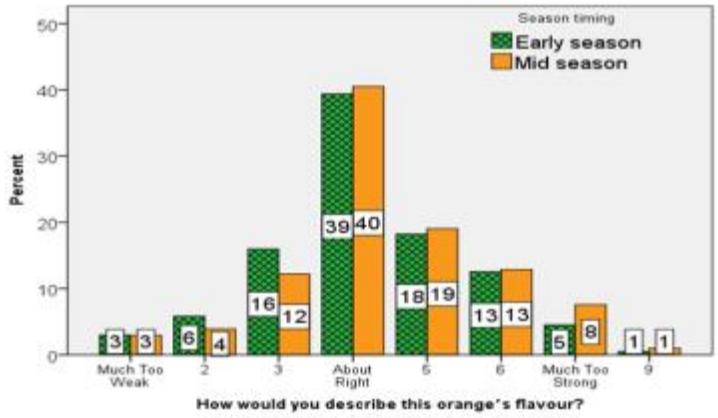
Figure 56 Orange Samples Californian Standard – Early V. Mid-Season



Orange Consumer Perceptions Early V. Mid-Season Samples

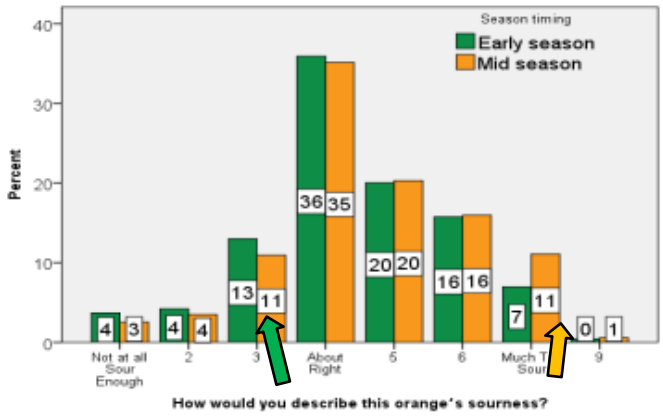
Mid-season orange samples were perceived to have a stronger flavour (mean 4.4 V. early 4.2) (Figure 57).

Figure 57 Orange Consumer Flavour Perceptions – Early V. Mid-Season



Mid-season orange samples were perceived to be more sour (mean 4.6 V. early 4.4) (Figure 58).

Figure 58 Orange Consumer Sour Perceptions – Early V. Mid-Season



Early V. Mid-Season Orange Sample Conclusions

In conclusion, there were significant differences in the orange samples offered in the mid-season panels compared to the early season panels. As expected the mid-season samples had more consistent sugar but the wider range of acid resulted in a wider range of sugar to acid ratio and Californian Standard. With these differences in the orange samples the panellists perceived the mid-season samples were less sweet, had a stronger flavour and were sourer.

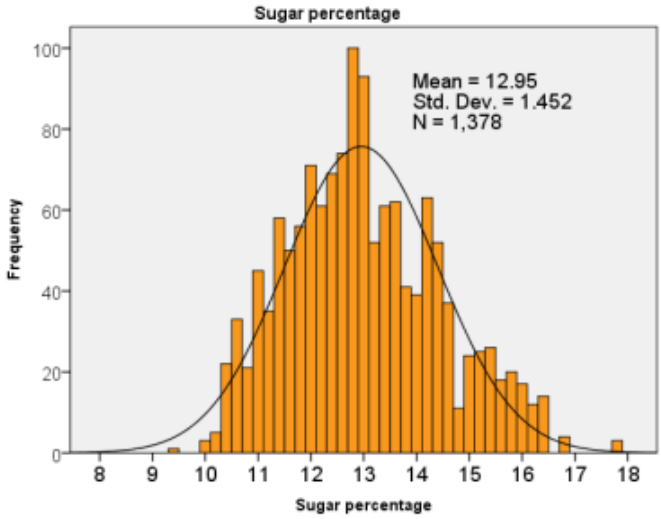
Mandarin Samples

Mandarin samples were measured in terms of Brix (total soluble solids) and acid percentage and their maturity expressed as a Brix acid ratio and the Californian Standard.

Mandarin Brix (Total Soluble Solids TSS)

Mandarin samples averaged 13% Brix with most samples (68%) between 11.5% to 14.4% (mean 13 +/- standard deviation 1.45) indicating the samples offered had a wide range of Brix (Figure 59).

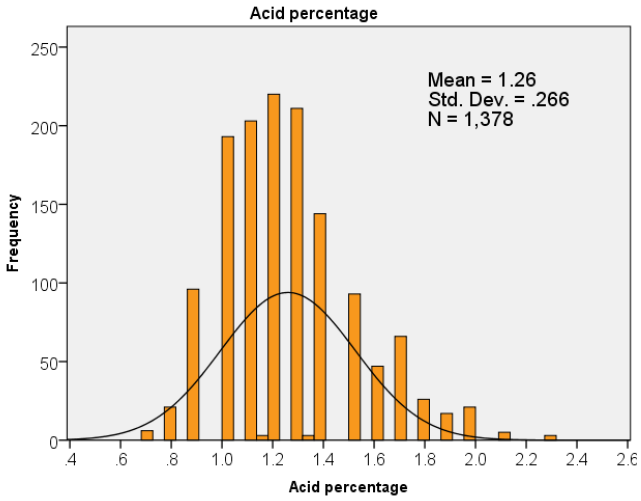
Figure 59 Mandarin Brix (Total Soluble Solids TSS)



Mandarin Acid %

Mandarin samples averaged 1.3 percent acid with most samples (68%) between 1% - 1.5% (mean 1.26 +/- standard deviation 0.27) indicating the samples offered had a wide range of acid (Figure 60).

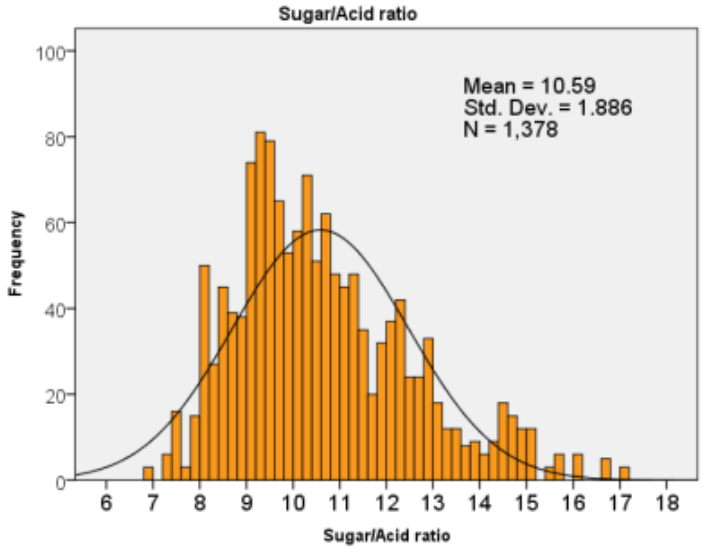
Figure 60 Mandarin Samples Acid %



Mandarin Brix Acid Ratio

Mandarin samples averaged 10.6 Brix to acid ratio with most samples (68%) between 8.7 to 12.5 (mean 10.6 +/- standard deviation 1.9) indicating the samples offered had a wide range of Brix to acid (Figure 61).

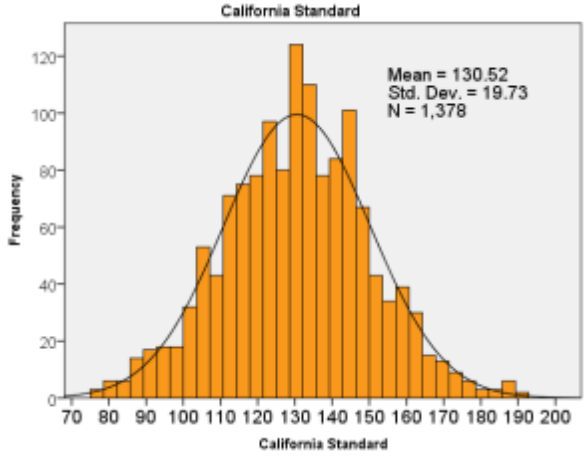
Figure 61 Mandarin Samples Brix Acid Ratio



Mandarin Californian Standard

Mandarin samples averaged a Californian standard of 130 with most samples (68%) between 111 to 150 (mean 130 +/- standard deviation 20) indicating the samples offered had a wide range of standards (Figure 62).

Figure 62 Mandarin Samples Californian Standard



On assessing the characteristics of the samples, it was concluded the mandarin samples offered to the panellists had a wide range of attributes to enable consumers to evaluate which mandarin samples were more to their taste.

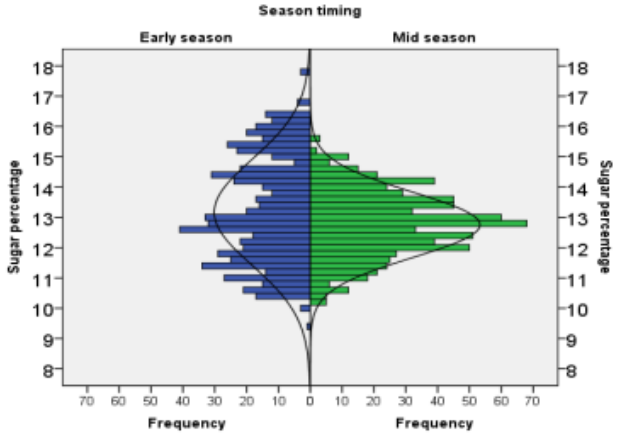
Comparisons - Early V. Mid-Season Panel Samples

To determine whether the mandarin samples provided to the early-season panels were different to those in the mid-season panels, the characteristics of the mandarin samples were compared in terms of Brix (total soluble solids), acid %, brix acid ratio and Californian Standard. Differences were also assessed in terms of the panellist's responses of perceived sweetness, flavour, sourness and sweet and sour balance of the mandarin samples.

Mandarin Brix (Total Soluble Solids TSS)

Mid-season mandarin samples had more consistent Brix of between 12% to 14% (Early season Mean 13.2% standard deviation 1.75; Mid-season Mean 12.75% standard deviation 1.07) (Figure 63). There was no statistically significant in mandarin panelists perception of sample sweetness.

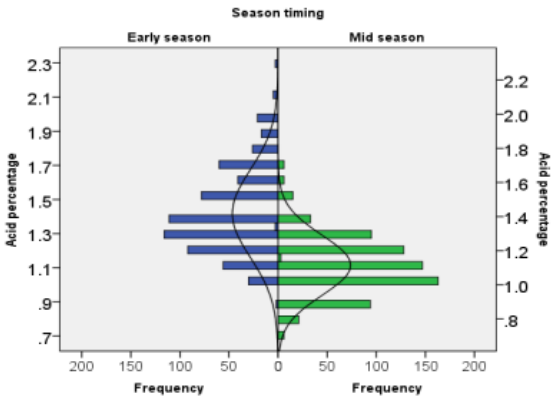
Figure 63 Mandarin Brix (Total Soluble Solids TSS) – Early V. Mid-Season



Mandarin Acid %

Mid-season mandarin samples had consistently lower acid % (average 1.1% not 1.4%; standard deviation early season 0.26; mid-season 0.18) (Figure 64).

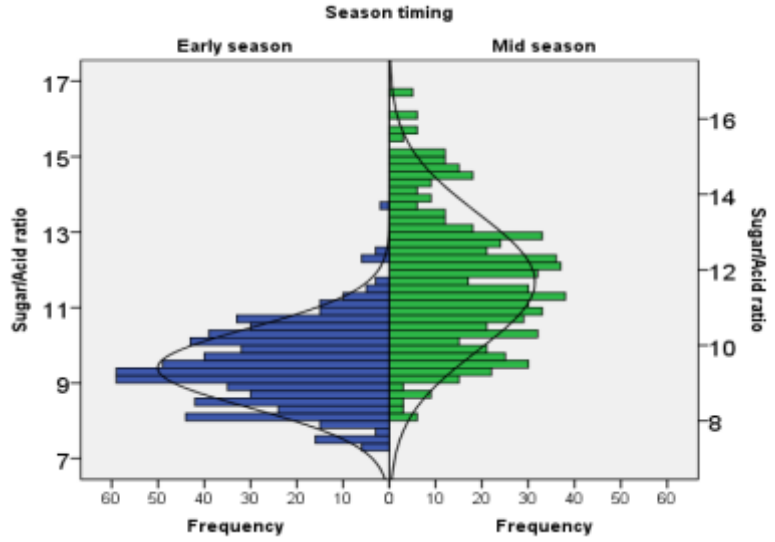
Figure 64 Mandarin Acid % – Early V. Mid-Season



Mandarin Brix Acid Ratio

Mid-season mandarin samples had a higher Brix to acid ratio (average 11.7 not 9.4) and more variation in the Brix to acid ratio (standard deviation early season 1.05; mid-season 1.8) (Figure 65).

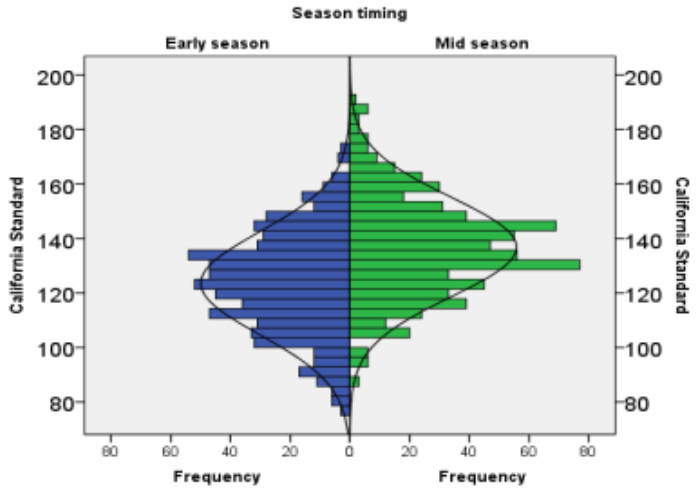
Figure 65 Mandarin Brix Acid Ratio – Early V. Mid-Season



Mandarin Californian Standard

Mid-season mandarin samples had an overall higher Californian standard (average 137 V. early season 124) (Figure 66).

Figure 66 Mandarin Samples Californian Standard – Early V. Mid-Season



Consumer Perceptions Early V. Mid-Season Samples

The only statistically significant difference in panellists' perceptions was that the Mid-season mandarin samples were less tangy and less sour. There were no statistically significant differences in panellists' perceptions in terms of: overall like/dislike of the sample, willingness to purchase, willingness to purchase more, flavour or sweetness.

Early V. Mid-Season Mandarin Sample Conclusions

In conclusion, there were significant differences in the mandarin samples offered in the mid-season panels compared to the early season panels. As expected the mid-season samples had more consistent Brix, lower acid and as a result a higher Brix to acid ratio and Californian Standard. Despite these technical differences the panellists picked up was that the mid-season samples were perceived to be less tangy and less sour.

Appendix 3 Surveys

Navel Orange Survey

Location: Date: 2013 Consumer #.....

Sample 1 Sample # .....

Before tasting the sample please: 1) Rinse your mouth with a few sips of water, 2) Clean mouth with a small bite of cracker, 3) Rinse all of the cracker from your mouth with water and then 4) Taste enough of the orange sample to answer the following questions.

1. What best describes your opinion about the sample you just tasted (*circle one number)*

	1	2	3	4	5	6	7	9
Opinion	*Extreme Dislike*			*Neither Like or Dislike*			*Like Very Much*	*Don't know*

2. Would you purchase this orange if it was available for a reasonable price where you normally shop? (*circle one number)*

	1	2	3	4	5	6	7	9
Purchase	*Definitely Not Purchase*			*Unsure*			*Definitely Purchase*	*Don't know*

3. How would the taste of this orange affect the way you currently shop for oranges? (*circle one number)*

	1	2	3	4	5	6	7	9
Shopping	*Purchase Less*			*No change*			*Purchase More*	*Don't know*

4. How would you describe this orange's flavour? (*circle one number)*

	1	2	3	4	5	6	7	9
Flavour	*Much too Weak*			*About Right*			*Much too Strong*	*Don't know*

5. How would you describe this orange's sweetness? (*circle one number)*

	1	2	3	4	5	6	7	9
Sweetness	*Not at all Sweet enough*			*About right*			*Much too Sweet*	*Don't know*

6. How would you describe this orange's sourness? (*circle one number)*

	1	2	3	4	5	6	7	9
Sour	*Not at all Sour enough*			*About right*			*Much too Sour*	*Don't Know*

7. How would you describe this orange's tanginess (balance of sweet and sour)**?** (*circle)*

	1	2	3	4	5	6	7	9
Tangy	*Not at all Tangy enough*			*About right*			*Much too Tangy*	*Don't Know*

Page1

Please check you have completed all questions above before continuing to the next sample

Location: Date: 2013 Consumer #.....

Sample 2

Sample # .....

Before tasting the next sample can you please: 1) Clean mouth with a small bite of cracker, 2) Rinse all of the cracker from your mouth with water and then 3) Taste enough of the orange sample to answer the following questions.

1. What best describes your opinion about the sample you just tasted (*circle one number)*

	1	2	3	4	5	6	7	9
Opinion	*Extreme Dislike*			*Neither Like or Dislike*			*Like Very Much*	*Don't know*

2. Would you purchase this orange if it was available for a reasonable price where you normally shop? (*circle one number)*

	1	2	3	4	5	6	7	9
Purchase	*Definitely Not Purchase*			*Unsure*			*Definitely Purchase*	*Don't know*

3. How would the taste of this orange affect the way you currently shop for oranges? (*circle one number)*

	1	2	3	4	5	6	7	9
Shopping	*Purchase Less*			*No change*			*Purchase More*	*Don't know*

4. How would you describe this orange's flavour? (*circle one number)*

	1	2	3	4	5	6	7	9
Flavour	*Much too Weak*			*About Right*			*Much too Strong*	*Don't know*

5. How would you describe this orange's sweetness? (*circle one number)*

	1	2	3	4	5	6	7	9
Sweetness	*Not at all Sweet enough*			*About right*			*Much too Sweet*	*Don't know*

6. How would you describe this orange's sourness? (*circle one number)*

	1	2	3	4	5	6	7	9
Sour	*Not at all Sour enough*			*About right*			*Much too Sour*	*Don't know*

7. How would you describe this orange's tanginess (balance of sweet and sour)**?** (*circle)*

	1	2	3	4	5	6	7	9
Tangy	*Not at all Tangy enough*			*About right*			*Much too Tangy*	*Don't know*

Page2

Please check you have completed all questions above before continuing to the next sample

Location: Date: 2013 Consumer #.....

Sample 3 Sample # .....

Before tasting the next sample please: 1) Clean mouth with a small bite of cracker, 2) Rinse all of the cracker from your mouth with water and then 3) Taste enough of the orange sample to answer the following questions.

1. What best describes your opinion about the sample you just tasted (*circle one number)*

	1	2	3	4	5	6	7	9
Opinion	*Extreme Dislike*			*Neither Like or Dislike*			*Like Very Much*	*Don't know*

2. Would you purchase this orange if it was available for a reasonable price where you normally shop? (*circle one number)*

	1	2	3	4	5	6	7	9
Purchase	*Definitely Not Purchase*			*Unsure*			*Definitely Purchase*	*Don't know*

3. How would the taste of this orange affect the way you currently shop for oranges? (*circle one number)*

	1	2	3	4	5	6	7	9
Shopping	*Purchase Less*			*No change*			*Purchase More*	*Don't know*

4. How would you describe this orange's flavour? (*circle one number)*

	1	2	3	4	5	6	7	9
Flavour	*Much too Weak*			*About Right*			*Much too Strong*	*Don't know*

5. How would you describe this orange's sweetness? (*circle one number)*

	1	2	3	4	5	6	7	9
Sweetness	*Not at all Sweet enough*			*About right*			*Much too Sweet*	*Don't Know*

6. How would you describe this orange's sourness? (*circle one number)*

	1	2	3	4	5	6	7	9
Sour	*Not at all Sour enough*			*About right*			*Much too Sour*	*Don't Know*

7. How would you describe this orange's tanginess (balance of sweet and sour)**?** (*circle)*

	1	2	3	4	5	6	7	9
Tangy	*Not at all Tangy enough*			*About right*			*Much too Tangy*	*Don't Know*

Page3

Please check you have completed all questions above before continuing with background questions Page 2

Location: Date: 2013 Consumer #.....

Background

The following information will be kept confidential and will help Australian citrus growers make decisions about how to better satisfy your needs.

1. How often do you eat oranges on average? (*circle one*)

1) Almost every day
2) Three or four times a week
3) Once or twice a week
4) Once or twice a month
5) Four or five times a year
6) A few times a year
7) Do not eat oranges

2. When do you eat fresh oranges? (*circle any*)

1) Breakfast
2) Lunch
3) Dinner
4) Dessert
5) Snack
6) Other .....

3. When oranges are purchased for your household how important are the following?

	Not at all Important			*Neutral*			*Very Important*	*Don't Know*
Price/Value for money	1	2	3	4	5	6	7	9
Easy to peel	1	2	3	4	5	6	7	9
Skin colour	1	2	3	4	5	6	7	9
Blemish free	1	2	3	4	5	6	7	9
Juiciness	1	2	3	4	5	6	7	9
Freshness	1	2	3	4	5	6	7	9
Health benefits	1	2	3	4	5	6	7	9
Good taste/Flavour	1	2	3	4	5	6	7	9
Tangy flavour	1	2	3	4	5	6	7	9
Sweet and Sour Balance	1	2	3	4	5	6	7	9
Sweetness	1	2	3	4	5	6	7	9
Sour	1	2	3	4	5	6	7	9

4. Do you like to eat any other fresh fruit that is tangy? (*please circle*)

2) No (*go to next Question 5*)
1) Yes ..... What fruit do you like tangy?.....

5. Which is your age category? *(circle one)*

1) Under 17 years
2) 17 to 19 years
3) 20 to 24 years
4) 25 to 29 years
5) 30 to 39 years
6) 40 to 49 years
7) 50 to 59 years
8) 60 years or older

6. What country/ies have you lived in the longest? .....

7. How many years have you lived in Australia? ..... Years.

8. How would you describe your ethnic origin?.....

9. Please circle your gender 1) Female 2) Male

Thank you for completing the survey. Citrus growers appreciate your participation

Afourer Mandarin Survey

Location: Date: 2013 Consumer #.....

Sample 1 Sample # .....

Before tasting the sample please: 1) Rinse your mouth with a few sips of water, 2) Clean mouth with a small bite of cracker, 3) Rinse all of the cracker from your mouth with water and then 4) Taste enough of the mandarin sample to answer the following questions.

1. What best describes your opinion about the sample you just tasted (*circle one number)*

	1	2	3	4	5	6	7	9
Opinion	*Extreme Dislike*			*Neither Like or Dislike*			*Like Very Much*	*Don't know*

2. Would you purchase this mandarin if it was available for a reasonable price where you normally shop? (*circle one number)*

	1	2	3	4	5	6	7	9
Purchase	*Definitely Not Purchase*			*Unsure*			*Definitely Purchase*	*Don't know*

3. How would the taste of this mandarin affect the way you currently shop for mandarins? (*circle one number)*

	1	2	3	4	5	6	7	9
Shopping	*Purchase Less*			*No change*			*Purchase More*	*Don't know*

4. How would you describe this mandarin's flavour? (*circle one number)*

	1	2	3	4	5	6	7	9
Flavour	*Much too Weak*			*About Right*			*Much too Strong*	*Don't know*

5. How would you describe this mandarin's sweetness? (*circle one number)*

	1	2	3	4	5	6	7	9
Sweetness	*Not at all Sweet enough*			*About right*			*Much too Sweet*	*Don't know*

6. How would you describe this mandarin's sourness? (*circle one number)*

	1	2	3	4	5	6	7	9
Sour	*Not at all Sour enough*			*About right*			*Much too Sour*	*Don't Know*

7. How would you describe this mandarin's tanginess (balance of sweet and sour)**?** (*circle)*

	1	2	3	4	5	6	7	9
Tangy	*Not at all Tangy enough*			*About right*			*Much too Tangy*	*Don't Know*

Page1

Please check you have completed all questions above before continuing to the next sample

Location: Date: 2013 Consumer #.....

Sample 2

Sample # .....

Before tasting the next sample can you please: 1) Clean mouth with a small bite of cracker, 2) Rinse all of the cracker from your mouth with water and then 3) Taste enough of the mandarin sample to answer the following questions.

1. What best describes your opinion about the sample you just tasted (*circle one number)*

	1	2	3	4	5	6	7	9
Opinion	*Extreme Dislike*			*Neither Like or Dislike*			*Like Very Much*	*Don't know*

2. Would you purchase this mandarin if it was available for a reasonable price where you normally shop? (*circle one number)*

	1	2	3	4	5	6	7	9
Purchase	*Definitely Not Purchase*			*Unsure*			*Definitely Purchase*	*Don't know*

3. How would the taste of this mandarin affect the way you currently shop for mandarins? (*circle one number)*

	1	2	3	4	5	6	7	9
Shopping	*Purchase Less*			*No change*			*Purchase More*	*Don't know*

4. How would you describe this mandarin's flavour? (*circle one number)*

	1	2	3	4	5	6	7	9
Flavour	*Much too Weak*			*About Right*			*Much too Strong*	*Don't know*

5. How would you describe this mandarin's sweetness? (*circle one number)*

	1	2	3	4	5	6	7	9
Sweetness	*Not at all Sweet enough*			*About right*			*Much too Sweet*	*Don't know*

6. How would you describe this mandarin's sourness? (*circle one number)*

	1	2	3	4	5	6	7	9
Sour	*Not at all Sour enough*			*About right*			*Much too Sour*	*Don't know*

7. How would you describe this mandarin's tanginess (balance of sweet and sour)**?** (*circle)*

	1	2	3	4	5	6	7	9
Tangy	*Not at all Tangy enough*			*About right*			*Much too Tangy*	*Don't know*

Page2

Please check you have completed all questions above before continuing to the next sample

Location: Date: 2013 Consumer #.....

Sample 3 Sample # .....

Before tasting the next sample please: 1) Clean mouth with a small bite of cracker, 2) Rinse all of the cracker from your mouth with water and then 3) Taste enough of the mandarin sample to answer the following questions.

1. What best describes your opinion about the sample you just tasted (*circle one number)*

	1	2	3	4	5	6	7	9
Opinion	*Extreme Dislike*			*Neither Like or Dislike*			*Like Very Much*	*Don't know*

2. Would you purchase this mandarin if it was available for a reasonable price where you normally shop? (*circle one number)*

	1	2	3	4	5	6	7	9
Purchase	*Definitely Not Purchase*			*Unsure*			*Definitely Purchase*	*Don't know*

3. How would the taste of this mandarin affect the way you currently shop for mandarins? (*circle one number)*

	1	2	3	4	5	6	7	9
Shopping	*Purchase Less*			*No change*			*Purchase More*	*Don't know*

4. How would you describe this mandarin's flavour? (*circle one number)*

	1	2	3	4	5	6	7	9
Flavour	*Much too Weak*			*About Right*			*Much too Strong*	*Don't know*

5. How would you describe this mandarin's sweetness? (*circle one number)*

	1	2	3	4	5	6	7	9
Sweetness	*Not at all Sweet enough*			*About right*			*Much too Sweet*	*Don't Know*

6. How would you describe this mandarin's sourness? (*circle one number)*

	1	2	3	4	5	6	7	9
Sour	*Not at all Sour enough*			*About right*			*Much too Sour*	*Don't Know*

7. How would you describe this mandarin's tanginess (balance of sweet and sour)**?** (*circle)*

	1	2	3	4	5	6	7	9
Tangy	*Not at all Tangy enough*			*About right*			*Much too Tangy*	*Don't Know*

Page3

lease check you have completed all questions above before continuing with background questions Page 2

Location: Date: 2013 Consumer #.....

Background

The following information will be kept confidential and will help Australian citrus growers make decisions about how to better satisfy your needs.

1. How often do you eat mandarins on average? (*circle one*)

1) Almost every day
2) Three or four times a week
3) Once or twice a week
4) Once or twice a month
5) Four or five times a year
6) A few times a year
7) Do not eat mandarins

2. When do you eat fresh mandarins? (*circle any*)

1) Breakfast
2) Lunch
3) Dinner
4) Dessert
5) Snack
6) Other .....

3. When mandarins are purchased for your household how important are the following?

	Not at all Important			*Neutral*			*Very Important*	*Don't Know*
Price/Value for money	1	2	3	4	5	6	7	9
Easy to peel	1	2	3	4	5	6	7	9
Skin colour	1	2	3	4	5	6	7	9
Blemish free	1	2	3	4	5	6	7	9
Juiciness	1	2	3	4	5	6	7	9
Pips	1	2	3	4	5	6	7	9
Freshness	1	2	3	4	5	6	7	9
Health benefits	1	2	3	4	5	6	7	9
Good taste/Flavour	1	2	3	4	5	6	7	9
Tangy flavour	1	2	3	4	5	6	7	9
Sweet and Sour Balance	1	2	3	4	5	6	7	9
Sweetness	1	2	3	4	5	6	7	9
Sour	1	2	3	4	5	6	7	9

4. Do you like to eat any other fresh fruit that is tangy? (*please circle)*

2) No (*go to next Question 5*)
1) Yes ..... What fruit do you like tangy?.....

5. Which is your age category? *(circle one)*

1) Under 17 years
2) 17 to 19 years
3) 20 to 24 years
4) 25 to 29 years
5) 30 to 39 years
6) 40 to 49 years
7) 50 to 59 years
8) 60 years or older

6. What country/ies have you lived in the longest? .....

7. How many years have you lived in Australia? ..... Years.

8. How would you describe your ethnic origin (where you and your family are from)?
.....

9. Please circle your gender 1) Female 2) Male

Page4

Thank you for completing the survey. Citrus growers appreciate your participation

Appendix 4 Project details

Deliverables

- Questionnaire
- Collation and analysis of data
- Power point presentation of results
- Final report
  (Table 5)

Milestone 1: July 2012
Achievement criteria: Completion of data collection $25,000

Milestone 2: 31 November 2013
Achievement criteria: Completion of report $7,520

Table 5 Timing of Deliverables

2013	April	May	June	July	Aug	Sept	Oct
Questionnaire							
Collation and analysis of data							
Power point presentation							
Final report							

Delivery Team:

A multidisciplinary project team of laboratory, social research, management skills were used from Fruit West, DAFWA, Curtin and Citrus Australia and collaborators from New Zealand.

1. **Team Leader**
   - Graham McAlpine, Fruit West
   - Nathan Hancock, Citrus Australia

2. **Research Design and logistics management**
   - Dr Christine Storer, Asterisk Pty Ltd
   - Survey Team

3. **Technical Support**
   - Chris Hall, TQAS
   - Kevin Lacey, DAFWA
   - Graham McAlpine, Fruit West
   - Bronwyn Walsh, DAFWA
   - Andrew Harty

4. **Analysis**
   - Dr Christine Storer
   - And collaborators
     - Bob Jordan, Delytics
     - Mark Loeffen, Mark Loeffen & Associates

Proposal Costs

Research activities were delivered at the costs outlined in Table 5. The total cost to Citrus Australia was $32,520. This included the costs for the quality testing team. In-kind contribution was for the project oversight and assistance during testing to the value of $44,170.The total project cost was $77,690 (excluding Citrus Australia costs) (Table 6).

Table 6. Fruit West Budget

Item	Function	Qty	In-kind *	External (CA)	Total ($)
G McAlpine	Team leader	9	10.500		
G McAlpine	Panel prep	6	13125		
K Lacey	Panel prep	6	10,438		
B Walsh	Panel prep	6	10,107		
Sub total			**44,170**		**44,170**
C Hall	Panel prep / sourcing fruit WA	6		6,120	
C Storer	Reporting			8,000	
	Run WA	6 x $1000		6,000	
	Run Vic GM	Accom		1800	
		Airfare		1500	
		Meals		600	
	Survey Team WA	6@ 3 x $25 x 5hr		2,250	
	Survey Team Vic	6@ 3 x $25 x 5hr		2,250	
Consumables	Table hire, venue hire, paper plates, drinks, incentives			4,000	
Sub total ($)				**32,520**	**32,520**
Total ($)					**76,690**

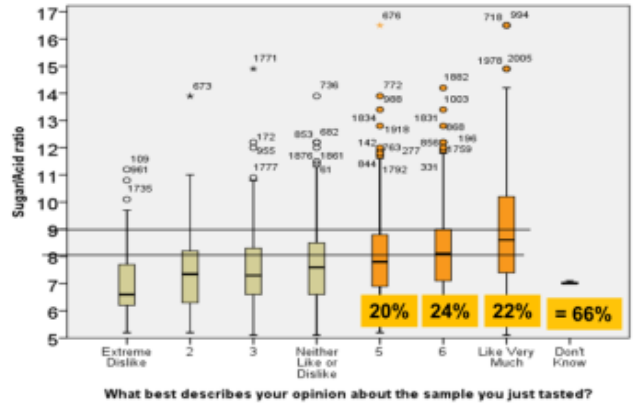
*includes on-costs and corp'

Appendix 5 Brix acid ratio V. Consumer Orange Response

Opinion about Orange Sample V. Brix acid ratio

Minimum standard of 8:1 for 50% 5 & 6 like (Figure 67).

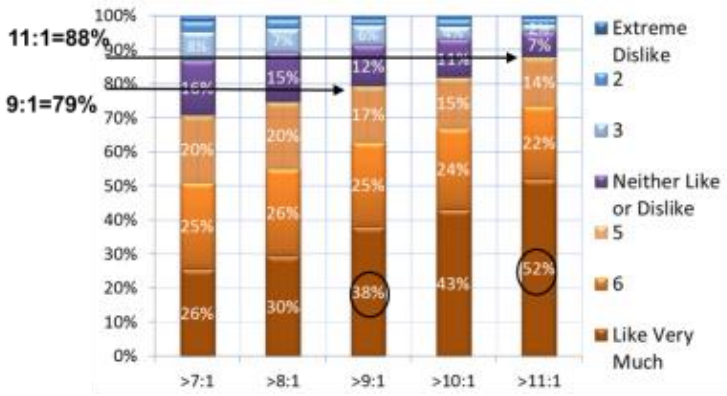
Figure 67 Opinion Orange sample v. Brix acid ration



Like Orange Sample V. Brix acid ratio

For a Ratio of 9:1 = 79% Like and for a Ratio 11:1 = 88% Like (Figure 68).

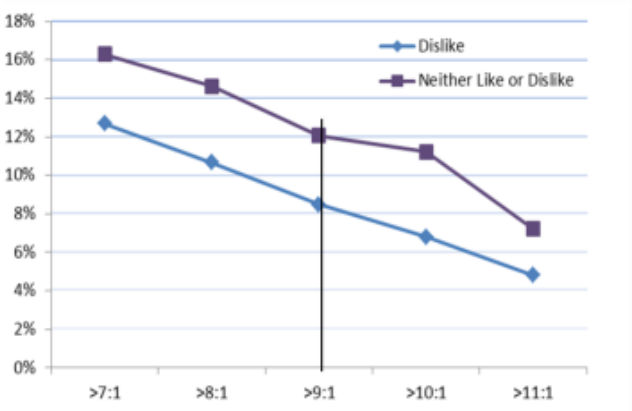
Figure 68 Like orange sample v Brix acid ratio



Dislike V. Brix acid ratio

At a Ratio of 9:1 Dislike = 8.5%; Neither = 12% and at a Ratio of 11:1 Dislike = 4.8%, Neither = 7% (Figure 69).

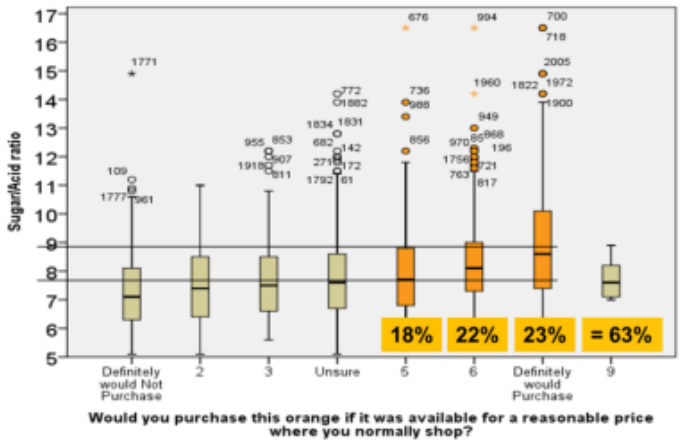
Figure 69 Opinion Dislike V. Brix acid ratio



Would Purchase Orange V. Brix acid ratio

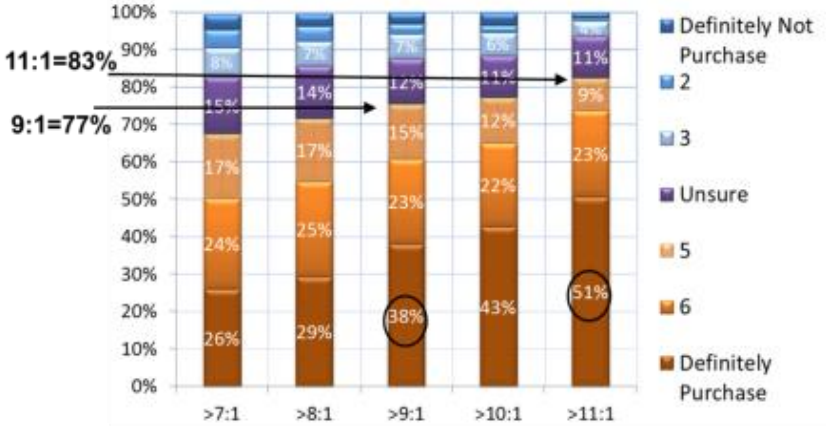
A minimum of 7.8 for 50% purchase 5 (Figure 70).

Figure 70 Would purchase orange V. Brix acid ratio



At Ratio 9:1 Purchase = 76% and at Ratio 11:1 Purchase = 83% (Figure 71).

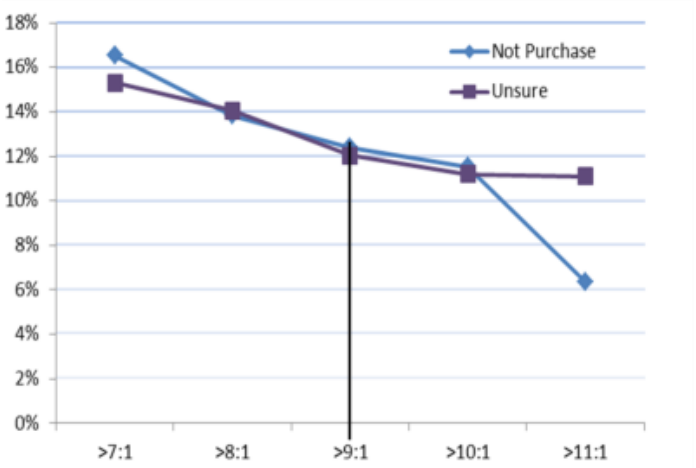
Figure 71 Would purchase V. Brix acid ratios



Would Not Purchase Oranges V. Brix acid ratio

At Ratio 9:1 Not Purchase = 12.4% and at Ratio 11:1 Not Purchase = 6.3%.

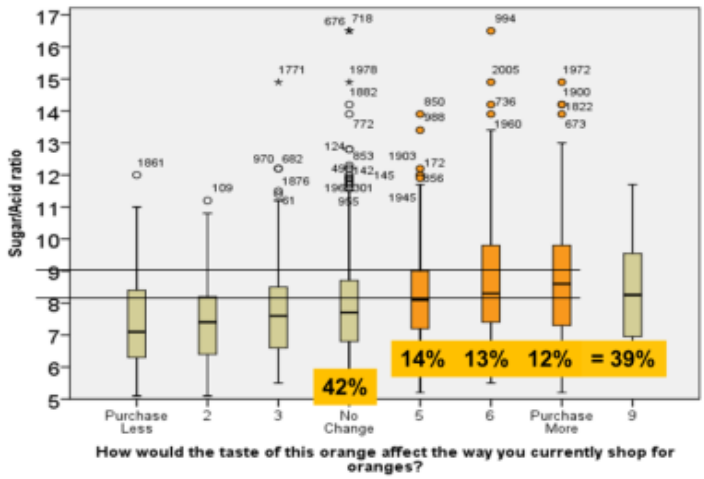
Figure 72 Would not purchase V Brix acid ratios



Would Purchase More Oranges V. Brix acid ratio

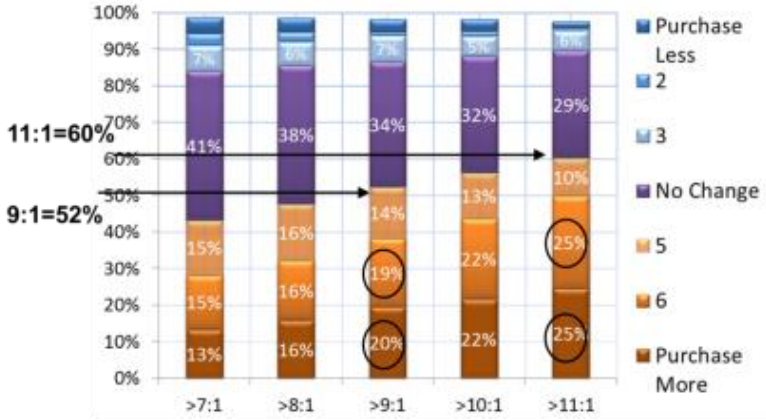
Min8.2 for 50% purchase more 5.

Figure 73



At Ratio 9:1 Purchase More = 52%.
At Ratio 11:1 Purchase More = 60%.

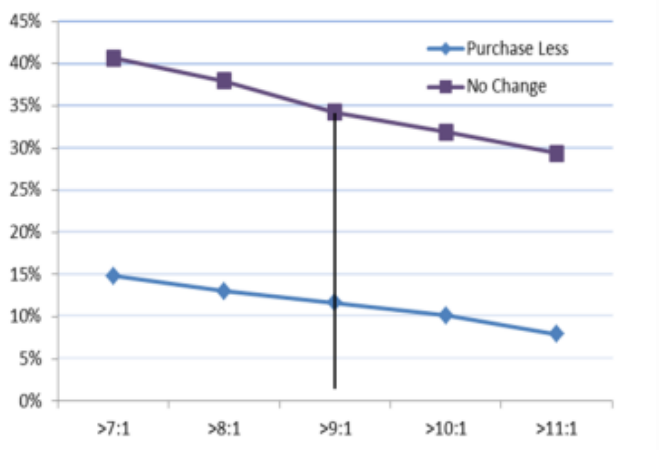
Figure 74



Would Not Purchase More Oranges V. Brix acid ratio

At Ratio 9:1 Purchase Less = 11.7%.
At Ratio 11:1 Purchase Less = 7.9%.

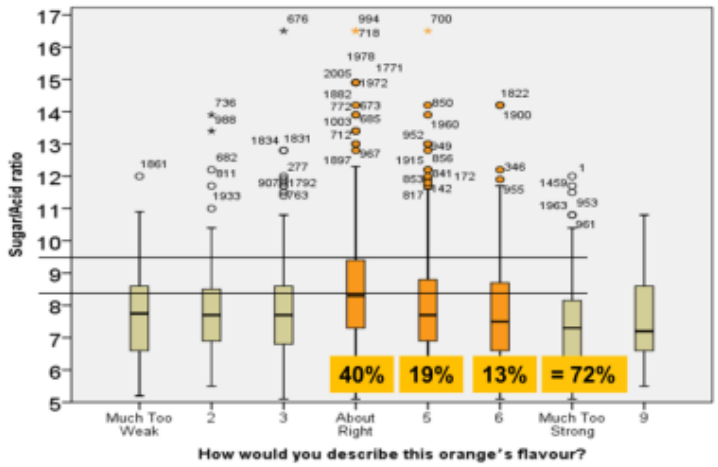
Figure 75



Perceived Orange Flavour V. Brix acid ratio

Min 8.2 for 50% about right.

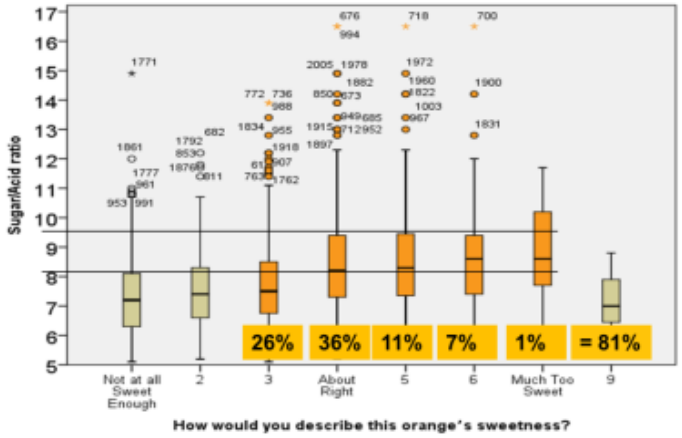
Figure 76



Perceived Orange Sweetness V. Brix acid ratio

Min 8.2 for 50% about right.

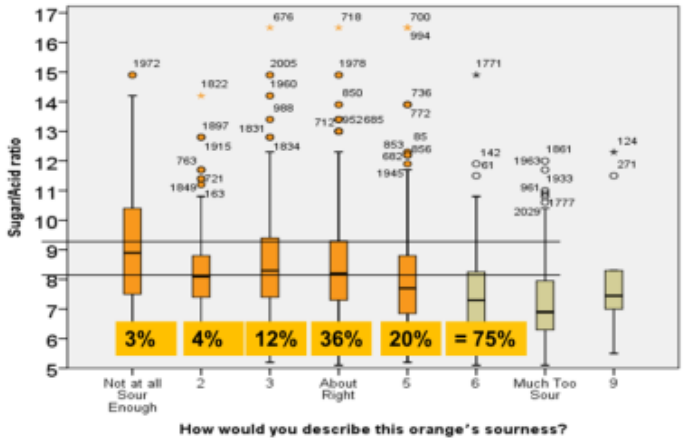
Figure 77



Perceived Orange Sourness V. Brix acid ratio

Min 8.2 for 50% about right.

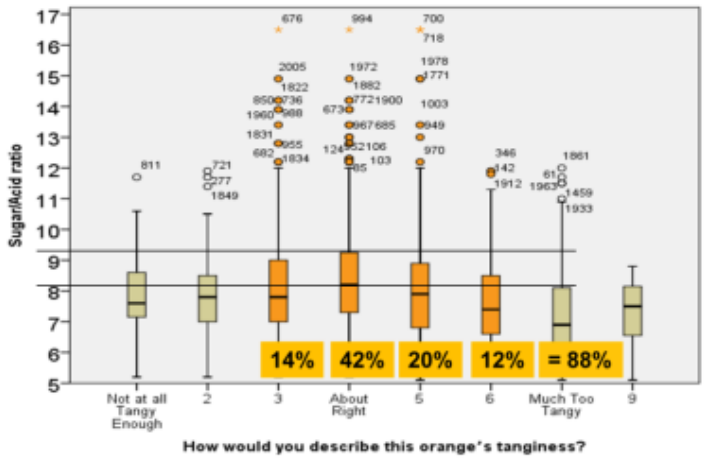
Figure 78



Perceived Orange Tanginess V. Brix acid ratio

Min 8.2 for 50% about right.

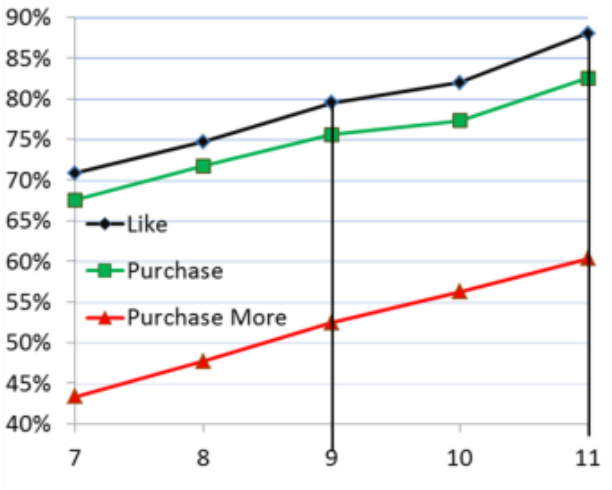
Figure 79



Brix acid ratio Conclusions

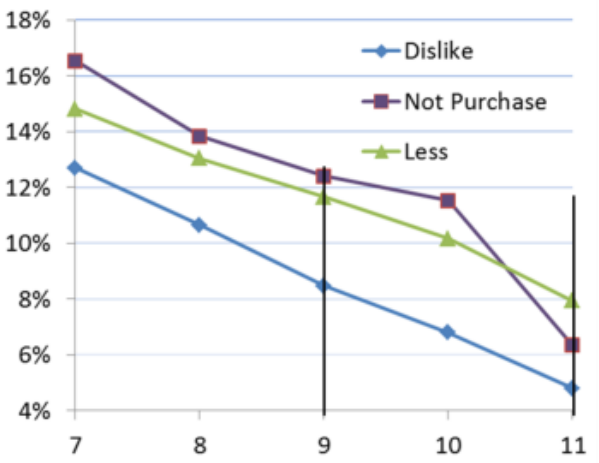
Satisfy Most Orange Consumers at Brix acid ratio 9:1 – 11:1.

Figure 80



Reduce negative responses at Ratio 9:1 – 11:1.

Figure 81

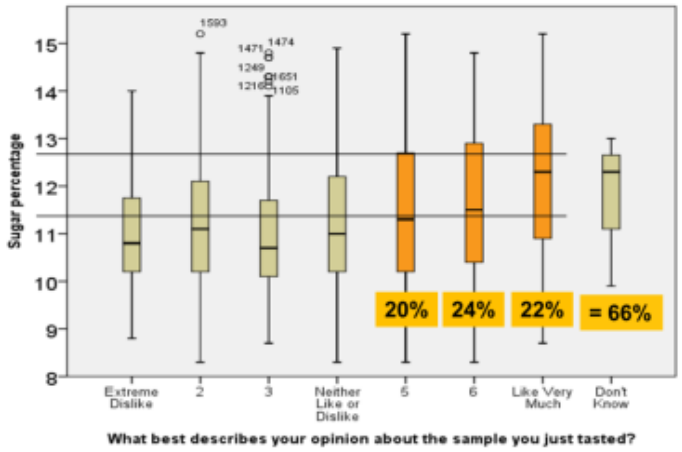


Appendix 6 Brix (Total Soluble Solids) V. Consumer Orange Response

Opinion about Orange Sample V. Brix

Min11.4 for 50% opinion 5.

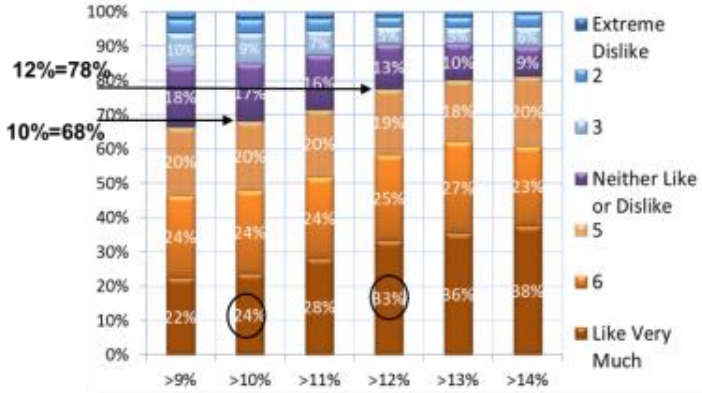
Figure 82



Like Orange Sample V. Brix

Brix 10% = 79% Like; Brix 12% = 82% Like.

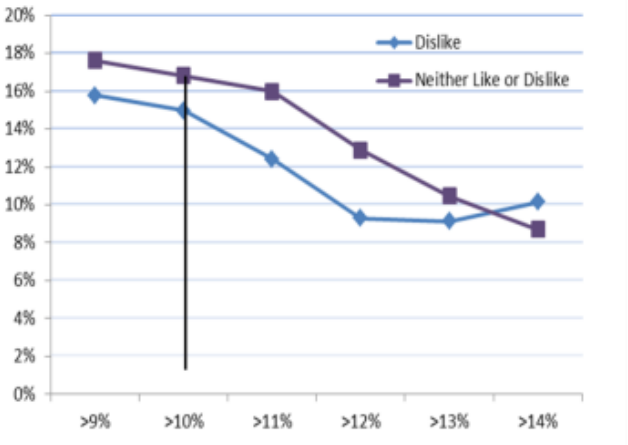
Figure 83



Dislike V. Brix

Brix 10% = 15% Dislike; Brix 12% = 9% Dislike.

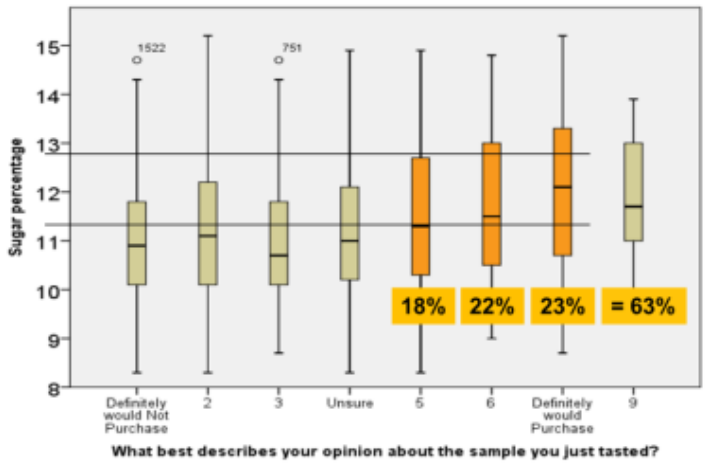
Figure 84



Would Purchase Oranges V. Brix

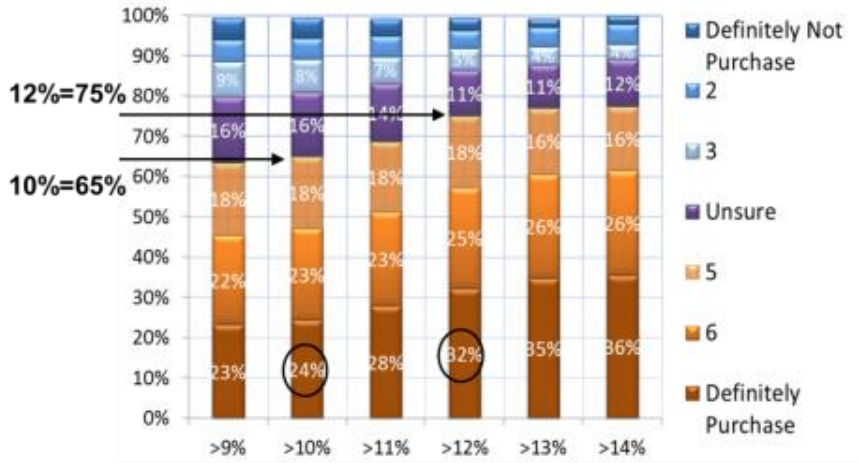
Min11.4 for 50% purchase 5.

Figure 85



Brix 10% = 65% Purchase; Brix 12% = 75% Purchase.

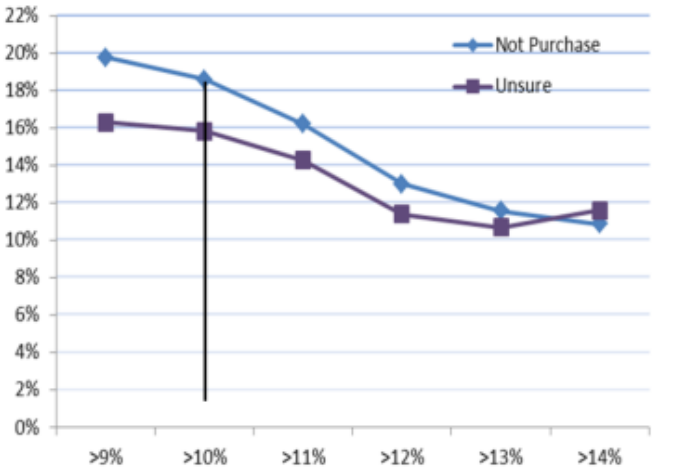
Figure 86



Would Not Purchase Oranges V. Brix

Brix 10% = 19% Not Purchase; Brix 12% = 13% Not Purchase.

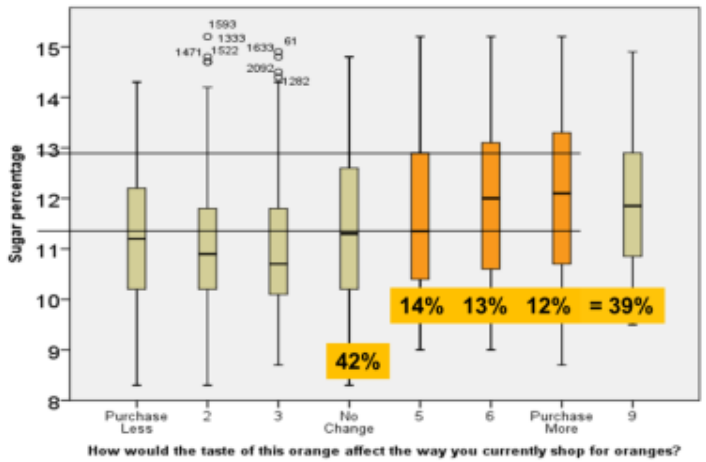
Figure 87



Would Purchase More Oranges V. Brix

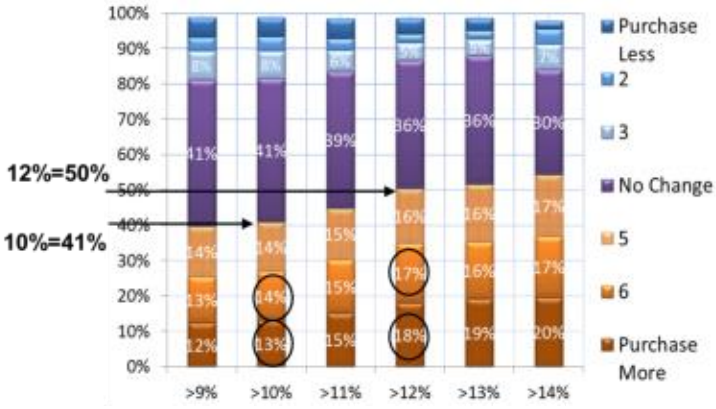
Min11.3 for 50% more 5.

Figure 88



Brix 10% = 41% Purchase More; Brix 12% = 50% Purchase More.

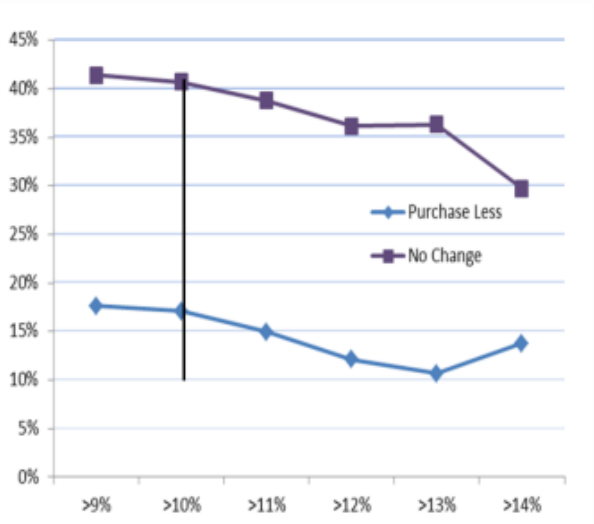
Figure 89



Would Purchase Less Oranges V. Brix

Brix 10% = 17% Purchase Less; Brix 12% = 12% Purchase Less.

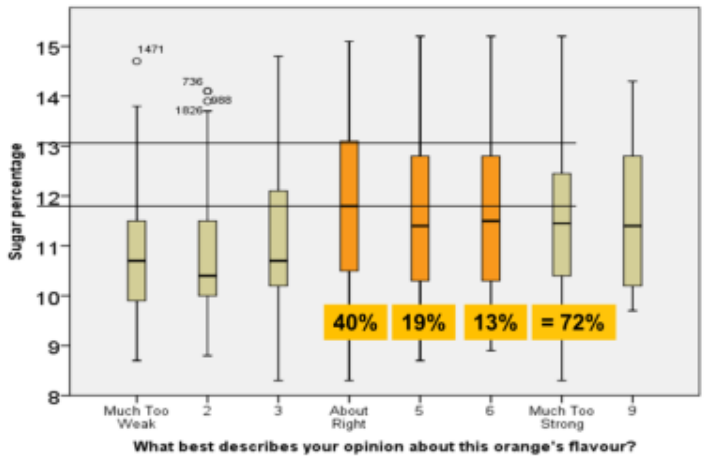
Figure 90



Perceived Orange Flavour V. Brix

Min11.8 for 50% about right.

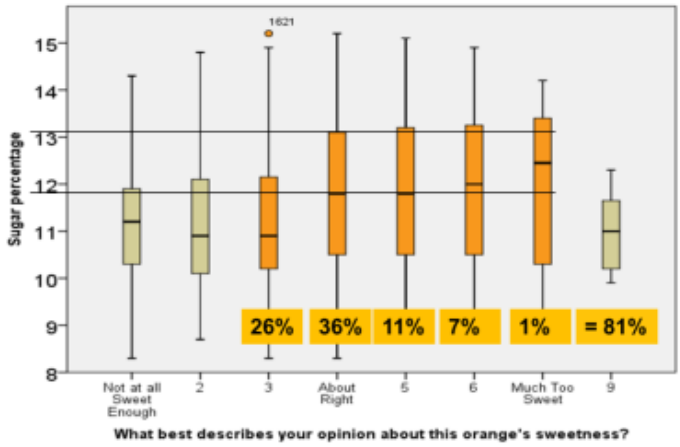
Figure 91



Perceived Orange Sweetness V. Brix

Min 11.8 for 50% about right.

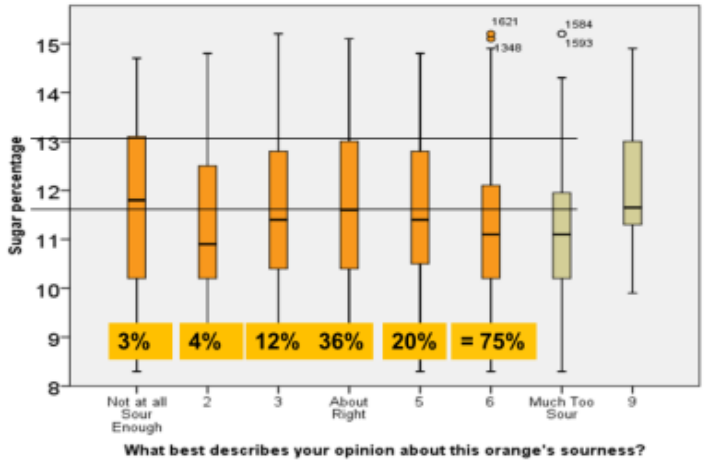
Figure 92



Perceived Orange Sourness V. Brix

Min11.7 for 50% about right.

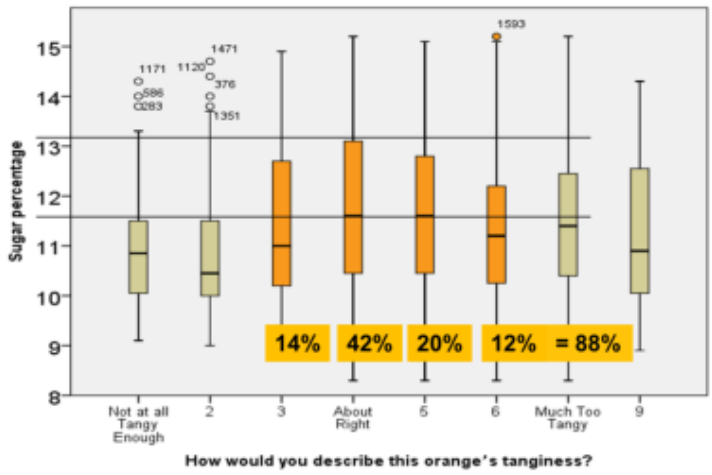
Figure 93



Perceived Orange Tanginess V. Brix

Min11.6 for 50% about right.

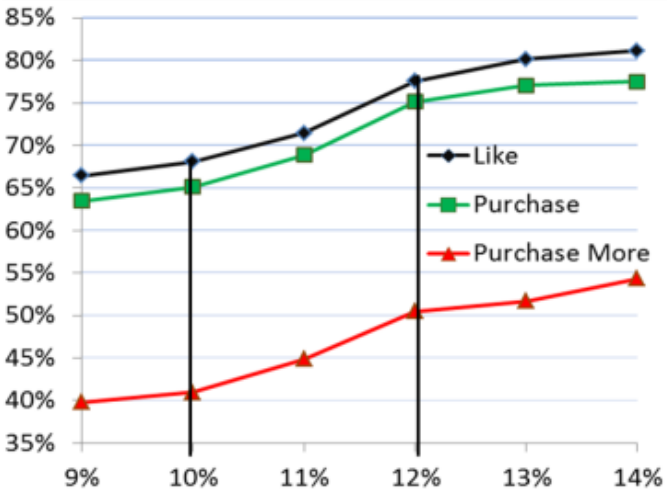
Figure 94



Brix Conclusions

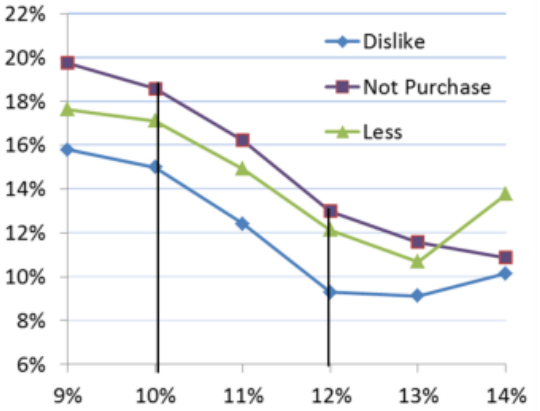
Satisfy Most Orange Consumers at Brix = 10% - 12%.

Figure 95



Reduce negative responses at Brix 10% - 12%.

Figure 96

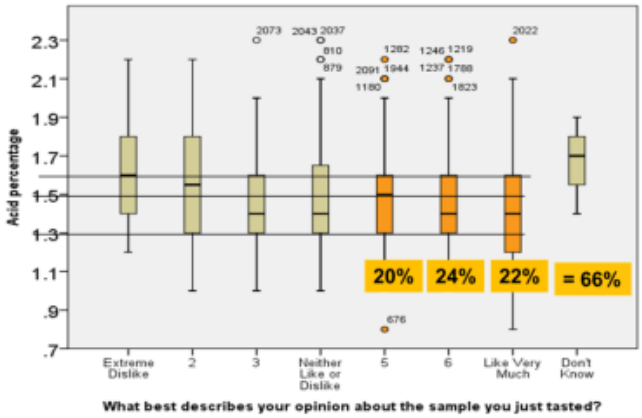


Appendix 7 Acid Percentage V. Consumer Orange Response

Opinion about Orange Sample V. Acid %

Max 1.3 for 25% opinion 5; 1.5 for 50% and 1.4 for 75%.

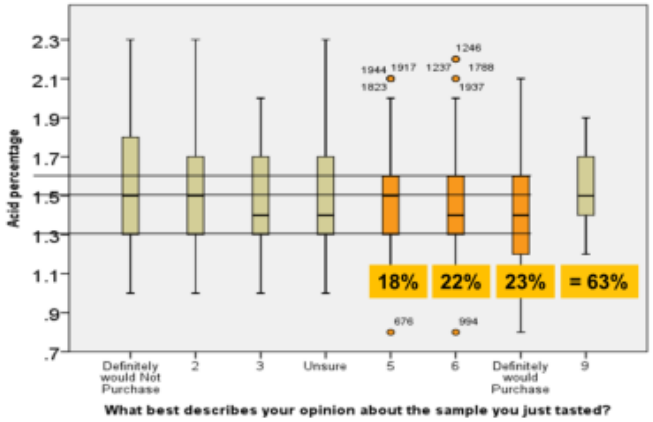
Figure 97



Would Purchase Orange V. Acid %

Max 1.3 for 25% opinion 5; 1.5 for 50% and 1.4 for 75%.

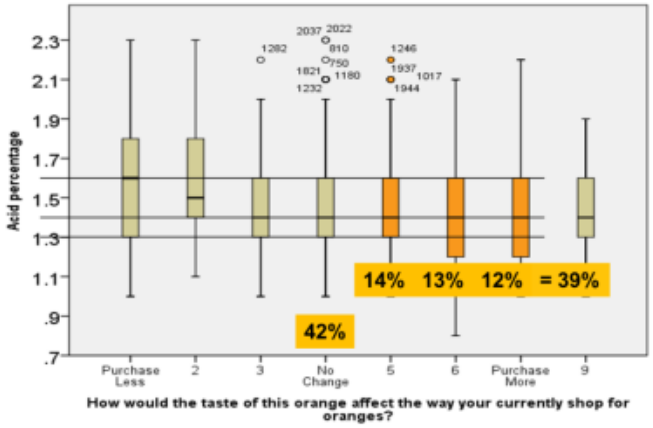
Figure 98



Would Purchase More Oranges V. Acid %

Max 1.3 for 25% opinion 5; 1.4 for 50% and 1.4 for 75%.

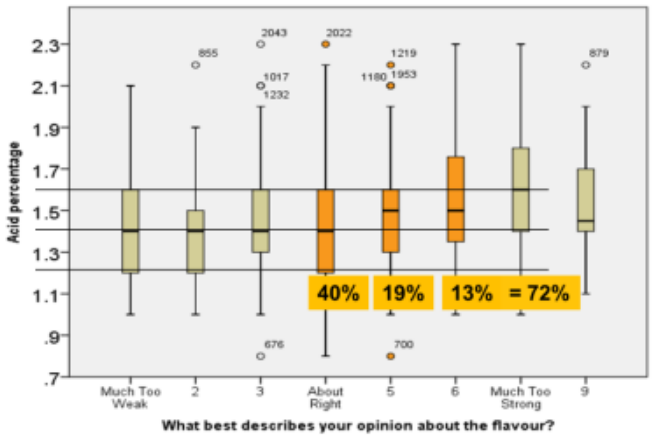
Figure 99



Perceived Orange Flavour V. Acid %

Max 1.2 for 25% about right; 1.4 for 50% and 1.4 for 75%.

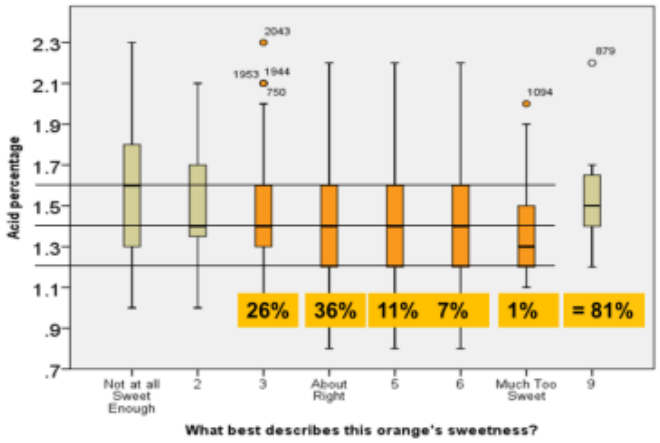
Figure 100



Perceived Orange Sweetness V. Acid %

Max 1.2 for 25% about right; 1.4 for 50% and 1.4 for 75%.

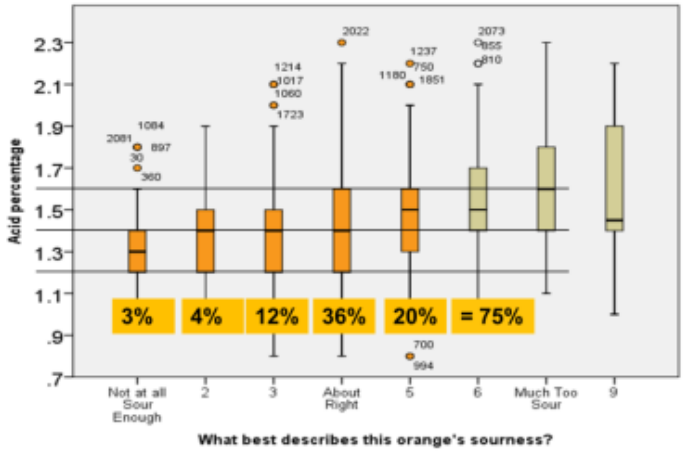
Figure 101



Perceived Orange Sourness V. Acid %

Max 1.2 for 25% about right; 1.4 for 50% and 1.4 for 75%.

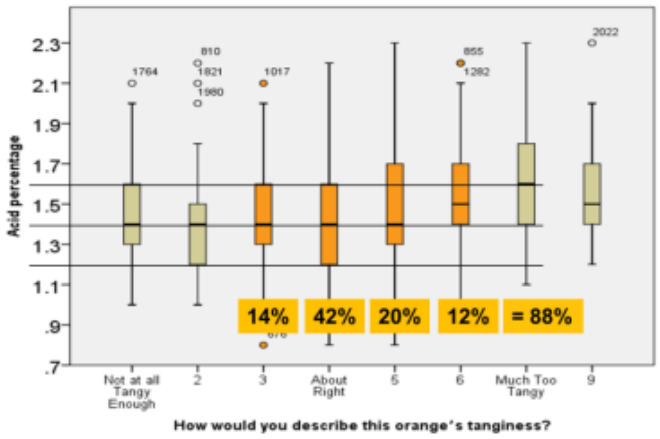
Figure 102



Perceived Orange Tanginess V. Acid %

Max 1.2 for 25% about right; 1.4 for 50% and 1.4 for 75%.

Figure 103



Acid % Conclusions

Minimum Standards to Satisfy Most Consumers Brix acid ratio 7.8 to 8.2.

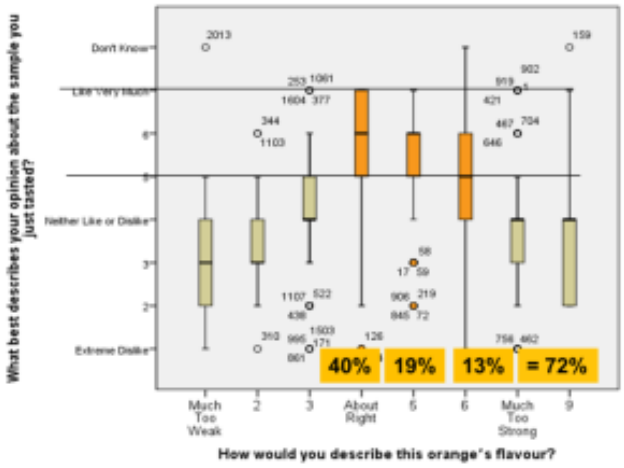
Appendix 8 Perceptions about Orange Samples

Perceptions about orange samples was further made by comparisons of the overall like/dislike opinion against consumers perception of orange sample sweetness, sourness and tanginess.

Perceived Orange Flavour V. Opinion

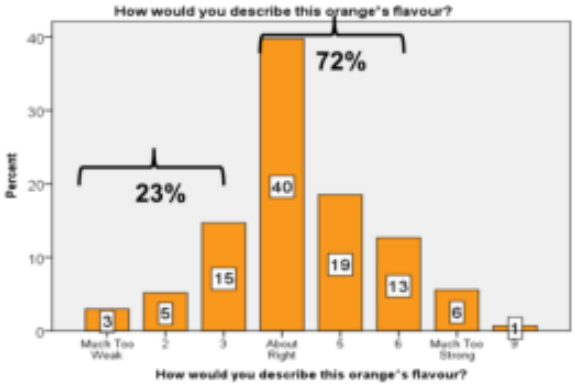
Consumers liked oranges (5-7) when the flavour rating was from 4 'about right' to 6 (Figure 104).

Figure 104 Perceived Orange Flavour V. Opinion



This equated to most (72%) liking the flavour of the orange samples (4-6), while a quarter (23%) thought samples were weak and a few (6%) too strong (Figure 105).

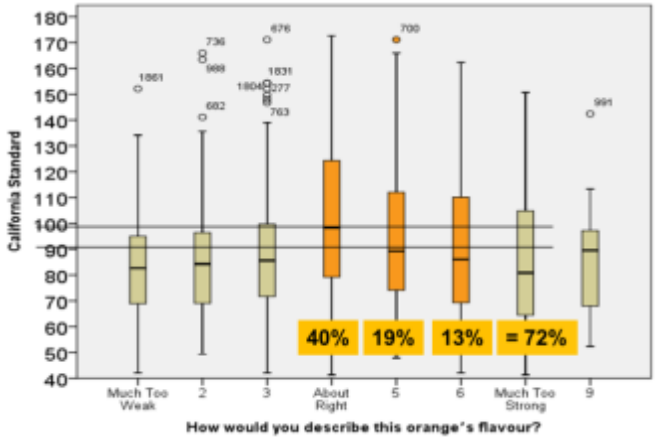
Figure 105 Perceived Orange Flavour



Orange Flavour V. Californian Standard

In looking at flavour, the Standard would be set at 98 to satisfy 50% of consumers rating the orange samples 4 'just right' and the Standard would be set at 90 to satisfy 50% of consumers rating the orange samples 5 (Figure 106).

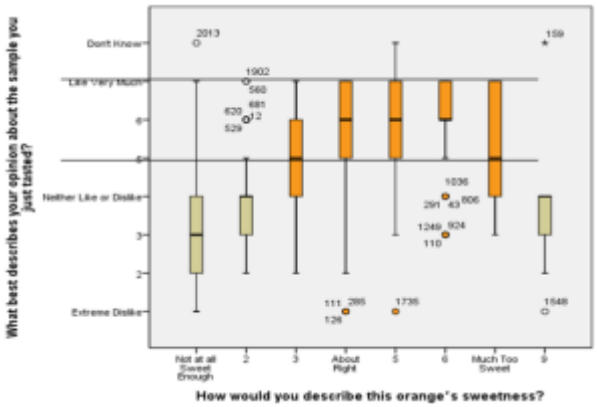
Figure 106 Perceived Orange Flavour V. Californian Standard



Perceived Orange Sweetness V. Opinion

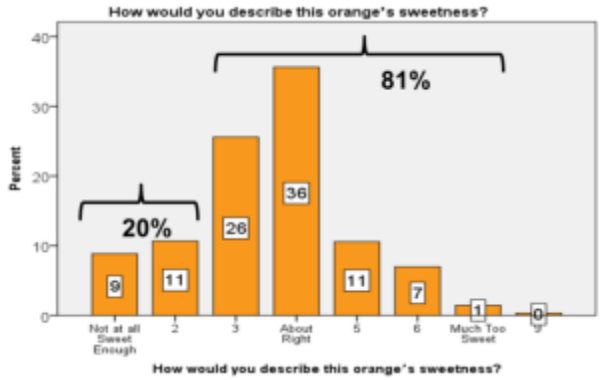
Consumers liked oranges (5-7) when the sweetness rating was between 3 to 7 'much too sweet' indicating too much sweetness did not affect consumers liking the oranges (Figure 107).

Figure 107 Perceived Orange Sweetness V. Opinion



This equated to most (81%) liking the sweetness of the orange samples (3-7), while a fifth (20%) thought samples were not sweet enough (Figure 108).

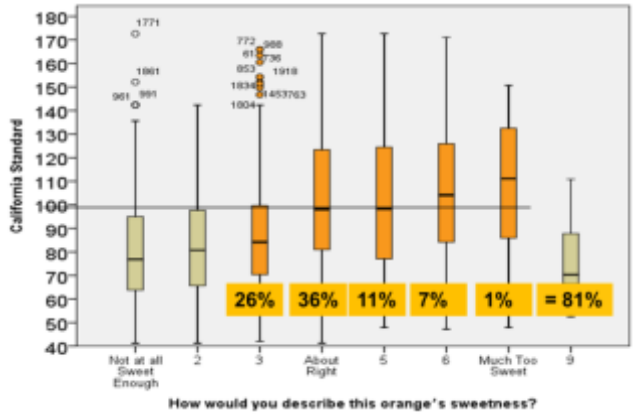
Figure 108 Perceived Orange Sweetness



Orange Sweetness V. Californian Standard

In looking at sweetness, the Standard would be set at 100 to satisfy 50% of consumers rating the orange samples 4 'about right', 5 and 6 (Figure 109).

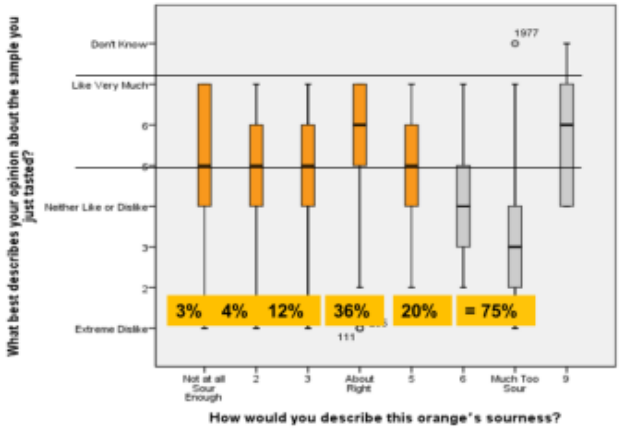
Figure 109 Perceived Orange Sweetness V. Californian Standard



Perceived Orange Sourness V. Opinion

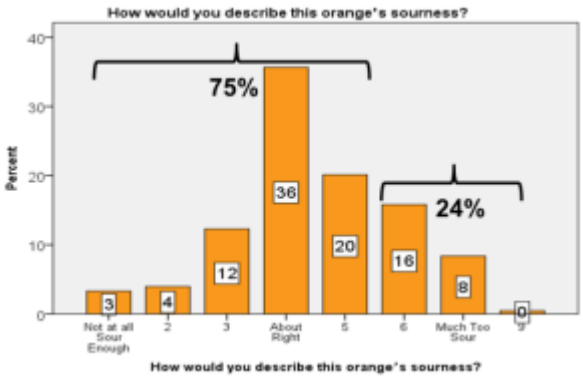
Consumers liked oranges (5-7) when the sourness rating was between 1 'not at all sour enough' to 5 indicating not being sour enough did not affect consumers liking the oranges but they did not like oranges too sour (Figure 110).

Figure 110 Perceived Orange Sourness V. Opinion



This equated to most (75%) liking the sourness of the orange samples (1-5), while a quarter (24%) thought samples were too sour (Figure 111).

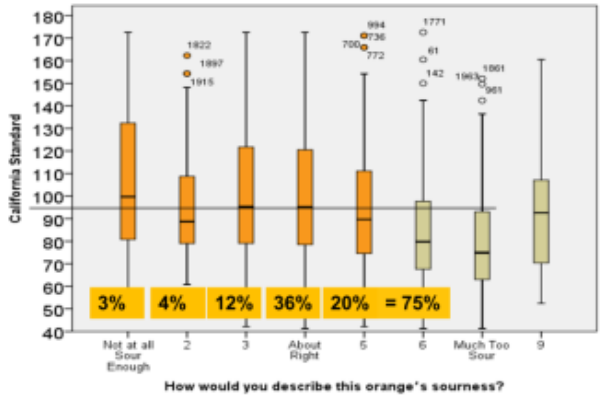
Figure 111 Perceived Orange Sourness



Orange Sourness V. Californian Standard

In looking at sourness, the Standard would be set at 95 to satisfy 50% of consumers rating the orange samples 3 and 4 'about right' (Figure 112).

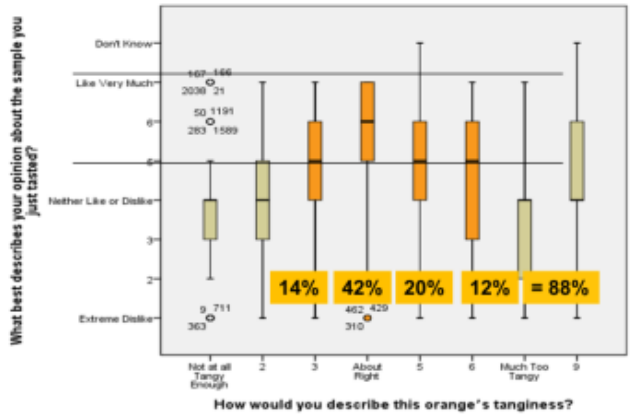
Figure 112 Perceived Orange Sourness V. Californian Standard



Perceived Orange Tanginess V. Opinion

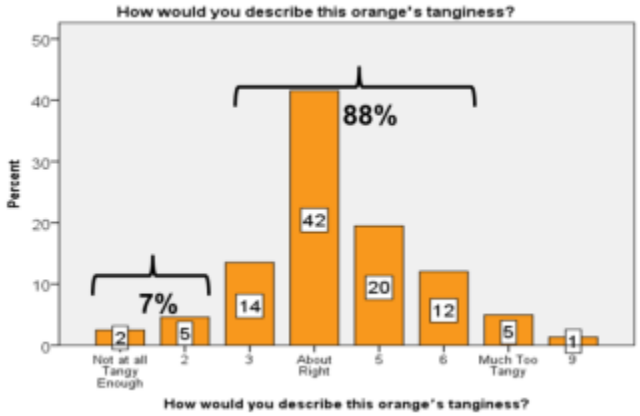
Consumers liked oranges (5-7) when the Tanginess rating was between 3 to 6 (Figure 113).

Figure 113 Perceived Orange Tanginess V. Opinion



This equated to most (88%) liking the Tanginess of the orange samples (3-6), while a few thought samples were too tangy (5%) or not tangy enough (7%) (Figure 114).

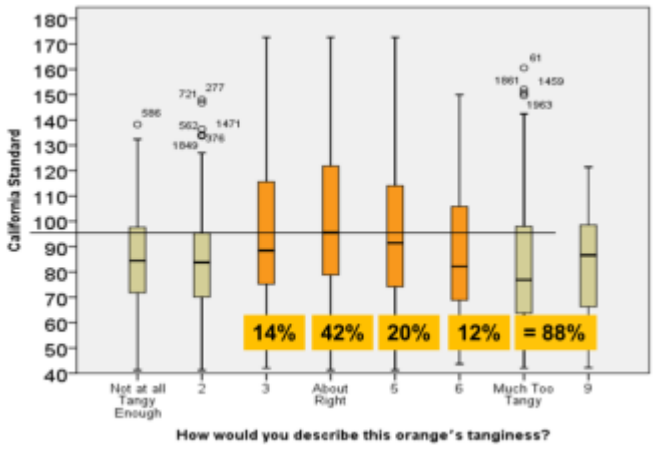
Figure 114 Perceived Orange Tanginess



Orange Tanginess V. Californian Standard

In looking at Tanginess, the Standard would be set at 95 to satisfy 50% of consumers rating the orange samples 3, 4 'about right', 5 and 6 (Figure 115).

Figure 115 Perceived Orange Tanginess V. Californian Standard



Orange Perception Conclusions

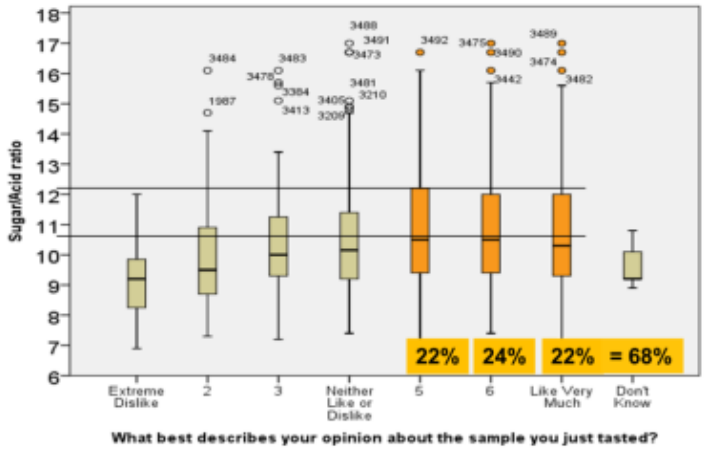
In conclusion, preliminary assessment of what the minimum orange standard should be based on the panellists' perceptions of the orange samples ranged between 90 and 100 (flavour=90-95, sweetness=100, sourness=95 and tanginess=95). This provides confidence in previous analysis as it is close to the assessments of the orange samples in terms of liking, willingness to purchase and purchase more (minimum standard of 90).

Appendix 9 Brix Acid Ratio V. Consumer Mandarin Response

Opinion about Mandarin Sample V. Brix Acid Ratio

Min 10.5 for 50% opinion 5 and 12.1 for 75%.

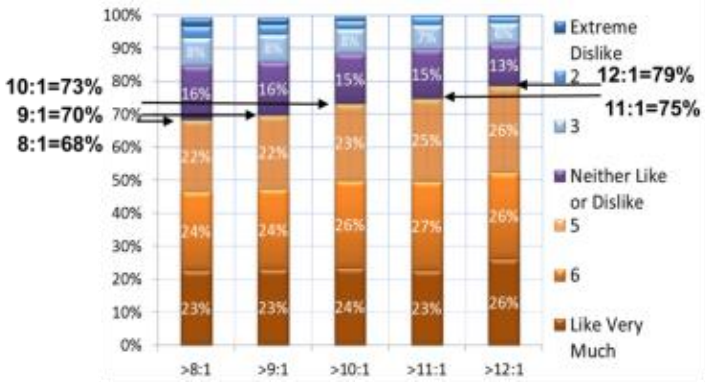
Figure 116



Like Mandarins Sample V. Brix Acid Ratio

Ratio 8:1 = 68% Like; Ratio 10:1 = 73% Like.

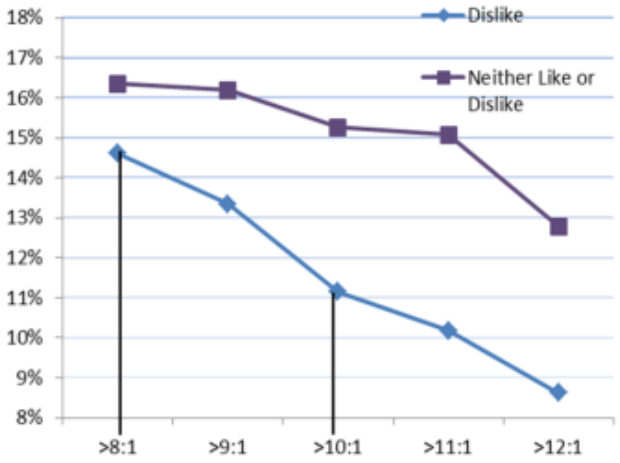
Figure 117



Dislike Mandarins V. Brix Acid Ratio

Ratio 8:1 = 15% Dislike; Ratio 10:1 = 11% Dislike.

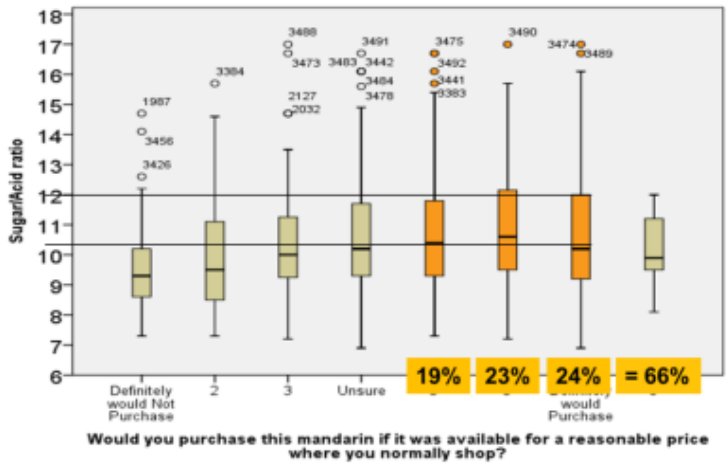
Figure 118



Would Purchase Mandarin V. Brix Acid Ratio

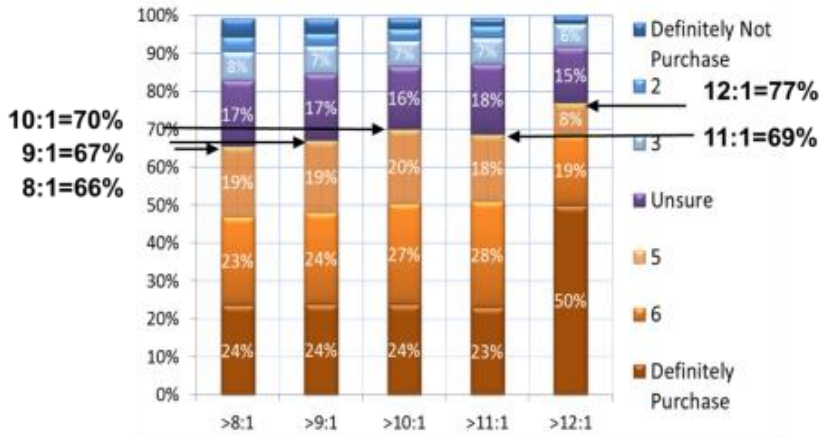
Min 10.2 for 50% purchase 5 and 11.9 for 75%.

Figure 119



Ratio 8:1 = 66% Purchase; Ratio 10:1 = 70% Purchase.

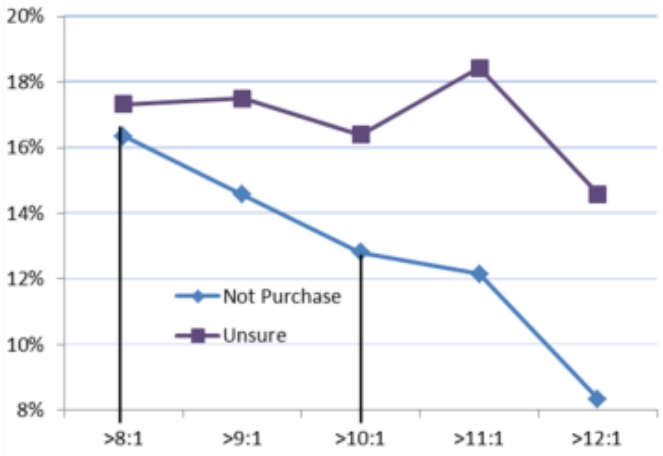
Figure 120



Would Not Purchase Mandarins V. Brix Acid Ratio

Ratio 8:1 = 16% Not Purchase; Ratio 10:1 = 13% Not Purchase.

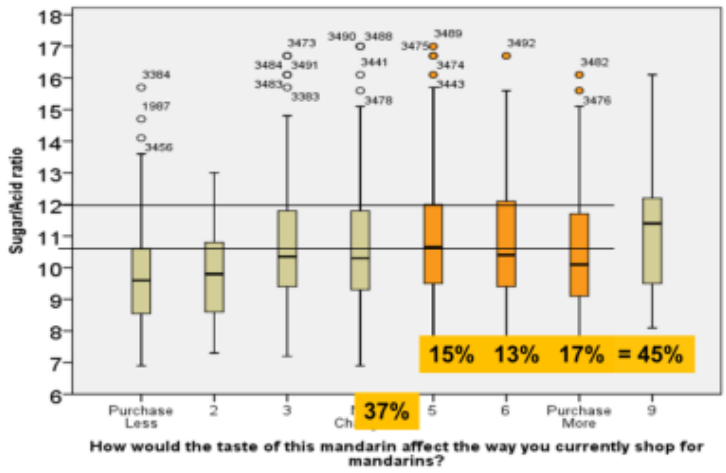
Figure 121



Would Purchase More Mandarins V. Brix Acid Ratio

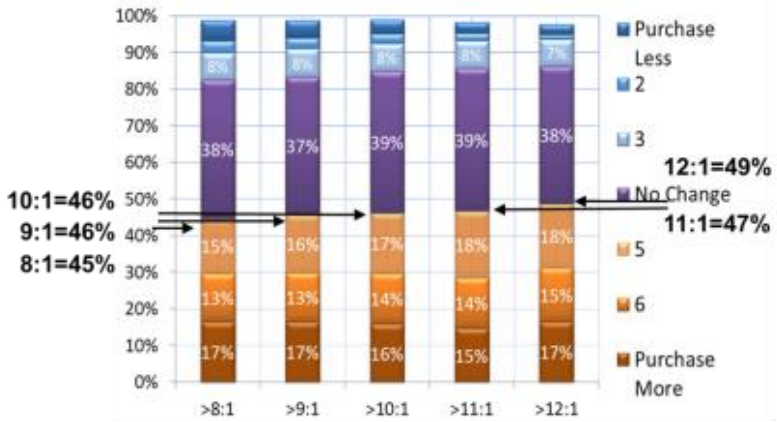
Min 10.5 for 50% more 5 and 12 for 75%.

Figure 122



Ratio 8:1 = 45% Purchase More; Ratio 10:1 = 46% Purchase More.

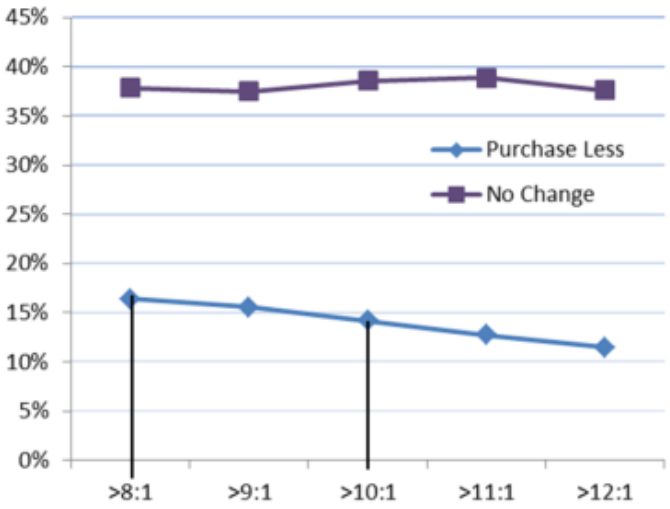
Figure 123



Would Purchase Less Mandarins V. Brix Acid Ratio

Ratio 8:1 = 16% Purchase Less; Ratio 10:1 = 14% Purchase Less.

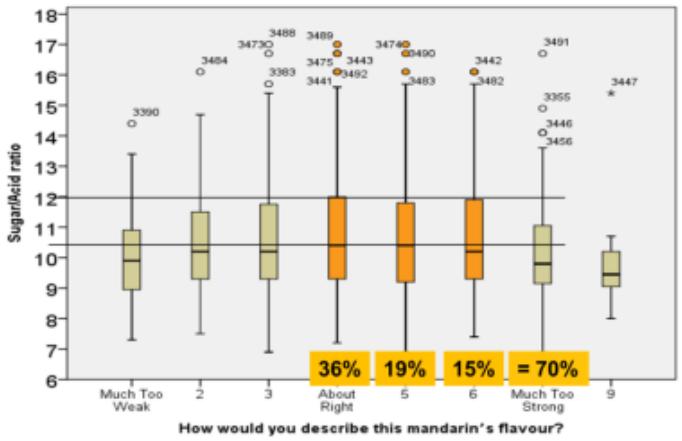
Figure 124



Perceived Mandarin Flavour V. Brix Acid Ratio

Min 10.4 for 50% about right and 12 for 75%.

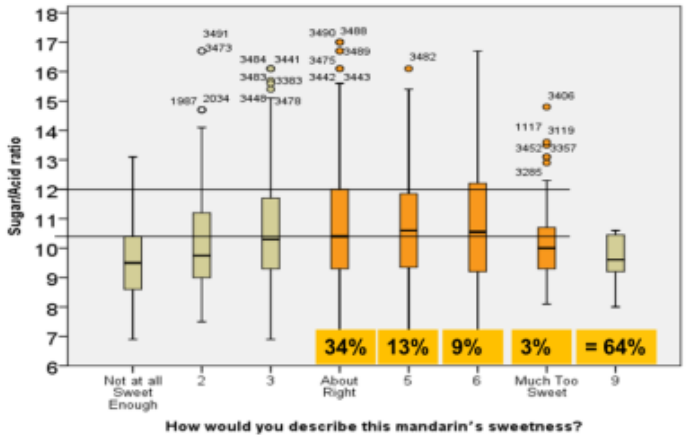
Figure 125



Perceived Mandarin Sweetness V. Brix Acid Ratio

Min 10.4 for 50% about right and 12 for 75%.

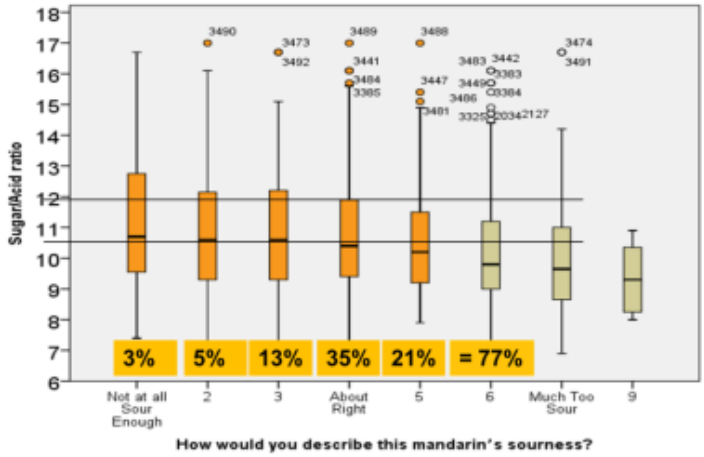
Figure 126



Perceived Mandarin Sourness V. Brix Acid Ratio

Min 10.5 for 50% about right and 11.9 for 75%.

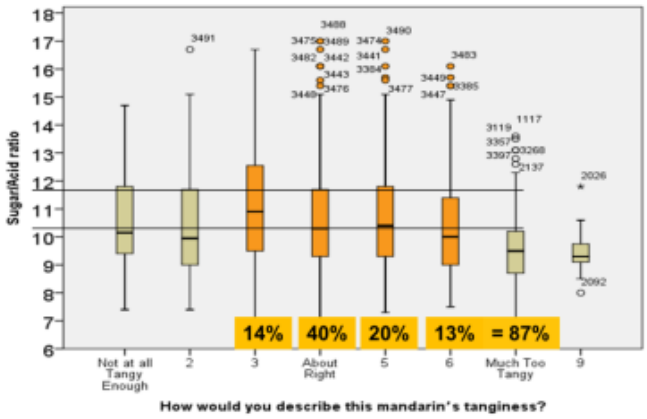
Figure 127



Perceived Mandarin Tanginess V. Brix Acid Ratio

Min 10.3 for 50% about right and 11.8 for 75%.

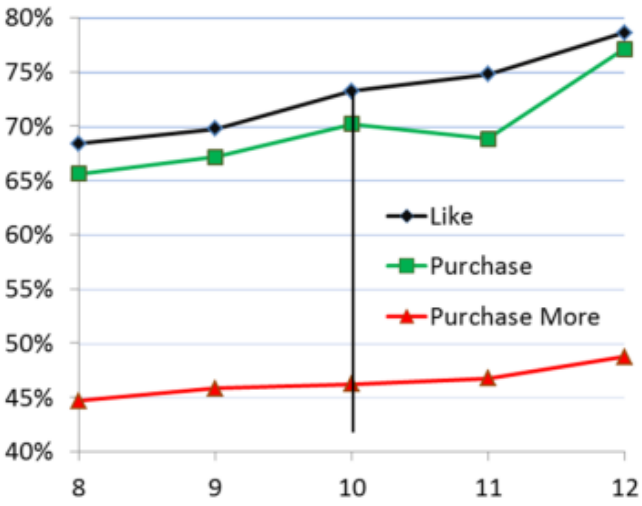
Figure 128



Brix Acid Ratio Conclusions

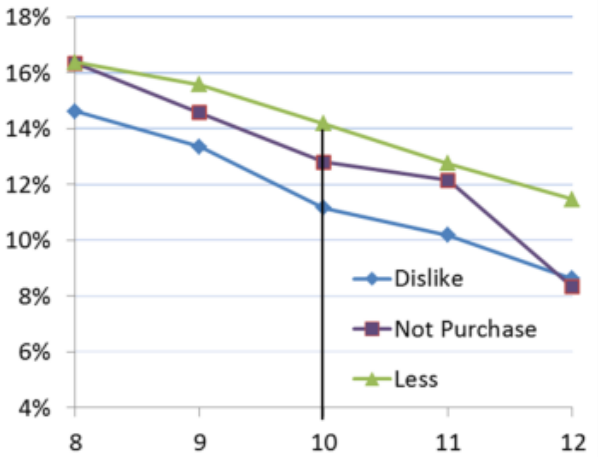
Satisfy Most Mandarin Consumers at: Ratio = 10:1.

Figure 129



Reduce negative responses Ratio = 10:1.

Figure 130

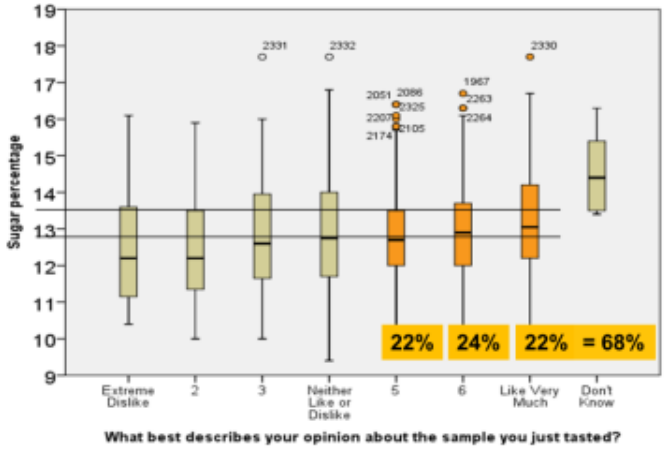


Appendix 10 Brix (Total Soluble Solids) V. Mandarin Response

Opinion about Mandarin Sample V. Brix

Min12.7 for 50% opinion 5 and 13.5 for 75%.

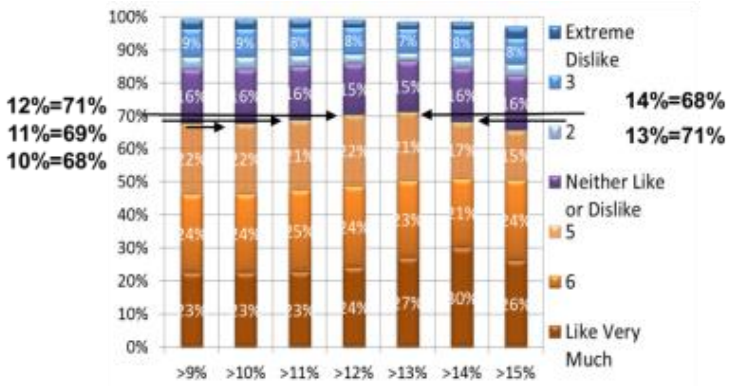
Figure 131



Like Mandarins Sample V. Brix

Ratio 10% = 68% Like; Ratio 12% = 71% Like.

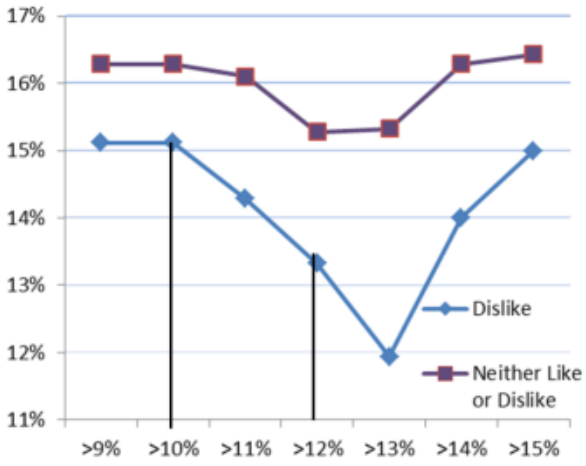
Figure 132



Dislike Mandarins V. Brix

Ratio 10% = 68% Dislike; Ratio 12% = 71% Dislike.

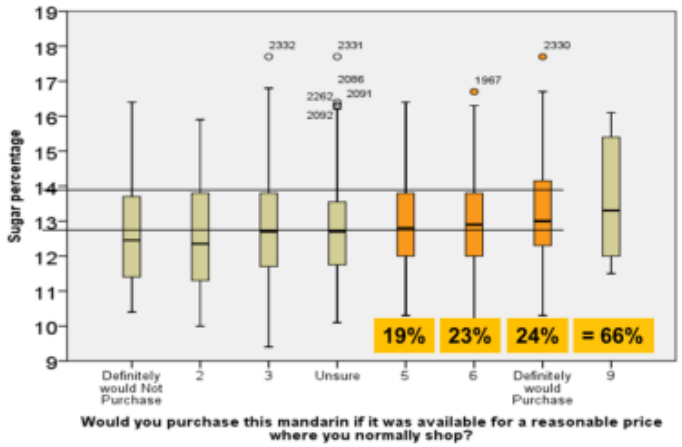
Figure 133



Would Purchase Mandarin V. Brix

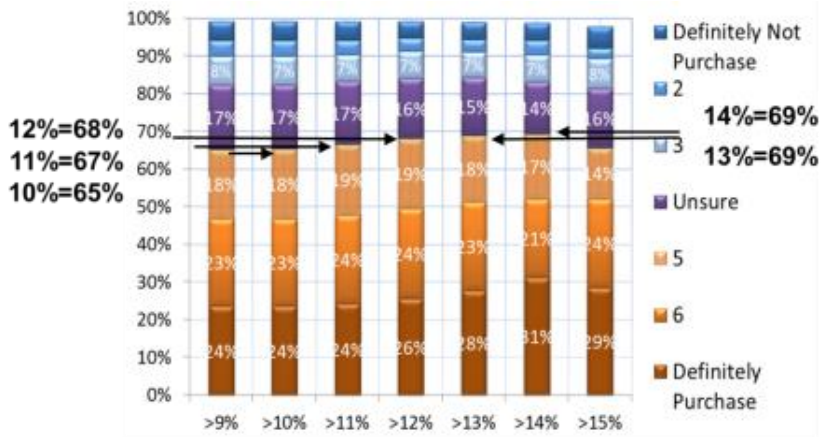
Min12.7 for 50% purchase 5; and 13.8 for 75%.

Figure 134



Ratio 10% = 65% Purchase; Ratio 12% = 68% Purchase.

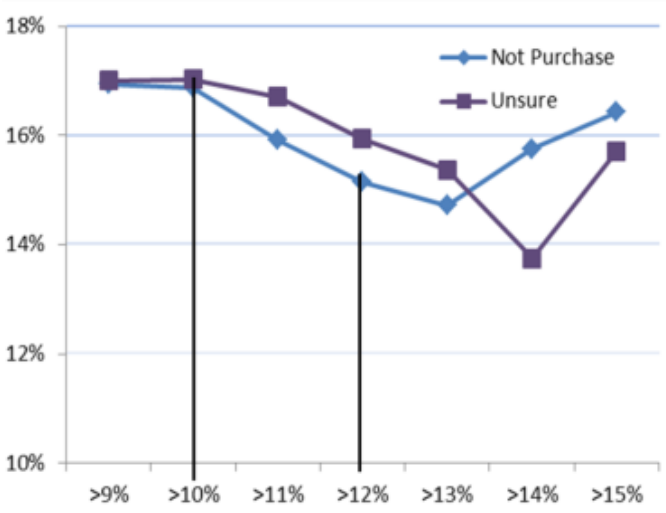
Figure 135



Would Not Purchase Mandarins V. Brix

Ratio 10% = 68% Not Purchase; Ratio 12% = 71% Not Purchase.

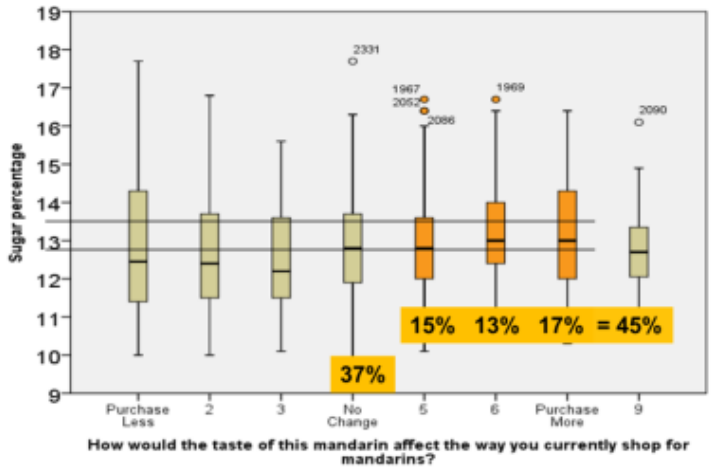
Figure 135



Would Purchase More Mandarins V. Brix

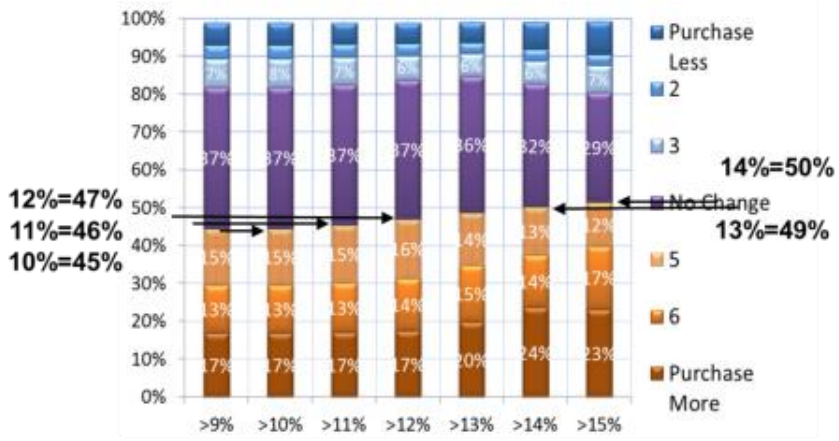
Min12.7 for 50% more 5; and 13.6 for 75%.

Figure 136



Ratio 10% = 45% Purchase More; Ratio 12% = 47% Purchase More.

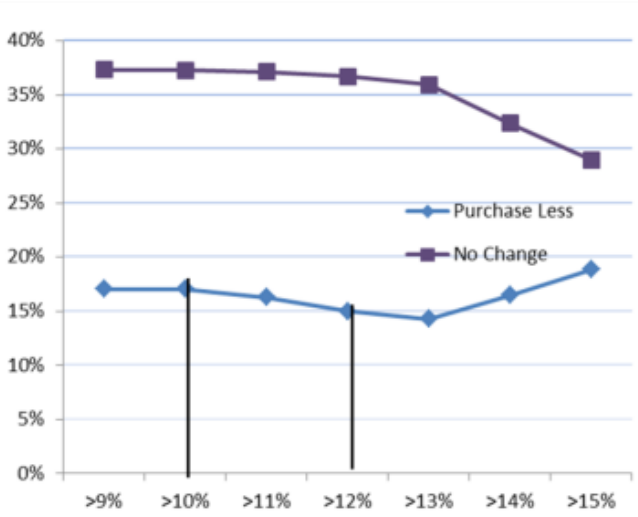
Figure 137



Would Purchase Less Mandarins V. Brix

Ratio 10% = 17% Purchase Less; Ratio 12% = 15% Purchase Less.

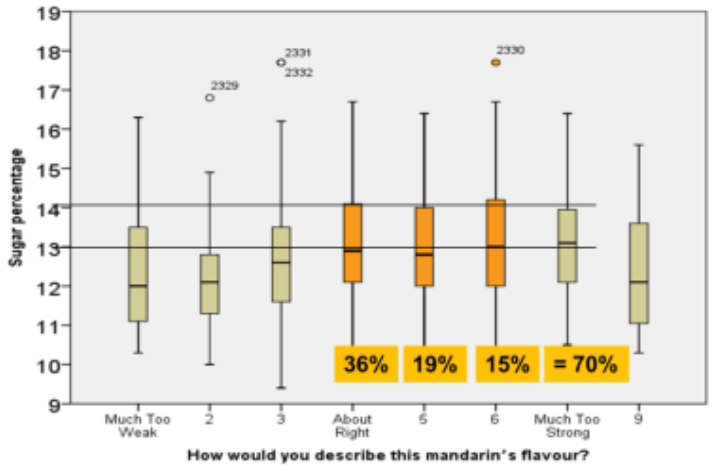
Figure 138



Perceived Mandarin Flavour V. Brix

Min13 for 50% about right and 14 for 75%.

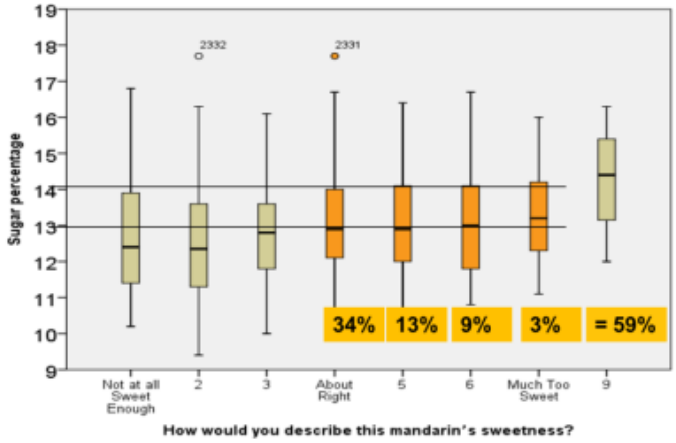
Figure 139



Perceived Mandarin Sweetness V. Brix

Min 13 for 50% about right and 14 for 75%.

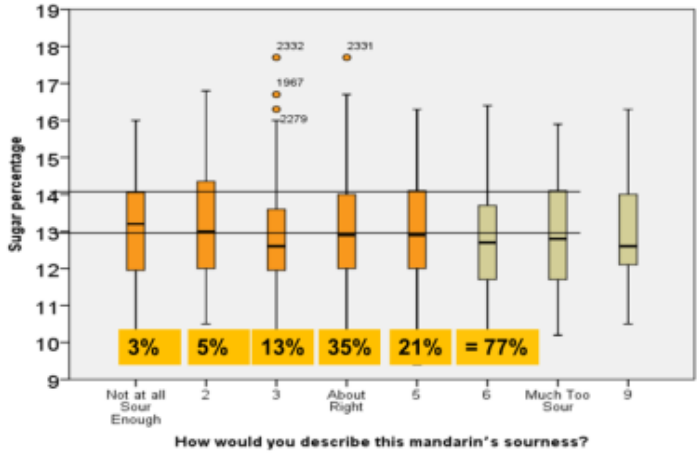
Figure 140



Perceived Mandarin Sourness V. Brix

Min13 for 50% about right and 14 for 75%.

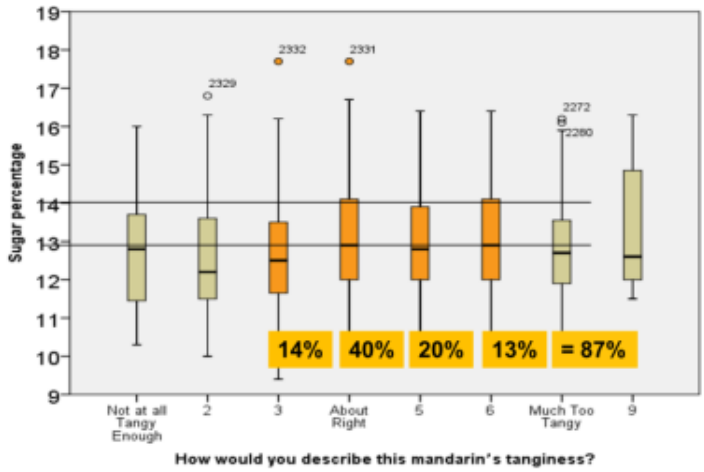
Figure 141



Perceived Mandarin Tanginess V. Brix

Min13 for 50% about right and 14 for 75%.

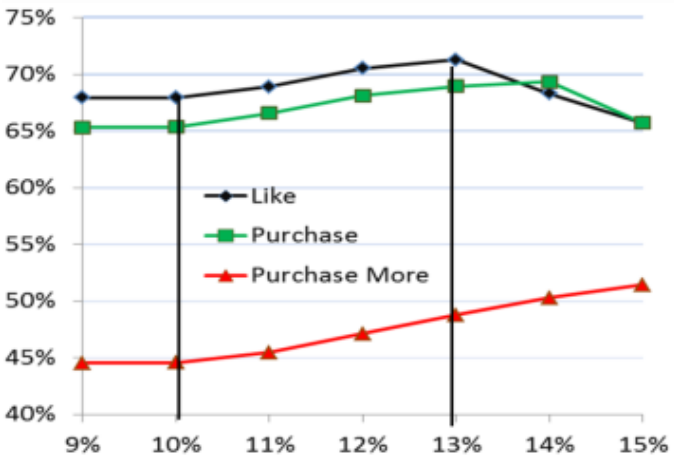
Figure 142



Brix Conclusions

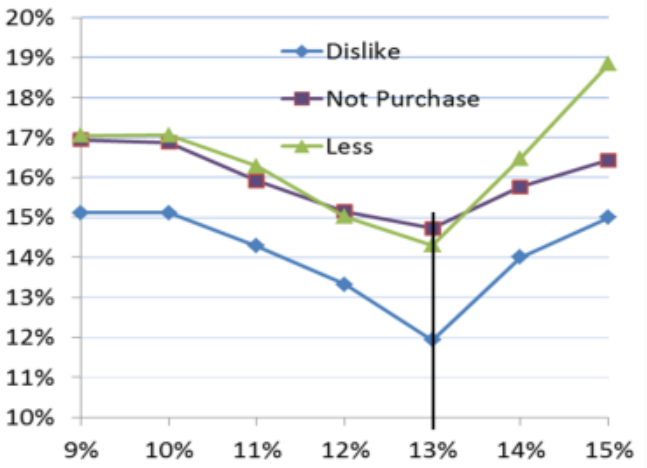
Satisfy Most Mandarin Consumers at: Brix = 10%-13%.

Figure 143



Reduce negative responses Brix = 13%.

Figure 144

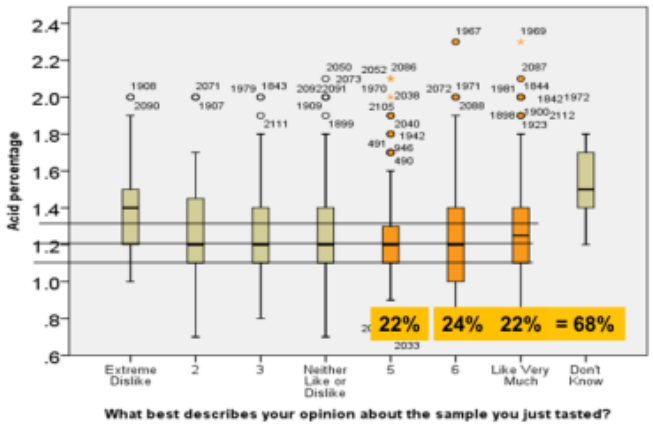


Appendix 11 Acid Percentage V. Consumer Mandarin Response

Opinion about Mandarin Sample V. Acid %

Max 1.3 for 25% opinion 5; 1.2 for 50% and 1.1 for 75%.

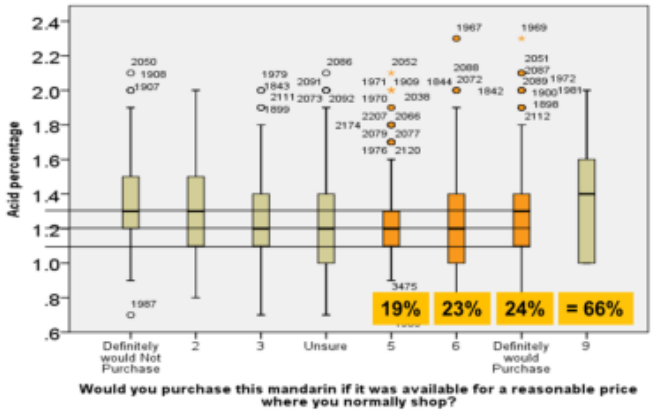
Figure 145



Would Purchase Mandarin V. Acid %

Max 1.3 for 25% opinion 5; 1.2 for 50% and 1.1 for 75%.

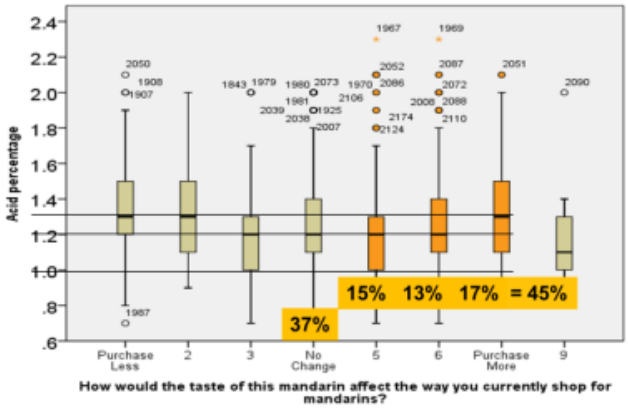
Figure 146



Would Purchase More Mandarins V. Acid %

Max 1.3 for 25% opinion 5; 1.2 for 50% and 1.0 for 75%.

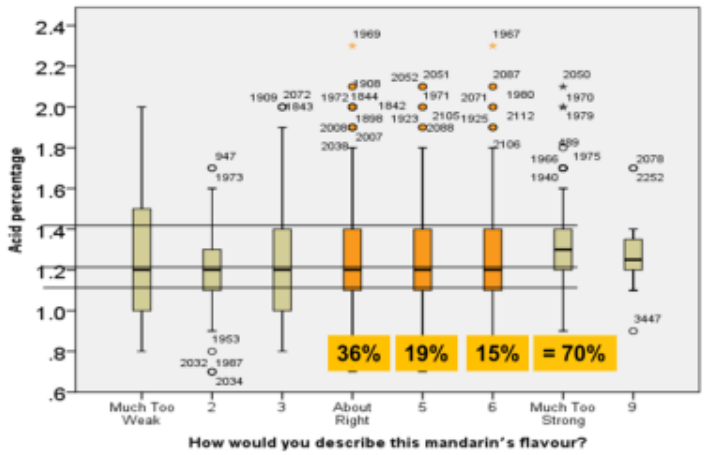
Figure 147



Perceived Mandarin Flavour V. Acid %

Max 1.4 for 25% about right; 1.2 for 50% and 1.1 for 75%.

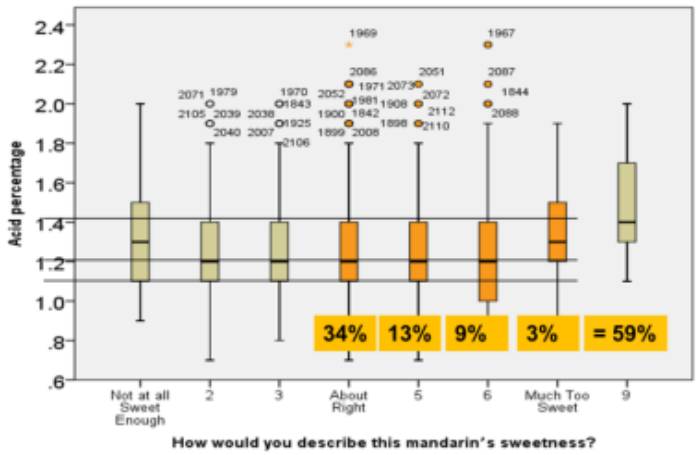
Figure 148



Perceived Mandarin Sweetness V. Acid %

Max 1.4 for 25% about right; 1.2 for 50% and 1.1 for 75%.

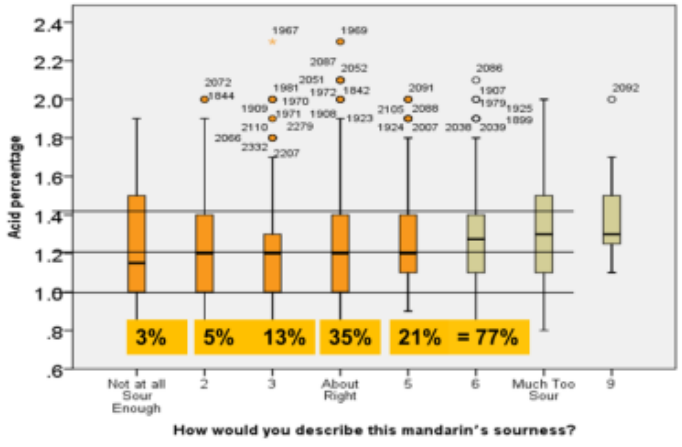
Figure 149



Perceived Mandarin Sourness V. Acid %

Max 1.4 for 25% about right; 1.2 for 50% and 1.0 for 75.

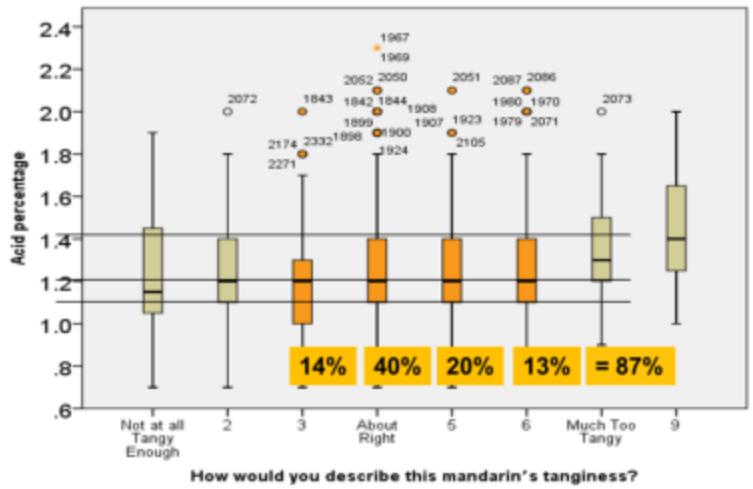
Figure 150



Perceived Mandarin Tanginess V. Acid %

Max 1.4 for 25% about right; 1.2 for 50% and 1.1 for 75%.

Figure 151



Acid % Conclusions

Minimum Standards to Satisfy Most Consumers Acid 1.3% to 1.4%

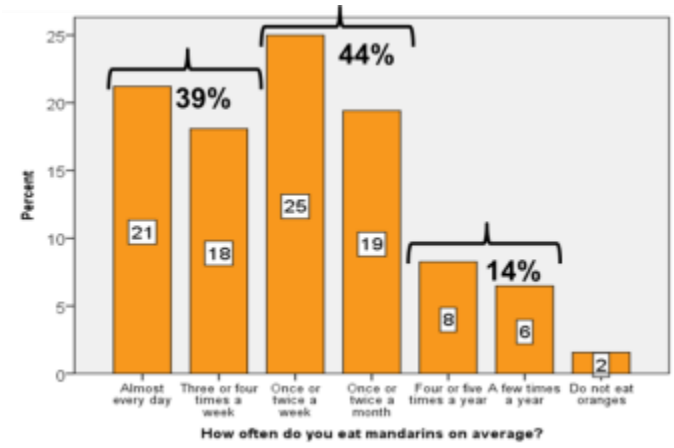
Appendix 11 Mandarin Consumption Patterns

General mandarin consumption pattern information was collected on the frequency and occasions mandarins were eaten, if other tangy fruit was eaten and what were important attributes when shopping for mandarins.

Frequency Mandarins Eaten

A third (39%) of consumers ate mandarin frequently – on average almost once a day and three or four times a week (Figure 152). Nearly half (44%) ate mandarins regularly – once to twice a week/month.

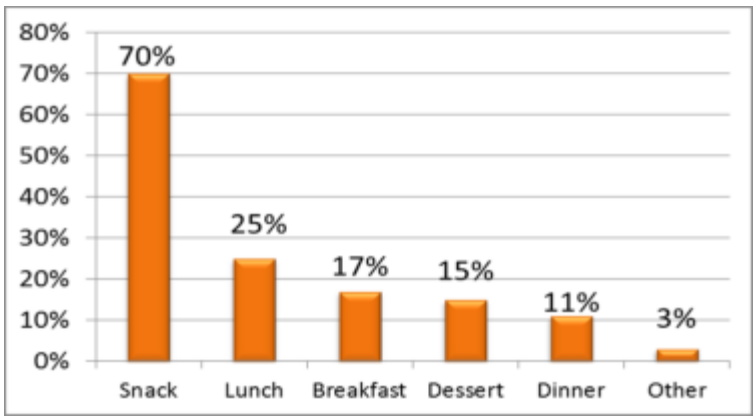
Figure 152 Frequency Mandarins Eaten



Occasions Mandarins Eaten

Mandarins were mostly eaten mostly for snacks (70%) (Figure 153).

Figure 153 Occasions Mandarins Eaten



Eating Other Tangy Fruit

Over half (57%) of mandarin eaters also ate other tangy fruit. The most popular other tangy fruit was oranges (25%) and kiwi fruit (8%) (Figure 154).

Figure 154 Other Tangy Fruit Eaten

Orange	25%
Kiwi fruit	8%
Grapefruit	6%
Apple	6%
Pineapple	6%
Lemon	5%
Mango	4%

Important Attributes when Shopping for Mandarins

The most important attributes when shopping for mandarins were good taste/flavour (mean 6.7) followed by freshness (mean 6.6) and juiciness (mean 6.2) (Figure 155). Notably the taste attributes were by far more important than other attributes like price/value for money (mean 5.4), easy to peel (5.3), no seeds (5.3), being blemish free (mean 5.2) and skin colour (mean 5.0).

Figure 155 Important Attributes when Shopping for Oranges

How important when purchasing oranges is	Mean	Std. Deviation
Good taste/Flavour	6.7	0.8
Freshness	6.6	0.9
Juiciness	6.2	1.2
Health benefits	6.0	1.4
Sweetness	5.9	1.3
Sweet and Sour Balance	5.9	1.3
Tangy flavour	5.6	1.5
Price/Value for money	5.4	**1.7**
Easy to peel	5.3	**1.8**
No seeds	5.3	**1.8**
Blemish free	5.2	**1.7**
Skin colour	5.0	**1.7**
Sour	4.7	**1.8**

Related mandarins shopping attributes were determined based on a factor analysis. Different types of attributes included visual appeal, taste and skin attributes, sweetness, no seeds and price/value for money were not related to the other mandarins shopping attributes (Figure 156).

Figure 156 Related Attributes when Shopping for Oranges

How important when purchasing oranges is:	1	2	3
Visual Appeal Attributes			
Freshness	.80		
Good taste/Flavour	.74		
Juiciness	.50		
Health benefits	.62		
Taste Attributes			
Tangy flavour		.80	
Sour		.77	
Sweet and Sour Balance		.66	
Skin Attributes			
Blemish free			.83
Skin colour			.79
Easy to peel			.62
Other Attributes			
Sweetness			
No seeds			.41
Price/Value for money			
Eigen Value	3.7	1.2	1.6
Cronbach Alpha	0.62	0.67	0.70
50% Variance Explained	28%	9%	12%

Mandarin Eating & Shopping Pattern Conclusions

Most panellists ate mandarins regularly (44%), with a third eating them frequently (39%) and fewer eat oranges occasionally (14%). Mandarins were mostly eaten for snacks (70%). Over half (54%) of mandarins eaters also ate other tangy fruit with the most popular being oranges (25%), kiwifruit (8%), grapefruit (6%) and apples (6%). The most important attributes when shopping for mandarins were good taste/flavour (mean 6.7) followed by freshness (mean 6.6) and juiciness (mean 6.2) (Figure 131). Notably the taste attributes were by far more important than other attributes like price/value for money (mean 5.4), easy to peel (5.3), no seeds (5.3), being blemish free (mean 5.2) and skin colour (mean 5.0).

1. Mandarin Ethnic Origin Differences

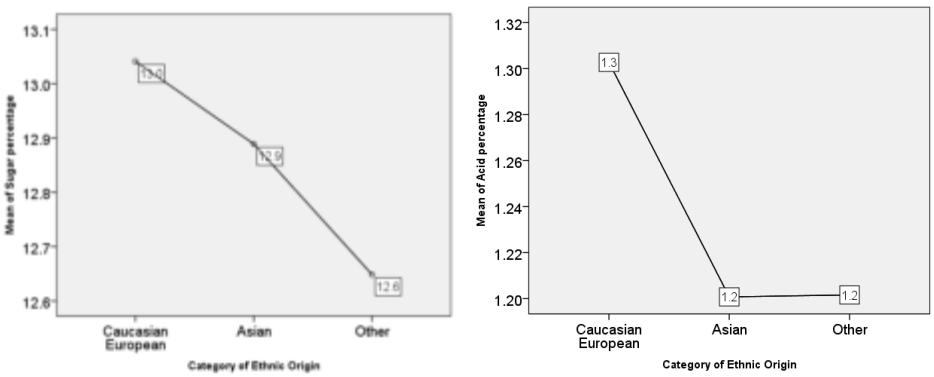
The ethnic origins of the panels were varied with most from 'European Caucasian' descent (57% = 256 consumers) followed by 'Asian descent' (34% = 157) and 'Other' groups (7% = 33). Based on anecdotal comments of differences in demands for oranges by consumers of Asian descent, ethnic origin were assessed in terms of sample characteristics and attributes important when shopping.

Mandarin Sample Characteristics V. Ethnic Origin

There were some statistically significant differences between ethnic groups for mandarin samples provided in terms of Brix, Acid percentage, Brix Acid ratio and Californian standard as well as opinion about the mandarin samples and tanginess. There were no significant differences between ethnic groups for mandarins sample provided in terms of: Flavour; Sourness or Sweetness nor in terms of responses to willingness to purchase or purchase more.

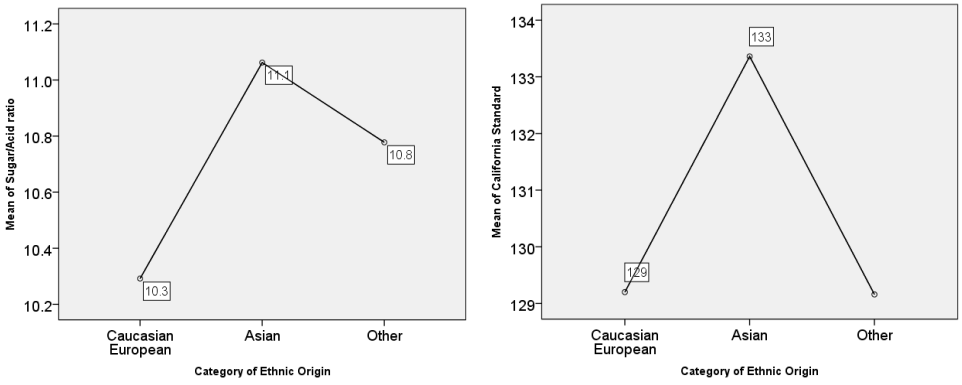
Panellists of 'Caucasian Europeans' descent received mandarin samples that were more sweet and more acidic (Figure 157).

Figure 157 Mandarin Brix and Acid % V. Ethnic Origin



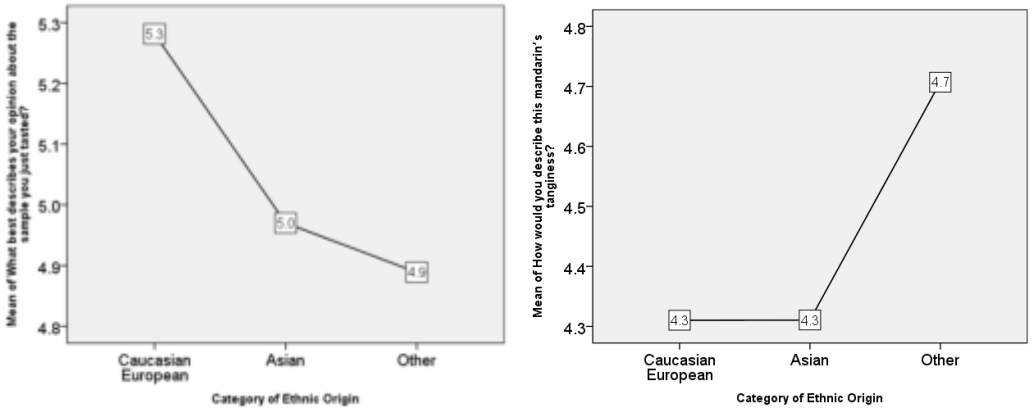
Panellists of 'Caucasian Europeans' descent received mandarin samples with a lower brix acid ratio and a lower Californian Standard (Figure 158).

Figure 158 Mandarin Brix acid ratio & Californian Standard V. Ethnic Origin



Panellists of 'Caucasian Europeans' descent liked the mandarin samples they received more than other ethnic groups (Figure 159). Panellists of 'Other' descents perceived the mandarin samples were more tangy.

Figure 159 Mandarin Opinion V. Ethnic Origin

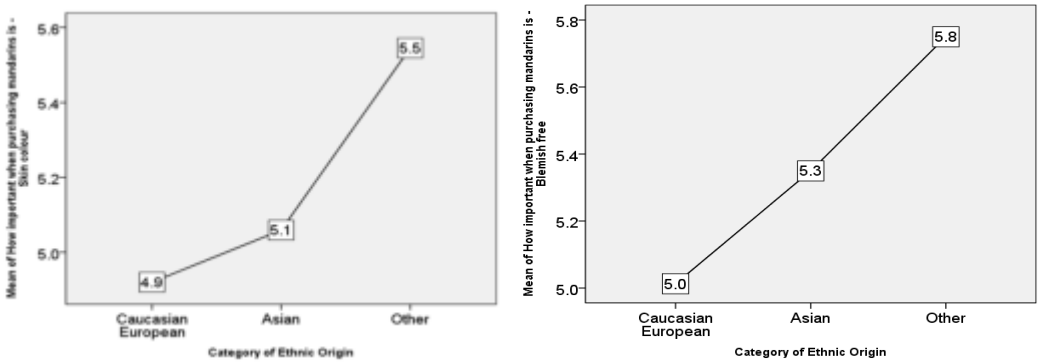


Important Mandarin Shopping Attributes V. Ethnic Origin

There were differences between ethnic groups when shopping for mandarins looking for: Skin colour, Blemish free, Health benefits, Good taste/ flavour, Tanginess, Price/ Value for Money and Juiciness. There were no significant differences between ethnic groups when shopping for mandarins: Easy to peel, No Seeds, Freshness, Sweet & sour balance, Sweetness and Sourness.

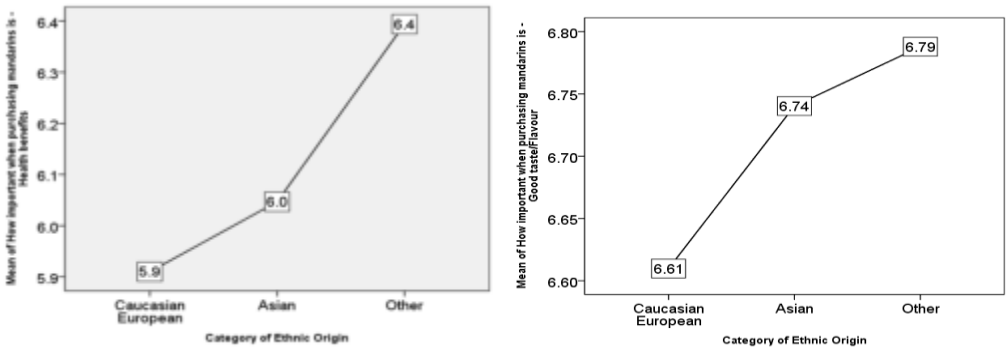
Panellists of 'Other' ethnic origins looked more for skin colour and blemish free (Figure 160).

Figure 160 Mandarin Skin Colour & Blemish Free V. Ethnic Origin



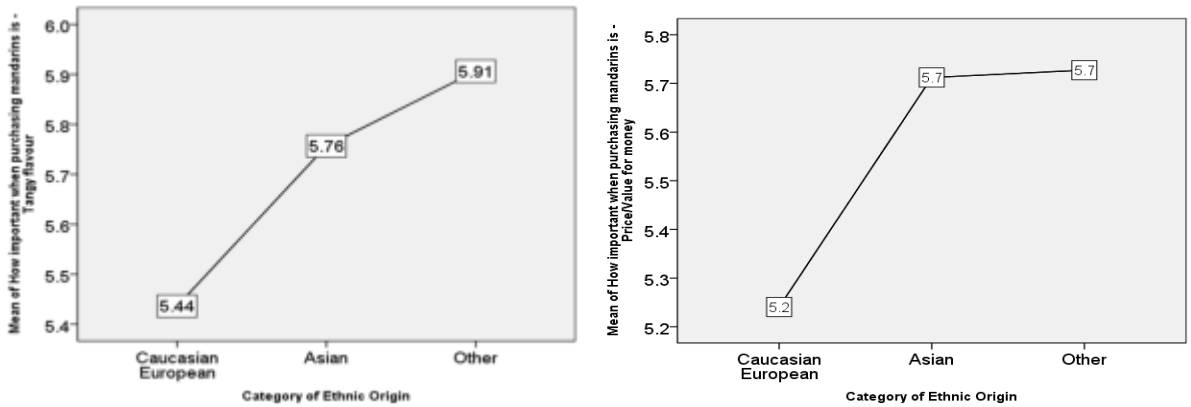
Panellists of 'Other' ethnic origins looked more for health benefits and good taste/flavour (Figure 161).

Figure 161 Mandarin Health Benefits and Good taste/flavour V. Ethnic Origin



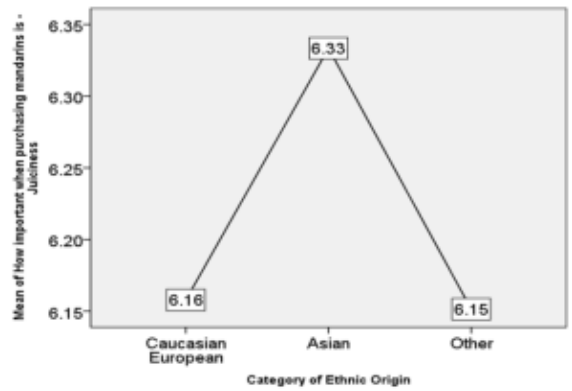
Panellists of 'Other' ethnic origins looked more for tangy flavour. Price/ value for money was less important for those from 'Caucasian Europeans' ethnic origin (Figure 162).

Figure 162 Mandarin Tangy Flavour & Price/ Value for Money V. Ethnic Origin



Panellists of 'Asian' descent looked more for juiciness (Figure 163).

Figure 163 Mandarin Juiciness V. Ethnic Origin



Conclusions Mandarin Ethnic Origin Differences

Panellists of 'Caucasian Europeans' descent received mandarin samples that were more sweet and higher acid % that resulted in a lower brix acid ratio and Californian Standard.

Panellists of 'Other' ethnic origin received mandarin samples were less sweet had a lower acid percentage and resultant Californian standard. Those of 'Other' ethnic origin liked mandarin samples less and perceived samples were more tangy. Once again, given the random chance groups of different ethnic origin received slightly different types of mandarin samples it is hard to know if the differences in response to the mandarin samples may be due to the samples tasted or ethnic origin. Further research will need to be undertaken to determine this. Preferably research was conducted in overseas countries as the time spent in Australia may have an influence on response.

There were some differences in what different ethnic origins were looking for when shopping. Those of 'Asian' origin were more likely to look for juiciness in mandarins. Those of 'Other' ethnic origin looked more for mandarin skin colour, blemish free, health benefits, tangy flavour and good taste/ flavour. Those of 'Caucasian European' origin looked less for mandarin price/ value for money, skin colour, blemish free, health benefits, tangy flavour and good taste/ flavour.

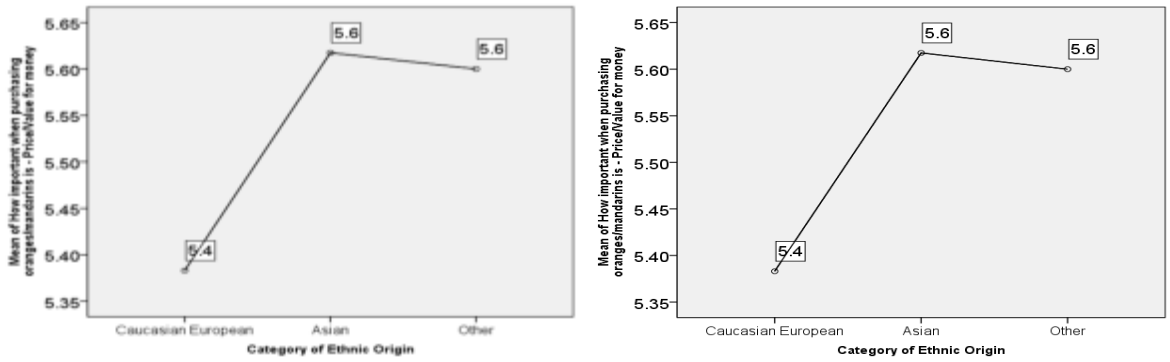
Important Mandarin & Orange Shopping Attributes V. Ethnic Origin

When comparing the ethnic origin differences to what consumers were looking for when shopping there was some similarity in responses from both the mandarin and orange panel surveys. To see if a clearer picture of results the two panel results were combined and the analyses run again.

In looking at all mandarin and orange panellists together, there were statistically significant differences between ethnic groups when looking for: Price/ Value for Money, Easy to peel, Skin colour, Blemish free, Health benefits, Sweetness, Juiciness, Freshness, Sweet & sour balance and Tanginess. There were no significant differences between ethnic groups when shopping for mandarins in looking for: Sourness, No Seeds and Good taste/ flavour.

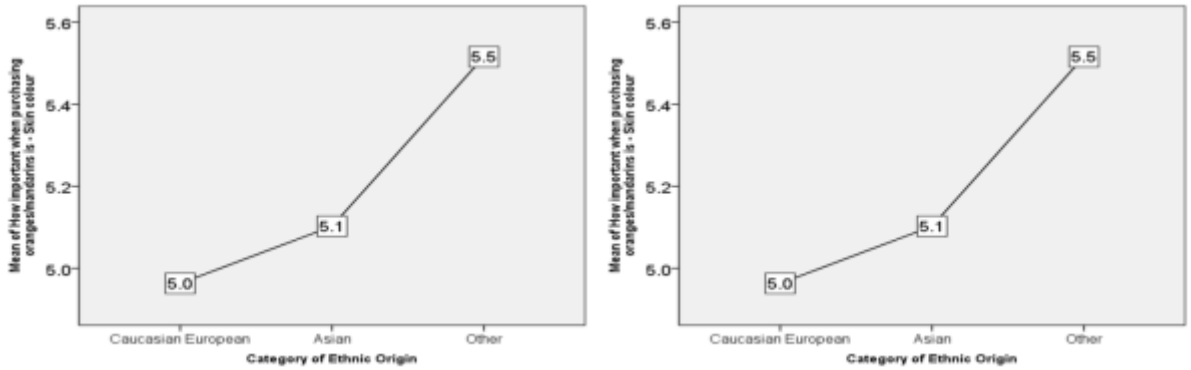
For panellists of Caucasian Europeans' ethnic origin price/value for money and easy to peel was less important (Figure 164).

Figure 164 Orange & Mandarin Price/ Value for Money and Easy to Peel V. Ethnic Origin



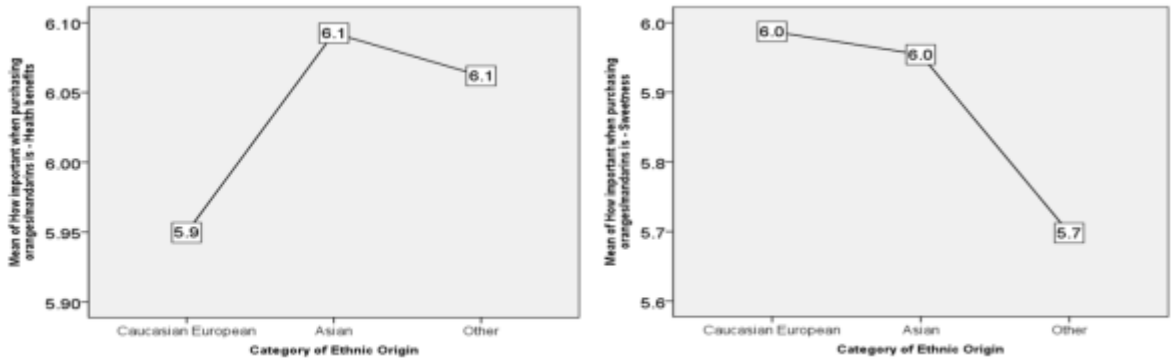
Panellists of 'Other' ethnic origins looked more for skin colour and blemish free (Figure 165).

Figure 165 Orange & Mandarin Skin Colour & Blemish Free V. Ethnic Origin



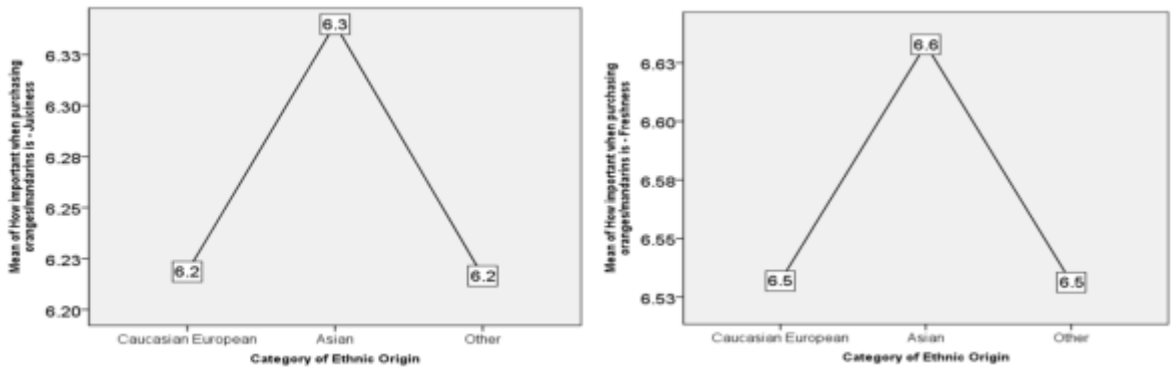
For panellists of Caucasian Europeans' ethnic origin health benefits was less important and for panellists of 'Other' ethnic origins sweetness was less important (Figure 166).

Figure 166 Orange & Mandarin Health Benefits and Sweetness V. Ethnic Origin



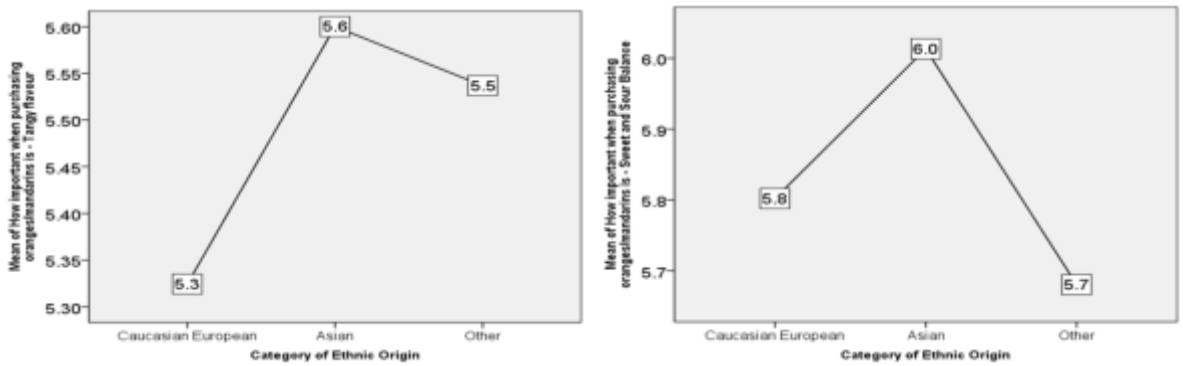
Panellists of 'Asian' descent looked more for juiciness and freshness (Figure 167).

Figure 167 Orange & Mandarin Juiciness and Freshness V. Ethnic Origin



Panellists of 'Asian' descent looked more for tangy flavour and a balance of sweet and sour flavours (Figure 168).

Figure 168 Orange & Mandarin Tangy Sweet & Sour Balance and Flavour V. Ethnic Origin



Conclusions Mandarin and Orange Ethnic Origin Differences in Shopping Attributes

There were some differences in what consumers from different ethnic origins were looking for when shopping for orange and mandarin citrus fruit. Those of 'Asian' origin were more likely to look for juiciness, freshness and a tangy flavour so long as there is a balance in sweet and sour flavours. Those of 'Other' ethnic origin looked more for citrus skin colour and blemish free but not as much for sweetness. Those of 'Caucasian European' origin looked less for citrus price/ value for money and easy to peel.

2. Age Differences

From anecdotal evidence it was suggested that there may be differences in younger and older consumers mandarin eating habits. To test this hypothesis, the differences in age groups were assessed in terms of demographic characteristics of consumers, mandarin eating and purchasing patterns as well as sample attributes and responses to mandarin samples.

Age Categories V. Demographics

To determine if there were differences in age categories in the people recruited to the mandarin taste panels they were compared in terms of gender, time lived in Australia and ethnic origin.

More females in older categories (45% 30+ years) were recruited to the mandarin taste panels. This related to the larger number of older female shoppers recruited in the shopping centre panels.

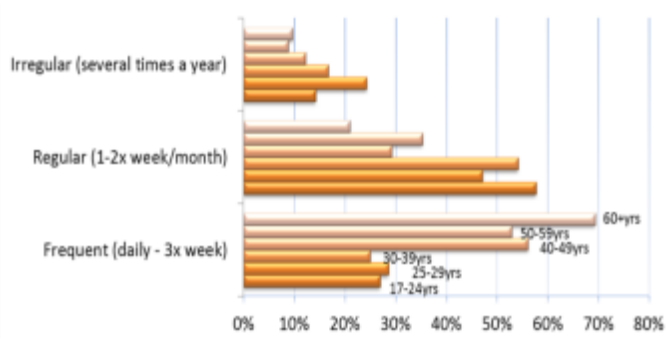
The finding that younger mandarin panellists had lived less time in Australia was to be expected. Similarly it was expected that the older mandarin panellists were more likely to be Caucasian European ethnic origin (40+ years) as the younger recruits from the Universities were more likely to be from international backgrounds.

Age Categories V. Mandarin Eating Patterns

General mandarin eating and shopping pattern information was collected on the frequency and occasions mandarins were eaten, if other tangy fruit was eaten and what were important attributes when shopping for mandarins.

It was found that older panellists (40 years plus; n=138 – 31%) more consistently eat mandarin daily to three times a week (Figure 169). Those 30 years and younger were more likely to eat mandarin 1-2 times a week or month. Irregular mandarin consumers were similar across all age categories. This finding may relate to older panellists being more likely to eat other tangy fruit.

Figure 169 Age Categories V. Mandarin Eating Frequency



The pattern of occasions (meals) when mandarin are eaten was mixed with younger panellists eating mandarins more for snacks and older panellists eating mandarins more for lunch.

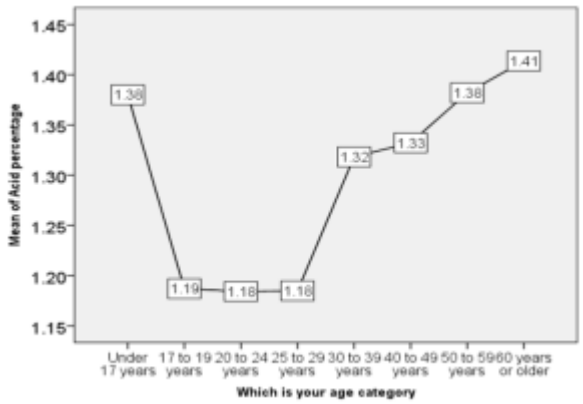
Age Categories V. Mandarin Sample Responses

To determine if the mandarin samples provided to the age categories were different, the characteristics of the mandarin samples were compared in terms of Brix (total soluble solids), acid %, brix acid ratio and Californian Standard. Differences were assessed in terms of panellist's responses to mandarin sample perceived sweetness, flavour, sourness and sweet and sour balance.

There were significant differences by age group categories for mandarin samples in terms the characteristics of samples presented for mandarin acid percentage, brix to acid ratio and California standard. However there were no significant differences by age group for mandarin sample Brix and no differences in panellists' responses to the mandarin samples (overall liking/disliking the mandarin samples, willingness to purchase mandarins if a reasonable price, willingness to purchase more mandarin and perceived mandarin sample flavour, sweetness, tanginess and sourness).

The younger panellists (< 17 years; n=15 – 3%) and older panellists (30+ years; n=163 – 37%) were also offered orange samples that had statistically higher acid percentage (Figure 170).

Figure 170 Age Categories V. Mandarin Acid %



This resulted in getting samples with a lower brix acid ratio (Figure 171) and lower Californian standard (Figure 172).

Figure 171 Age Categories V. Mandarin Brix to acid Ratio

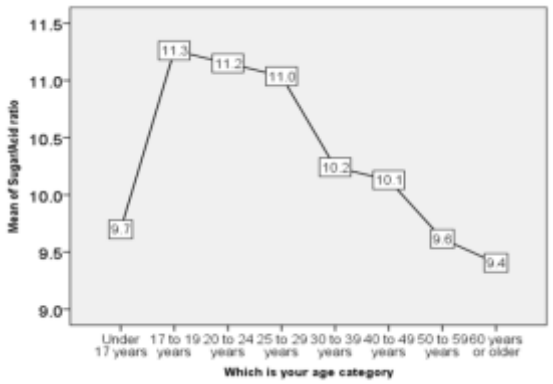
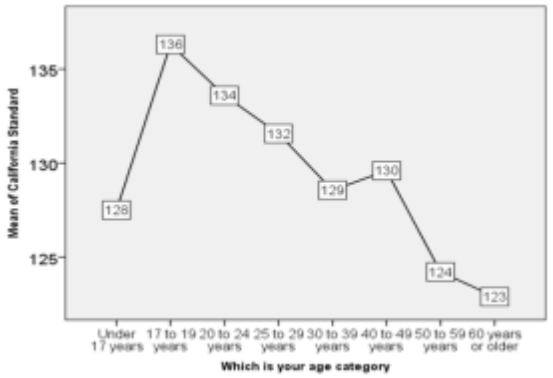


Figure 172 Age Categories V. Mandarin Californian Standard



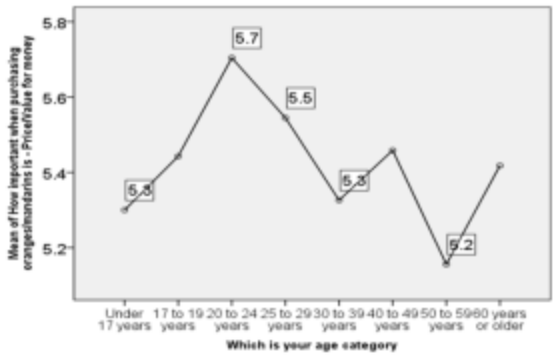
Age Categories V. Mandarin & Orange Shopping Attributes

In looking at the differences of age categories on attributes of importance when shopping, the responses from both the mandarin and orange panels were combined. This was done to sufficient numbers in the small group of those under 17 years that showed significant differences in the orange analysis.

There were statistically significant differences (95% confidence) in age categories in term of older shoppers looking more for Easy to Peel, Juiciness, No Seeds, Freshness, Health Benefits, Good Taste / Flavour, Sweet & Sour Balance and Sweetness. The older shoppers looked less for Value for Money and Sourness. There were no statistically significant differences between age groups in terms of looking for: Skin Colour, Blemish Free and Tangy Flavour

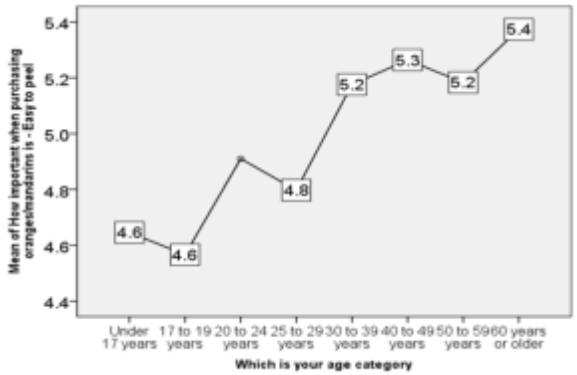
Price/ Value for Money was generally less important as shoppers got older with the exception of those under 17 years of age (Figure 173). Significant different means are labelled in the figure e.g. 5.7.

Figure 173 Age Categories V. Price/Value for Money



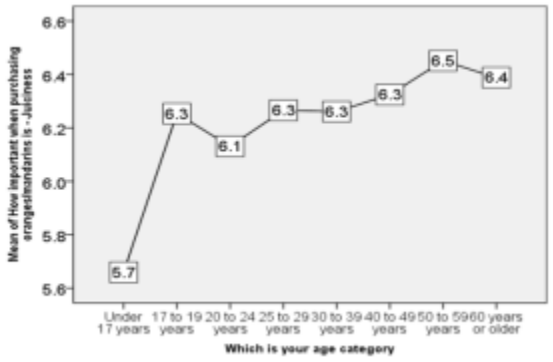
Easy to peel more important as shoppers got older (Figure 174).

Figure 174 Age Categories V. Easy to Peel



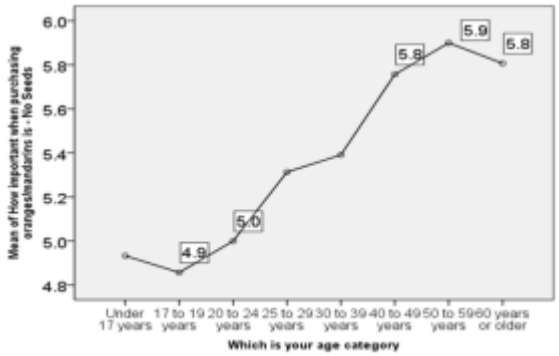
Juiciness more important as shoppers got older (Figure 175).

Figure 175 Age Categories V. Juiciness



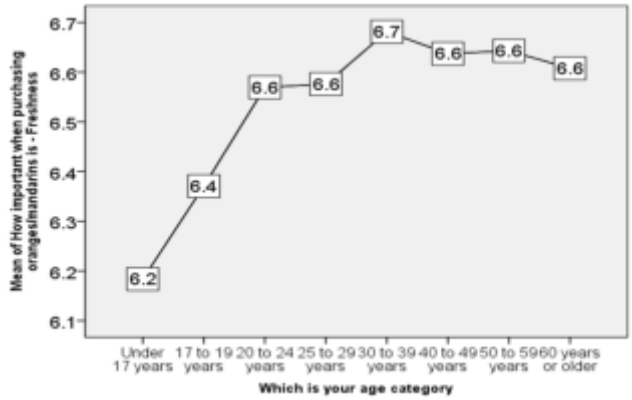
No seed was more important as shoppers got older (Figure 176).

Figure 176 Age Categories V. No Seeds



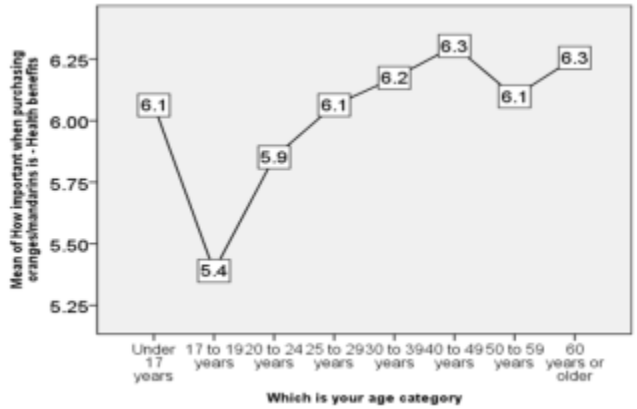
Freshness more important as shoppers got older (Figure 177).

Figure 177 Age Categories V. Freshness



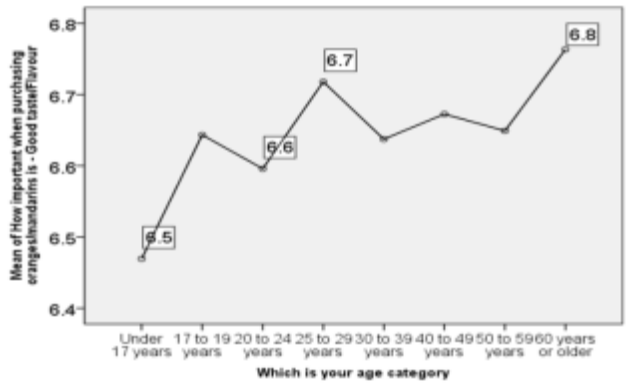
Health benefits were more important as shoppers got older (Figure 178).

Figure 178 Age Categories V. Health Benefits



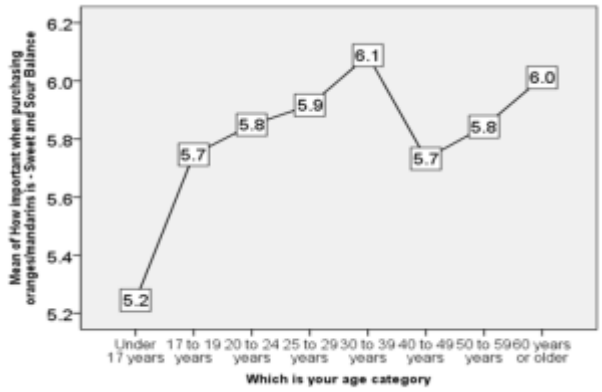
Good taste/flavour was more important as shoppers got older (Figure 179).

Figure 179 Age Categories V. Good Taste/Flavour



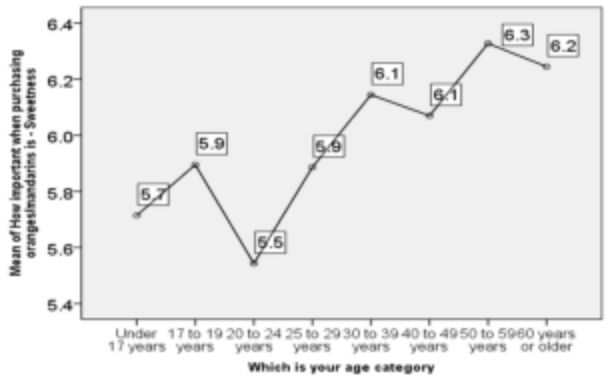
Sweet and sour balance was less important to younger consumers (< 17 years) (Figure 180).

Figure 180 Age Categories V. Sweet & Sour Balance



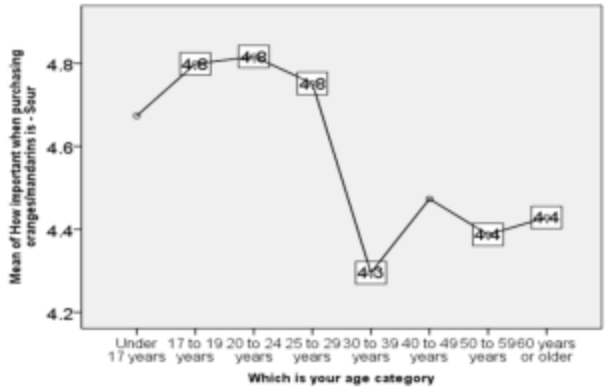
Sweetness more important as shoppers got older (except 20-24 years) (Figure 181).

Figure 181 Age Categories V. Sweetness



Sourness was less important as shoppers got older (Figure 182).

Figure 182 Age Categories V. Sourness



Age Category Differences Conclusions

In conclusion there were more females in the older age categories of mandarin panellists. Older age categories eat mandarins more frequently and were more likely to eat other tangy fruit. Older consumers ate mandarins more for lunch and the younger ate mandarins more for snacks.

Orange and mandarin attributes of increasing important as shoppers got older: Easy to peel, Juiciness, No Seeds, Freshness, Health benefits, Good Taste/ Flavour, Sweet & Sour Balance, Sweetness. Attributes of reducing important as orange and mandarin shoppers got older were Sourness and Value for Money.

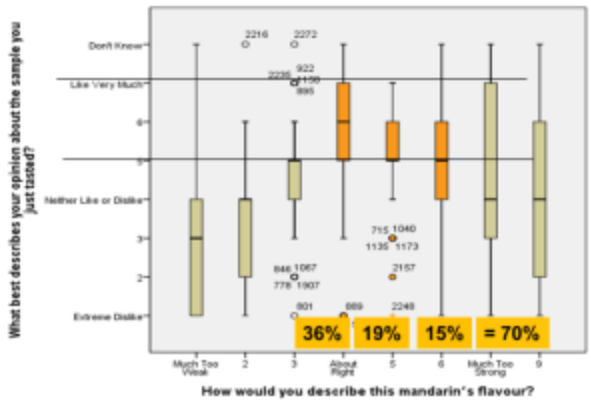
1.4 Perceptions about Mandarin Samples

Perceptions about mandarin samples was further by comparisons of the overall like/dislike opinion against consumers perception of mandarin sample sweetness, sourness and tanginess.

Perceived Mandarin Flavour V. Opinion

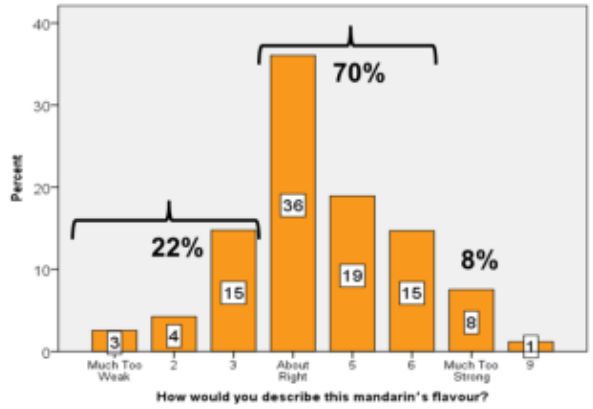
Consumers liked mandarins (5-7) when the flavour rating was from 4 'about right' to 6 (Figure 183).

Figure 183 Perceived Mandarin Flavour V. Opinion



This equated to most (70%) liking the flavour of the mandarin samples (4-6), while a quarter (22%) thought samples were weak and a few (8%) too strong (Figure 184).

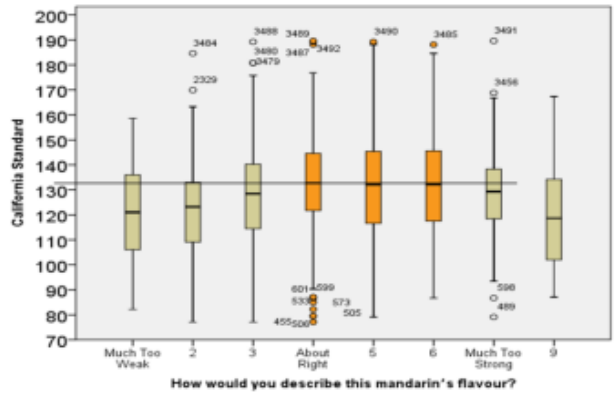
Figure 184 Perceived Mandarin Flavour



Mandarin Flavour V. Californian Standard

In looking at mandarin flavour, the Standard would be set at 132 to satisfy 50% of consumers rating the mandarin samples 4 'just right', 5 and 6 (Figure 185).

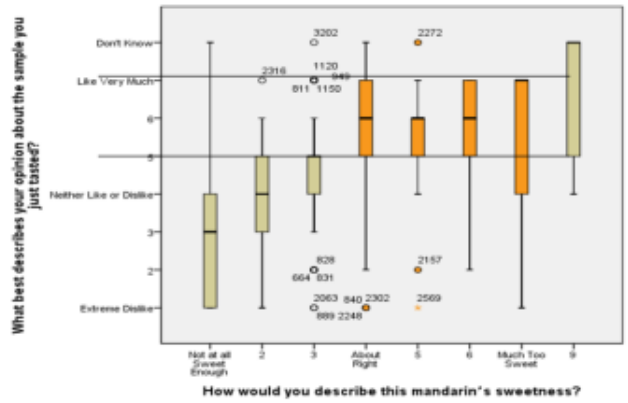
Figure 185 Perceived Mandarin Flavour V. Californian Standard



Perceived Mandarin Sweetness V. Opinion

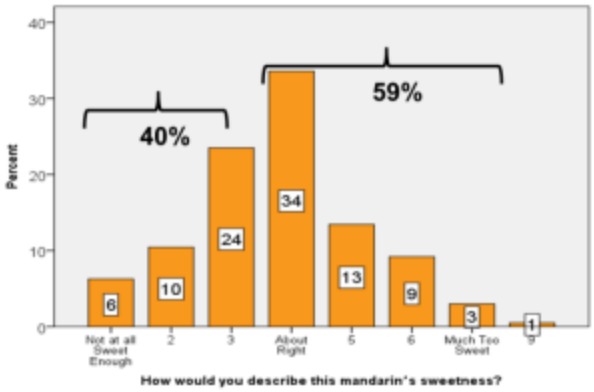
Consumers liked mandarins (5-7) when the sweetness rating was between 4 'just right' to 7 'much too sweet' indicating having too much sweetness did not affect liking mandarins (Figure 186).

Figure 186 Perceived Mandarin Sweetness V. Opinion



This equated to most (59%) liking the sweetness of the mandarin samples (4-7), while over a third (40%) thought samples were not sweet enough (Figure 187).

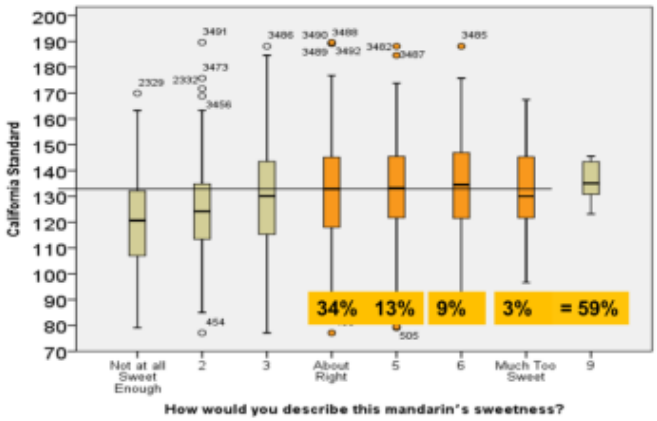
Figure 187 Perceived Mandarin Flavour



Mandarin Sweetness V. Californian Standard

In looking at mandarin sweetness, the Standard would be set at 132 to satisfy 50% of consumers rating the mandarin samples 4 'just right', 5 and 6 (Figure 188).

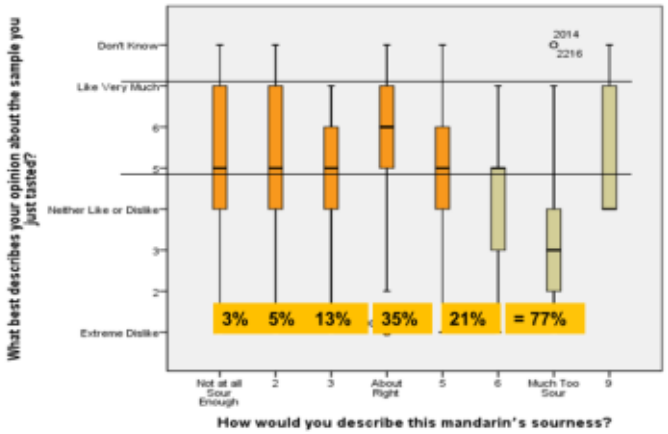
Figure 188 Perceived Mandarin Sweetness V. Californian Standard



Perceived Mandarin Sourness V. Opinion

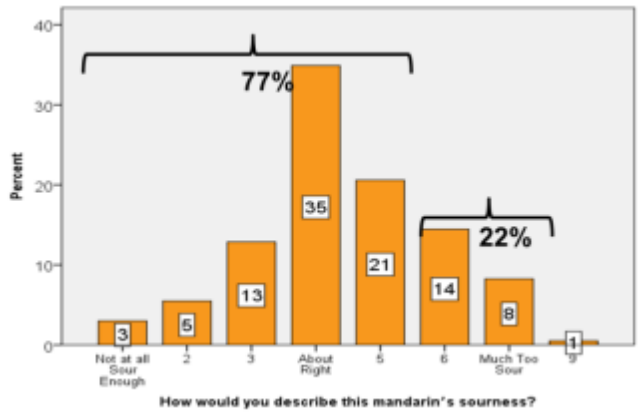
Consumers liked mandarins (5-7) when the sourness rating was between 1 'not at all sour enough' to 5 indicating having not enough sourness did not affect liking mandarins (Figure 189).

Figure 189 Perceived Mandarin Sourness V. Opinion



This equated to most (77%) liking the sourness of the mandarin samples (1-5), while a quarter (22%) thought samples were too sour (Figure 190).

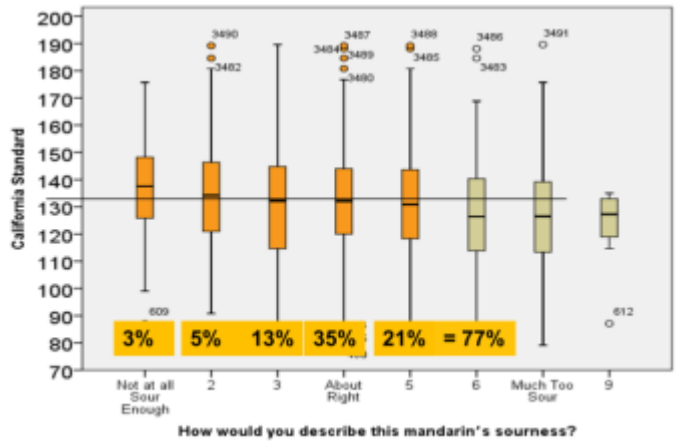
Figure 190 Perceived Mandarin Sourness



Mandarin Sourness V. Californian Standard

In looking at mandarin sourness, the Standard would be set at 132 to satisfy 50% of consumers rating the mandarin samples 2, 3, 4 'just right' and 5 (Figure 191).

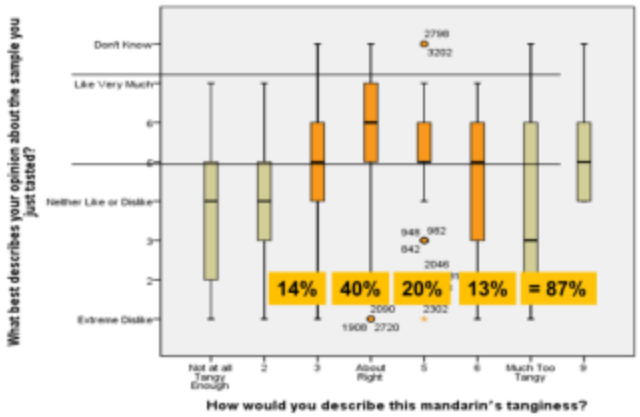
Figure 191 Perceived Mandarin Sourness V. Californian Standard



Perceived Mandarin Tanginess V. Opinion

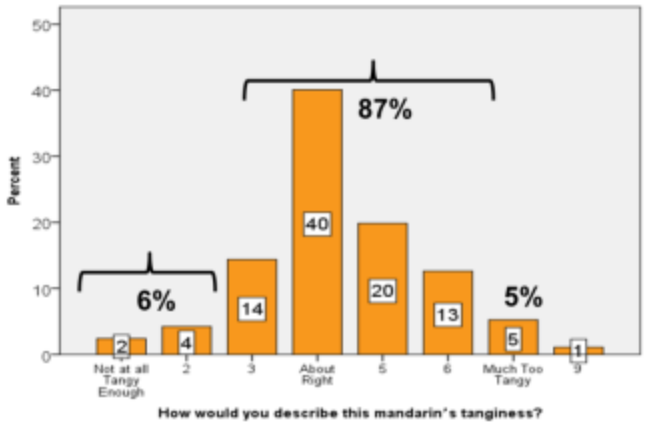
Consumers liked mandarins (5-7) when the tanginess rating was between 3 to 6 (Figure 192).

Figure 192 Perceived Mandarin Tanginess V. Opinion



This equated to most (87%) liking the tanginess of the mandarin samples (3-6), while some thought samples were too tangy (5%) or not tangy enough (6%) (Figure 193).

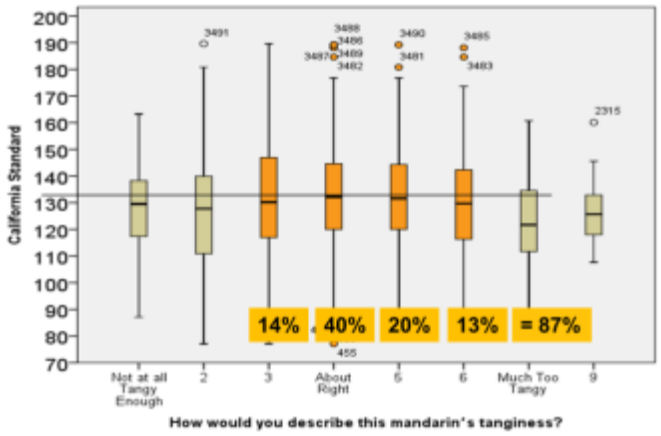
Figure 193 Perceived Mandarin Tanginess



Mandarin Tanginess V. Californian Standard

In looking at mandarin tanginess, the Standard would be set at 132 to satisfy 50% of consumers rating the mandarin samples3, 4 'just right', 5 and 6 (Figure 194).

Figure 194 Perceived Mandarin Tanginess V. Californian Standard



Mandarin Perception Conclusions

In conclusion preliminary assessment of the minimum mandarin standard based on the perceptions of the mandarin samples in terms of flavour, sweetness, sourness and tanginess was to set it at 132. This provides confidence in previous analysis as it is close to the assessments of the mandarin samples in terms of liking, willingness to purchase and purchase more (minimum standard of 130).

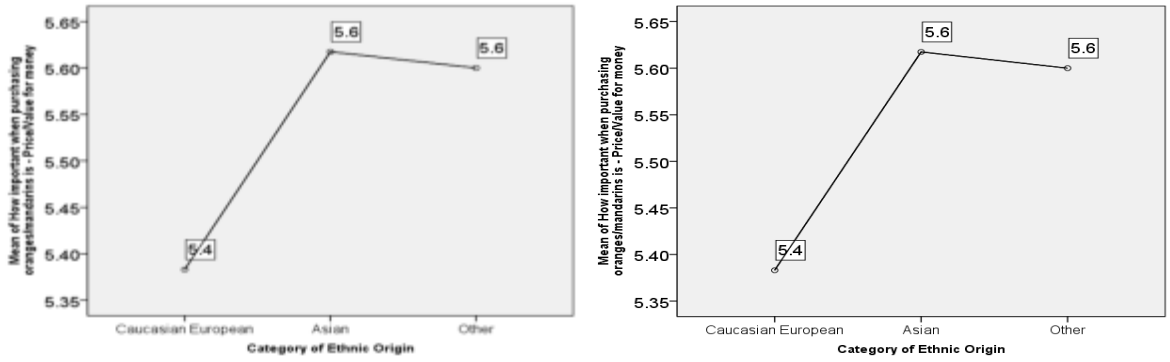
Appendix 12 Important Mandarin & Orange Shopping Attributes V. Ethnic Origin

When comparing the ethnic origin differences to what consumers were looking for when shopping there was some similarity in responses from both the mandarin and orange panel surveys. To see if a clearer picture of results the two panel results were combined and the analyses run again.

In looking at all mandarin and orange panellists together, there were statistically significant differences between ethnic groups when looking for: Price/ Value for Money, Easy to peel, Skin colour, Blemish free, Health benefits, Sweetness, Juiciness, Freshness, Sweet & sour balance and Tanginess. There were no significant differences between ethnic groups when shopping for mandarins in looking for: Sourness, No Seeds and Good taste/ flavour.

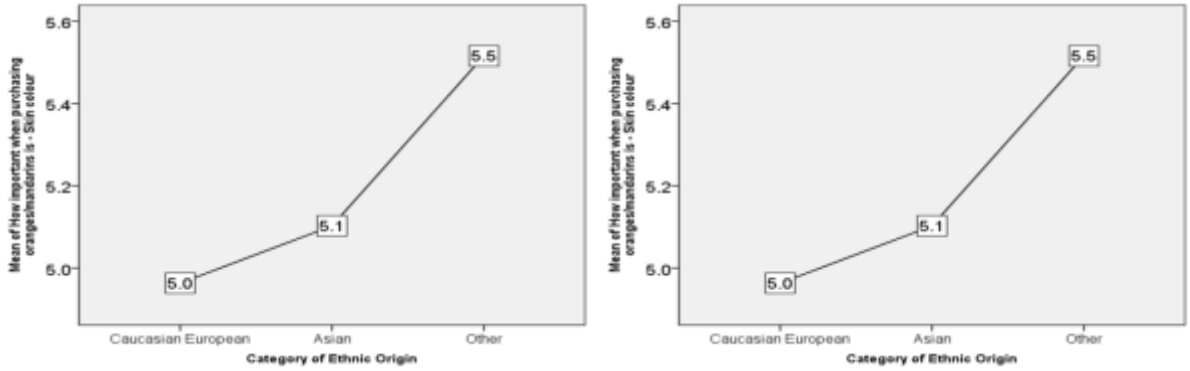
For panellists of Caucasian Europeans' ethnic origin price/value for money and easy to peel was less important (Figure 195).

Figure 195 Orange & Mandarin Price/ Value for Money and Easy to Peel V. Ethnic Origin



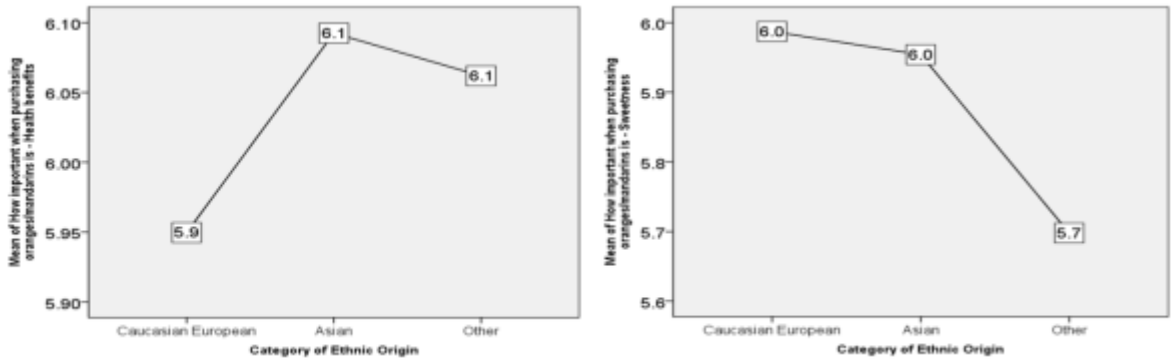
Panellists of 'Other' ethnic origins looked more for skin colour and blemish free (Figure 196).

Figure 196 Orange & Mandarin Skin Colour & Blemish Free V. Ethnic Origin



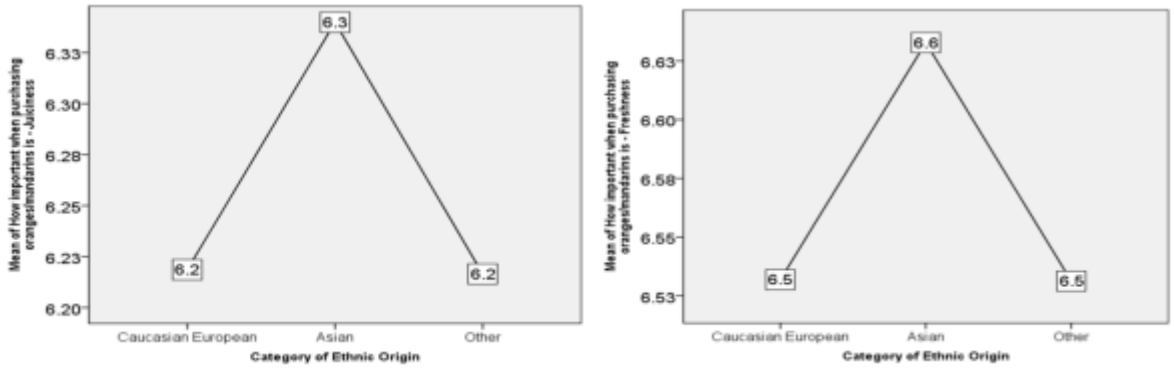
For panellists of Caucasian Europeans' ethnic origin health benefits was less important and for panellists of 'Other' ethnic origins sweetness was less important (Figure 197).

Figure 197 Orange & Mandarin Health Benefits and Sweetness V. Ethnic Origin



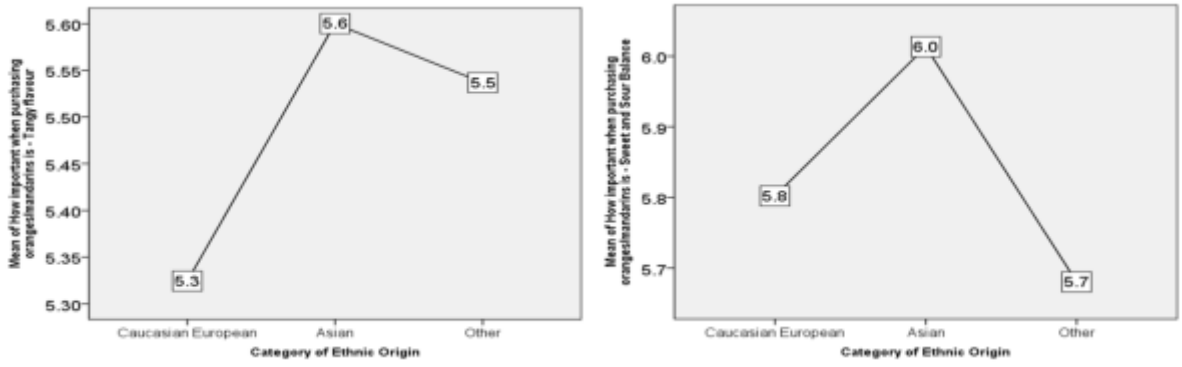
Panellists of 'Asian' descent looked more for juiciness and freshness (Figure 198).

Figure 198 Orange & Mandarin Juiciness and Freshness V. Ethnic Origin



Panellists of 'Asian' descent looked more for tangy flavour and a balance of sweet and sour flavours (Figure 199).

Figure 199 Orange & Mandarin Tangy Sweet & Sour Balance and Flavour V. Ethnic Origin



Conclusions Mandarin and Orange Ethnic Origin Differences in Shopping Attributes

There were some differences in what consumers from different ethnic origins were looking for when shopping for orange and mandarin citrus fruit. Those of 'Asian' origin were more likely to look for juiciness, freshness and a tangy flavour so long as there is a balance in sweet and sour flavours. Those of 'Other' ethnic origin looked more for citrus skin colour and blemish free but not as much for sweetness. Those of 'Caucasian European' origin looked less for citrus price/ value for money and easy to peel.

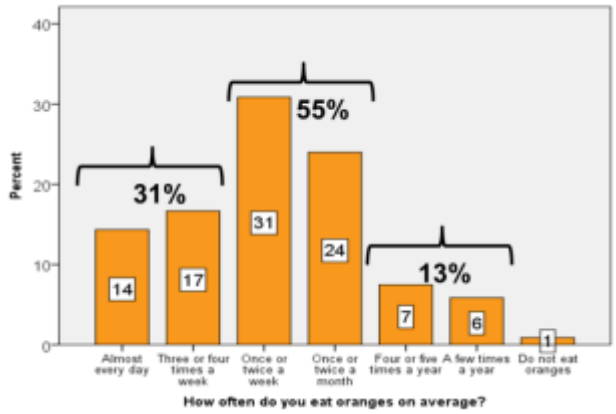
Appendix 13 -Orange Eating & Shopping Patterns

General Orange eating and shopping pattern information was collected on the frequency and occasions oranges were eaten, if other tangy fruit was eaten and what were important attributes when shopping for oranges.

Frequency Oranges Eaten

A third (31%) of consumers ate oranges frequently – on average almost once a day and three or four times a week (Figure 200). Over half (55%) ate oranges regularly – once to twice a week/month.

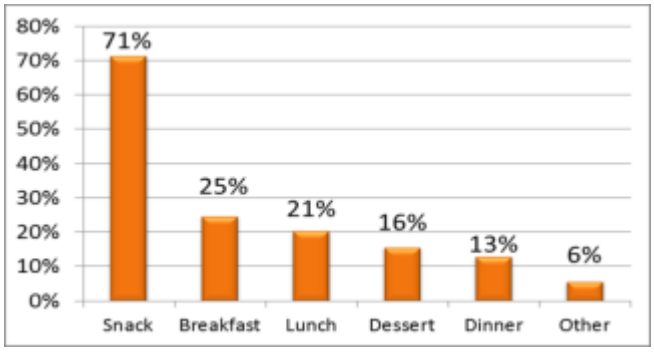
Figure 200 Frequency Oranges Eaten



Occasions Oranges Eaten

Oranges were mostly eaten mostly for snacks (71% - Figure 201)

Figure 201 Occasions Oranges Eaten



Eating Other Tangy Fruit

Over half (54%) of oranges eaters also ate other tangy fruit. The most popular other tangy fruit was mandarins (11%), grapefruit (8%) and lemons (7%) (Figure 202).

Figure 202 Other Tangy Fruit Eaten

Mandarin	11%
Grapefruit	8%
Lemon	7%
Apple	6%
Kiwi fruit	6%
Pineapple	6%
Lime	4%
Mango	2%

Important Attributes when Shopping for Oranges

The most important attributes when shopping for oranges were good taste/flavour (mean 6.6) followed by freshness (mean 6.5) and juiciness (mean 6.3) (Figure 203). Notably the taste attributes were by far more important than other attributes like price/value for money (mean 5.4) and visual attributes like being blemish free and skin colour (mean 5.1).

Figure 203 Important Attributes when Shopping for Oranges

How important when purchasing oranges is	Mean	Std. Deviation
Good taste/Flavour	6.6	0.8
Freshness	6.5	0.9
Juiciness	6.3	1.1
Health benefits	5.9	1.5
Sweetness	5.9	1.3
Sweet and Sour Balance	5.9	1.3
Price/Value for money	5.4	**1.6**
Tangy flavour	5.4	1.5
Blemish free	5.1	**1.8**
Skin colour	5.1	**1.7**
Easy to peel	4.7	**2.0**
Sour	4.7	**1.7**

Related shopping attributes were determined based on a factor analysis. Different types of attributes included visual appeal, taste and skin attributes (Figure 204).

Figure 204 Related Attributes when Shopping for Oranges

How important when purchasing oranges is:	1	2	3	4
Visual Appeal Attributes				
Freshness	.80			
Good taste/Flavour	.78			
Juiciness	.66			
Health benefits	.63			
Sweetness	.56			
Taste Attributes				
Sour		.82		
Tangy flavour		.79		
Sweet and Sour Balance		.72		
Skin Attributes				
Skin colour			.84	
Blemish free			.83	
Easy to peel			.52	
Other Attributes				
Price/Value for money				.87
Eigen Value	3.7	1.6	1.3	0.9
Cronbach Alpha	0.75	0.71	0.66	
63% Variance Explained	31%	13%	11%	7%

Orange Eating & Shopping Pattern Conclusions

Most panellists ate oranges regularly (55%), with a third eating them frequently (31%) and fewer eat oranges occasionally (13%). They were mostly eaten for snacks (71%). Over half (54%) of oranges eaters also ate other tangy fruit with the most popular being mandarins (11%), grapefruit (8%) and lemons (7%). The most important attributes when shopping for oranges were good taste/flavour (mean 6.6) followed by freshness (mean 6.5) and juiciness (mean 6.3). The taste attributes were by far more important to consumers than other attributes like price/value for money (mean 5.4) and visual attributes like being blemish free and skin colour (mean 5.1) often pushed by dealers in food chains.

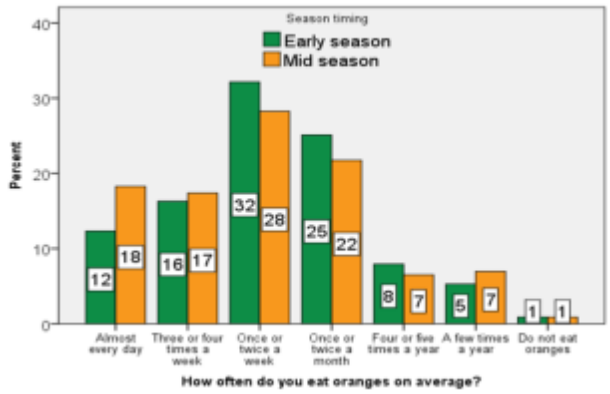
Comparisons Early V. Mid-Season Orange Panel Eating & Shopping Patterns

Comparisons were made between responses in the early and mid-season panels in terms of eating and shopping patterns.

Orange Eating Frequency – Early V. Mid-Season Panels

Oranges were eaten more frequency mid-season and in the early season (Figure 205).

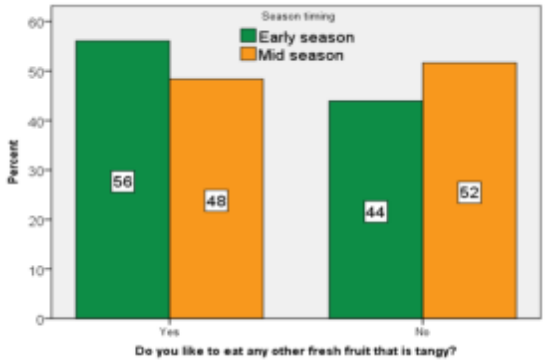
Figure 205 Orange Eating Frequency – Early V. Mid-Season Panels



Eating Tangy Fruit – Early V. Mid-Season Panels

More tangy fruit was eaten early in season (56%) than in mid-season (48%) (Figure 206).

Figure 206 Eating Tangy Fruit – Early V. Mid-Season Panels

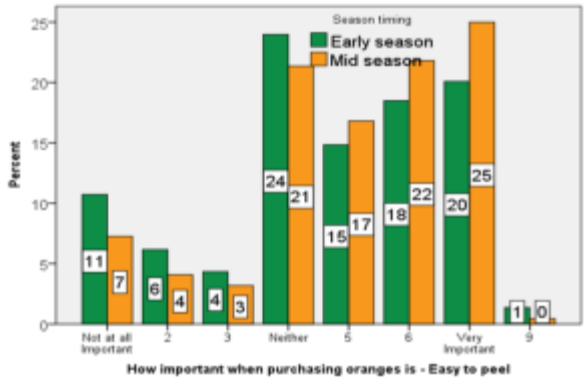


Important Orange Shopping Attributes – Early V. Mid-Season Panels

There were no significant differences of importance when shopping for: Price / Value for Money, Skin Colour, Blemish Free, Juiciness, Freshness, and Good Taste / Flavour. There were statistically some significant differences.

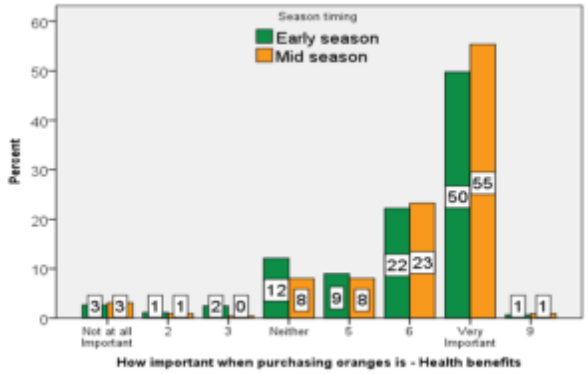
Easy to peel was rated as more important mid-season than in the early season panels (mean mid-season 5.1 V early 4.7) (Figure 207).

Figure 207 Orange Easy to Peel – Early V. Mid-Season Panels



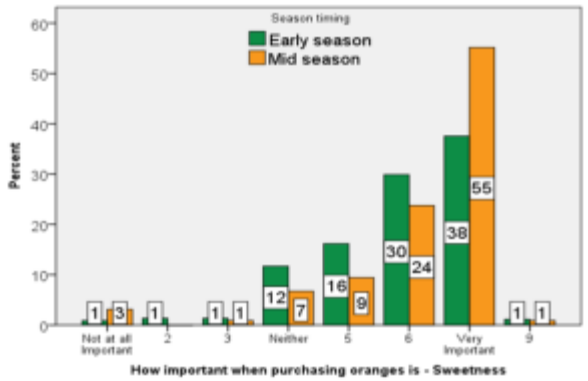
Health benefits was rated as more important mid-season than in the early season panels (mean mid-season 6.1 V early 5.9 (Figure 208).

Figure 208 Orange Health Benefits – Early V. Mid-Season Panels



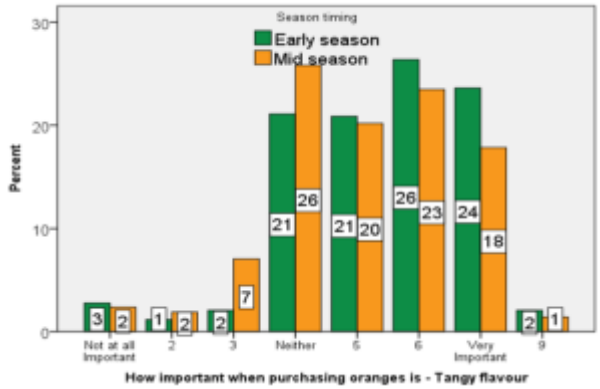
Sweetness was rated as more important mid-season than in the early season panels (mean mid-season 6.1 V early 5.9) (Figure 209).

Figure 209 Orange Sweetness – Early V. Mid-Season Panels



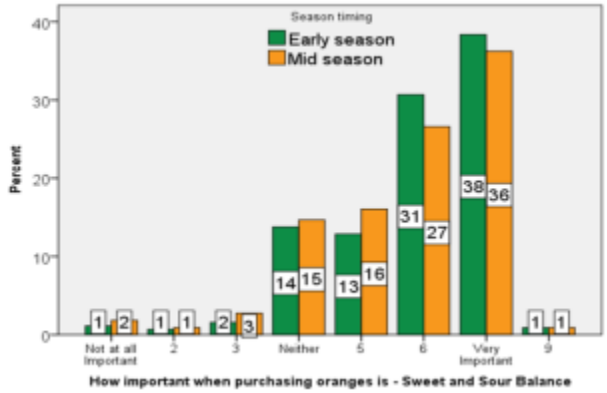
Tangy flavour was rated as less important mid-season than in the early season panels (mean mid-season 5.1 V early 5.4) (Figure 210).

Figure 210 Orange Tangy Flavour – Early V. Mid-Season Panels



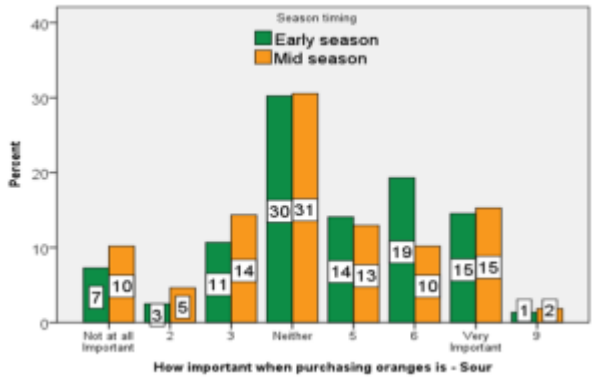
Sweet sour balance was rated as less important mid-season than in the early season panels (mean mid-season 5.7 V early 5.9) (Figure 211).

Figure 211 Orange Sweet & Sour Balance – Early V. Mid-Season Panels



Sourness was rated as less important mid-season than in the early season panels (mean mid-season 4.3 V early 4.7) (Figure 212).

Figure 212 Orange Sourness – Early V. Mid-Season Panels



Orange Early V. Mid-season Conclusions

In terms of eating patterns, oranges were eaten more frequently mid-season and less tangy fruit was eaten mid-season.

Attributes more important when shopping for oranges mid-season were easy to peel, health benefits and sweetness. Attributes less important when shopping for oranges mid-season were tangy flavour, sweet & sour balance and sourness.

Appendix 14 - Ethnic Origin Orange Differences

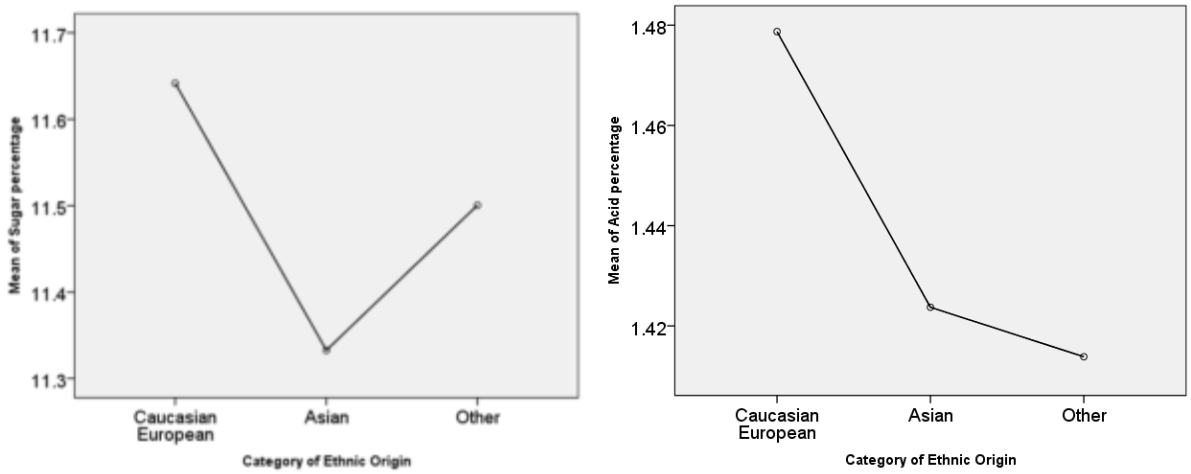
The ethnic origins of the orange panellists were varied with most from 'European Caucasian' descent (66% = 466 consumers) followed by 'Asian descent' (22% = 154) and 'Other' groups (9% = 65). Based on anecdotal comments of differences in demands for oranges by consumers of Asian descent, ethnic origin were assessed in terms of sample characteristics and attributes important when shopping.

Orange Sample Characteristics V. Ethnic Origin

There were some statistically significant differences between ethnic groups for orange samples provided in terms of Brix and Acid percentage. There were no significant differences between ethnic groups for orange sample provided in terms of Flavour; Sourness; Tanginess; Sugar/acid ratio or California Standard.

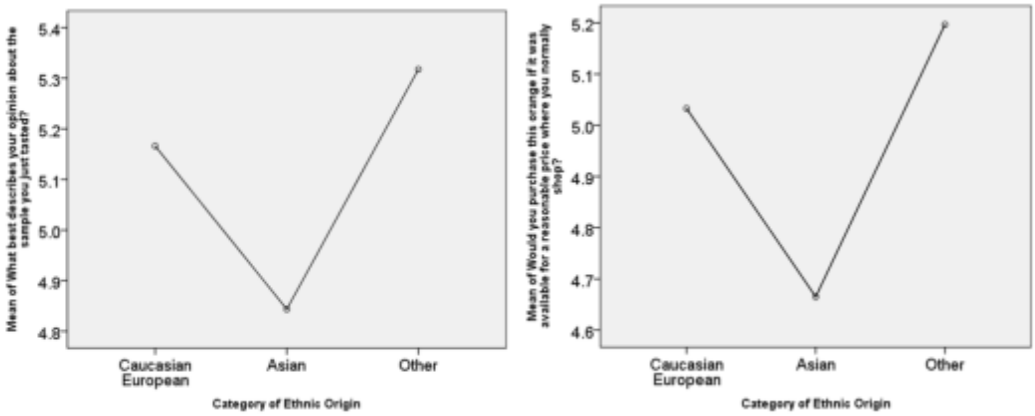
Panellists of 'Asian' descent received orange samples that were less sweet and those of European Caucasian descent received samples that were more acidic (Figure 213).

Figure 213 Orange Brix and Acid % V. Ethnic Origin



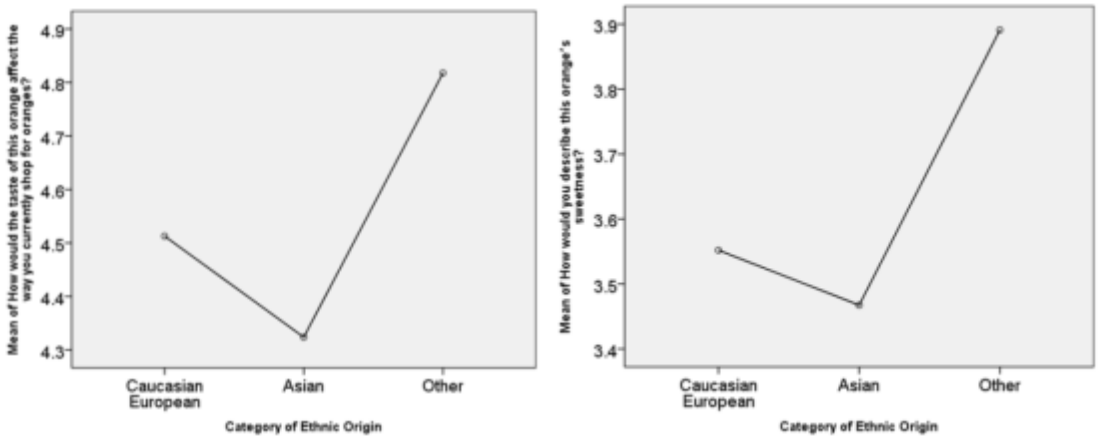
Panellists of 'Asian' descent liked fewer of the orange samples and were less likely to purchase oranges like the samples tasted (Figure 214).

Figure 214 Orange Opinion & Willingness to Purchase V. Ethnic Origin



Panellists of 'Other' descents were more willing to purchase orange samples tasted and perceived the orange samples were sweeter (Figure 215).

Figure 215 Orange Opinion & Willingness to Purchase V. Ethnic Origin

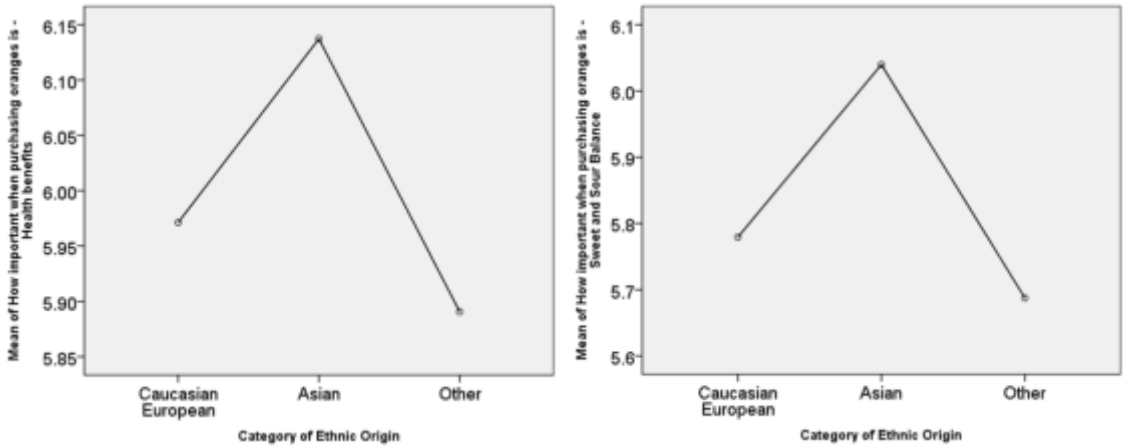


Important Orange Shopping Attributes V. Ethnic Origin

There were differences between ethnic groups in what they were looking for when shopping for oranges: Easy to peel, Health benefits, Sweet & sour balance, Skin colour, Good taste/ flavour, Blemish free and Sweetness. There were no significant differences between ethnic groups when shopping in looking for: Price/ Value for Money, Juiciness, Freshness, Tanginess and Sourness.

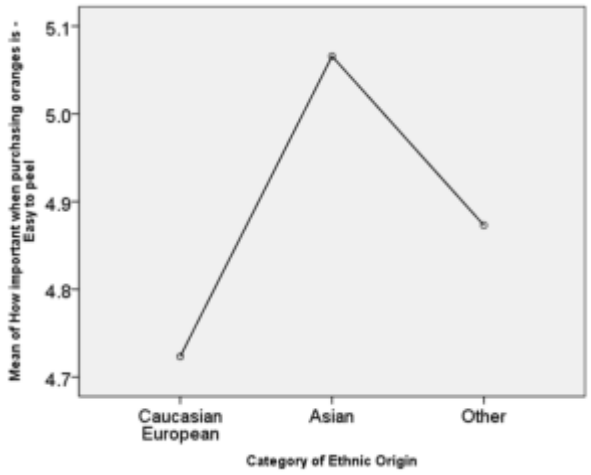
Panellists of 'Asian' descent looked more for health benefits and sweet & sour balance in oranges (Figure 216).

Figure 216 Orange Health Benefits and Sweet & Sour Balance V. Ethnic Origin



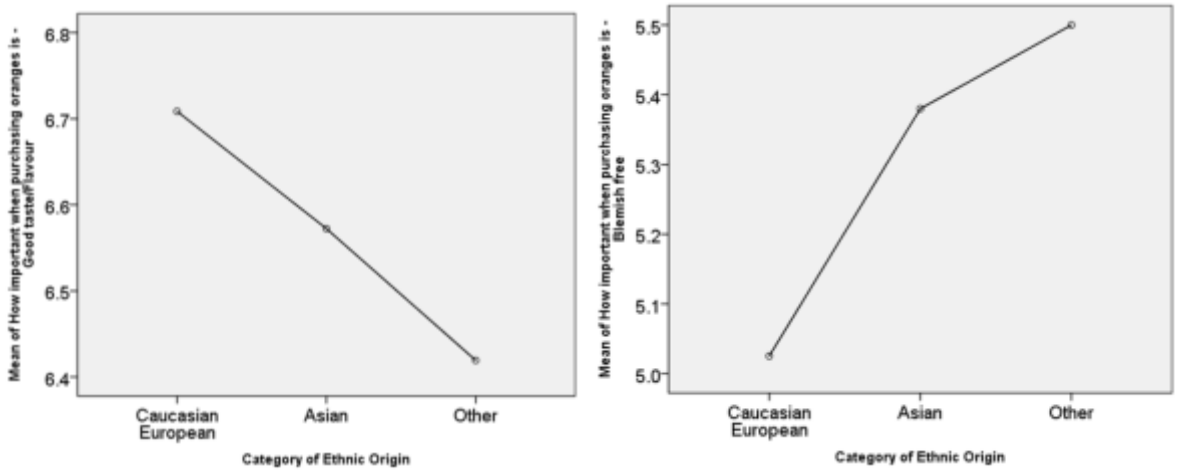
Panellists of 'Asian' descent looked more for easy to peel oranges than 'Caucasian Europeans' (Figure 217).

Figure 217 Orange Easy to Peel V. Ethnic Origin



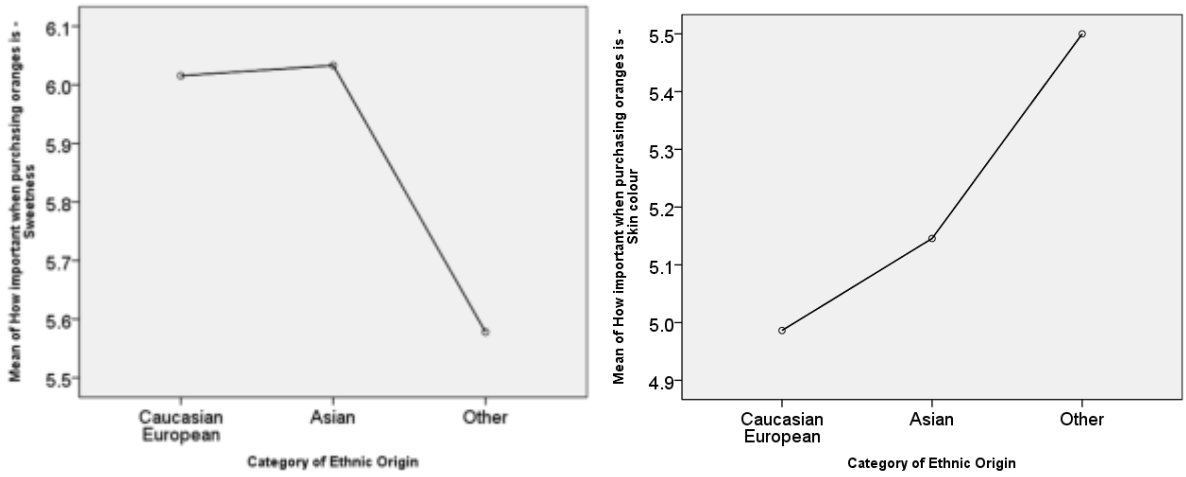
Panellists of 'Caucasian Europeans' descent looked more for Good taste/flavour and less for Blemish free oranges (Figure 218).

Figure 218 Orange Good taste/flavour & Blemish free V. Ethnic Origin



Panellists of 'Other' descents looked less for sweetness and more for skin colour in oranges (Figure 219).

Figure 219 Orange Sweetness & Skin Colour V. Ethnic Origin



Conclusions Orange Ethnic Origin Differences

Panellists of 'Asian' descent received orange samples that were less sweet, liked them less and were less likely to purchase them. Panellists of 'Other' ethnic origin perceived orange samples were sweeter and were more likely to purchase more. Panellists' of 'European Caucasian' descent received orange samples that were more acidic. Given the random chance groups of different ethnic origin received slightly different types of orange samples it is hard to know if the differences in response to the orange samples may be due to the nature of samples tasted or ethnic origin. Further research will need to be undertaken to determine this. Preferably research would be conducted in overseas countries as the time spent in Australia may have an influence on response.

There were some differences in what groups from different ethnic origins were looking for when shopping for oranges. Those of 'Asian' origin were more likely to look for: easy to peel, health benefits and sweet & sour balance in oranges. Those of 'Caucasian European' origin looked more for good taste/ flavour oranges and less than other groups for blemish free oranges. Those of 'Other' ethnic origin looked more for skin colour but less for sweetness in oranges. There were no differences in importance for orange: price/ value for money, juiciness, freshness, tangy flavour and sourness.

Appendix 15 Age Differences

From anecdotal evidence it was suggested that there may be differences in younger and older consumers orange eating habits and their potentially their responses to the orange samples. To test this hypothesis, the differences in age groups were assessed in terms of demographic characteristics of consumers, orange eating and purchasing patterns as well as sample attributes and responses to samples.

Age Categories V. Demographics

To determine if there were differences in age categories in the people recruited to the orange taste panels they were compared in terms of gender, time lived in Australia and ethnic origin.

More females in older categories (62% 30+ years) were recruited to the orange taste panels. This related to the larger number of older female shoppers recruited in the shopping centre panels.

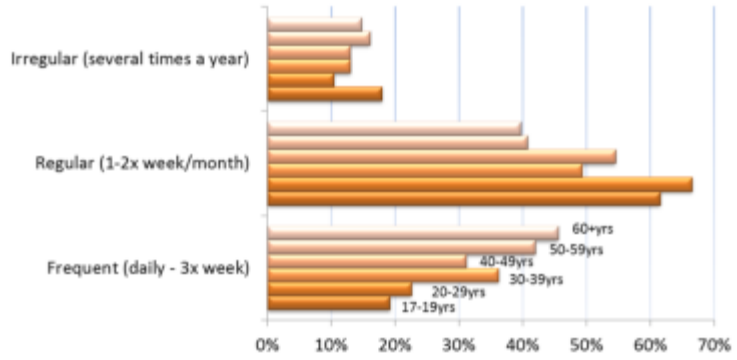
The finding that younger orange panellists had lived less time in Australia was to be expected. Similarly it was expected that the older orange panellists were more likely to be Caucasian European ethnic origin (40+ years) as the younger recruits from the Universities were more likely to be from international backgrounds.

Age Categories V. Orange Eating Patterns

General Orange eating and shopping pattern information was collected on the frequency and occasions oranges were eaten, if other tangy fruit was eaten and what were important attributes when shopping for oranges.

It was found that older panellists (50 years plus) more consistently eat oranges daily to three times a week (Figure 220). Those 20 years and younger were more likely to eat oranges 1-2 times a week or month. Irregular orange consumers were similar across all age categories.

Figure 220 Age Categories V. Orange Eating Frequency



This finding may relate to older panellists (50+ years) being more likely to eat other tangy fruit (59%-63%).

The pattern of occasions (meals) when oranges were eaten was mixed:

Breakfast 17-19 years 30%

Lunch for <17 years 29% & 50-59 years 27%

Dinner 25-29 years 23%

Desert 17-19 years 26%

Snack 40-49 years 79%

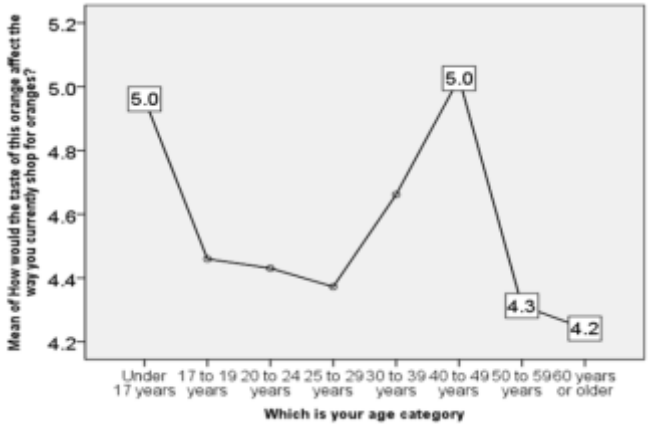
Age Categories V. Orange Sample Responses

To determine how the orange samples provided each of the age categories were different, the characteristics of the orange samples were compared in terms of Brix (total soluble solids), acid %, brix acid ratio and Californian Standard. Differences were also assessed in terms in panellist's responses to orange sample perceived sweetness, flavour, sourness and sweet and sour balance.

There were significant differences by age group for orange sample characteristics in terms of consumers' willingness to purchase more oranges, perceived orange sample flavour, perceived orange sample sweetness and sample Brix levels, orange sample perceived tanginess and acid percentage. There were no significant differences by age group for: overall opinion about orange samples, willingness to purchase oranges if a reasonable price, orange sugar to acid ratio, California standard and orange sample sourness.

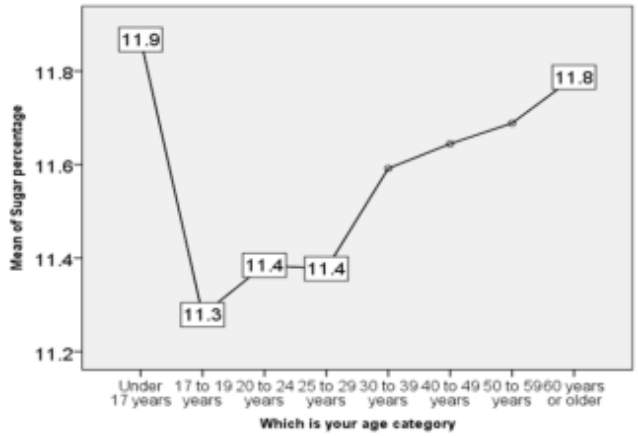
There was greater willingness to purchase more by panellists less than 17 years (n=33 – 5%) and between 40 and 49 years (n=77 – 11%) compared to those 50 years and over (Figure 221). The age categories that were significantly different to other categories are indicated by the mean response shown in the figure e.g. 5.0 and 4.2. The differences in responses may be explained by the characteristics of the samples presented to the age groups.

Figure 221 Age Categories V. Orange Purchase More



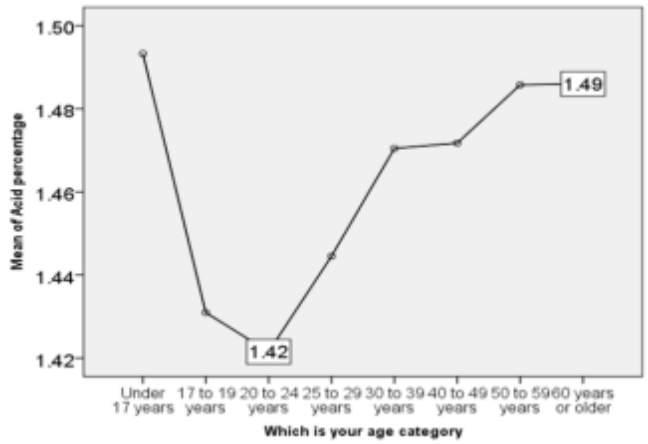
The younger panellists (< 17 years; n=33 – 5%) and older panellists (60+ years; n=137 – 20%) were offered orange samples that had statistically higher Brix (Figure 222).

Figure 222 Age Categories V. Orange Brix



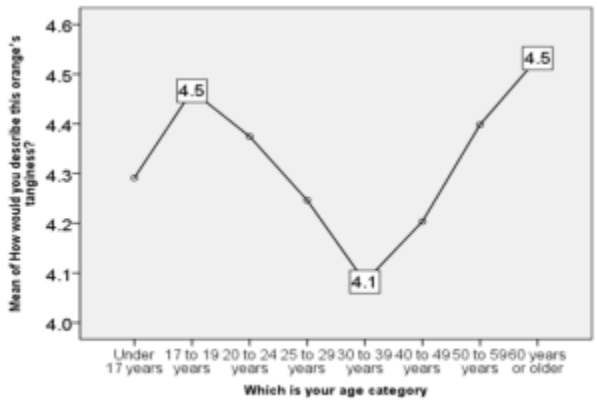
The younger panellists (< 17 years; n=33 – 5%) and older panellists (60+ years; n=137 – 20%) were also offered orange samples that had statistically higher acid percentage compared to those 20-24 years (n=113 – 16%) (Figure 223). However in practical terms this level of discernment is difficult for consumers to pick up and the principle finding is that sugar and acid are considered in a balance not individually by consumers.

Figure 223 Age Categories V. Orange Acid %



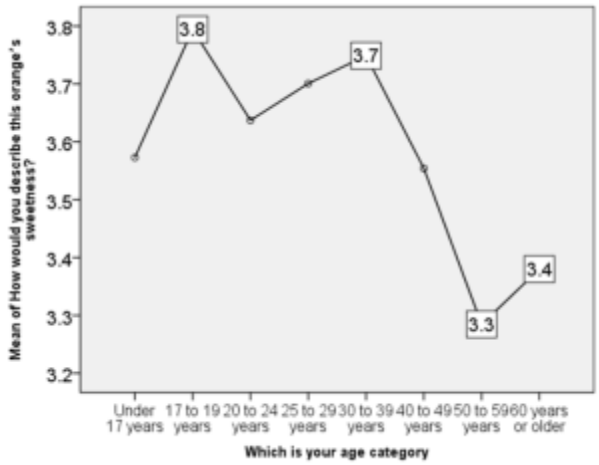
The older panellists (60+ years; n=137 – 20%) perceived the orange sample they tasted was more tangy (Figure 224).

Figure 224 Age Categories V. Orange Tang Perception



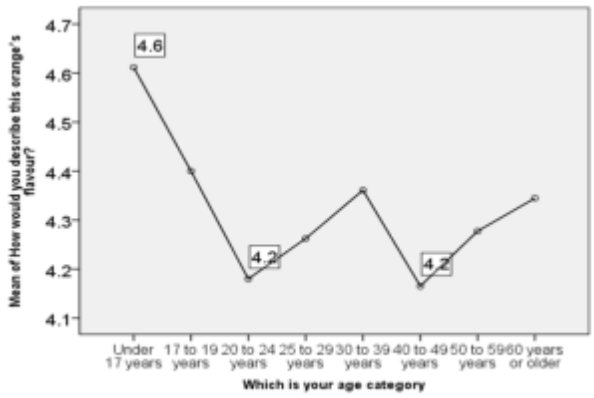
The older panellists (50+ years; n=219 – 31%) perceived the orange sample they tasted was less sweet (Figure 225).

Figure 225 Age Categories V. Sample Orange Sweetness Perception



The younger panellists (< 17 years; n=33 – 5%) perceived the orange sample they tasted had a stronger flavour (Figure 226).

Figure 226 Age Categories V. Orange Flavour

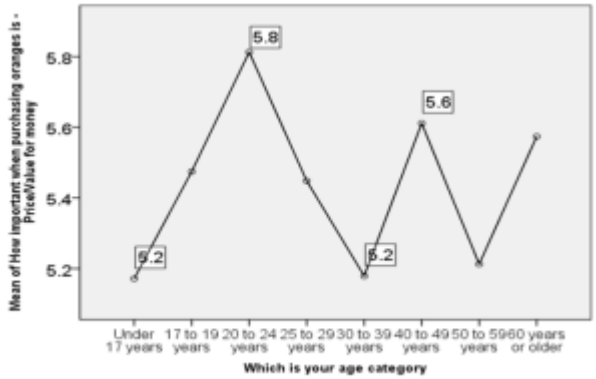


Age Categories V. Orange Purchase Attributes

There were statistically significant differences in age categories for: Value for Money, Easy to Peel, Juiciness, Freshness, Health Benefits, Good Taste / Flavour, Sweetness, Sourness, Sweet & Sour Balance. There were no statistically significant differences in age categories for: Skin Colour, Blemish Free, Tangy Flavour.

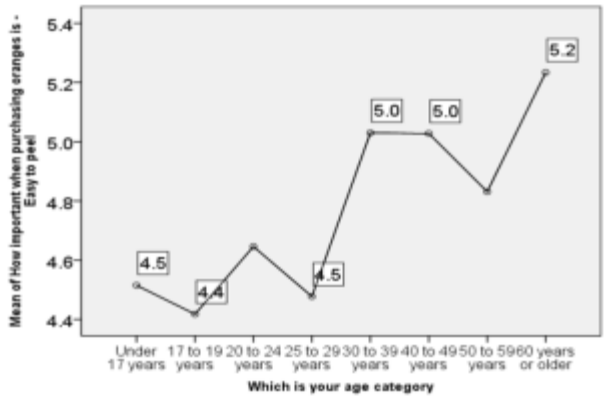
Age group differences in value for money importance pattern was unclear (Figure 227). The differences may relate to family life cycle stage with value for money being important when being a student away from home (20-24 years) and rearing a family and paying off a mortgage/school fees (40-49 years). However, as data was not collected on this question the reason can only be hypothesised.

Figure 227 Age category V Value for money importance



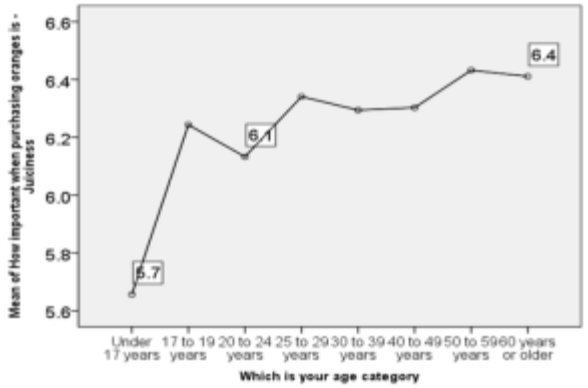
Easy to peel was more important for older shoppers (Figure 228).

Figure 228 Age Categories V. Orange Easy to Peel Importance



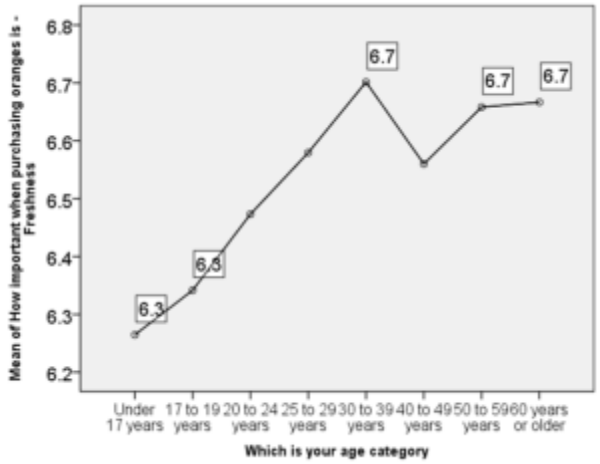
Juiciness was more important older shoppers (Figure 229).

Figure 229 Age Categories V. Orange Juiciness Importance



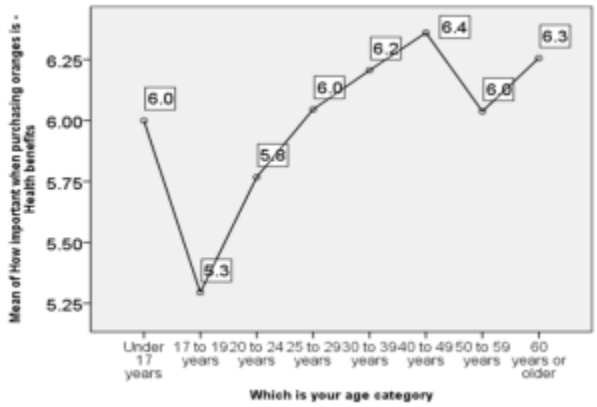
Freshness was more important to older shoppers (Figure 230).

Figure 230 Age Categories V. Orange Freshness Importance



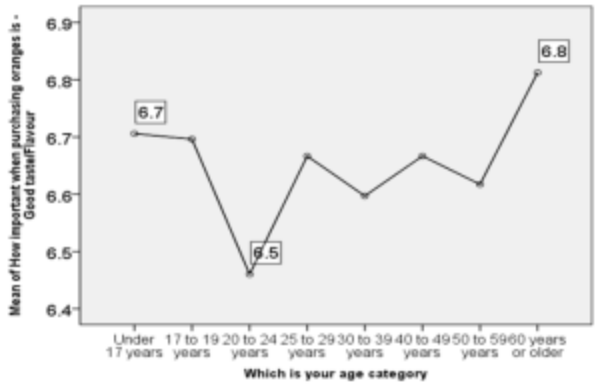
Health benefits were more important to older shoppers (Figure 231).

Figure 231 Age Categories V. Orange Health Benefits Importance



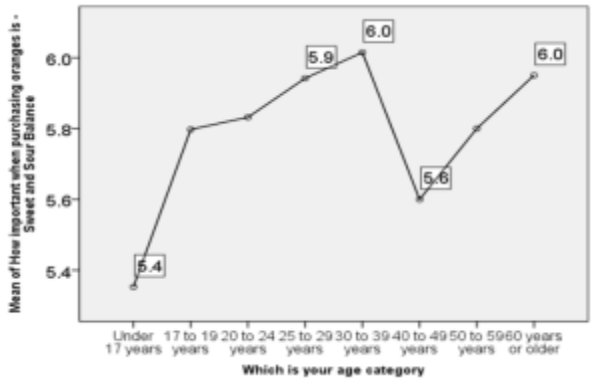
A good taste/flavour seemed more important to older shoppers (except <19 years) although the sample numbers were small (Figure 232).

Figure 232 Age Categories V. Orange Good Taste/Flavour Importance



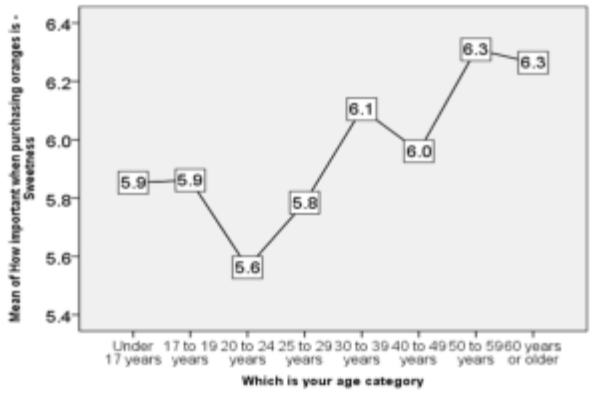
The sweet sour balance was more important to adult shoppers (except 40-49 years) (Figure 233).

Figure 233 Age Categories V. Orange Sweet Sour Balance Importance



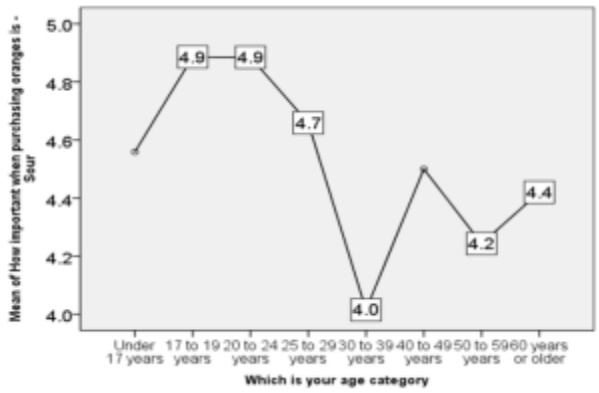
Sweetness was more important to adult shoppers (except <19 years) (Figure 234).

Figure 234 Age Categories V. Orange Sweetness Importance



Sourness was less important to older shoppers (Figure 235).

Figure 235 Age Categories V. Orange Sourness Importance



Conclusions Orange Age Category Differences

Older panellists more consistently eat oranges and were more likely to eat other tangy fruit. Most attributes were more important for older shoppers: Easy to peel, Juiciness, Freshness, Health benefits, Good taste/flavour, Sweet & sour balance, Sweetness. Sourness was less important. All attributes may be important with a greater professional home maker role but this information was not collected so the reason is unclear in this research.

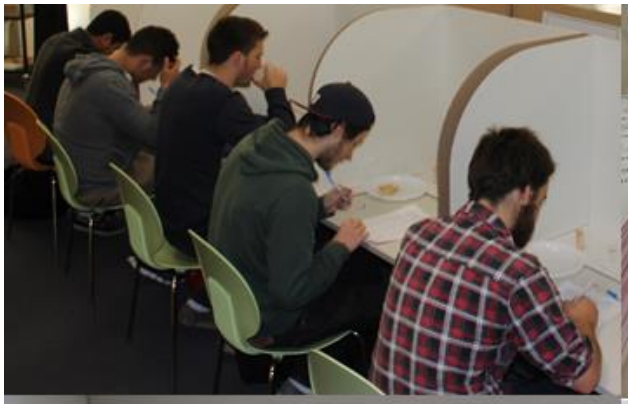
Conclusions cannot be drawn from the results on younger consumers orange taste preferences because they were presented with statistically different orange samples. Conclusion can be drawn on how they responded to the different samples. While both the younger and older panellists tasted fruit that had a higher Brix and higher acid, the older panellists perceived these orange samples as being less sweet and more tangy while the younger consumers perceived these orange samples as being more flavoursome. The younger consumers were more willing to purchase more of this fruit while the older consumers were less willing. With the small sample sizes it is recommended that further work is done to corroborate these results.

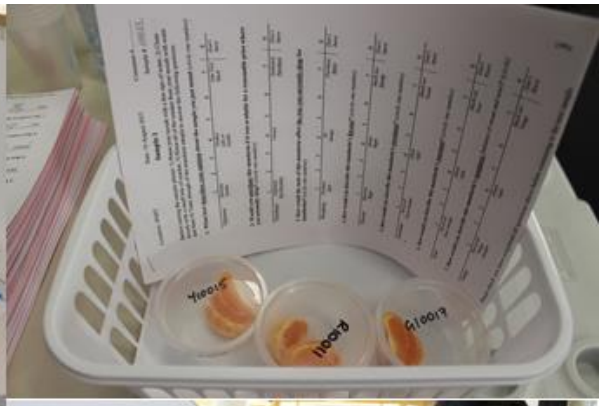
Appendix 16 Photographs depicting key aspects of the methodology

- Fruit was harvested from blocks that had been selected after a series of fruit maturity tests were conducted and analysed.
- Fruit was pre sized in the orchard and later size graded on the packing line. 73-79mm range navels and 50-57mm Afourers were chosen (most popular retail sizes).
- External colour of the fruit was not important as the skins were removed prior to the consumer seeing he sample.

- Fruit was picked and packed in a maximum of 4 hours.
- Fruit received fungicide treatment and waxing to replicate normal processing of citrus for consumers.
- Any split or damaged fruit was rejected
- The same processes were carried out for both mandarin and navel fruit.
- The fruit was batched through the packing line to keep the different varieties and maturity categories separate through the process.

- The fruit was halved through the axis. A wedge was cut to remove the stem and navel ends of the fruit for juicing.
- The flesh was removed from the skin for each sample. Each container contained two bite sized pieces.
- The navel and stem ends were used to create the juice sample for testing, using a garlic crusher and sieve.
- Brix readings of the juice sample were obtained using a digital refractometer. Acid percentage was determined using titration.
- Results were recorded on a record sheet by hand and then entered directly into an excel spreadsheet to determine the maturity levels. Some fruit were discarded at this point based on required parameters.
- Samples were numbered and traceable from consumer response to orchard block.
- Samples were kept cool to avoid development of off flavours.





- The research team conducted surveys in shopping centers, fresh food markets and at university campuses.
- University campuses preferred the use of survey booths for privacy and ethical purposes where as super markets requested low height, open tables to reduce the visual impact on the store.
- Each survey was assigned a consumer number and the numbers of the samples entered on the form by a research assistant. Samples were placed randomly, but each consumer had a sample from each maturity range.
- Consumers had water and crackers to cleanse their palate, toothpicks to pick up the samples, paper towel, a survey and pen and three fruit samples provided prior to them being seated.
- Research assistants provided explanation and assistance as required.
- Consumers were 'recruited by research assistants and brought to the sampling area.
- Analysis of the demographics showed a good range of gender, age and ethnicity was achieved.

Sensory evaluation of imperial mandarins by a trained panel using Quantitative Descriptive Analysis (QDA®) tool

An interim report submitted to Citrus Australia Ltd.

Prepared by

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Summary

Imperial mandarins are the most common form of mandarins' in Queensland supermarkets. This study was designed to evaluate and demonstrate the performance of the sensory panel trained for the QDA® (quantitative descriptive analysis) assessment of imperial mandarins and to provide Citrus Board Australia with useful information about the sensory characteristics of non-granulated imperial mandarins that differentiates them from granulated mandarins. Imperial mandarins with different levels of granulation were investigated and sensory profiles were established and compared. The panel have successfully developed a sensory lexicon for imperial mandarins with and without granulation. The panel then followed it with successfully discriminating mandarins with different levels of granulation for all the sensory attributes except sourness. The pheno-physiological characteristics (size of the fruit, colour, brix, juice content, pH, acidity, hardness and chewiness of the mandarin segments with different level of granulation were measured. The measurements do not show any specific trend with degree of granulation.

Introduction

Imperial mandarin was introduced in Emu Plains, near Sydney, Australia in 1890 which is the hybrid of 'Mediterranean' and 'Willowleaf' mandarin. It is widely produced in Australia, with a major portion grown in Queensland. Imperial mandarins are small to medium sized, firm, easy to peel fruits intended primarily for fresh market. However, the imperial mandarins are highly susceptible to granulation or dryness. The high rate of granulated fruit has resulted in high reduction of fruit quality and acceptability, thus decreasing the commercial value (Siebert, Krueger, Kahn, Bash & Vidalakis, 2010).

The main cause of granulation has yet to be identified but it has been related with many factors like frequency or irrigation, level of nitrogen, luxurious growth, rootstocks, harvesting time, nutritional requirements during growth and many more. It is very implausible that the granulation will be purged, so the most significant way through the condition is to either develop the method which can sort the granulated and non-granulated ones or establish the permissible limit up to which the granulation can be ignored. The occurrence of granulation is variable and depends on many factors. It has been studied for years but no sufficient evidence has been collected to address this defect. Many trials to confirm the cause and reduce the number of granulated mandarins has been undertaken, though some are successful, many had no fruitful result (Food, 2013).

Any fruit has a unique sensory characteristic that precisely identifies with all of the perceived sensory attributes of that product. Descriptive sensory analysis study results in a profile of those sensory characteristics. The sensory analysis helps to identify variations in sensory attributes of the products associated with growth, environmental factors, processing variables, additives, storage etc., which helps resolve numerous other issues important to the acceptance of these products by consumers.

Dry fruit or granulation is a condition associated with Imperial mandarins in which the juice sacs become turgid because of gel formation. Imperial mandarins when affected by granulation develop low juice levels and loss of taste. The fruit develop a flat, insipid taste as they lose some of their sugar and acid which is held predominantly in the juice.

Sensory evaluation of mandarins both with and without granulation by a trained panel will help establish the sensory differences between them.

The main objectives of the current research are

(a) To develop a vocabulary that describes the sensory properties of imperial mandarins with a trained panel using descriptive sensory analysis.
(b) The panel will be selected and trained following the ISO standard 8586-1.
(c) The trained panelists will evaluate mandarins with and without granulation and categorise the fruits based on different levels of granulations, juiciness, and sweetness.
(d) The physico-chemical properties like pH, brix, acidity and colour of the mandarins will be evaluated. Texture, amount of fruit juice
(e) A scale will be developed to describe the granulation
(f) The relevant sensory attributes and scale will also be evaluated by a consumer panel.

Materials and Methods

Materials

Mandarins: The imperial Mandarins for the study were provided by growers located in different parts of Queensland. The samples were posted to the School of Agriculture and Food Science which were stored in the refrigerator at temperature of 4-5˚C before analysis.

Chemicals: The chemicals used for titration - 0.1N Sodium Hydroxide, Phenolphthalein Indicator and pH buffers 4 and 7 were all of analytical grade and obtained from the University chemical store.

Equipment's: Texture Analyser, Colorimeter, Analytical balance, Refractometer, Digital Vernier Callipers, Hand Held Juicer, Refrigerator, 1-2 mm Diameter mesh, Titration set-up (Burette, clamp and stand, conical flask)

Methods (physio-chemical and sensory)

Segments of mandarins from the same fruit were used for physio-chemical and sensory analysis. For texture and colour measurement, the instruments were directly operated on the segments of the mandarin. Other measurements like pH, Brix and acidity, were carried out on the extracted juice from the sample. The juice was extracted using a hand held juicer.

Physio-chemical analysis on imperial mandarins

pH

The pH of the mandarin juice was measured using a pH meter. The electrode of the pH meter was calibrated with buffers 4 and 7 before use. An aliquot of the juice sample was taken in a beaker into which the pH electrode was dipped and the pH recorded.

Brix

The Brix of the mandarin juice was measured using a digital refractometer. The refractometer is calibrated using deionised water. 3-4 drops of juice was placed in the well of refractometer and the Brix recorded.

Acidity

The acidity of the mandarin juice was measured titre metrically. An aliquot of the juice sample was titrated against 0.1N sodium hydroxide in presence of 3-4 drops of phenolphthalein indicator. The volume of sodium hydroxide consumed was taken into account for calculating acidity using equation Acidity = ml of NaOH * 0.064

Brix/Acid Ratio

The value of Brix and acidity obtained from acidity and Brix measurement was used to calculate the brix/acid ratio.

Colour

The colour of the mandarin samples was measured using the CR-400 Chromameter (Konica Minolta, Tokyo, Japan). After calibration with the white plate, the Chromameter is placed directly onto the mandarin segments and pressed to obtain the CIE L*a*b*

color space values. Further calculation for colour determination was done as per (Lee, 2000).

Texture

The texture analysis of the mandarin segments were done using a CT3 Texture Analyser (Brookfield Engineering, Essex, UK) fitted with a load cell of 4500g, which was remotely controlled by a computer and a cone-shaped acrylic probe (TA2/1000, 60° angle, 30mm diameter). The Texture Analyser was installed with application software (Brookfield Texture PROCT).

A Texture Profile Analysis (TPA) with two-cycle compression was used to measure the force-time curves as penetration profiles, using a trigger load of 1.0g, pre-set test speed 1mm/s and a 10 points/s data rate. Two successive compressions were carried out on each sample directly in the sample, at the test and return speed of 4.5mm/s and target depth of 6mm.

Upon completion of the two compression cycle, the probe was automatically returned to the initial starting point. The probe was cleaned of residual sample sticking to it, and the Texture Analyser reset for the next sample analysis. The resulting force-time curves were developed to obtain hardness, hardness work done, adhesiveness and cohesiveness, with the results automatically calculated by the Texture Analyzer software. The results were tabulated onto Microsoft Excel. All texture analyses were conducted at normal room temperature.

Sensory evaluation

Preparation of samples for sensory analysis

The samples were first weighed; their diameter was measured and labelled in accordance with the growers. Afterwards, the mandarins were cut through cross section

and both the halves of the mandarin were labelled so as to have track of the grower. All the samples were then segregated as per their granulation level following the chart (Figure 1) for further analysis.

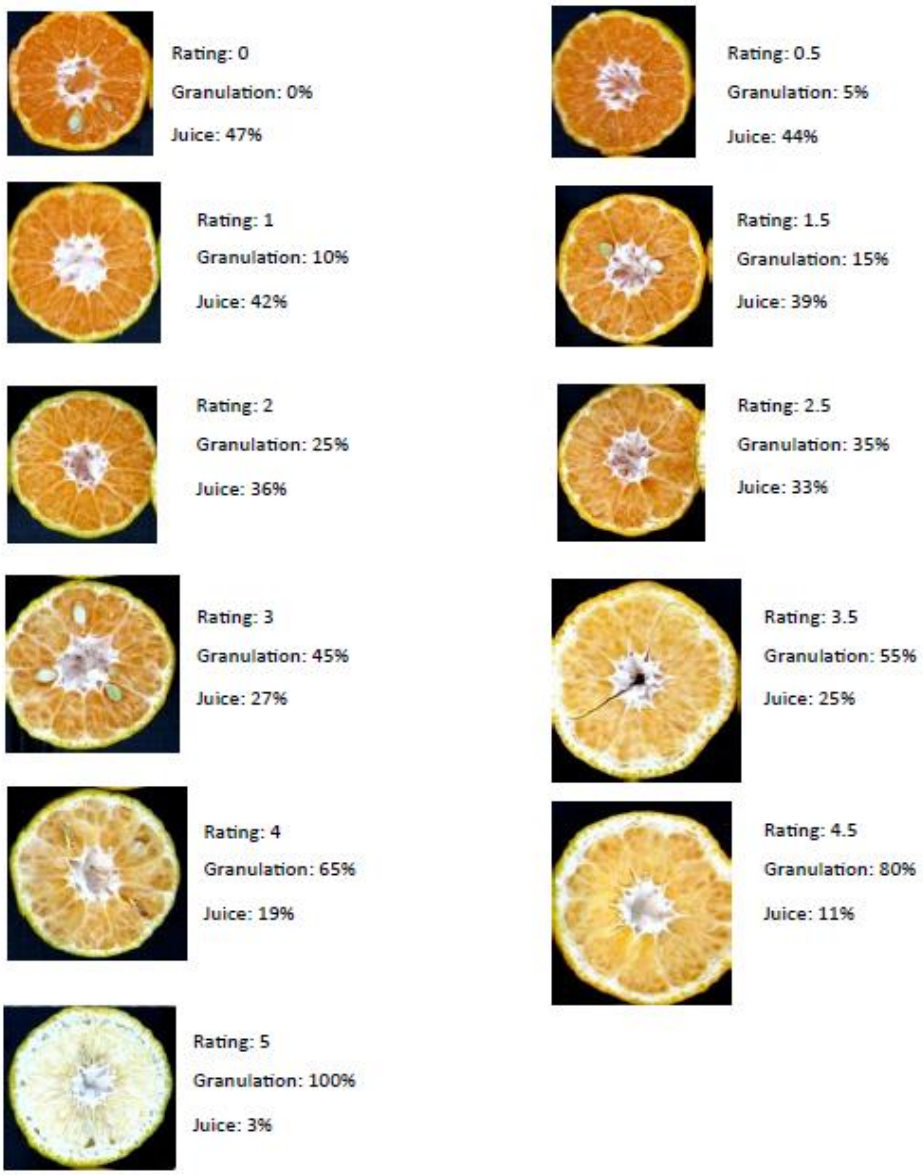


Figure 1. Different Level of Granulation in Imperial Mandarin (Source: Citrus Australia, 2014)

Sensory Evaluation using QDA®

1. Screening of the panel
2. Language development

3. Training on scale
4. Assessment of the imperial mandarins

Language Development

The language development was conducted over 3-4 sessions. The panellists received 10 different samples of imperial mandarins with varying levels of granulation and were to describe their whole eating experience and list the various attributes that described the sensory properties of mandarin. The attributes were later used for training and assessment after a common consensus among the panellists for the sensory attributes

Training on scale and Assessment

The panel were then trained on an unstructured intensity linear 15 cm scale as recommended in QDA for the various sensory attributes listed by them during the language development sessions. Appropriate references will be provided when required. The panel consistency was examined by assessing duplicate samples and then monitoring the correlation coefficient and average difference between the average scores. Once the panel was consistent in their performance they will then assess the samples of imperial mandarins with various degree of granulation. The segments were segregated as per granulation level and each panellist assessed the samples in duplicates. To be able to relate the sensory properties to physio-chemical properties, one half of the fruit was used for sensory assessment and the other half of the same fruit was used for analytical purpose.

Figure 2. Sensory booth at the University of Queensland for sensory evaluation of imperial mandarin

Experimental design

A randomized complete block design will be used to compare the intensities of sensory attributes of imperial mandarin. A maximum of 10 samples will be assessed by the panel in a one-hour session. Each panel evaluated the samples in the sensory booth (Figure 2) equipped with Compusense software for data acquisition. To estimate the individual performances of panellists, two samples of each level of granulation of imperial mandarin will be served to them in a randomized way.

Data Analysis

Multivariate analysis of data and mixed linear model analysis will be used to assess the performance of the panel and to draw conclusions about imperial mandarin products from sensory evaluations. The analysis was conducted with the corresponding procedures in Minitab 16 (Minitab Inc., Chicago).

Results and Discussions

Three sessions were allocated altogether for developing the lexicons for sensory attributes of imperial mandarins with different level of granulations. Table Error**! No**

text of specified style in document. contains the sensory attributes and their definition.

Table Error! No text of specified style in document.**: Sensory attributes and definition for imperial mandarins**

Descriptor	Definition
Appearance	
Colour	The colour of the Mandarin as it appears to naked eye
Glossy	Level of shininess
Dry	Without tasting the product does it appear dry to naked eye
Ripeness	Without tasting does the piece of mandarin appear ripe
Fibrous	Without tasting does the piece of mandarin appear very fibrous
Taste	
Sweet	Intensity of sweet taste
Sour	Intensity of sour taste
Bitter	Intensity of bitter taste
Flavour	
Acidic	Intensity of sourness flavour
Mandarin	Intensity of mandarin flavour
Eating Experience	
Hardness	Degree of hardness when you bite the mandarin between the teeth's
Juiciness	State of being full of juice
Chewiness	Ease of chewability based on toughness of mandarin
Ease of swallowing the bolus	The ease with which the bolus can be swallowed
Feel individual juice sac	The perception of individual juice sacs
Fibrous	Consisting of fibres
Aftertaste	
Bitter	Degree of bitterness
Bland	No taste at all includes sweet, sour, bitter
Mandarin	Intensity of mandarin flavour

Panel performance

Following the language development the panel was trained for scoring the intensity of each attributes of imperial mandarin. The intensity of each attribute was measured on a horizontal unstructured 12.5-cm line scale anchored at the left end and at the right end as seen in the score sheet below (Figure 3). The figure only shows the appearance attributes.

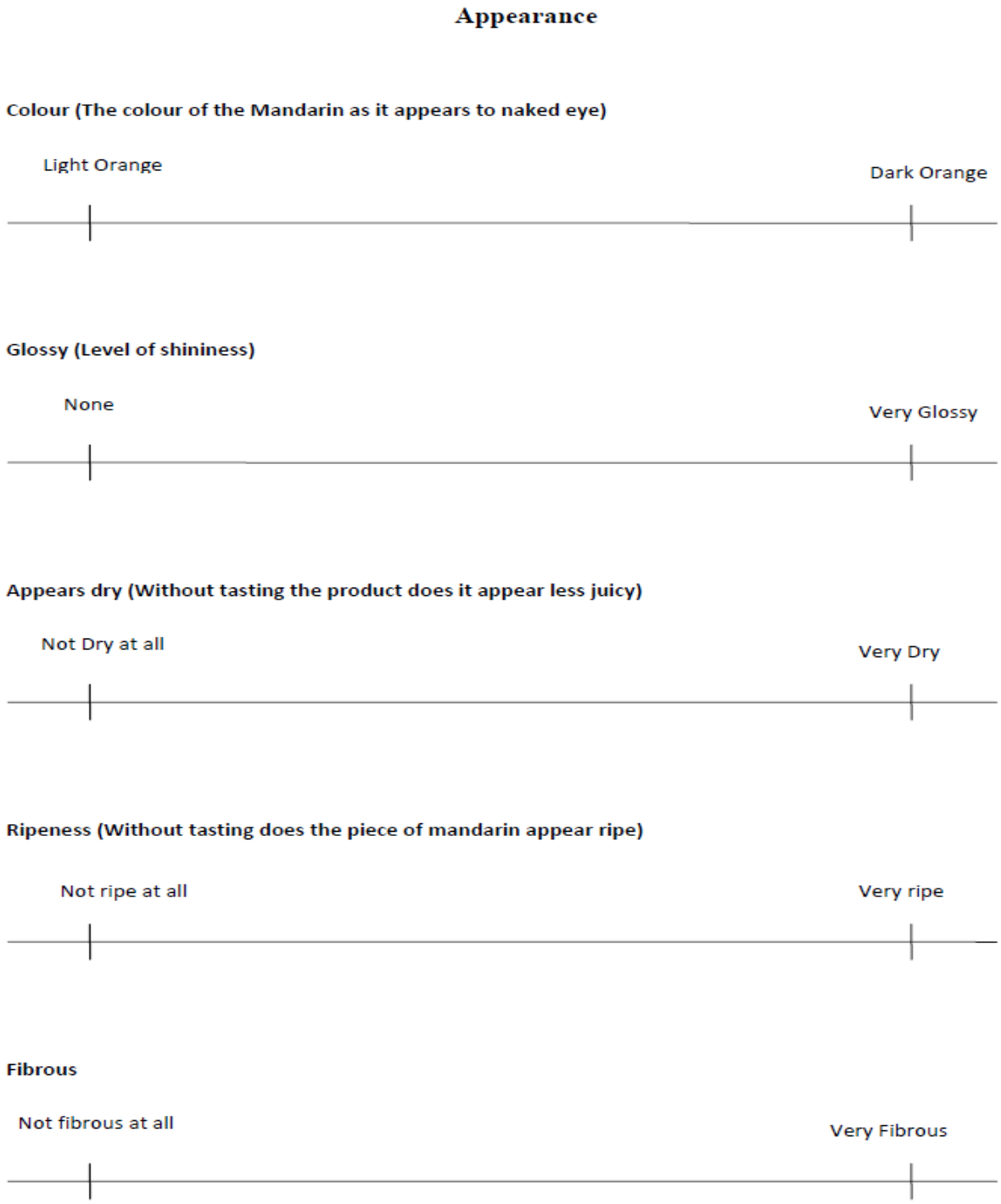


Figure 3: Score sheet used for sensory evaluation of mandarins using QDA®

The performance was assessed on the basis of two criteria:

(a) The reproducibility of scores for duplicate samples of the mandarin and

(b) Product-by-panelist interaction.

The overall reproducibility of scores was quantified with the correlation coefficient for each attribute and the average difference between the replicates. If either the correlation coefficient was weak (<0.55 for the panel size of 10 panelists; <0.67 for the

panel size of 7 panelists) or the average difference is significantly non-zero, it was agreed that the assessment of that attribute was not consistent. The panel performance summary is shown in Table 2.

The attributes shown in bold in Table 2 can be reliably used for comparing imperial mandarins. We have to comment, however, that this performance analysis only provides a sufficient condition of reliability for an attribute. If a specific attribute has not been confirmed by the panel on a single specific product, one needs to examine at least the following two conditions:

(a) If the range of the scores given by the panel is very narrow and the average score is low, it may well be that that attribute is absent in the product chosen.
(b) If the range of the scores is very wide, it may well be that there is a panelist-by-attribute interaction and this has to be carefully examined

Table 2. Correlation coefficient and average difference between the assessments of two samples of imperial mandarin

Attribute (reliable are in bold)	Correlation coefficient	Average difference and its (SE)
Appearance		
Colour	0.74	-0.57 (0.25)
Glossy	0.70	-0.27 (0.23)
Dry	0.99	-0.66 (0.20)
Ripeness	0.78	0.03 (0.28)
Fibrous	0.99	-0.26 (0.23)
Taste		
Sweet	0.98	0.21 (0.20)
Sour	0.65	-0.97 (1.01)
Bitter	0.98	0.39 (0.17)
Flavour		
Acidic	0.84	-0.43 (0.80)
Mandarin	0.95	0.00 (0.44)
Eating Experience		
Hardness	0.97	0.01 (0.22)
Juiciness	0.79	-0.07 (0.22)
Chewiness	0.92	0.40 (0.45)
Ease of swallowing the bolus	0.90	0.24 (0.35)
Feel individual juice sac	0.96	0.24 (0.35)
Fibrous	0.97	1.10 (0.23)
Aftertaste		
Bitter	0.97	-0.17 (0.11)
Bland	0.97	-0.21 (0.35)
Mandarin	0.97	0.20 (0.30)

In the analysis we have only focused on those attributes whose reliability has been confirmed (shown in bold in

Table 2). For evaluating the panel performance, we considered the selected mandarins as being a random sample of products, and conducted the principal component analysis on the scores given by panelists. This type of multivariate analysis operates with cumulative indices calculated from scores for individual attributes and allows one to segregate panelists into groups on the basis of their overall assessment. The analysis showed that panelists were mostly separated on the basis of their cumulative total score for most of the attributes excepting sour attributes. Some panelists used the lower end of the scale while other used the upper end. The QDA method does not require that panelists are similar in their average scores and this does not affect the power of the panel to discriminate between the products. The performance of the panel is adequate for all the attributes shown in bold in

Table 2.

The performance analysis also allowed us to identify further needs in training for individual panelists. The panelists were not consistent in identifying 'sour taste'. Closer examination of their results reveals a wide variation in score. We expect that providing an additional training for these panelists on distinguishing between different intensity of sourness would further improve the performance of the panel.

In order to demonstrate the capability of the panel, we conducted the analysis of the products by using the mixed model approach, in which we treat products as a fixed selection and panelists as a random factor. The results of the analysis are presented in Figure 4 (only those attributes that are significantly different among mandarins with different level of granulations are presented)

The evaluation presented in **Error! Reference source not found.**4 is consistent with what was expected. The panel could discriminate between different levels of granulation based on certain attributes. As the degree of granulation increased from 15

to 55% there was a decrease in orange colour, glossiness, ripeness, juiciness, sweetness and increase in dryness (appearance), fibrous, hardness etc. The effect of the degree of granulation on the various sensory attributes is presented in the Appendix.

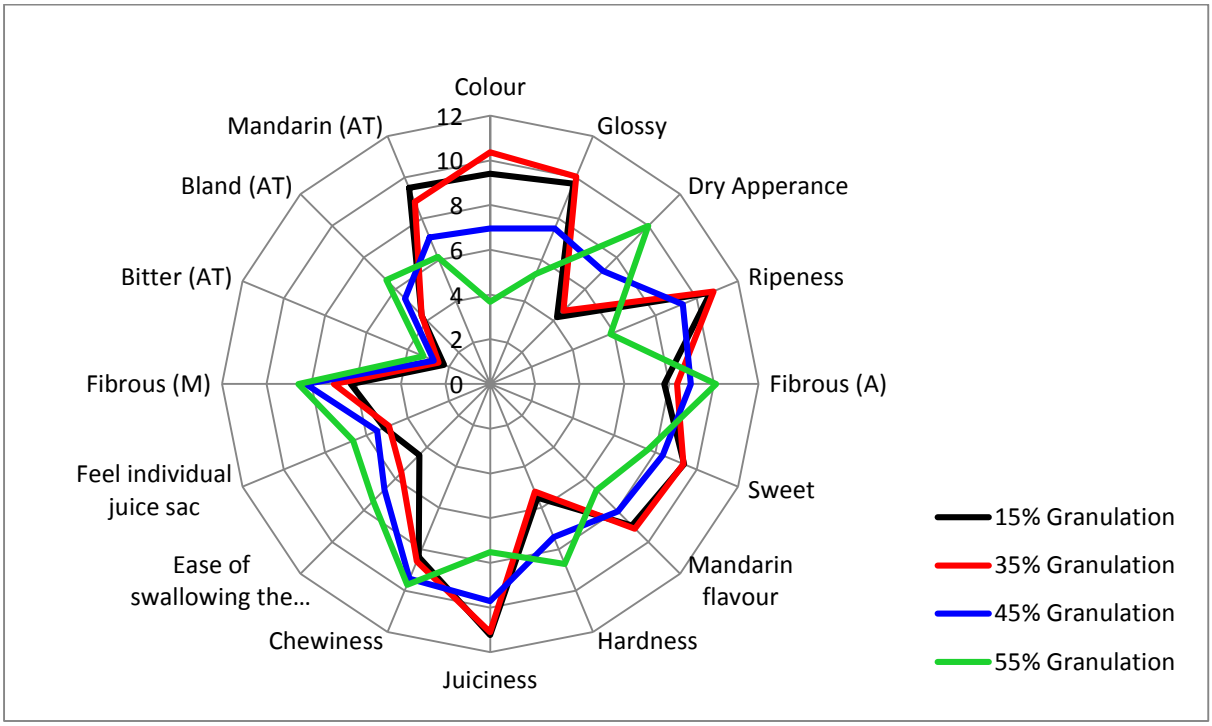


Figure 4: Appearance, taste, flavour, eating experience and aftertaste evaluation of the granulated imperial mandarins (A- appearance; AT – aftertaste; M – eating experience in mouth)

To determine if the products were significantly different from each other we conducted the analysis of the 4 different products by using the mixed model approach, in which we treat products as a fixed selection and panelists as a random factor. The results of the analysis are presented in Table 3. The complete data analysis is presented in the appendix.

Table. 3 Average scores and significance of all the sensory attributes of imperial mandarins with different levels of granulations

	Appearance					Taste			Flavour	
Degree of granulation (%)	Colour	Glossy	Dry Appearance	Ripeness	Fibrous	Sweet	Sour	Bitter	Acidic	Mandarin flavour
15	9.40	9.69	4.23	10.66	7.79	9.38	7.10	3.01	6.51	8.96
35	10.36	10.03	4.63	10.81	8.35	9.35	6.91	3.63	7.07	9.15
45	6.96	7.52	7.14	9.31	8.97	8.35	7.44	3.37	6.99	8.07
55	3.68	5.32	9.99	5.81	10.09	7.64	6.62	3.80	6.28	6.72
LSD	2.19	1.80	2.68	2.79	2.09	1.70	2.89	1.59	2.45	1.58
p-value	0.00	0.00	0.00	0.00	0.00	0.01	0.77	0.71	0.56	0.00

Note: Scores separated by more than their LSD5% are pairwise significantly different. P-value is the significance of the test for the difference in products from the mixed model analysis

Table 3 contd...

	Eating experience						Aftertaste		
Degree of granulation (%)	Hardness	Juiciness	Chewiness	Ease of swallowing the bolus	Feel individual juice sac	Fibrous	Bitter	Bland	Mandarin
15	5.51	11.22	8.37	4.49	5.12	6.24	2.24	4.34	9.50
35	5.21	11.10	8.59	5.61	4.90	7.00	2.51	4.35	8.81
45	7.41	9.71	9.43	6.69	5.48	8.26	2.73	5.39	7.09
55	8.71	7.52	9.72	7.41	6.64	8.59	3.23	6.56	6.14
LSD	1.19	1.66	1.75	2.41	2.11	2.46	2.37	1.01	1.39
p-value	0.00	0.00	0.03	0.00	0.00	0.01	0.04	0.00	0.00

Note: Scores separated by more than their LSD5% are pairwise significantly different. P-value is the significance of the test for the difference in products from the mixed model analysis

Sensory analysis of imperial mandarins with 5-80% of degree of granulation

In a second session the panel evaluated mandarins with 5, 10, 45, 55 and 80% level of granulation. The results of the analysis are presented in Figure 5 (only those attributes that are significantly different among mandarins with different level of granulations are presented)

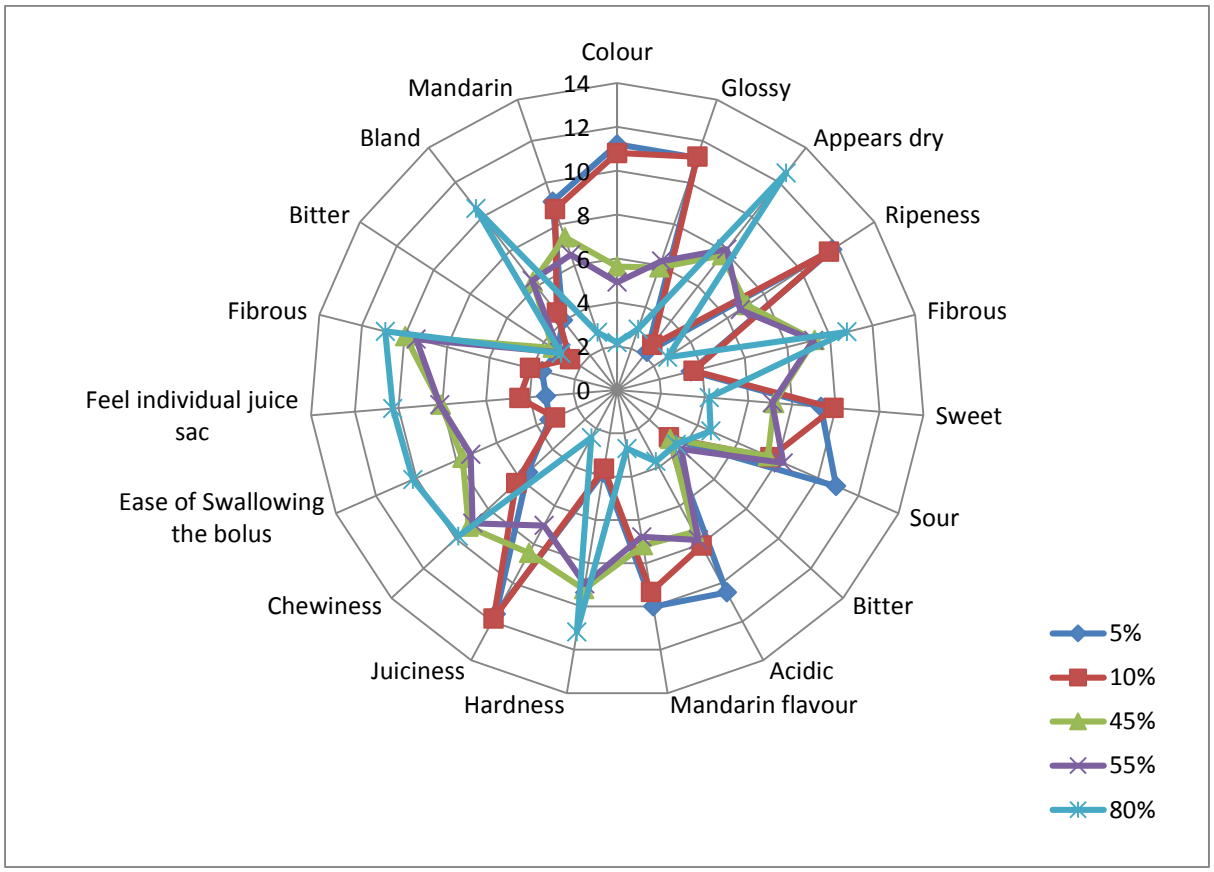


Figure 5: Appearance, taste, flavour, eating experience and aftertaste evaluation of the granulated (5-80%) imperial mandarins (A- appearance; AT – aftertaste; M – eating experience in mouth)

To determine if the products (5, 10, 45, 55 and 80% granulation) were significantly different from each other we conducted the analysis of the 5 different products by using the mixed model approach. The results of the analysis are presented in Table 4. The results suggest no significant difference between mandarins with 45 and 55% granulation for all the attributes. The complete data analysis is presented in the appendix.

Table 4: Average scores and significance of all the sensory attributes of imperial mandarins with different levels of granulations (5-80%)

	Appearance					Taste			Flavour	
Degree of granulation	**Colour**	**Glossy**	**Appears dry**	**Ripeness**	**Fibrous**	**Sweet**	**Sour**	**Bitter**	**Acidic**	**Mandarin flavour**
5%	11.20	11.19	2.20	11.71	3.46	9.32	10.89	3.26	10.49	10.00
10%	10.80	11.24	2.61	11.53	3.59	9.90	7.63	3.19	8.07	9.33
45%	5.63	5.91	7.78	7.07	9.28	7.18	7.50	3.29	7.35	7.18
55%	4.92	6.22	8.13	6.70	9.23	7.09	8.27	3.97	7.76	6.78
80%	2.17	2.94	12.54	2.74	10.80	4.21	4.66	3.65	3.70	2.70
LSD	2.30	2.47	2.58	2.90	2.60	2.63	2.81	2.64	2.25	2.18
p-value	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.75	0.00	0.00

Table 4 cont……..

	Eating experience						Aftertaste		
Degree of granulation	**Hardness**	**Juiciness**	**Chewiness**	**Ease of Swallowing the bolus**	**Feel individual juice sac**	**Fibrous**	**Bitter**	**Bland**	**Mandarin**
5%	3.81	11.62	5.53	3.36	3.26	3.53	3.24	4.03	9.08
10%	3.64	11.84	6.26	3.12	4.48	4.10	2.58	4.48	8.73
45%	9.20	8.44	9.21	7.70	8.06	9.97	3.52	6.25	7.36
55%	8.97	7.02	8.96	7.29	8.11	9.46	3.13	6.32	6.53
80%	11.18	2.47	9.84	10.17	10.27	10.91	3.05	10.49	2.78
LSD	2.47	1.98	3.86	2.99	4.30	1.95	2.18	2.97	2.54
p-value	0.00	0.00	0.00	0.00	0.00	0.00	0.65	0.00	0.00

Physio-chemical analysis on imperial mandarins

Size of the fruit

The measurement of size of different level of granulated mandarins showed erratic pattern. No particular trend was observed between level of granulation and size of the fruit. The size of 45% granulated mandarin was the largest of all with 0% being the smallest. The size of 100% granulated mandarin could not be observed in triplicate as the 100% granulated sample was only observed twice during the entire session which counted only 1 or 2 in number. The plot of level of granulation versus size is shown in Figure 6.

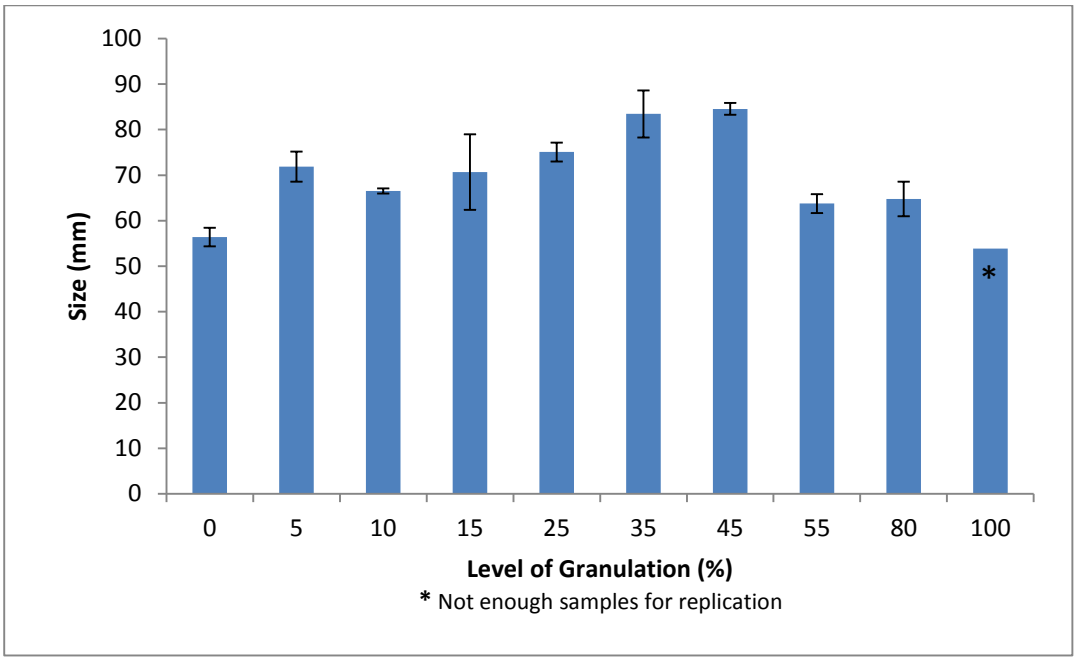


Figure 6: Plot of Level of Granulation Vs Size on Imperial mandarin

Brix

The brix value of the imperial mandarin samples didn't follow a particular trend and had values in between 10-12 ˚Bx. The 5% granulated mandarin had the highest brix and 65% had least. The plot of ˚Bx and level of granulation is shown in Figure 7.

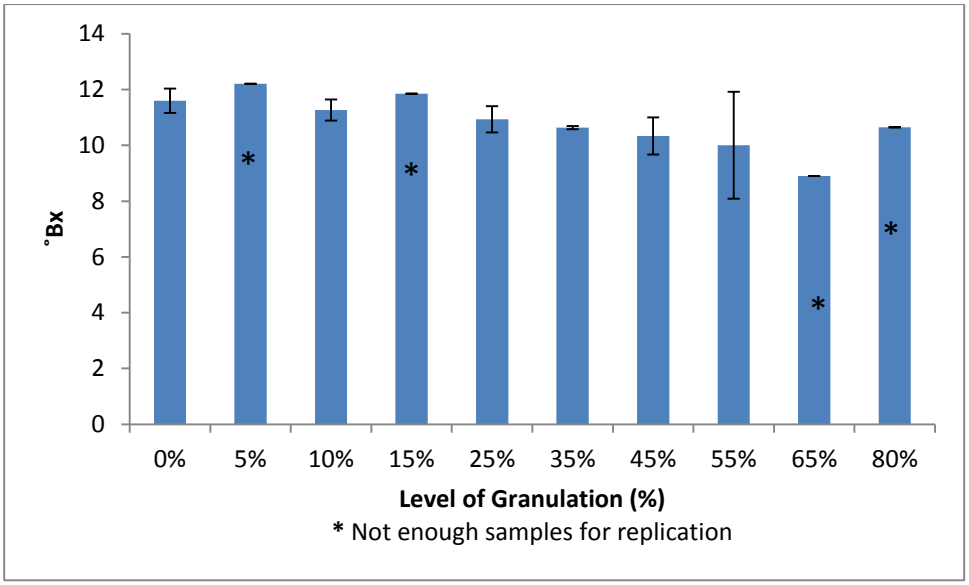


Figure 7: Plot of Brix vs. Granulation Level

pH

The pH of the mandarin samples also exhibited an erratic pattern with no particular trend. The pH values of all the level of granulation tested were found to be in between 3.5-4 except the 80% one. The plot of granulation against pH of mandarin samples is shown in Figure 8.

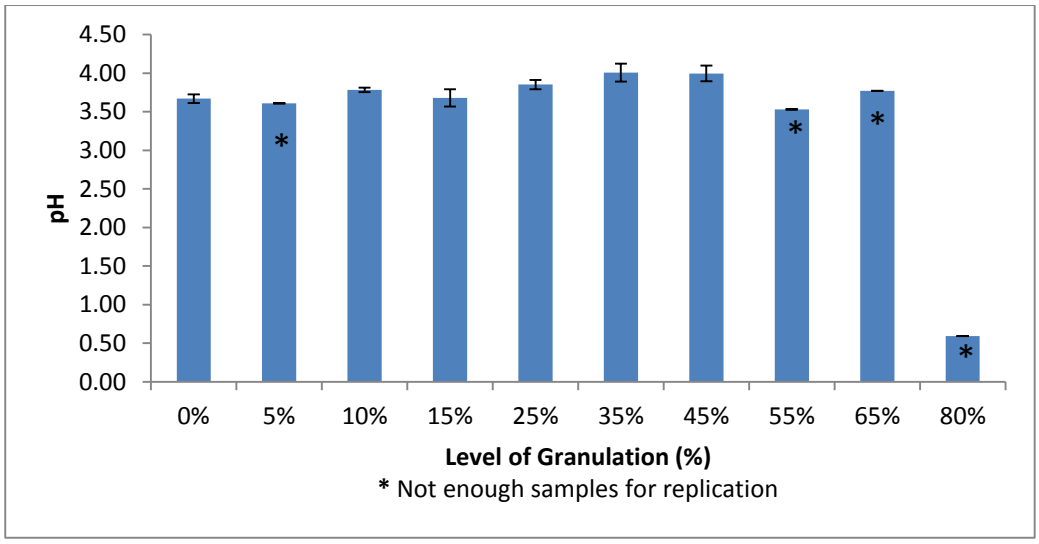


Figure 8: Plot of granulation level vs. pH

Acidity

The acidity of mandarin samples also varied to great extent and no sample exceeded the value above 0.7. The plot of granulation level vs. acidity is shown in Figure 9.

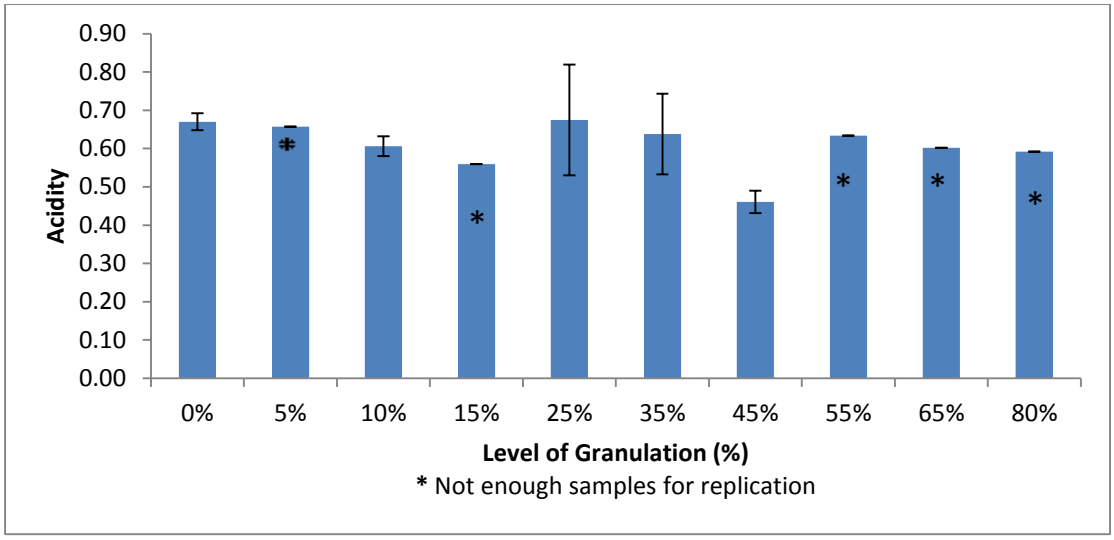


Figure 9: Plot of granulation level vs. acidity

Brix/Acid ratio

The brix/acid ratio also depicted the irregular pattern with granulation level. The plot of brix/acid ratio vs. granulation level is shown in Figure 10.

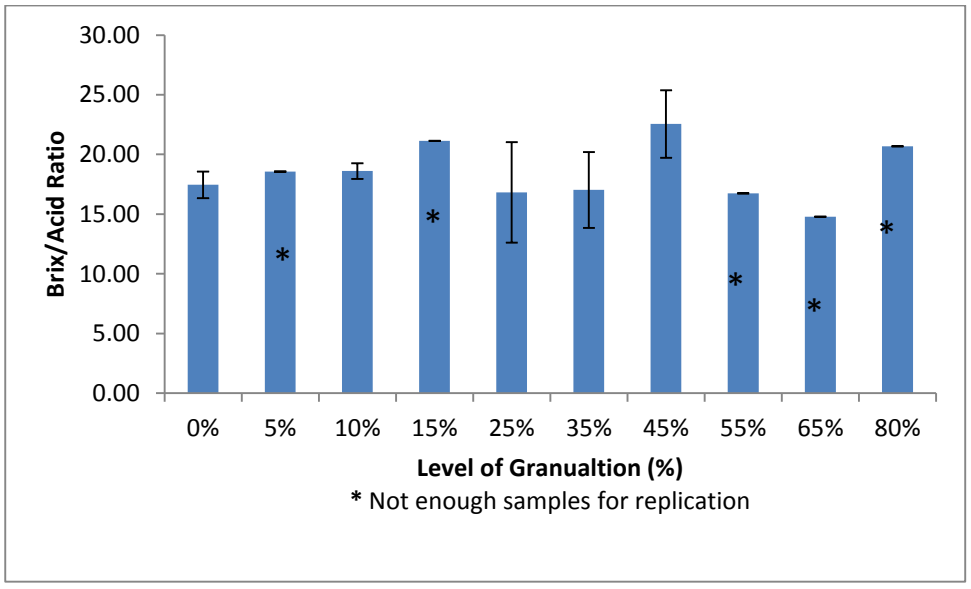


Figure 10: Plot of Brix/Acid ratio vs. granulation Level

Australian Citrus Standard (ACS)

The Australian Citrus Standard was calculated using the measured brix and acidity. Table 5 presents the ACS values for the different level of granulated mandarins with no clear trend.

Table 5: Australian Citrus standard calculated taking into account the average brix and acidity

Level of Granulation (%)	Brix	Acidity	ACS = [Brix-(Acid *4) X16.5
0%	11.60	0.67	147.18
5%	12.20	0.66	157.74
10%	11.27	0.61	145.70
15%	11.85	0.56	158.57
25%	10.93	0.67	136.13
35%	10.63	0.64	133.16
45%	10.33	0.46	140.09
55%	10.00	0.63	123.42
65%	8.90	0.60	107.25
80%	10.65	0.59	136.79

Colour

The colour of the mandarin samples were mainly based on their L* that is degree of lightness and b* (degree of yellowness). The L* value showed an increasing trend with increasing level of granulation (Figure 11) also confirmed from Figure 12 (A-B), the orange juice getting lighter as the degree of granulation increased. The b* value less correlated with granulation level (Figure 13).

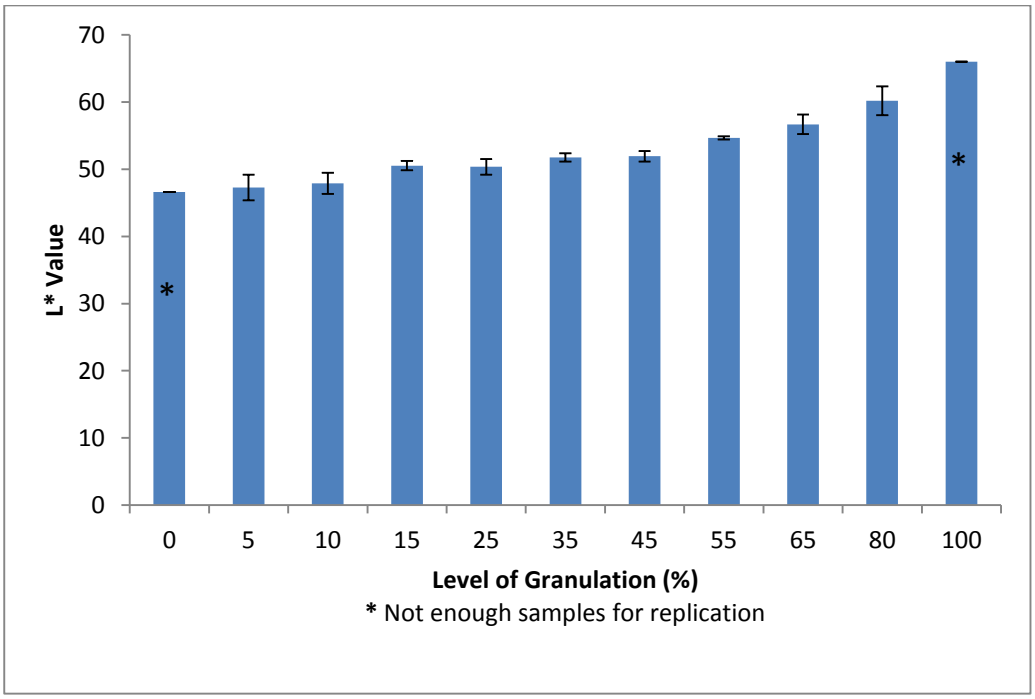
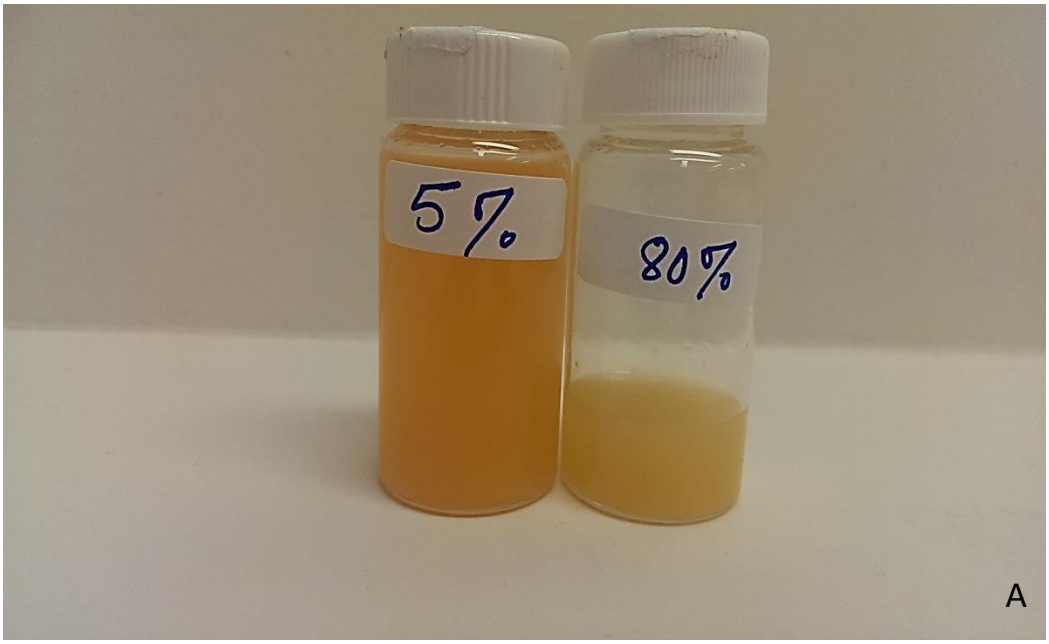


Figure 11. Plot of Granulation vs. L* Value



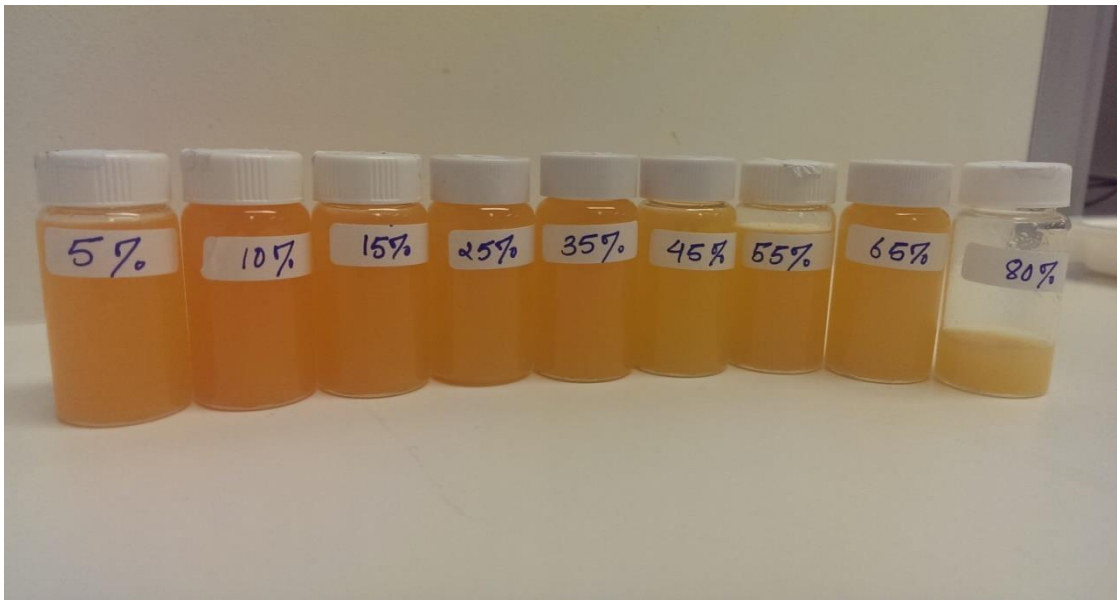


Figure 12: Comparison of colour of juice from mandarins with 5 and 80% degree of granulation (A) and 5 to 80% degree of granulation

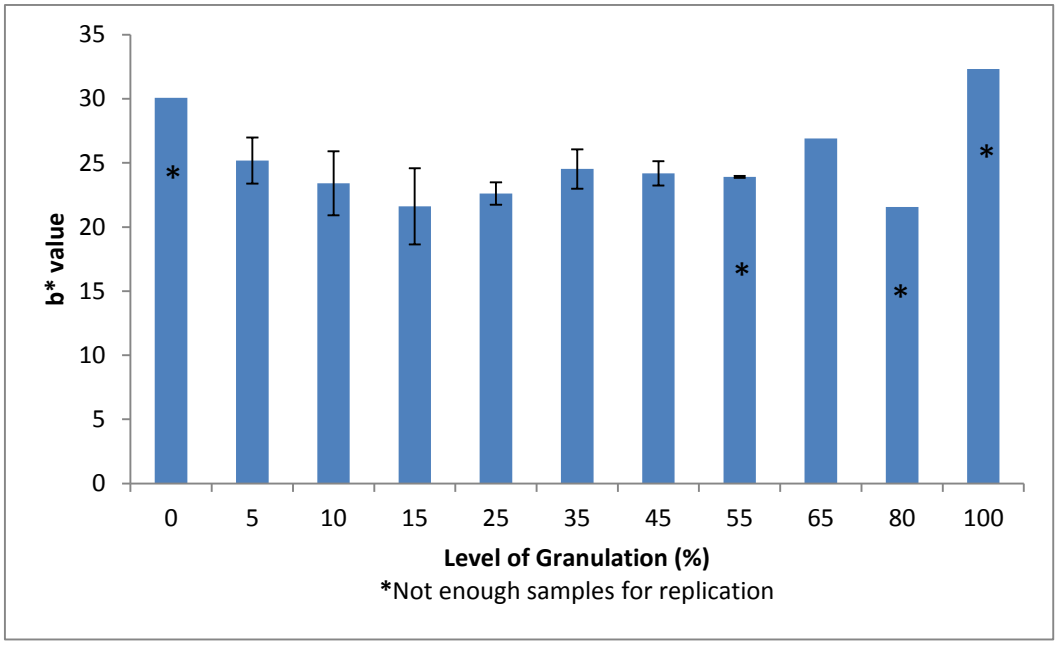


Figure 13: Plot of granulation Level vs. b* value

Textural hardness

The level of hardness was found to be increasing with the level of granulation except in 55% granulated sample. The 0% sample was found to be less hard and 100% had the highest degree of hardness. The plot of hardness vs. granulation level shown in Figure 14.

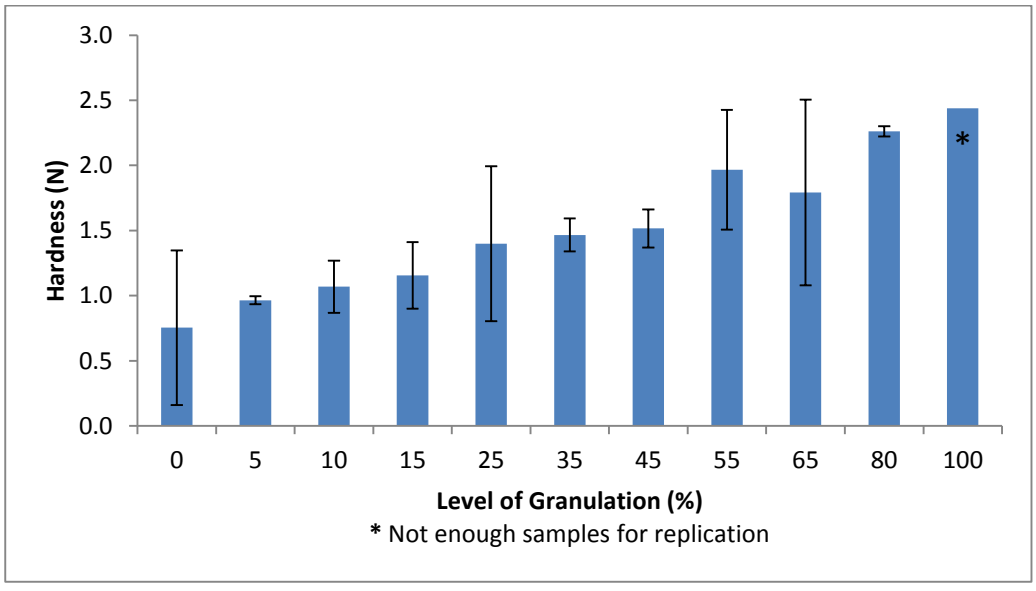


Figure 14: Plot of hardness of the mandarin segment vs. granulation Level

Textural chewiness

The chewiness of the mandarin samples demonstrated the irregular pattern. The 55% granulated mandarin had highest degree of chewiness. The plot of chewiness and granulation level is shown in Figure 15.

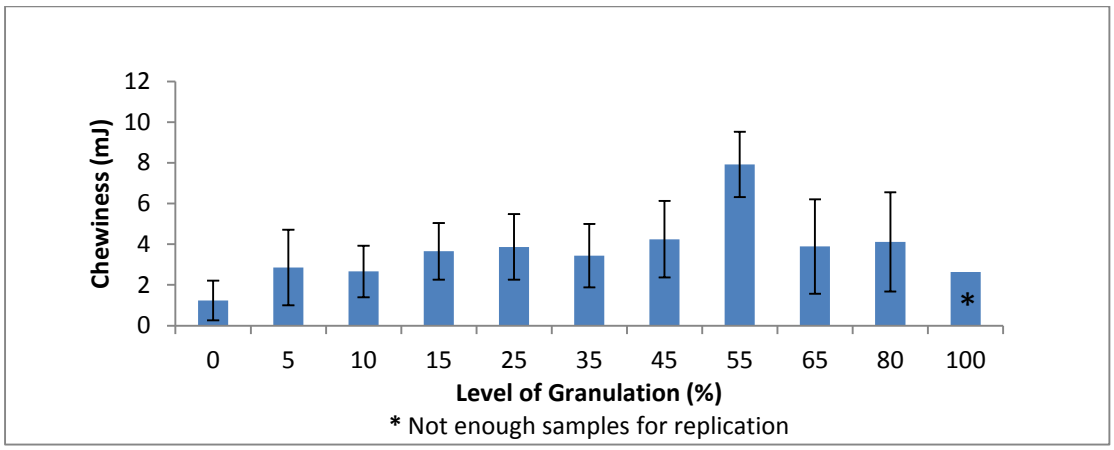


Figure 15: Plot of chewiness of the mandarin segment vs. granulation Level

Conclusions

The sensory evaluation conducted by the panel is valid, accurate, easy to interpret and consistent with the expectations which can be drawn from the literature on the basis of the degree of granulations in imperial mandarin. The panel was able to discriminate the different granulation level in the mandarin segments based on their appearance, eating experience, flavor and aftertaste although in some instances the adjacent granulation levels (ex. 5 and 10%, Table 5 or 45 and 55%, Table 4) were not significantly different on certain attributes. The chewiness, hardness, fibrousness of the mandarin segments increased while juiciness and ease of swallowing the bolus decreased with increase in granulation. The segments lost the bright orange colour appearance with increase in granulation level. The dry and fibrous appearance increased while the juiciness and glossy appearance of the segments reduced with increase in granulation level. The mandarin flavor and aftertaste decreased with increase in granulation level.

The measured pheno-physicochemical properties of the imperial mandarins with and without granulation showed no particular trend.

Appendix

```
Welcome to Minitab, press F1 for help.
```

Correlations: Colour_1, Colour_2

```
Pearson correlation of Colour_1 and Colour_2 = 0.737
P-Value = 0.059
```

Paired T-Test and CI: Colour_1, Colour_2

```
Paired T for Colour_1 - Colour_2

            N    Mean  StDev  SE Mean
Colour_1    7   9.114  0.886    0.335
Colour_2    7   9.686  0.960    0.363
Difference  7  -0.571  0.673    0.254


95% CI for mean difference: (-1.193, 0.051)
T-Test of mean difference = 0 (vs not = 0): T-Value = -2.25  P-Value = 0.066
```

Correlations: Glossy_1, Glossy_2

```
Pearson correlation of Glossy_1 and Glossy_2 = 0.701
P-Value = 0.079
```

Paired T-Test and CI: Glossy_1, Glossy_2

```
Paired T for Glossy_1 - Glossy_2

            N    Mean  StDev  SE Mean
Glossy_1    7   9.557  0.832    0.315
Glossy_2    7   9.829  0.757    0.286
Difference  7  -0.271  0.618    0.234


95% CI for mean difference: (-0.843, 0.300)
T-Test of mean difference = 0 (vs not = 0): T-Value = -1.16  P-Value = 0.290
```

Correlations: Appears dry_1, Appears dry_2

```
Pearson correlation of Appears dry_1 and Appears dry_2 = 0.986
P-Value = 0.000
```

Paired T-Test and CI: Appears dry_1, Appears dry_2

```
Paired T for Appears dry_1 - Appears dry_2

               N    Mean  StDev  SE Mean
Appears dry_1  7    3.90   2.88     1.09
Appears dry_2  7    4.56   3.06     1.16
Difference     7  -0.657  0.535    0.202


95% CI for mean difference: (-1.152, -0.162)
T-Test of mean difference = 0 (vs not = 0): T-Value = -3.25  P-Value = 0.017
```

Correlations: Ripeness_1, Ripeness_2

```
Pearson correlation of Ripeness_1 and Ripeness_2 = 0.781
P-Value = 0.038
```

Paired T-Test and CI: Ripeness_1, Ripeness_2

```
Paired T for Ripeness_1 - Ripeness_2

            N    Mean  StDev  SE Mean
Ripeness_1  7  10.671  1.134    0.429
Ripeness_2  7  10.643  1.081    0.409
Difference  7   0.029  0.734    0.278


95% CI for mean difference: (-0.650, 0.708)
T-Test of mean difference = 0 (vs not = 0): T-Value = 0.10  P-Value = 0.921
```

Correlations: Fibrous_1, Fibrous_2

```
Pearson correlation of Fibrous_1 and Fibrous_2 = 0.991
P-Value = 0.000
```

Paired T-Test and CI: Fibrous_1, Fibrous_2

```
Paired T for Fibrous_1 - Fibrous_2

            N    Mean  StDev  SE Mean
Fibrous_1   7    7.66   2.67     1.01
Fibrous_2   7    7.91   3.13     1.18
Difference  7  -0.257  0.600    0.227


95% CI for mean difference: (-0.812, 0.297)
T-Test of mean difference = 0 (vs not = 0): T-Value = -1.13  P-Value = 0.300
```

Correlations: Sweet_1, Sweet_2

```
Pearson correlation of Sweet_1 and Sweet_2 = 0.976
P-Value = 0.000
```

Paired T-Test and CI: Sweet_1, Sweet_2

```
Paired T for Sweet_1 - Sweet_2

            N   Mean  StDev  SE Mean
Sweet_1     7  9.486  2.151    0.813
Sweet_2     7  9.271  2.337    0.883
Difference  7  0.214  0.524    0.198


95% CI for mean difference: (-0.270, 0.699)
T-Test of mean difference = 0 (vs not = 0): T-Value = 1.08  P-Value = 0.321
```

Correlations: Sour_1, Sour_2

```
Pearson correlation of Sour_1 and Sour_2 = 0.645
P-Value = 0.118
```

Paired T-Test and CI: Sour_1, Sour_2

```
Paired T for Sour_1 - Sour_2

            N   Mean  StDev  SE Mean
Sour_1      7   6.61   3.25     1.23
Sour_2      7   7.59   3.11     1.18
Difference  7  -0.97   2.68     1.01


95% CI for mean difference: (-3.45, 1.51)
T-Test of mean difference = 0 (vs not = 0): T-Value = -0.96  P-Value = 0.375
```

Correlations: Bitter_1, Bitter_2

```
Pearson correlation of Bitter_1 and Bitter_2 = 0.975
P-Value = 0.000
```

Paired T-Test and CI: Bitter_1, Bitter_2

```
Paired T for Bitter_1 - Bitter_2

            N   Mean  StDev  SE Mean
Bitter_1    7  3.200  2.064    0.780
Bitter_2    7  2.814  2.083    0.787
Difference  7  0.386  0.460    0.174


95% CI for mean difference: (-0.040, 0.811)
T-Test of mean difference = 0 (vs not = 0): T-Value = 2.22  P-Value = 0.068
```

Correlations: Acidic_1, Acidic_2

```
Pearson correlation of Acidic_1 and Acidic_2 = 0.836
P-Value = 0.019
```

Paired T-Test and CI: Acidic_1, Acidic_2

```
Paired T for Acidic_1 - Acidic_2

            N    Mean  StDev  SE Mean
Acidic_1    7    6.30   3.11     1.18
Acidic_2    7    6.73   3.86     1.46
Difference  7  -0.429  2.120    0.801


95% CI for mean difference: (-2.389, 1.532)
T-Test of mean difference = 0 (vs not = 0): T-Value = -0.53  P-Value = 0.612
```

Correlations: Mandarin flavour_1, Mandarin flavour_2

```
Pearson correlation of Mandarin flavour_1 and Mandarin flavour_2 = 0.952
P-Value = 0.001
```

Paired T-Test and CI: Mandarin flavour_1, Mandarin flavour_2

```
Paired T for Mandarin flavour_1 - Mandarin flavour_2
```

```
                    N   Mean  StDev  SE Mean
Mandarin flavour_1  7   8.96   2.59     0.98
Mandarin flavour_2  7   8.96   3.30     1.25
Difference          7  0.000  1.155    0.436


95% CI for mean difference: (-1.068, 1.068)
T-Test of mean difference = 0 (vs not = 0): T-Value = 0.00  P-Value = 1.000
```

Correlations: Hardness_1, Hardness_2

```
Pearson correlation of Hardness_1 and Hardness_2 = 0.970
P-Value = 0.000
```

Paired T-Test and CI: Hardness_1, Hardness_2

```
Paired T for Hardness_1 - Hardness_2

            N   Mean  StDev  SE Mean
Hardness_1  7  5.514  2.366    0.894
Hardness_2  7  5.500  2.158    0.816
Difference  7  0.014  0.587    0.222


95% CI for mean difference: (-0.529, 0.557)
T-Test of mean difference = 0 (vs not = 0): T-Value = 0.06  P-Value = 0.951
```

Correlations: Juiciness_1, Juiciness_2

```
Pearson correlation of Juiciness_1 and Juiciness_2 = 0.793
P-Value = 0.033
```

Paired T-Test and CI: Juiciness_1, Juiciness_2

```
Paired T for Juiciness_1 - Juiciness_2

             N    Mean  StDev  SE Mean
Juiciness_1  7  11.186  0.915    0.346
Juiciness_2  7  11.257  0.580    0.219
Difference   7  -0.071  0.577    0.218


95% CI for mean difference: (-0.605, 0.462)
T-Test of mean difference = 0 (vs not = 0): T-Value = -0.33  P-Value = 0.754



95% CI for mean difference: (-1.056, 0.913)
T-Test of mean difference = 0 (vs not = 0): T-Value = -0.18  P-Value = 0.865
```

Correlations: Chewiness_1, Chewiness_2

```
Pearson correlation of Chewiness_1 and Chewiness_2 = 0.915
P-Value = 0.004
```

Paired T-Test and CI: Chewiness_1, Chewiness_2

```
Paired T for Chewiness_1 - Chewiness_2
```

```
             N   Mean  StDev  SE Mean
Chewiness_1  7   8.57   2.77     1.05
Chewiness_2  7   8.17   2.93     1.11
Difference   7  0.400  1.186    0.448


95% CI for mean difference: (-0.697, 1.497)
T-Test of mean difference = 0 (vs not = 0): T-Value = 0.89  P-Value = 0.407
```

Correlations: Ease of Swallowing the bolus_1, Ease of Swallowing the bolus_2

```
Pearson correlation of Ease of Swallowing the bolus_1 and Ease of Swallowing
     the bolus_2 = 0.897
P-Value = 0.006
```

Paired T-Test and CI: Ease of Swallowing the b, Ease of Swallowing the b

```
Paired T for Ease of Swallowing the bolus_1 - Ease of Swallowing the bolus_2

                          N   Mean  StDev  SE Mean
Ease of Swallowing the b  7  4.614  1.903    0.719
Ease of Swallowing the b  7  4.371  2.077    0.785
Difference                7  0.243  0.920    0.348


95% CI for mean difference: (-0.608, 1.094)
T-Test of mean difference = 0 (vs not = 0): T-Value = 0.70  P-Value = 0.511
```

Correlations: Feel individual juice sac_1, Feel individual juice sac_2

```
Pearson correlation of Feel individual juice sac_1 and Feel individual juice
     sac_2 = 0.961
P-Value = 0.001
```

Paired T-Test and CI: Feel individual juice sac_1, Feel individual juice sac_2

```
Paired T for Feel individual juice sac_1 - Feel individual juice sac_2

                          N   Mean  StDev  SE Mean
Feel individual juice sa  7   5.24   3.12     1.18
Feel individual juice sa  7   5.00   3.28     1.24
Difference                7  0.243  0.913    0.345


95% CI for mean difference: (-0.601, 1.087)
T-Test of mean difference = 0 (vs not = 0): T-Value = 0.70  P-Value = 0.508
```

Correlations: Fibrous_1_1, Fibrous_1_2

```
Pearson correlation of Fibrous_1_1 and Fibrous_1_2 = 0.971
P-Value = 0.000
```

Paired T-Test and CI: Fibrous_1_1, Fibrous_1_2

```
Paired T for Fibrous_1_1 - Fibrous_1_2

             N   Mean  StDev  SE Mean
Fibrous_1_1  7  6.786  2.429    0.918
```

```
Fibrous_1_2  7  5.686  2.165    0.818
Difference   7  1.100  0.611    0.231


95% CI for mean difference: (0.535, 1.665)
T-Test of mean difference = 0 (vs not = 0): T-Value = 4.76  P-Value = 0.003
```

Correlations: Bitter_1_1, Bitter_1_2

```
Pearson correlation of Bitter_1_1 and Bitter_1_2 = 0.974
P-Value = 0.000
```

Paired T-Test and CI: Bitter_1_1, Bitter_1_2

```
Paired T for Bitter_1_1 - Bitter_1_2

            N    Mean  StDev  SE Mean
Bitter_1_1  7   2.157  0.613    0.232
Bitter_1_2  7   2.329  0.848    0.321
Difference  7  -0.171  0.287    0.108


95% CI for mean difference: (-0.437, 0.094)
T-Test of mean difference = 0 (vs not = 0): T-Value = -1.58  P-Value = 0.165
```

Correlations: Bland_1, Bland_2

```
Pearson correlation of Bland_1 and Bland_2 = 0.973
P-Value = 0.000
```

Paired T-Test and CI: Bland_1, Bland_2

```
Paired T for Bland_1 - Bland_2

            N    Mean  StDev  SE Mean
Bland_1     7    4.23   3.44     1.30
Bland_2     7    4.44   2.89     1.09
Difference  7  -0.214  0.919    0.347


95% CI for mean difference: (-1.064, 0.636)
T-Test of mean difference = 0 (vs not = 0): T-Value = -0.62  P-Value = 0.560
```

Correlations: Mandarin_2, Mandarin_1

```
Pearson correlation of Mandarin_2 and Mandarin_1 = 0.974
P-Value = 0.000
```

Paired T-Test and CI: Mandarin_1, Mandarin_2

```
Paired T for Mandarin_1 - Mandarin_2

            N   Mean  StDev  SE Mean
Mandarin_1  7  9.600  1.870    0.707
Mandarin_2  7  9.400  2.484    0.939
Difference  7  0.200  0.785    0.297


95% CI for mean difference: (-0.526, 0.926)
```

T-Test of mean difference = 0 (vs not = 0): T-Value = 0.67 P-Value = 0.526

Results for: Worksheet 1

General Linear Model: Colour, Glossy, ... versus Panelists, Products

Factor	Type	Levels	Values
Panelists	fixed	7	Alona, Balkumari, Huma, Jane, Karishma, MAX, Pramesh
Products	fixed	4	15% Granulation, 35% Granulation, 45% Granulation, 55% Granulation

Analysis of Variance for Colour, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Panelists	6	28.170	28.170	4.695	2.29	0.063
Products	3	373.410	373.410	124.470	60.80	0.000
Panelists*Products	18	68.620	68.620	3.812	1.86	0.068
Error	28	57.320	57.320	2.047		
Total	55	527.520				

S = 1.43078   R-Sq = 89.13%   R-Sq(adj) = 78.66%

Analysis of Variance for Glossy, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Panelists	6	57.837	57.837	9.639	4.07	0.005
Products	3	200.271	200.271	66.757	28.17	0.000
Panelists*Products	18	46.103	46.103	2.561	1.08	0.416
Error	28	66.345	66.345	2.369		
Total	55	370.556				

S = 1.53931   R-Sq = 82.10%   R-Sq(adj) = 64.83%

Analysis of Variance for Appears dry, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Panelists	6	227.169	227.169	37.862	16.30	0.000
Products	3	297.151	297.151	99.050	42.64	0.000
Panelists*Products	18	102.779	102.779	5.710	2.46	0.016
Error	28	65.040	65.040	2.323		
Total	55	692.139				

S = 1.52409   R-Sq = 90.60%   R-Sq(adj) = 81.54%

Analysis of Variance for Ripeness, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Panelists	6	92.871	92.871	15.479	13.54	0.000
Products	3	226.402	226.402	75.467	66.02	0.000
Panelists*Products	18	110.842	110.842	6.158	5.39	0.000
Error	28	32.005	32.005	1.143		
Total	55	462.120				

S = 1.06913   R-Sq = 93.07%   R-Sq(adj) = 86.40%

Analysis of Variance for Fibrous, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Panelists	6	170.627	170.627	28.438	25.76	0.000
Products	3	41.050	41.050	13.683	12.40	0.000
Panelists*Products	18	62.172	62.172	3.454	3.13	0.003
Error	28	30.910	30.910	1.104		
Total	55	304.760				

S = 1.05068 R-Sq = 89.86% R-Sq(adj) = 80.08%

Analysis of Variance for Sweet, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Panelists	6	218.622	218.622	36.437	16.25	0.000
Products	3	29.701	29.701	9.900	4.42	0.012
Panelists*Products	18	41.141	41.141	2.286	1.02	0.470
Error	28	62.785	62.785	2.242		
Total	55	352.248				

S = 1.49744 R-Sq = 82.18% R-Sq(adj) = 64.99%

Analysis of Variance for Sour, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Panelists	6	424.394	424.394	70.732	15.89	0.000
Products	3	4.911	4.911	1.637	0.37	0.777
Panelists*Products	18	36.206	36.206	2.011	0.45	0.959
Error	28	124.625	124.625	4.451		
Total	55	590.136				

S = 2.10971 R-Sq = 78.88% R-Sq(adj) = 58.52%

Analysis of Variance for Bitter, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Panelists	6	147.236	147.236	24.539	6.78	0.000
Products	3	4.993	4.993	1.664	0.46	0.713
Panelists*Products	18	85.575	85.575	4.754	1.31	0.253
Error	28	101.395	101.395	3.621		
Total	55	339.200				

S = 1.90296 R-Sq = 70.11% R-Sq(adj) = 41.28%

Analysis of Variance for Acidic, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Panelists	6	474.052	474.052	79.009	27.69	0.000
Products	3	6.035	6.035	2.012	0.71	0.557
Panelists*Products	18	35.489	35.489	1.972	0.69	0.791
Error	28	79.885	79.885	2.853		
Total	55	595.461				

S = 1.68909 R-Sq = 86.58% R-Sq(adj) = 73.65%

Analysis of Variance for Mandarin flavour, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Panelists	6	318.475	318.475	53.079	48.36	0.000
Products	3	51.464	51.464	17.155	15.63	0.000

Panelists*Products	18	20.276	20.276	1.126	1.03	0.464
Error	28	30.730	30.730	1.097		
Total	55	420.945				

S = 1.04762 R-Sq = 92.70% R-Sq(adj) = 85.66%

Analysis of Variance for Hardness, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Panelists	6	229.714	229.714	38.286	24.29	0.000
Products	3	114.661	114.661	38.220	24.25	0.000
Panelists*Products	18	39.416	39.416	2.190	1.39	0.212
Error	28	44.135	44.135	1.576		
Total	55	427.926				

S = 1.25549 R-Sq = 89.69% R-Sq(adj) = 79.74%

Analysis of Variance for Juiciness, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Panelists	6	20.715	20.715	3.452	2.15	0.079
Products	3	124.325	124.325	41.442	25.79	0.000
Panelists*Products	18	43.506	43.506	2.417	1.50	0.162
Error	28	44.995	44.995	1.607		
Total	55	233.541				

S = 1.26766 R-Sq = 80.73% R-Sq(adj) = 62.16%

Analysis of Variance for Chewiness, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Panelists	6	171.232	171.232	28.539	16.89	0.000
Products	3	17.664	17.664	5.888	3.49	0.029
Panelists*Products	18	83.138	83.138	4.619	2.73	0.008
Error	28	47.300	47.300	1.689		
Total	55	319.334				

S = 1.29973 R-Sq = 85.19% R-Sq(adj) = 70.90%

Analysis of Variance for Ease of Swallowing the bolus, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Panelists	6	383.636	383.636	63.939	26.38	0.000
Products	3	68.175	68.175	22.725	9.37	0.000
Panelists*Products	18	63.474	63.474	3.526	1.45	0.182
Error	28	67.875	67.875	2.424		
Total	55	583.160				

S = 1.55695 R-Sq = 88.36% R-Sq(adj) = 77.14%

Analysis of Variance for Feel individual juice sac, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Panelists	6	374.879	374.879	62.480	63.42	0.000
Products	3	25.046	25.046	8.349	8.47	0.000
Panelists*Products	18	86.235	86.235	4.791	4.86	0.000
Error	28	27.585	27.585	0.985		

Total 55 513.746

S = 0.992562 R-Sq = 94.63% R-Sq(adj) = 89.45%

Analysis of Variance for Fibrous_1, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Panelists	6	238.030	238.030	39.672	16.85	0.000
Products	3	50.385	50.385	16.795	7.13	0.001
Panelists*Products	18	79.989	79.989	4.444	1.89	0.064
Error	28	65.925	65.925	2.354		
Total	55	434.328				

S = 1.53443 R-Sq = 84.82% R-Sq(adj) = 70.18%

Analysis of Variance for Bitter_1, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Panelists	6	70.5736	70.5736	11.7623	14.76	0.000
Products	3	7.3391	7.3391	2.4464	3.07	0.044
Panelists*Products	18	14.5921	14.5921	0.8107	1.02	0.472
Error	28	22.3150	22.3150	0.7970		
Total	55	114.8198				

S = 0.892729 R-Sq = 80.57% R-Sq(adj) = 61.82%

Analysis of Variance for Bland, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Panelists	6	418.146	418.146	69.691	24.32	0.000
Products	3	47.065	47.065	15.688	5.48	0.004
Panelists*Products	18	65.732	65.732	3.652	1.27	0.275
Error	28	80.230	80.230	2.865		
Total	55	611.174				

S = 1.69274 R-Sq = 86.87% R-Sq(adj) = 74.21%

Analysis of Variance for Mandarin, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Panelists	6	256.601	256.601	42.767	82.64	0.000
Products	3	100.040	100.040	33.347	64.44	0.000
Panelists*Products	18	27.578	27.578	1.532	2.96	0.005
Error	28	14.490	14.490	0.518		
Total	55	398.709				

S = 0.719375 R-Sq = 96.37% R-Sq(adj) = 92.86%

Grouping Information Using Tukey Method and 95.0% Confidence for Colour

Products	N	Mean	Grouping
35% Granulation	14	10.364	A
15% Granulation	14	9.400	A
45% Granulation	14	6.957	B
55% Granulation	14	3.679	C

Means that do not share a letter are significantly different.

Grouping Information Using Tukey Method and 95.0% Confidence for Glossy

Products	N	Mean	Grouping
35% Granulation	14	10.029	A
15% Granulation	14	9.693	A
45% Granulation	14	7.521	B
55% Granulation	14	5.321	C

Means that do not share a letter are significantly different.

Grouping Information Using Tukey Method and 95.0% Confidence for Appears dry

Products	N	Mean	Grouping
55% Granulation	14	9.986	A
45% Granulation	14	7.143	B
35% Granulation	14	4.629	C
15% Granulation	14	4.229	C

Means that do not share a letter are significantly different.

Grouping Information Using Tukey Method and 95.0% Confidence for Ripeness

Products	N	Mean	Grouping
35% Granulation	14	10.807	A
15% Granulation	14	10.657	A
45% Granulation	14	9.314	B
55% Granulation	14	5.814	C

Means that do not share a letter are significantly different.

Grouping Information Using Tukey Method and 95.0% Confidence for Fibrous

Products	N	Mean	Grouping
55% Granulation	14	10.093	A
45% Granulation	14	8.971	B
35% Granulation	14	8.350	B C
15% Granulation	14	7.786	C

Means that do not share a letter are significantly different.

Grouping Information Using Tukey Method and 95.0% Confidence for Sweet

Products	N	Mean	Grouping
15% Granulation	14	9.379	A
35% Granulation	14	9.350	A
45% Granulation	14	8.350	A B
55% Granulation	14	7.643	B

Means that do not share a letter are significantly different.

Grouping Information Using Tukey Method and 95.0% Confidence for Sour

Products	N	Mean	Grouping
45% Granulation	14	7.436	A
15% Granulation	14	7.100	A
35% Granulation	14	6.907	A
55% Granulation	14	6.621	A

Means that do not share a letter are significantly different.

Grouping Information Using Tukey Method and 95.0% Confidence for Bitter

Products	N	Mean	Grouping
55% Granulation	14	3.800	A
35% Granulation	14	3.629	A
45% Granulation	14	3.371	A
15% Granulation	14	3.007	A

Means that do not share a letter are significantly different.

Grouping Information Using Tukey Method and 95.0% Confidence for Acidic

Products	N	Mean	Grouping
35% Granulation	14	7.071	A
45% Granulation	14	6.986	A
15% Granulation	14	6.514	A
55% Granulation	14	6.279	A

Means that do not share a letter are significantly different.

Grouping Information Using Tukey Method and 95.0% Confidence for Mandarin flavour

Products	N	Mean	Grouping
35% Granulation	14	9.150	A
15% Granulation	14	8.957	A
45% Granulation	14	8.071	A
55% Granulation	14	6.721	B

Means that do not share a letter are significantly different.

Grouping Information Using Tukey Method and 95.0% Confidence for Hardness

Products	N	Mean	Grouping
55% Granulation	14	8.707	A
45% Granulation	14	7.414	A
15% Granulation	14	5.507	B
35% Granulation	14	5.207	B

Means that do not share a letter are significantly different.

Grouping Information Using Tukey Method and 95.0% Confidence for Juiciness

Products	N	Mean	Grouping
15% Granulation	14	11.221	A
35% Granulation	14	11.100	A
45% Granulation	14	9.707	B
55% Granulation	14	7.521	C

Means that do not share a letter are significantly different.

Grouping Information Using Tukey Method and 95.0% Confidence for Chewiness

Products	N	Mean	Grouping
55% Granulation	14	9.721	A
45% Granulation	14	9.429	A B
35% Granulation	14	8.593	A B
15% Granulation	14	8.371	B

Means that do not share a letter are significantly different.

Grouping Information Using Tukey Method and 95.0% Confidence for Ease of

Swallowing the bolus

Products	N	Mean	Grouping
55% Granulation	14	7.407	A
45% Granulation	14	6.693	A B
35% Granulation	14	5.614	B C
15% Granulation	14	4.493	C

Means that do not share a letter are significantly different.

Grouping Information Using Tukey Method and 95.0% Confidence for Feel individual juice sac

Products	N	Mean	Grouping
55% Granulation	14	6.636	A
45% Granulation	14	5.479	B
15% Granulation	14	5.121	B
35% Granulation	14	4.900	B

Means that do not share a letter are significantly different.

Grouping Information Using Tukey Method and 95.0% Confidence for Fibrous_1

Products	N	Mean	Grouping
55% Granulation	14	8.586	A
45% Granulation	14	8.257	A B
35% Granulation	14	7.000	B C
15% Granulation	14	6.236	C

Means that do not share a letter are significantly different.

Grouping Information Using Tukey Method and 95.0% Confidence for Bitter_1

Products	N	Mean	Grouping
55% Granulation	14	3.229	A
45% Granulation	14	2.729	A B
35% Granulation	14	2.507	A B
15% Granulation	14	2.243	B

Means that do not share a letter are significantly different.

Grouping Information Using Tukey Method and 95.0% Confidence for Bland

Products	N	Mean	Grouping
55% Granulation	14	6.564	A
45% Granulation	14	5.393	A B
35% Granulation	14	4.350	B
15% Granulation	14	4.336	B

Means that do not share a letter are significantly different.

Grouping Information Using Tukey Method and 95.0% Confidence for Mandarin

Products	N	Mean	Grouping
15% Granulation	14	9.500	A
35% Granulation	14	8.814	A
45% Granulation	14	7.086	B
55% Granulation	14	6.143	C

Means that do not share a letter are significantly different.

General Linear Model: Colour, Glossy, ... versus Panelist, Product

Factor	Type	Levels	Values
Panelist	fixed	8	Alona, Balkumari, Christina, Huma, Jane, Karishma, Max, Pramesh
Product	fixed	5	10% Granulation, 45% Granulation, 5% Granulation, 55% Granulation, 80% Granulation

Analysis of Variance for Colour, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Panelist	7	92.454	92.454	13.208	6.42	0.000
Product	4	985.764	985.764	246.441	119.86	0.000
Panelist*Product	28	141.374	141.374	5.049	2.46	0.005
Error	40	82.245	82.245	2.056		
Total	79	1301.837				

S = 1.43392 R-Sq = 93.68% R-Sq(adj) = 87.52%

Analysis of Variance for Glossy, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Panelist	7	103.188	103.188	14.741	5.30	0.000
Product	4	842.520	842.520	210.630	75.73	0.000
Panelist*Product	28	162.792	162.792	5.814	2.09	0.016
Error	40	111.260	111.260	2.781		
Total	79	1219.760				

S = 1.66778 R-Sq = 90.88% R-Sq(adj) = 81.99%

Analysis of Variance for Appears dry, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Panelist	7	82.228	82.228	11.747	4.54	0.001
Product	4	1194.553	1194.553	298.638	115.40	0.000
Panelist*Product	28	178.105	178.105	6.361	2.46	0.005
Error	40	103.510	103.510	2.588		
Total	79	1558.395				

S = 1.60865 R-Sq = 93.36% R-Sq(adj) = 86.88%

Analysis of Variance for Ripeness, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Panelist	7	90.586	90.586	12.941	10.28	0.000
Product	4	902.638	902.638	225.660	179.29	0.000
Panelist*Product	28	224.630	224.630	8.022	6.37	0.000
Error	40	50.345	50.345	1.259		
Total	79	1268.199				

S = 1.12188 R-Sq = 96.03% R-Sq(adj) = 92.16%

Analysis of Variance for Fibrous, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Panelist	7	158.303	158.303	22.615	6.59	0.000
Product	4	774.165	774.164	193.541	56.42	0.000
Panelist*Product	28	180.281	180.281	6.439	1.88	0.033
Error	40	137.215	137.215	3.430		
Total	79	1249.964				

S = 1.85213   R-Sq = 89.02%   R-Sq(adj) = 78.32%

Analysis of Variance for Sweet, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Panelist	7	346.662	346.662	49.523	17.42	0.000
Product	4	322.405	322.405	80.601	28.35	0.000
Panelist*Product	28	184.981	184.981	6.606	2.32	0.007
Error	40	113.740	113.740	2.843		
Total	79	967.788				

S = 1.68627   R-Sq = 88.25%   R-Sq(adj) = 76.79%

Analysis of Variance for Sour, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Panelist	7	334.192	334.192	47.742	8.90	0.000
Product	4	316.675	316.675	79.169	14.76	0.000
Panelist*Product	28	210.365	210.365	7.513	1.40	0.161
Error	40	214.480	214.480	5.362		
Total	79	1075.712				

S = 2.31560   R-Sq = 80.06%   R-Sq(adj) = 60.62%

Analysis of Variance for Bitter, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Panelist	7	213.390	213.390	30.484	8.51	0.000
Product	4	6.941	6.941	1.735	0.48	0.747
Panelist*Product	28	186.799	186.799	6.671	1.86	0.035
Error	40	143.350	143.350	3.584		
Total	79	550.480				

S = 1.89308   R-Sq = 73.96%   R-Sq(adj) = 48.57%

Analysis of Variance for Acidic, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Panelist	7	263.174	263.174	37.596	8.04	0.000
Product	4	380.426	380.426	95.106	20.34	0.000
Panelist*Product	28	135.360	135.360	4.834	1.03	0.454
Error	40	187.055	187.055	4.676		
Total	79	966.015				

S = 2.16249   R-Sq = 80.64%   R-Sq(adj) = 61.76%

Analysis of Variance for Mandarin flavour, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Panelist	7	294.492	294.492	42.070	17.20	0.000
Product	4	524.931	524.931	131.233	53.66	0.000
Panelist*Product	28	127.277	127.277	4.546	1.86	0.036
Error	40	97.820	97.820	2.445		
Total	79	1044.520				

S = 1.56381   R-Sq = 90.63%   R-Sq(adj) = 81.50%

Analysis of Variance for Hardness, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Panelist	7	105.057	105.057	15.008	8.19	0.000
Product	4	751.534	751.534	187.884	102.51	0.000
Panelist*Product	28	163.124	163.124	5.826	3.18	0.000
Error	40	73.315	73.315	1.833		
Total	79	1093.030				

S = 1.35384 R-Sq = 93.29% R-Sq(adj) = 86.75%

Analysis of Variance for Juiciness, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Panelist	7	36.748	36.747	5.250	2.68	0.022
Product	4	947.060	947.060	236.765	120.94	0.000
Panelist*Product	28	105.103	105.103	3.754	1.92	0.029
Error	40	78.310	78.310	1.958		
Total	79	1167.220				

S = 1.39920 R-Sq = 93.29% R-Sq(adj) = 86.75%

Analysis of Variance for Chewiness, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Panelist	7	185.806	185.806	26.544	8.59	0.000
Product	4	237.816	237.816	59.454	19.24	0.000
Panelist*Product	28	396.980	396.980	14.178	4.59	0.000
Error	40	123.590	123.590	3.090		
Total	79	944.192				

S = 1.75777 R-Sq = 86.91% R-Sq(adj) = 74.15%

Analysis of Variance for Ease of Swallowing the bolus, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Panelist	7	136.334	136.334	19.476	11.87	0.000
Product	4	587.844	587.844	146.961	89.55	0.000
Panelist*Product	28	238.792	238.792	8.528	5.20	0.000
Error	40	65.645	65.645	1.641		
Total	79	1028.615				

S = 1.28106 R-Sq = 93.62% R-Sq(adj) = 87.40%

Analysis of Variance for Feel individual juice sac, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Panelist	7	87.492	87.492	12.499	5.47	0.000
Product	4	532.188	532.188	133.047	58.18	0.000
Panelist*Product	28	494.590	494.590	17.664	7.72	0.000
Error	40	91.475	91.475	2.287		
Total	79	1205.745				

S = 1.51224 R-Sq = 92.41% R-Sq(adj) = 85.02%

Analysis of Variance for Fibrous_1, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Panelist	7	166.584	166.584	23.798	17.39	0.000
Product	4	780.678	780.678	195.170	142.59	0.000
Panelist*Product	28	101.304	101.304	3.618	2.64	0.002
Error	40	54.750	54.750	1.369		
Total	79	1103.316				

S = 1.16994 R-Sq = 95.04% R-Sq(adj) = 90.20%

Analysis of Variance for Bitter_1, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Panelist	7	145.410	145.410	20.773	6.84	0.000
Product	4	7.601	7.601	1.900	0.63	0.647
Panelist*Product	28	127.463	127.463	4.552	1.50	0.118
Error	40	121.515	121.515	3.038		
Total	79	401.989				

S = 1.74295 R-Sq = 69.77% R-Sq(adj) = 40.30%

Analysis of Variance for Bland, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Panelist	7	659.890	659.890	94.270	17.27	0.000
Product	4	416.710	416.710	104.177	19.09	0.000
Panelist*Product	28	235.052	235.052	8.395	1.54	0.104
Error	40	218.310	218.310	5.458		
Total	79	1529.962				

S = 2.33618 R-Sq = 85.73% R-Sq(adj) = 71.82%

Analysis of Variance for Mandarin, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Panelist	7	423.142	423.142	60.449	21.62	0.000
Product	4	406.898	406.898	101.724	36.38	0.000
Panelist*Product	28	172.576	172.576	6.163	2.20	0.011
Error	40	111.840	111.840	2.796		
Total	79	1114.456				

S = 1.67212 R-Sq = 89.96% R-Sq(adj) = 80.18%

Least Squares Means

	Colour		Glossy		Appears dry		Ripene	
Product	Mean	SE Mean	Mean	SE Mean	Mean	SE Mean	Mean	SE Mean
10% Granulation	10.800	0.3585	11.244	0.4169	2.606	0.4022	11.525	0.4022
45% Granulation	5.631	0.3585	5.906	0.4169	7.781	0.4022	7.069	0.4022
5% Granulation	11.200	0.3585	11.194	0.4169	2.200	0.4022	11.706	0.4022
55% Granulation	4.919	0.3585	6.219	0.4169	8.131	0.4022	6.694	0.4022
80% Granulation	2.169	0.3585	2.938	0.4169	12.569	0.4022	2.738	0.4022

		Fibrous		Sweet		Sour	
Product	SE Mean	Mean	SE Mean	Mean	SE Mean	Mean	SE Mean

10% Granulation	0.2805	3.588	0.4630	9.894	0.4216	7.631	0.5789
45% Granulation	0.2805	9.275	0.4630	7.175	0.4216	7.500	0.5789
5% Granulation	0.2805	3.462	0.4630	9.319	0.4216	10.894	0.5789
55% Granulation	0.2805	9.231	0.4630	7.094	0.4216	8.269	0.5789
80% Granulation	0.2805	10.800	0.4630	4.206	0.4216	4.656	0.5789

					---Mandarin---		
	----Bitter----		-----Acidic----		----flavour----		Hardne
Product	Mean	SE Mean	Mean	SE Mean	Mean	SE Mean	Mean
10% Granulation	3.194	0.4733	8.069	0.5406	9.331	0.3910	3.644
45% Granulation	3.288	0.4733	7.350	0.5406	7.175	0.3910	9.200
5% Granulation	3.262	0.4733	10.488	0.5406	10.000	0.3910	3.812
55% Granulation	3.969	0.4733	7.763	0.5406	6.781	0.3910	8.969
80% Granulation	3.650	0.4733	3.700	0.5406	2.700	0.3910	11.181

					----Ease of----	
					-Swallowing the	
	---Juiciness---		---Chewiness--		-----bolus-----	
Product	SE Mean	Mean	SE Mean	Mean	SE Mean	Mean	SE Mean
10% Granulation	0.3385	11.837	0.3498	6.263	0.4394	3.106	0.3203
45% Granulation	0.3385	8.444	0.3498	9.206	0.4394	7.700	0.3203
5% Granulation	0.3385	11.619	0.3498	5.531	0.4394	3.362	0.3203
55% Granulation	0.3385	7.019	0.3498	8.963	0.4394	7.294	0.3203
80% Granulation	0.3385	2.469	0.3498	9.837	0.4394	10.169	0.3203

	Feel individual						-Bland
	---juice sac---		---Fibrous_1---		---Bitter_1---		
Product	Mean	SE Mean	Mean	SE Mean	Mean	SE Mean	Mean
10% Granulation	4.475	0.3781	4.100	0.2925	2.575	0.4357	4.481
45% Granulation	8.063	0.3781	9.969	0.2925	3.519	0.4357	6.250
5% Granulation	3.263	0.3781	3.531	0.2925	3.244	0.4357	4.031
55% Granulation	8.113	0.3781	9.456	0.2925	3.131	0.4357	6.319
80% Granulation	10.269	0.3781	10.906	0.2925	3.050	0.4357	10.494

		---Mandarin---	
Product	SE Mean	Mean	SE Mean
10% Granulation	0.5840	8.725	0.4180
45% Granulation	0.5840	7.362	0.4180
5% Granulation	0.5840	9.075	0.4180
55% Granulation	0.5840	6.525	0.4180
80% Granulation	0.5840	2.775	0.4180

Grouping Information Using Tukey Method and 95.0% Confidence for Colour

Product	N	Mean	Grouping
5% Granulation	16	11.200	A
10% Granulation	16	10.800	A
45% Granulation	16	5.631	B
55% Granulation	16	4.919	B
80% Granulation	16	2.169	C

Means that do not share a letter are significantly different.

Grouping Information Using Tukey Method and 95.0% Confidence for Glossy

Product	N	Mean	Grouping
10% Granulation	16	11.244	A
5% Granulation	16	11.194	A
55% Granulation	16	6.219	B
45% Granulation	16	5.906	B
80% Granulation	16	2.938	C

Means that do not share a letter are significantly different.

Grouping Information Using Tukey Method and 95.0% Confidence for Appears dry

Product	N	Mean	Grouping
80% Granulation	16	12.569	A
55% Granulation	16	8.131	B
45% Granulation	16	7.781	B
10% Granulation	16	2.606	C
5% Granulation	16	2.200	C

Means that do not share a letter are significantly different.

Grouping Information Using Tukey Method and 95.0% Confidence for Ripeness

Product	N	Mean	Grouping
5% Granulation	16	11.706	A
10% Granulation	16	11.525	A
45% Granulation	16	7.069	B
55% Granulation	16	6.694	B
80% Granulation	16	2.738	C

Means that do not share a letter are significantly different.

Grouping Information Using Tukey Method and 95.0% Confidence for Fibrous

Product	N	Mean	Grouping
80% Granulation	16	10.800	A
45% Granulation	16	9.275	A
55% Granulation	16	9.231	A
10% Granulation	16	3.588	B
5% Granulation	16	3.462	B

Means that do not share a letter are significantly different.

Grouping Information Using Tukey Method and 95.0% Confidence for Sweet

Product	N	Mean	Grouping
10% Granulation	16	9.894	A
5% Granulation	16	9.319	A
45% Granulation	16	7.175	B
55% Granulation	16	7.094	B
80% Granulation	16	4.206	C

Means that do not share a letter are significantly different.

Grouping Information Using Tukey Method and 95.0% Confidence for Sour

Product	N	Mean	Grouping
5% Granulation	16	10.894	A
55% Granulation	16	8.269	B
10% Granulation	16	7.631	B
45% Granulation	16	7.500	B
80% Granulation	16	4.656	C

Means that do not share a letter are significantly different.

Grouping Information Using Tukey Method and 95.0% Confidence for Bitter

Product	N	Mean	Grouping
55% Granulation	16	3.969	A
80% Granulation	16	3.650	A

45% Granulation	16	3.288	A
5% Granulation	16	3.262	A
10% Granulation	16	3.194	A

Means that do not share a letter are significantly different.

Grouping Information Using Tukey Method and 95.0% Confidence for Acidic

Product	N	Mean	Grouping
5% Granulation	16	10.488	A
10% Granulation	16	8.069	B
55% Granulation	16	7.763	B
45% Granulation	16	7.350	B
80% Granulation	16	3.700	C

Means that do not share a letter are significantly different.

Grouping Information Using Tukey Method and 95.0% Confidence for Mandarin flavour

Product	N	Mean	Grouping
5% Granulation	16	10.000	A
10% Granulation	16	9.331	A
45% Granulation	16	7.175	B
55% Granulation	16	6.781	B
80% Granulation	16	2.700	C

Means that do not share a letter are significantly different.

Grouping Information Using Tukey Method and 95.0% Confidence for Hardness

Product	N	Mean	Grouping
80% Granulation	16	11.181	A
45% Granulation	16	9.200	B
55% Granulation	16	8.969	B
5% Granulation	16	3.812	C
10% Granulation	16	3.644	C

Means that do not share a letter are significantly different.

Grouping Information Using Tukey Method and 95.0% Confidence for Juiciness

Product	N	Mean	Grouping
10% Granulation	16	11.837	A
5% Granulation	16	11.619	A
45% Granulation	16	8.444	B
55% Granulation	16	7.019	C
80% Granulation	16	2.469	D

Means that do not share a letter are significantly different.

Grouping Information Using Tukey Method and 95.0% Confidence for Chewiness

Product	N	Mean	Grouping
80% Granulation	16	9.837	A
45% Granulation	16	9.206	A
55% Granulation	16	8.963	A
10% Granulation	16	6.263	B
5% Granulation	16	5.531	B

Means that do not share a letter are significantly different.

Grouping Information Using Tukey Method and 95.0% Confidence for Ease of Swallowing the bolus

Product	N	Mean	Grouping
80% Granulation	16	10.169	A
45% Granulation	16	7.700	B
55% Granulation	16	7.294	B
5% Granulation	16	3.362	C
10% Granulation	16	3.106	C

Means that do not share a letter are significantly different.

Grouping Information Using Tukey Method and 95.0% Confidence for Feel individual juice sac

Product	N	Mean	Grouping
80% Granulation	16	10.269	A
55% Granulation	16	8.113	B
45% Granulation	16	8.063	B
10% Granulation	16	4.475	C
5% Granulation	16	3.263	C

Means that do not share a letter are significantly different.

Grouping Information Using Tukey Method and 95.0% Confidence for Fibrous_1

Product	N	Mean	Grouping
80% Granulation	16	10.906	A
45% Granulation	16	9.969	A B
55% Granulation	16	9.456	B
10% Granulation	16	4.100	C
5% Granulation	16	3.531	C

Means that do not share a letter are significantly different.

Grouping Information Using Tukey Method and 95.0% Confidence for Bitter_1

Product	N	Mean	Grouping
45% Granulation	16	3.519	A
5% Granulation	16	3.244	A
55% Granulation	16	3.131	A
80% Granulation	16	3.050	A
10% Granulation	16	2.575	A

Means that do not share a letter are significantly different.

Grouping Information Using Tukey Method and 95.0% Confidence for Bland

Product	N	Mean	Grouping
80% Granulation	16	10.494	A
55% Granulation	16	6.319	B
45% Granulation	16	6.250	B
10% Granulation	16	4.481	B
5% Granulation	16	4.031	B

Means that do not share a letter are significantly different.

Grouping Information Using Tukey Method and 95.0% Confidence for Mandarin

Product	N	Mean	Grouping
5% Granulation	16	9.075	A
10% Granulation	16	8.725	A B
45% Granulation	16	7.362	B C

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55%  Granulation  16  6.525      C
80%  Granulation  16  2.775        D

Means that do not share a letter are significantly different.
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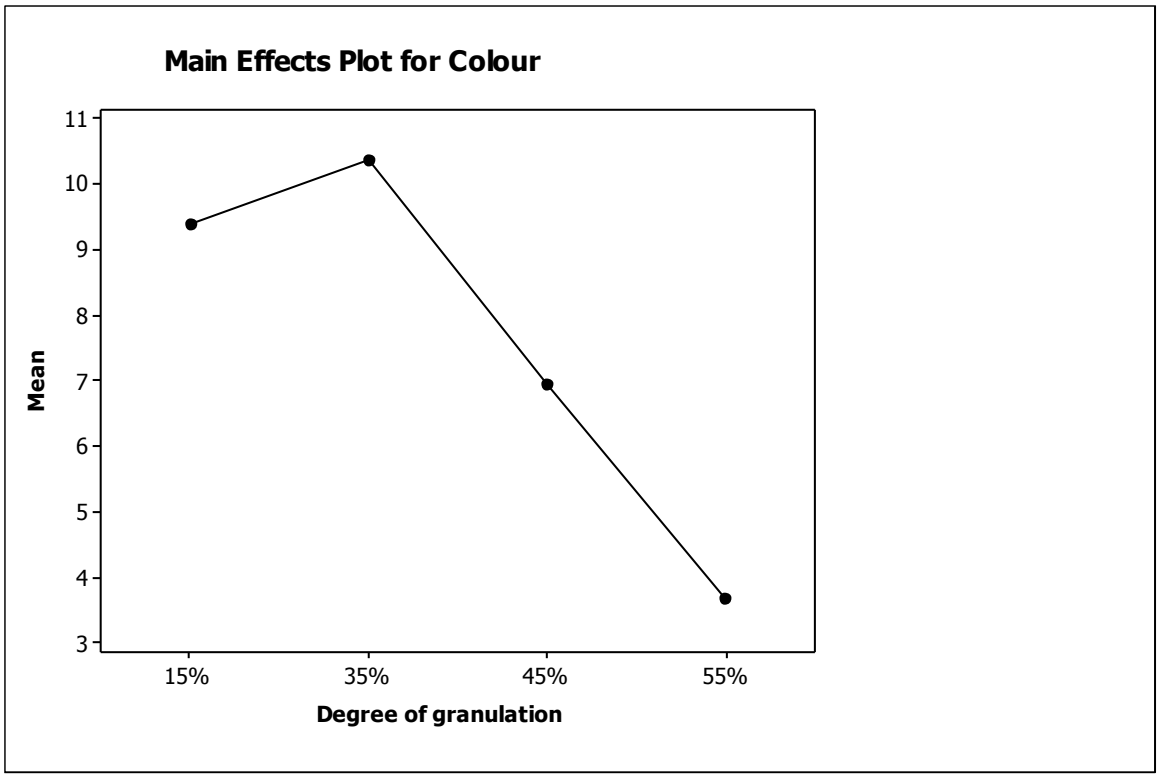
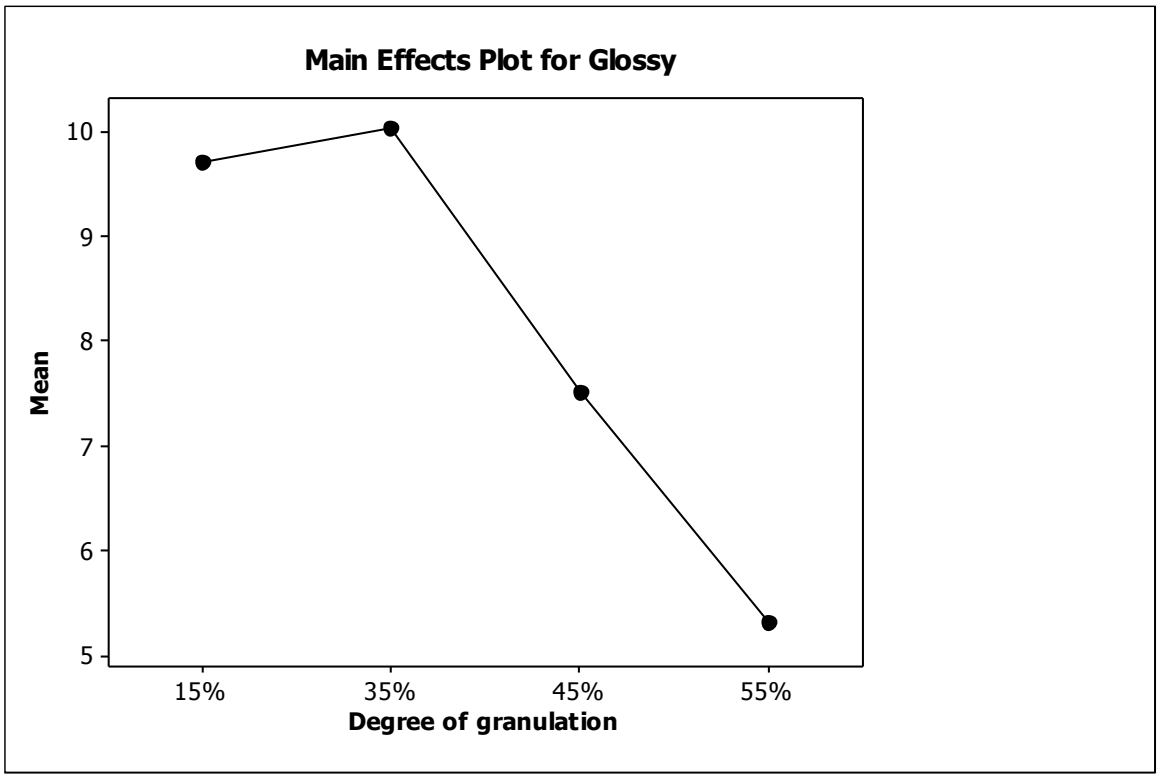
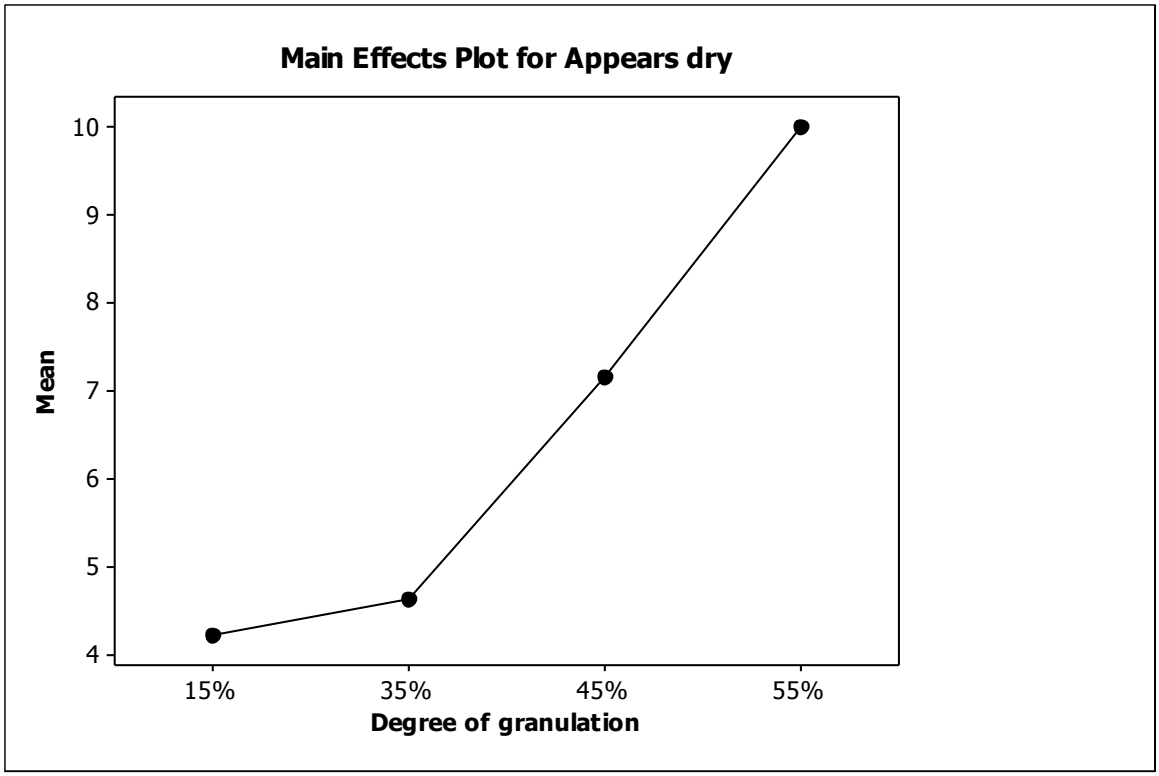
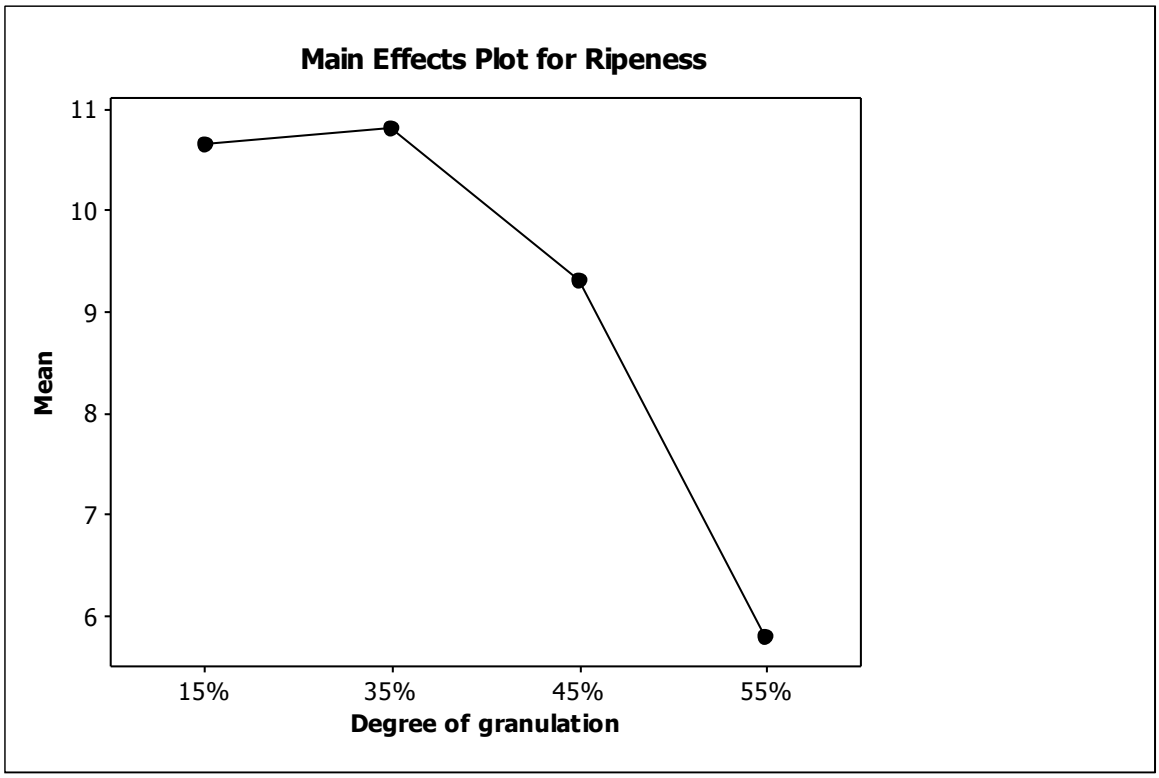
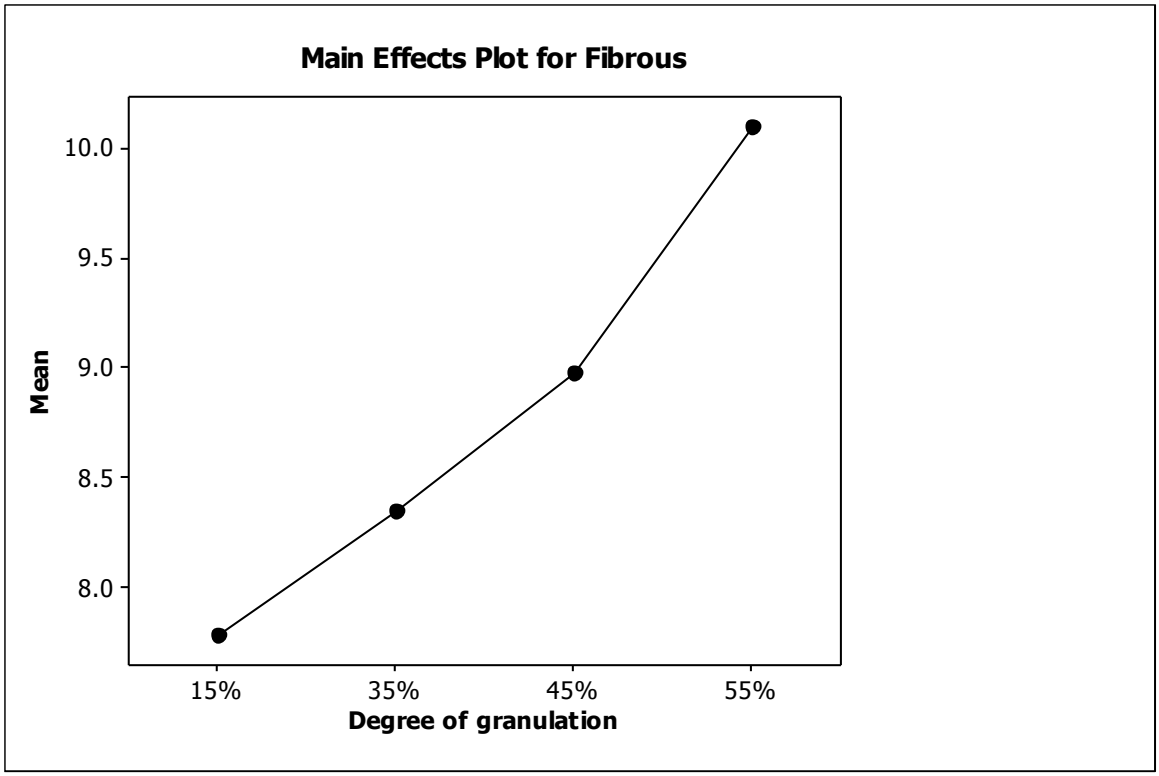





Main Effects Plot for Appears dry
Mean
10
9
8
7
6
5
4
15%
35%
45%
55%
Degree of granulation


Main Effects Plot for Ripeness
Mean
11
10
9
8
7
6
15%
35%
45%
55%
Degree of granulation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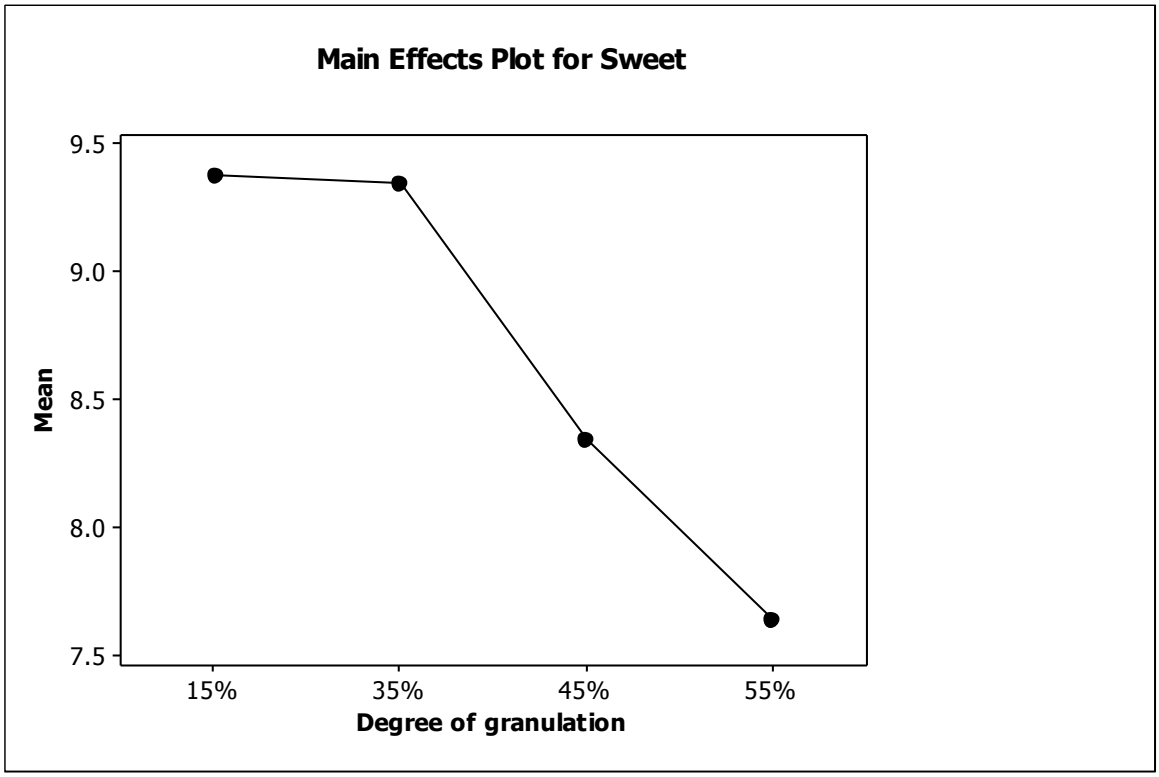
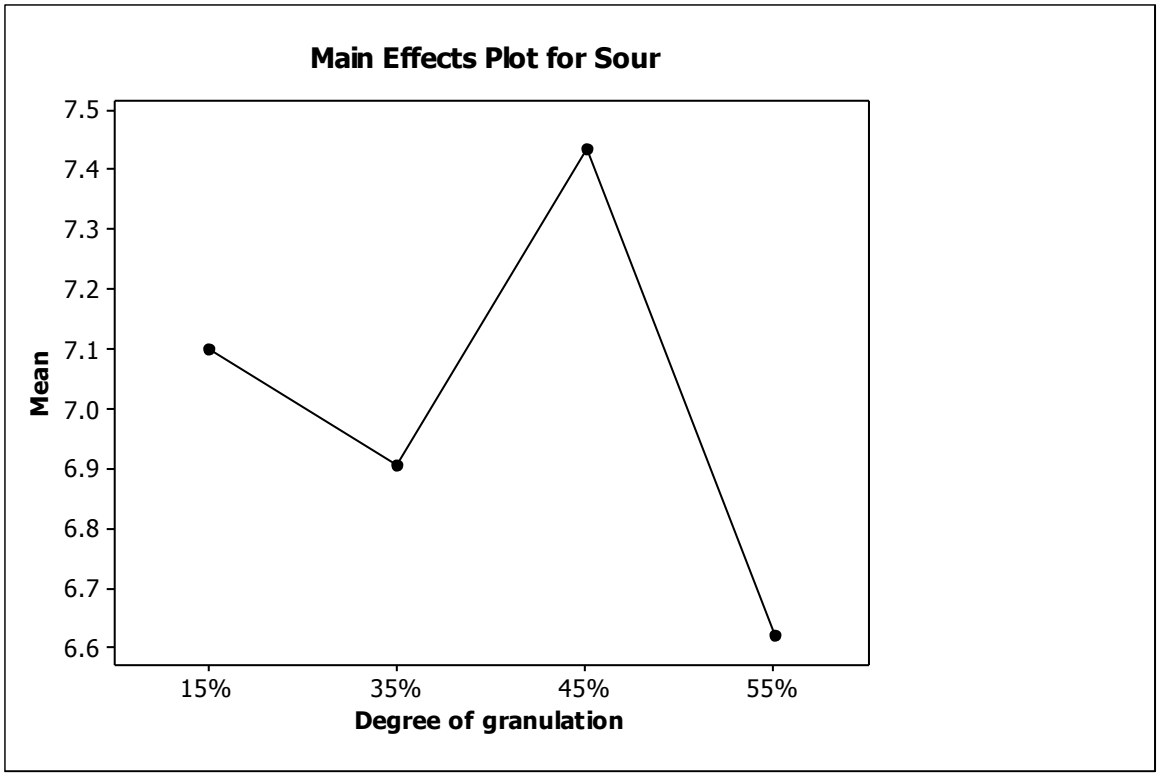
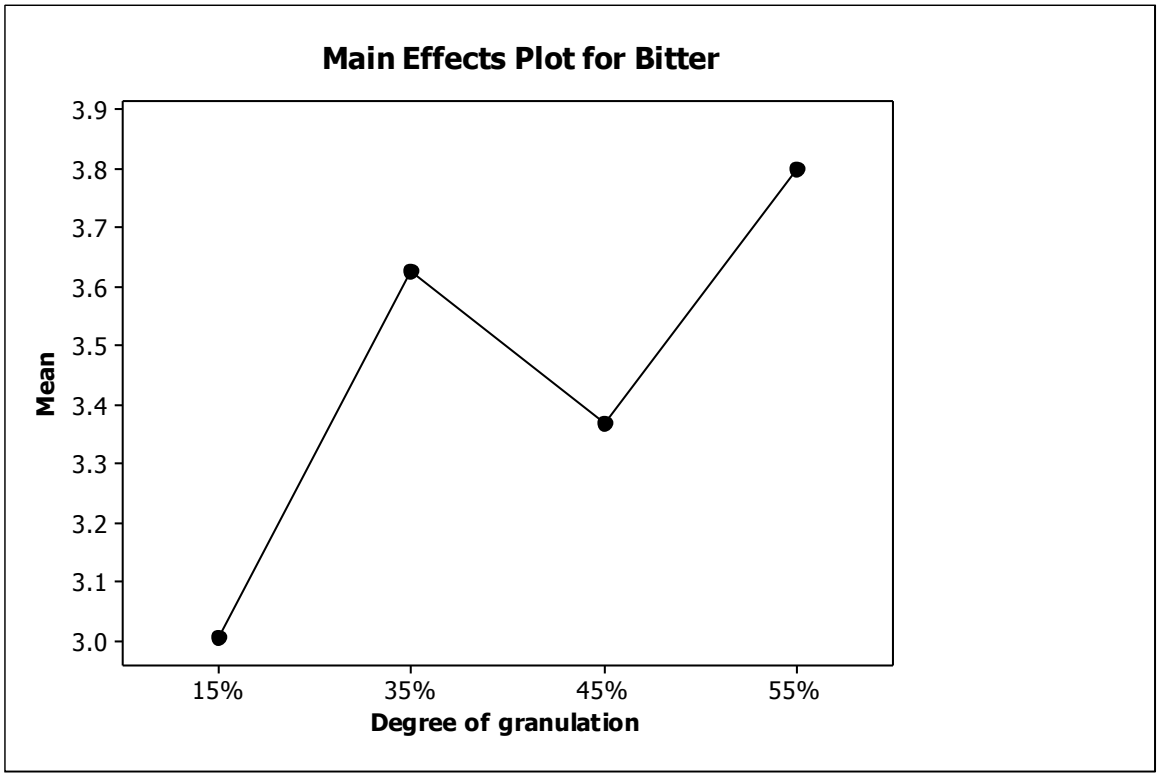
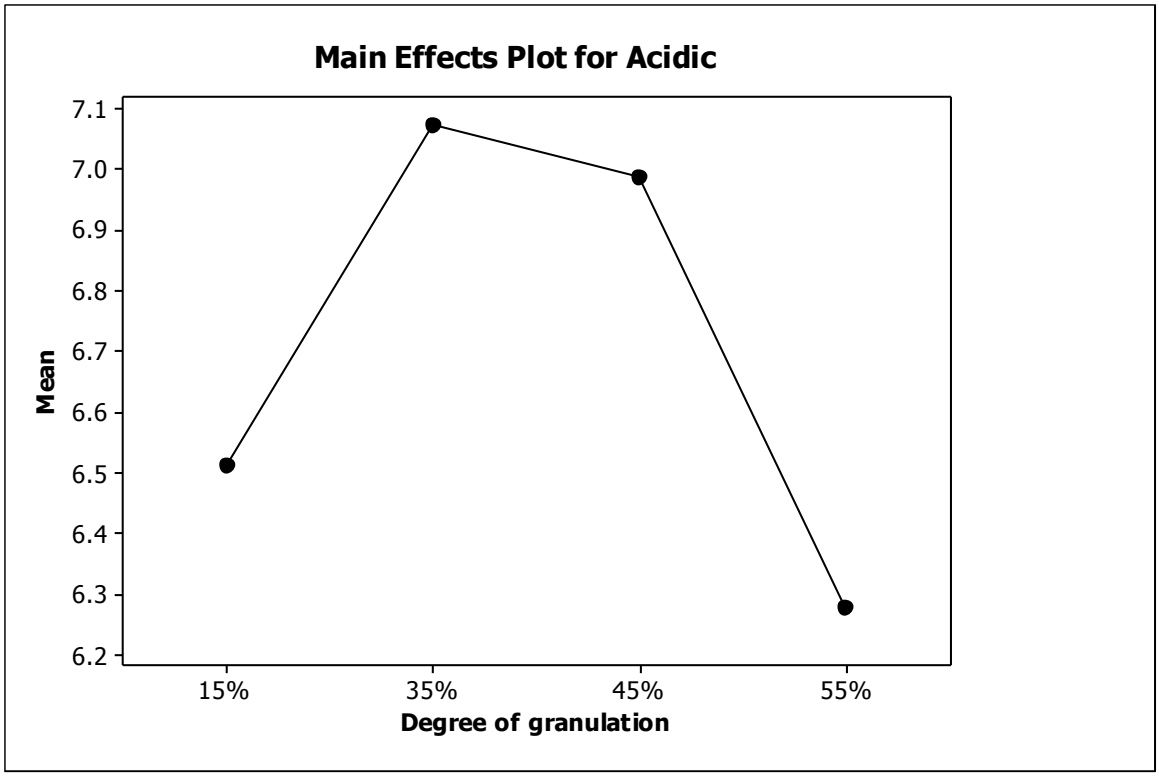
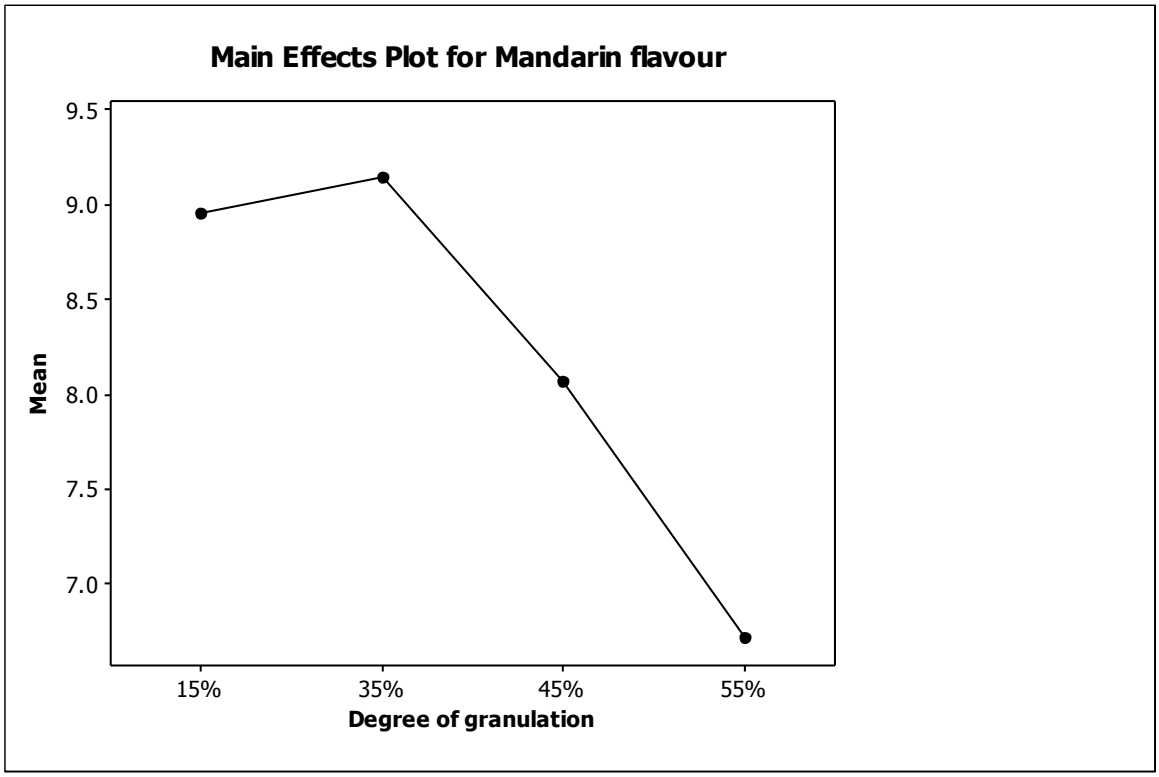
Mean
10.0
9.5
9.0
8.5
8.0
15%
35%
45%
55%
Degree of granulation

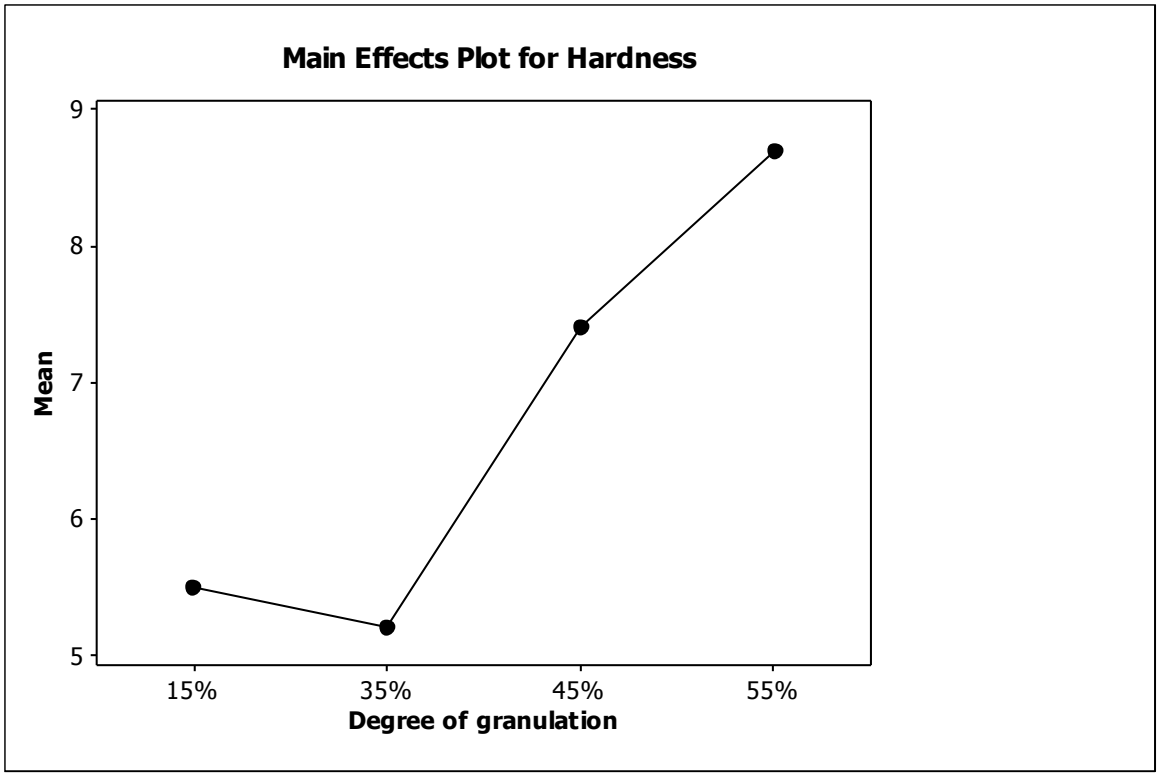

Main Effects Plot for Sweet
Mean
9.5
9.0
8.5
8.0
7.5
15%
35%
45%
55%
Degree of granulation

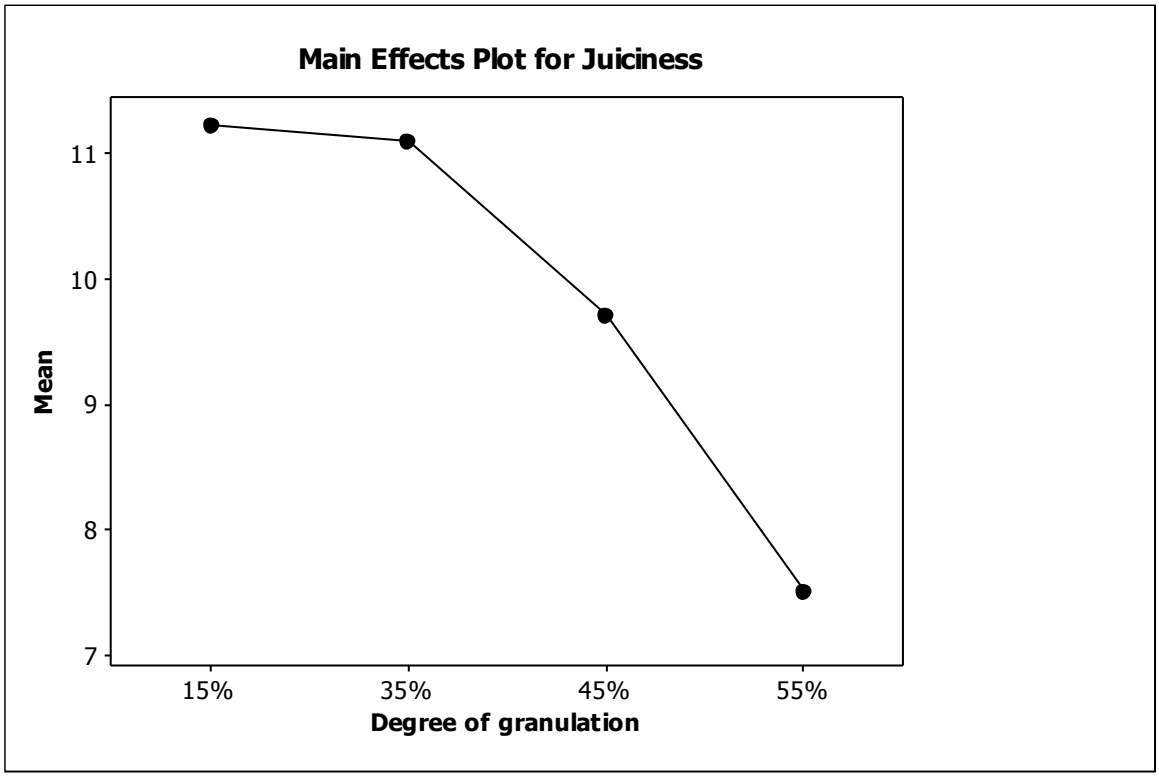

Main Effects Plot for Sour
Mean
7.5
7.4
7.3
7.2
7.1
7.0
6.9
6.8
6.7
6.6
15%
35%
45%
55%
Degree of granulation

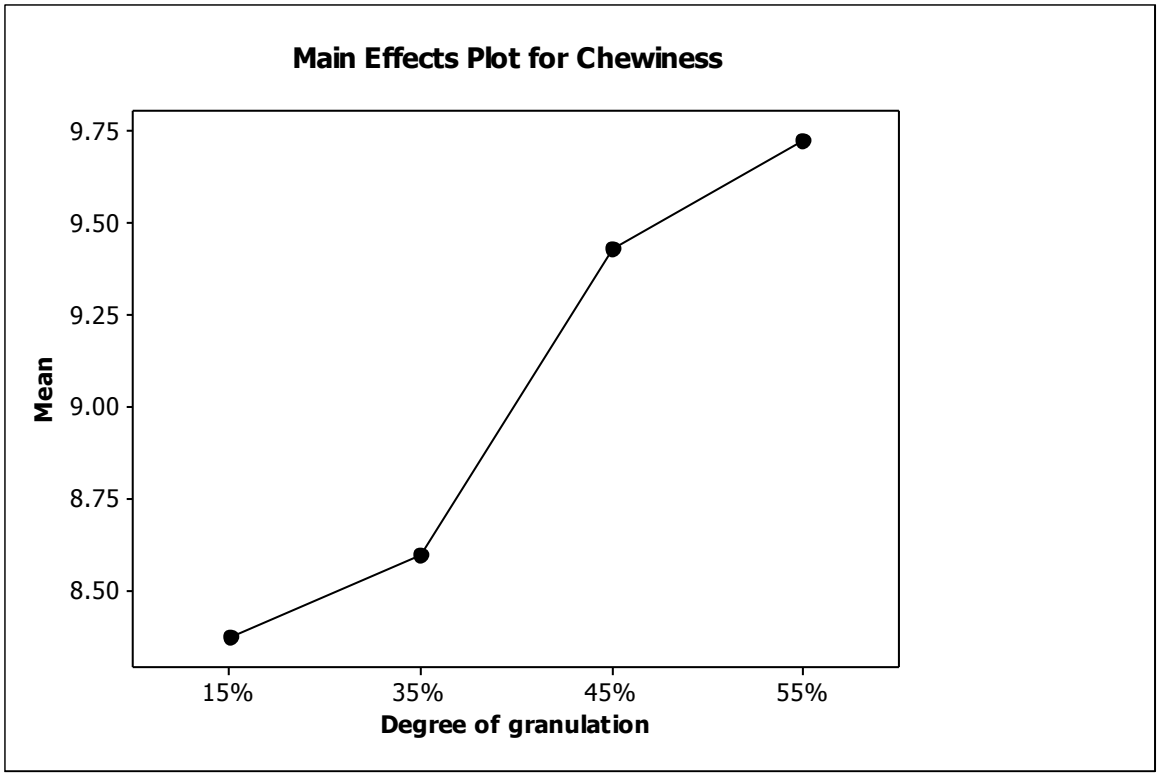

Main Effects Plot for Bitter
Mean
3.9
3.8
3.7
3.6
3.5
3.4
3.3
3.2
3.1
3.0
15%
35%
45%
55%
Degree of granulation

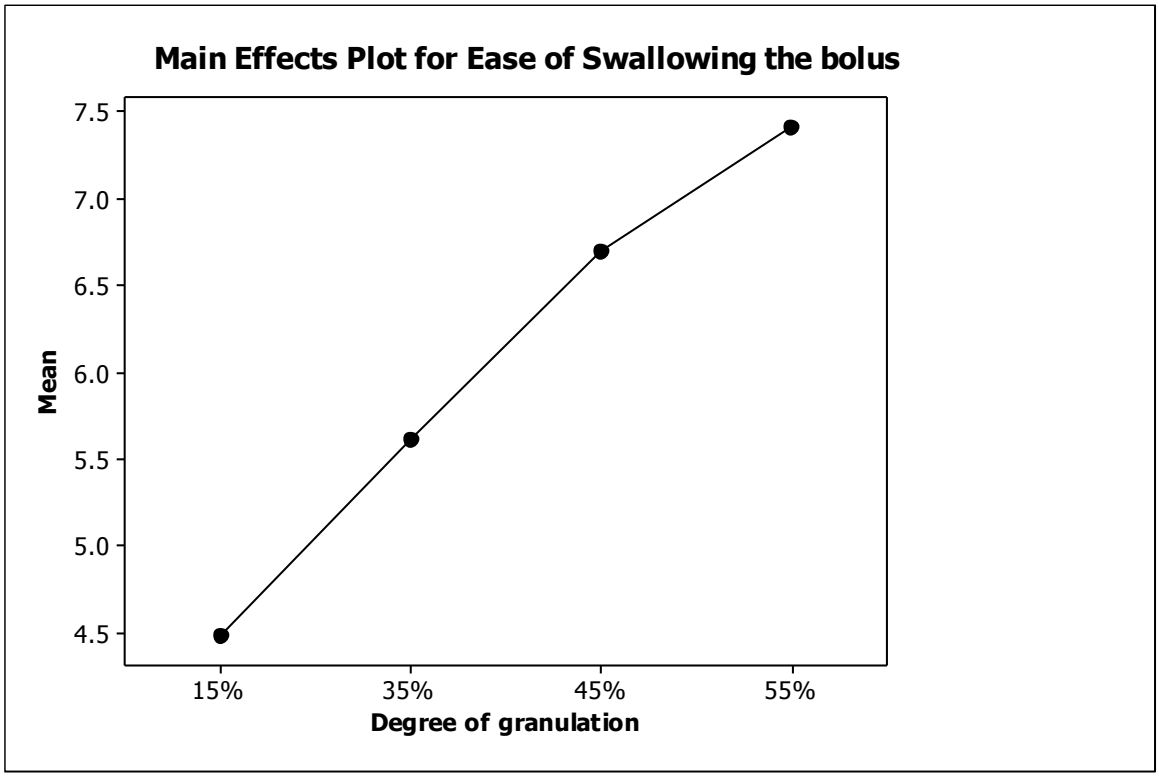

Main Effects Plot for Acidic
Mean
7.1
7.0
6.9
6.8
6.7
6.6
6.5
6.4
6.3
6.2
15%
35%
45%
55%
Degree of granulation

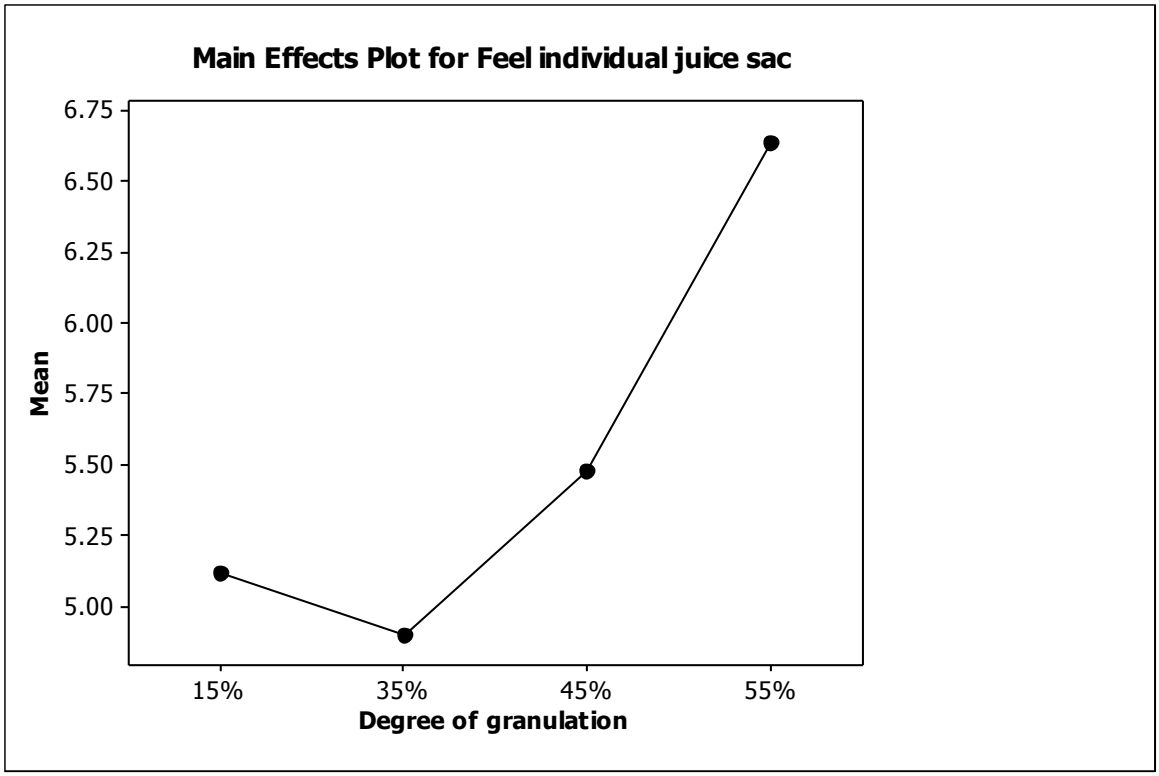

Main Effects Plot for Mandarin flavour
Mean
9.5
9.0
8.5
8.0
7.5
7.0
15%
35%
45%
55%
Degree of granulation

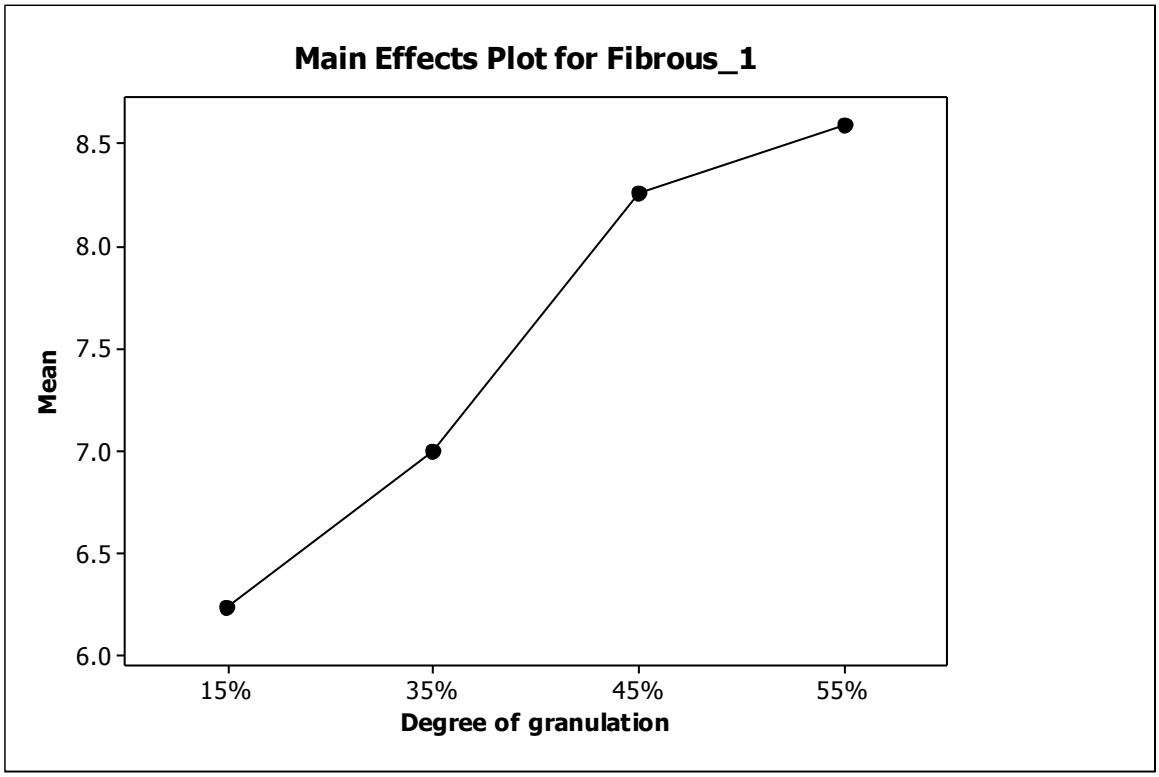

Main Effects Plot for Hardness
Mean
9
8
7
6
5
15%
35%
45%
55%
Degree of granulation

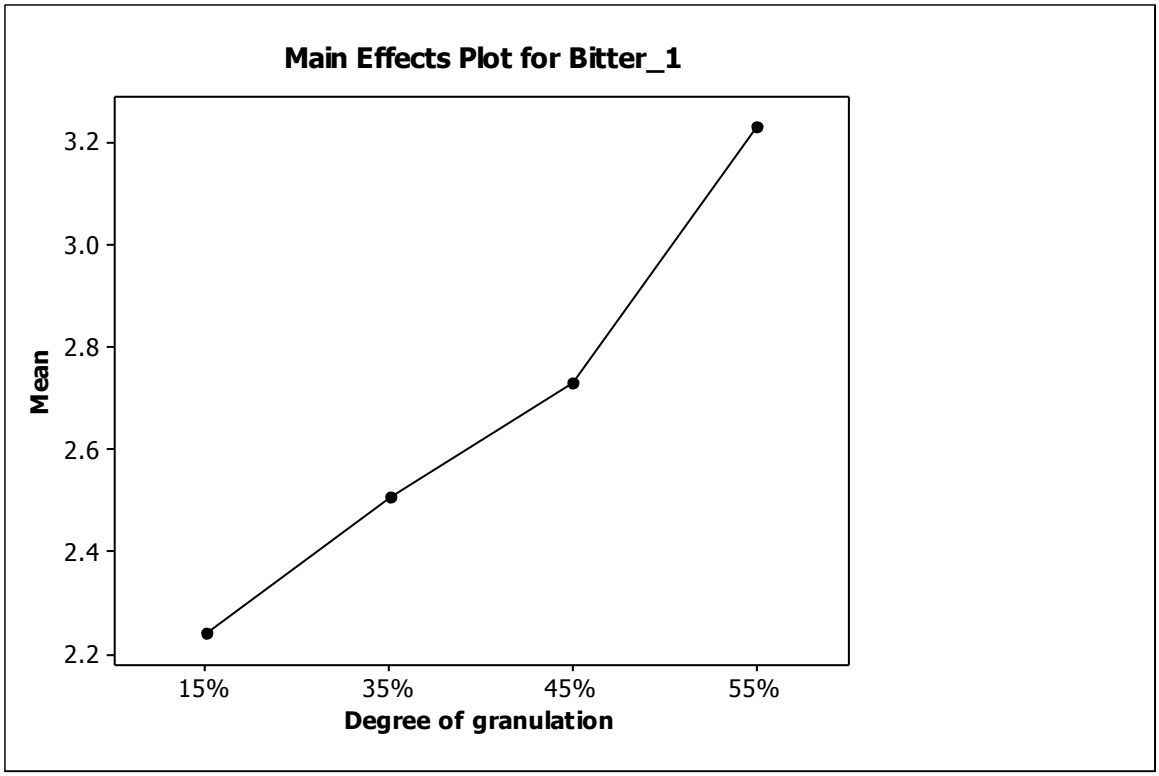

Main Effects Plot for Juiciness
Mean
11
10
9
8
7
15%
35%
45%
55%
Degree of granulation

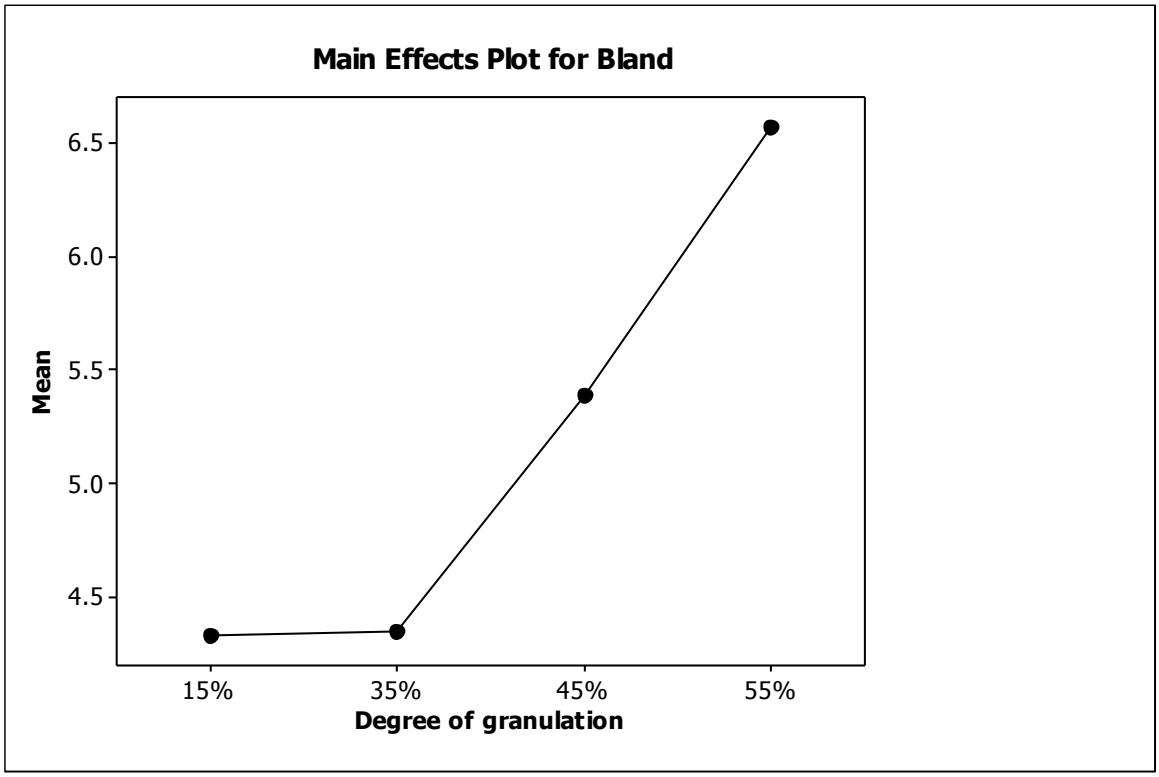

Main Effects Plot for Chewiness
Mean
9.75
9.50
9.25
9.00
8.75
8.50
15%
35%
45%
55%
Degree of granulation

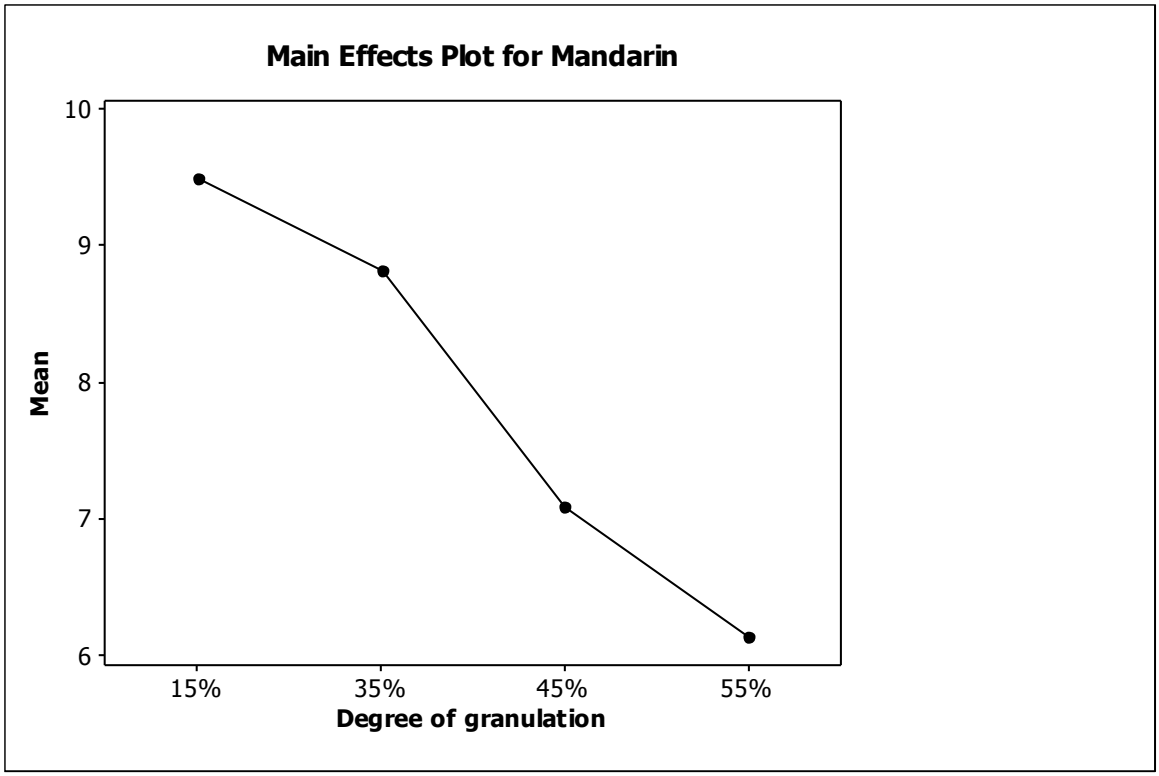

Main Effects Plot for Ease of Swallowing the bolus
Mean
7.5
7.0
6.5
6.0
5.5
5.0
4.5
15%
35%
45%
55%
Degree of granulation


Main Effects Plot for Feel individual juice sac
Mean
6.75
6.50
6.25
6.00
5.75
5.50
5.25
5.00
15%
35%
45%
55%
Degree of granulation


Main Effects Plot for Fibrous_1
Mean
8.5
8.0
7.5
7.0
6.5
6.0
15%
35%
45%
55%
Degree of granulation


Main Effects Plot for Bitter_1
Mean
3.2
3.0
2.8
2.6
2.4
2.2
15%
35%
45%
55%
Degree of granulation


Main Effects Plot for Bland
Mean
6.5
6.0
5.5
5.0
4.5
15%
35%
45%
55%
Degree of granulation


Main Effects Plot for Mandarin
Mean
10
9
8
7
6
15%
35%
45%
55%
Degree of granulation


80% GRANULATION