Improved handling in banana supply chains

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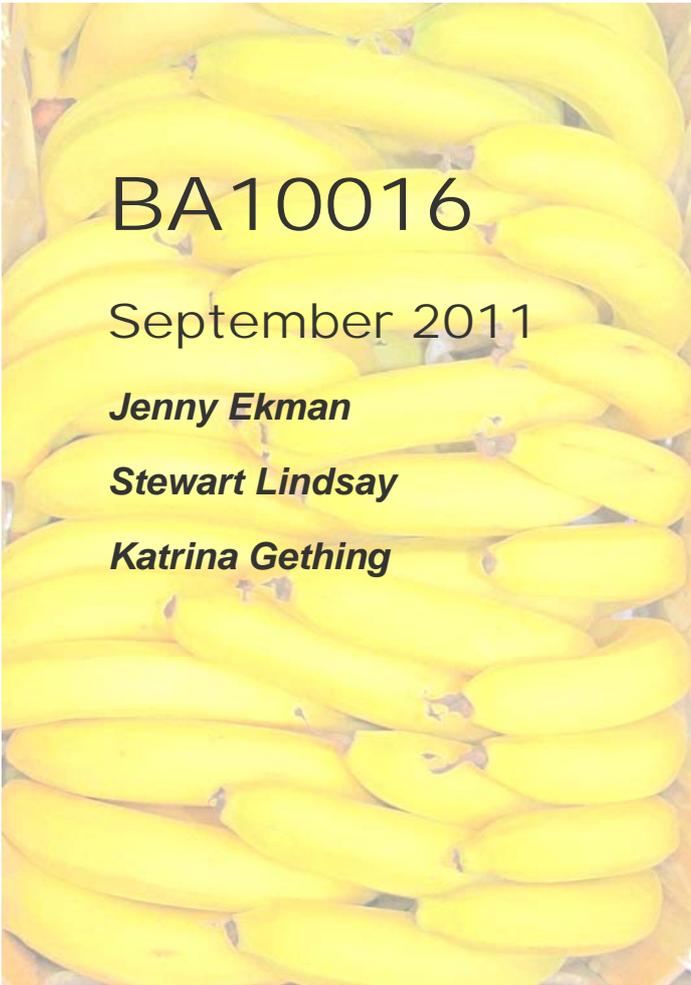
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Purpose of this report :

Damage between the farm and retail is a major issue for the banana industry. This pilot study has examined the quality of bananas offered at retail and the affect this has on consumer's willingness to purchase. In addition, a number of supply chains have been studied to determine where damage occurs during packing, transport and distribution, and how different types of damage can be reduced. The results have been presented to key members of the banana industry and may be used to guide a more extensive study.

Contents

Media Summary

Damage to bananas during packing, transport and distribution is a major issue for the banana industry. Not only does damage reduce the quality and value of fruit available to consumers, it increases costs within supply chains and can result in total loss. This pilot project aimed to find out;

1. How much of a problem is damage to bananas at retail

2. Does damage to bananas reduce consumers willingness to purchase the fruit

3. What factors affect damage to bananas, and where does injury occur within supply chains

The initial study of retail quality of bananas found that, although most were graded as good to excellent quality, many (approximately 50%) had noticeable rubs, marks, bruises or neck injury. Damage severity seemed to vary between types of packaging and specific retailers. In general, the best quality fruit sold for the highest prices.

The willingness of consumers to pay more for quality was tested in the next stage of the project. A simulated "auction" was held, in which consumers were invited to bid to exchange bruised, marked or injured bananas for 'perfect' fruit. While some devalued fruit on appearance alone, most were willing to pay extra to exchange bruised for undamaged bananas.

A number of supply chains were studied to determine where damage occurred and why. Fruit was evaluated after harvest, following ripening at the distribution centre (DC), then finally after delivery to retail stores.

Neck injury mainly occurred between the farm and the DC. Bruises and skin marks could occur anywhere on the supply chain, but increased markedly between the DC and the retail store. The top layer of fruit inside each carton was most likely to have neck injury, especially if it was on the middle or bottom layers of the pallet. Conversely, fruit in top layers of pallets were more likely to have rub marks and scuffing. Temperatures were monitored, and were found to fall dangerously low during distribution to retail stores, with some fruit below 7°C when delivered. Different cartons liners and carton types were also tested, with some positive results.

The results confirm that damage is a significant problem for members of the banana industry and also banana eating consumers. Strategies to minimise damage may include increasing carton strength and height, packing fruit into bags instead of standard liners and improved stabilisation of pallets. A larger project could examine other factors affecting damage levels and methods of reducing these issues.

Technical Summary

The banana industry has identified that damage during packing, transport and distribution is a major issue. Not only does damage reduce the quality and value of fruit available to consumers, it increases costs within supply chains and can result in total loss. This pilot project aimed to;

1. Conduct a benchmarking survey of damage and quality of bananas in retail stores

2. Assess the effect of different types of damage on consumers willingness to purchase

3. Study a number of supply chains to determine what types of damage occur at different points within chains and what factors affect the incidence and severity of such damage

The initial study of retail quality of bananas found that, although most were graded as good to excellent quality, many (approximately 50%) had noticeable rubs, marks, bruises or neck injury. Black rub was the most common problem, but neck injury was the most likely to be severe. Damage incidence varied between types of packaging and specific retailers, although this required further confirmation. A positive correlation was found between fruit quality and retail price, suggesting that better quality fruit is priced higher at retail.

The willingness of consumers to pay more for quality was tested in the next stage of the project. A simulated "auction" was held, in which randomly selected consumers were invited to bid to exchange bruised, marked or injured bananas for 'perfect' fruit. While some devalued fruit on appearance alone, most were willing to pay extra to exchange bruised for undamaged bananas. Consumers could be broadly divided into "forgiving" types, who devalued damaged fruit by ~18%, and "fanatical" types who devalued the same fruit by ~32%.

To determine where damage occurred and why, a number of North Queensland and NSW supply chains were studied. Fruit was evaluated after harvest, following ripening at the distribution centre (DC), then finally after delivery to retail stores.

In most cases, neck injury mainly occurred between the farm and the DC. The top layer of fruit inside each carton was most likely to have neck injury, especially if it was on the middle or bottom layers of the pallet. Conversely, fruit in top layers of pallets were more likely to have rub marks and scuffing. Bruises and skin marks could occur anywhere on the supply chain, but increased markedly between the DC and the retail store, especially if mixed pallets were not properly stabilised. In one case, most damage occurred after fruit was transferred to the retail display, due to unsuitable stacking and display design.

Temperatures were monitored, and were found to fall below temperatures likely to cause chilling injury in the fruit. Cooling was especially an issue during distribution to retail stores, with some fruit < 7°C when delivered. This could explain why 6% of fruit in the benchmarking survey appeared to be chilling injured.

The results confirm that damage is a significant problem for members of the banana industry and also banana eating consumers. Different carton liners and carton types were tested, with some positive results. Strategies to minimise damage may include increasing carton strength and height, packing fruit into bags instead of standard liners and improved stabilisation of pallets. A larger project could examine other factors affecting damage levels and methods of reducing these issues.

Acknowledgements

1.0 Introduction

1.1 What is the issue?

Banana fruit quality and its influence on consumption and pricing is a major priority for the Australian banana industry. The Banana Industry Strategic Plan 2009-14 has a key objective to "establish practices that enhance fruit quality throughout the value chain" (Objective 2, sub-strategy 2.1). In discussions instigated by the banana industry in 2010 it was indicated that physical damage to fruit causing quality loss and affecting saleability is an on-going issue. The cost to the industry of this damage was estimated at $20 million annually.

Fruit damage occurs at a range of points in the supply chain from harvesting through to the retail shelf, and accumulates through the chain. Damage can mean products must be repacked, quality is downgraded or result in total loss in severe cases.

There have been significant changes in the packing and post-harvest practices in the industry over the last 10 years. For example, the industry moved to packing clusters, changed cartons from 8 per layer to 6 per layer designs, experienced increased trans-shipping due to transport regulations (up to 8 pallet movements between Tully and a Sydney retailer) and has implemented more systematic quality assurance in the wholesale chain. The possible contribution of various changes in practice to the reported physical damage needed to be investigated and quantified. This would help identify ways to reduce damage and improve quality at retail.

While there had been some previous industry/HAL funded studies of physical damage in the supply chain much of this occurred prior to many of these changes. Privately conducted R&D into fruit damage has also been conducted in the last 15 years but much of this information is confidential and not available to the broader supply chain.

There has been a limited R&D effort to understand and quantify the impact on pricing and consumption of different physical damage types. Banana wholesalers report that physical damage impacts on the saleability of bananas and causes discounting of wholesale prices but little information is known about the extent of the damage and impact of physical damage on consumer purchasing.

As a result the banana industry commissioned this project to establish benchmark information of the nature of the physical damage, where in the chains it was occurring, the amount of fruit affected and the response of consumers to different levels and types of fruit damage.

1.2 Previous work

There have been some previous industry/HAL funded projects investigating aspects of fruit quality, physical damage and consumer attitudes to fruit quality:

* ✱ FR91009 Plantation/post-harvest factors affecting banana shelf-life
* ✱ FR95031 Improved fruit handling systems in bananas
* ✱ FR99013 Enhancing market penetration of Lady Finger bananas

* ★ FR99034 Central packing and innovative marketing of bananas (Carnarvon, WA)
* ★ FR99044 Banana supply chain management (BGF – terminated in year 1)
* ★ FR99049 Banana consumer research (Debra Wilson consulting)
* ★ BA08033 Market development for the subtropical banana industry
* ★ BA09034 Investigating alternative banana distribution channels (Freshlogic)

The project FR95031 "Improved fruit handling systems in bananas" investigated fruit damage levels in the period 1996-99. Fruit from north Queensland farms was assessed for damage at various points in the supply chain, from pre-harvest to wholesale ripe (table 1). Major conclusions from the project were:

* ★ Labour quality and management had more influence on fruit damage than any specific packing system technology.

* ★ A range of effects contribute to fruit damage and reject levels, and together these result in significant quality downgrading.

* ★ Although only low levels of fruit damage (reject level) occurred during packing and transport, most fruit incurred small amounts of damage. This damage accumulated along the chain.

Table 1.1 - Summary of damage assessments from FR95031

Fruit handling stage	Range of losses (% harvested fruit)	Average losses (% harvested fruit)
Pre-harvest (field damage)	0-11	4
Harvesting & transport to packing shed	1-11	4
Incorrectly culled (damage less than reject level)	0-10	3
Packing and transport to wholesale	0-2	0.5
Total	*2-29*	*11.5*

However, this project was conducted before the adoption of cluster packing and the use of 6 per layer cartons and so could not guide in the assessment of the effect of these practice changes. Interestingly, the incidence of neck injury at wholesale ripe was much less significant in this study, when the 8 per layer carton and whole hands were the standard.

In the last 10 years there have also been significant private investigations undertaken by retail chains, wholesalers and brokers and producer/packers looking at packaging, packing materials and transport. For example, from 1995-97 a major Australian retail chain undertook R&D to develop guidelines and systems for reducing waste in the banana category at the retail level. This work led to:

* ★ The introduction of cluster packing

* ★ The development of the 6 per layer carton

* ★ Use of absorbent paper for sap control

* ★ Development of product specifications and systematic quality assurance to monitor fruit out-turn at points along the chain

* ★ Implementation of improved cool chain facilities and processes from harvest through to retail

Unfortunately, much of the specific information generated by projects such as this is held by the participating parties and not publicly available.

While consumer research has been conducted in the past (Debra Wilson Consulting Services, 1999; Bread and Butter, 2007), there have not been any recent studies into consumer attitudes to quality attributes and their potential barriers to purchasing. Banana wholesalers report that physical damage impacts on the saleability of bananas and causes discounting of wholesale prices. However, there was no information on how different types and severity of damage affected the willingness of consumers to purchase bananas.

1.3   Aims of this project

This project was developed as a pilot study to examine damage in banana supply chains. The aim was to identify and define the problem, examine where and why it might be occurring, and develop strategies that could be used to solve this issue or, at least, recommendations for more extensive study at a later stage. The project was therefore conducted in a number of stages, which are reflected in the different chapters of this report;

1. Benchmark quality of fruit at retail. What quality of fruit are consumers likely to see when they go into a store to buy bananas? What sort of damage does it have? Does this vary between stores, packaging, fruit size, ripeness or other factors?

2. Consumer research. Does the type of damage that is common at retail affect consumers' willingness to buy bananas? Do different types of damage matter more or less than others? How much do consumers devalue damaged fruit?

3. Initial supply chain methods. How can we measure banana quality? How many individual fruit / cartons / pallets need to be examined to get a valid measure? What packaging and transport factors are most important?

4. Examination of different supply chains. Where in the supply chain do different types of damage occur? What is the effect of different types of liner or cartons, as well as factors such as position inside the carton or on the pallet? How could we reduce this damage?

5. Extension. What is the best way forward for the industry? How can we use what we know? Is more research and / or other resources required to optimise supply chains?

The original proposal was to conduct a series of studies of different types of supply chains. However, the destruction of banana plantations and resulting short supply of fruit caused by Cyclone Larry limited what it was possible to do in the time available. Despite this, the project has achieved most of the original aims and objectives, as well as raising yet more questions about issues that matter when it comes to handling bananas.

2.0   Benchmarking Quality at Retail

2.1   Background

The current project was developed because industry believed that quality loss during transport, distribution and marketing was a major issue. Damage can mean that products must be re-packed, quality is downgraded, or it can cause total loss in severe cases. One of the key objectives of the Banana Industry Strategic Plan 2009-14 is to "establish practices that enhance fruit quality throughout the value chain" (Objective 2, sub-strategy 2.1). However, it was not clear quite how much of an issue damage is.

It seemed logical to begin by determining whether there actually was a problem with banana quality by the time it arrived at retail stores. Measuring types of damage and severity at retail would provide some insight as to what issues we needed to examine throughout the banana value chain. It would also provide a benchmark, against which we could potentially gauge the success or failure of later interventions.

In order to assess damage at retail, we first needed to develop a grading system for quality and defects. This could then be used throughout the rest of the project. Such a system could then allow quality to be related to factors such as price, type of retailer, and even the type of carton fruit was supplied in.

The aim of this activity was to gain an overview of what consumers find when they go into a supermarket or fruit shop to buy bananas and develop a way of recording this information which minimises subjectivity of such assessments.

2.2   Method

2.2.1 Developing a grading scale

Devising a method of categorising and recording damage was complex, given the range of marks and bruises that are found on bananas. Bananas were purchased which displayed a range of injury symptoms. These were photographed to devise a standard scale to reduce variability in subjective quality assessments. Size and ripeness categories reflected industry standards, as noted on major retailer quality specifications. These were used to develop a pictorial scale using a combination of photographs, descriptions and diagrams. This accounted for all major postharvest defects and provided a scaled rating system.

2.2.2 Retail quality assessments

Bananas were purchased from randomly selected supermarkets and independent grocers in Sydney, on the NSW Central Coast and the NSW North Coast. A total of 55 stores (1,100 individual bananas) were surveyed between October 2010 and February 2011. After this time fruit was affected by Cyclone Yasi, so quality was not considered comparable to that which would be available under normal supply.

Stores were selected so as to reflect all the purchasing options within a shopping area, with the aim of approximately representing the proportion of purchases through each type of outlet. In total, bananas were purchased from:

* ★ 19 Independent grocers
* ★ 15 Coles
* ★ 12 Woolworths
* ★ 9 smaller supermarkets (IGA, Franklins, Bi Lo)
* ★ 4 Aldi

Each sample consisted of 20 single bananas selected randomly from all parts of the retail display. Bananas were handled gently at all times to minimise additional damage during purchase and transport. After selecting the fruit, retail staff were asked what type of carton the fruit came from – where possible this was photographed, recording packed on date, grower and carton type.

Carton types were divided into

* ★ One piece cartons (open, 6 / layer footprint)
* ★ Six per layer (cluster packs)
* ★ Eight per layer (traditional carton)
* ★ Pre-packs

The carton type could not always be determined and, moreover, there was no way to know whether the fruit on display were packed into the same type of carton as that produced by store staff. Results relating to carton type should therefore be treated with caution.

On return to the laboratory each banana was individually assessed. Quality factors recorded included ripeness, fruit size, neck injury, bruising, scuffing, black rubs and overall quality. The presence or absence of cuts, splits, rots and chilling injury were also recorded.

2.2.3 Data analysis

Data was analysed using CoStat statistical software (version 6.303, CoHort USA) to conduct ANOVA. Means were compared at the 95% confidence interval using Student-Newman-Keuls test.

2.3 Results

2.3.1 Grading scale

A pictorial grading scale was developed for assessing bananas (figure 2.1).
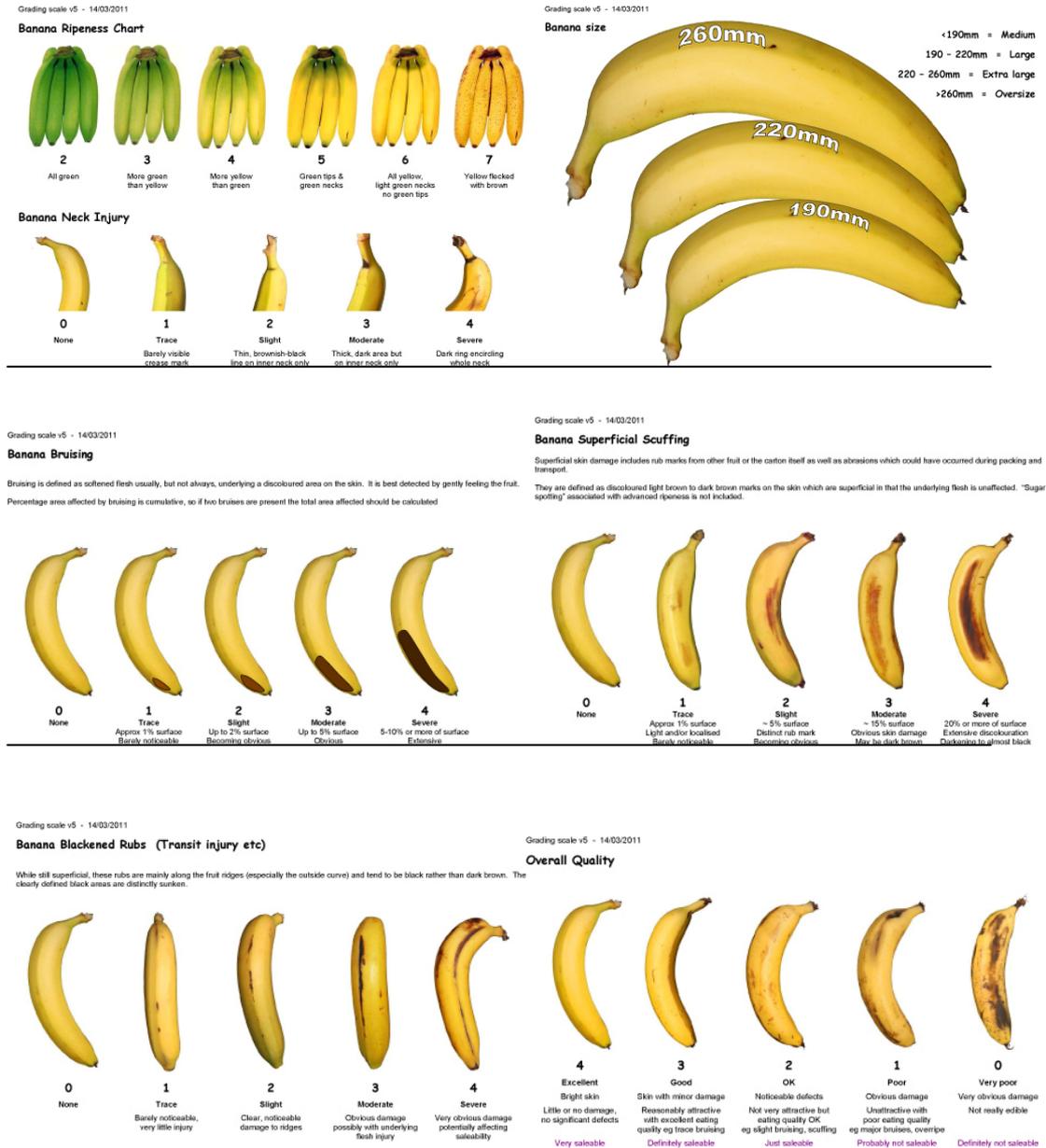
Figure 2.1 - Grading scale used to assess retail quality of bananas

The grading scale was tested by asking two different assessors to grade the same batch of fruit. Results were consistent, indicating that, although such measurements are necessarily subjective, the pictorial scale ensured a reasonable degree of consistency between assessments. Note that the grading scale shown in figure 2.1 was later expanded to include additional forms of damage as well as information regarding bruise position (Appendix A).

2.3.2 Fruit size, price and ripeness

The product specifications of the major retailers stipulate that bananas should be x-large (220 – 260mm outer body length). We found that 57% of the bananas sampled from Coles and Woolworths fell into this size bracket. Large fruit (190-220mm) made up 27% of the total with 17% oversize (>260mm). These figures were very similar to the average; 52% of all fruit sampled were x-large (figure 2.2).

medium
large
x-large
oversize
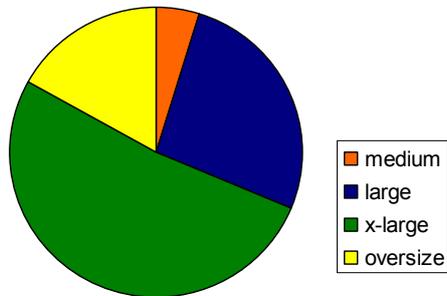
Figure 2.2 - Size categories of sampled bananas

Prices ranged from $1.25/kg to $4.00/kg, the average being $2.57. There was a small but significant difference between the major retailers and independent grocers, the independent being slightly cheaper on average. Prices at smaller supermarket chains were both higher and lower, although it was noted that Aldi was consistently cheaper than any other store ($1.50/kg).

Average ripeness was 5.7. Previous studies have shown that most (~64%) consumers prefer to buy bananas at stage 4-5. This effectively allows for a few days shelf life, as the most popular eating stages are 5 (31%) and 6 (38%) (Pritchard, 1999). This suggests that bananas were a little riper on average than what would have been preferred by consumers.

The exception to this trend was Woolworths, as many stores had a "some for now, some for later" display split between ripeness stages approximately 4-5 and 6 (figure 2.3). Woolworths fruit was significantly less ripe, on average, than that of most other retailers.
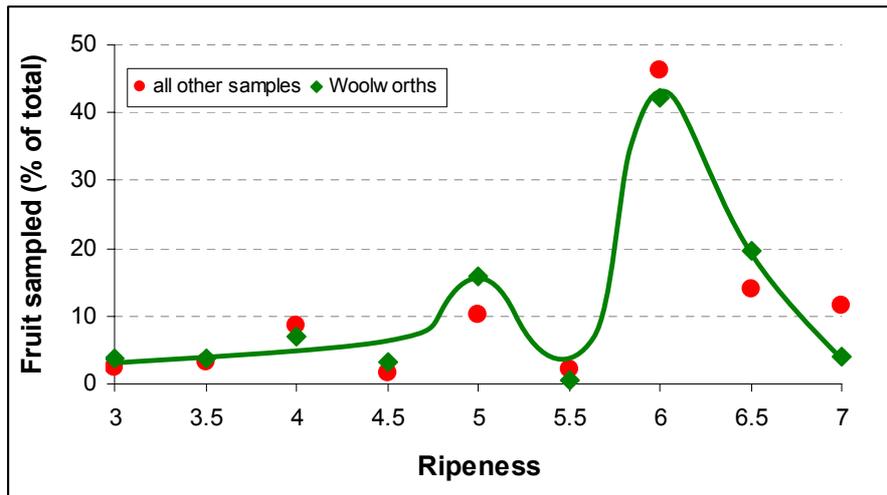
Figure 2.3 - Ripeness of sampled bananas. Woolworths stores now offer two different ripeness stages, resulting in two peaks of ripeness stage available. 40-50% of fruit at all stores was stage 6 ripeness

2.3.3 Damage recorded at retail

The majority of bananas sampled had some type of damage evident; only 21% of fruit had no scuffs, bruises or injuries of any kind, although damage was slight at most on an additional 29% of fruit. Damage was significant (grade = 2 or more) on around 50% of fruit, with around 20% of bananas having moderate or severe injury of at least one kind.

The most frequent injury recorded was "black rub", followed by skin scuffs and bruises (figure 2.4). Although neck injury was less frequent, damage was moderate or severe (grade 3-4) on 9.1% of fruit, which was a higher proportion than other categories. Essentially, bananas were either neck damaged or not, whereas other forms of damage were often more subtle.
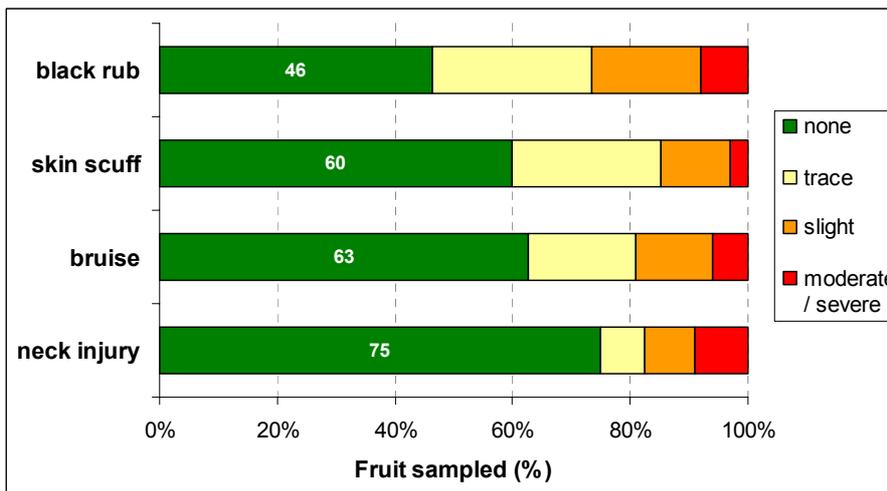
Figure 2.4 - Proportion of sampled bananas with different types and severity of damage

Other defects recorded included cuts and splits, which affected 1-2% of all fruit. Rots were uncommon, with only 6 fruit from the 1,100 examined having evidence of disease.

Chilling injury, expressed as grey skin or under-peel discolouration, affected nearly 6% of all fruit surveyed. This result might have been expected if the survey had been conducted in winter or early spring, when night temperatures can fall low enough to damage fruit.

However, it seems unlikely that North Qld grown fruit assessed in November would have been subject to chilling temperatures in the field. It seemed more likely that fruit had been subjected to chilling temperatures at some point postharvest.

Significant differences in damage incidence and severity were found between the different types of carton (figure 2.5). However, care should be taken with this result. In some cases the carton type could not be determined and in many cases it could not be absolutely confirmed. Damage on sampled bananas could easily have resulted from handling on the display, and be unrelated to the carton type. Moreover, sample sizes varied greatly – only two samples were in pre-packs, compared to 26 in 6 / layer cartons. Nevertheless, it is interesting to note that less neck injury was observed in cartons packed in the traditional 8 layer cartons, and that pre-packs of small fruit had less bruising than the larger fruit packed into normal cartons.
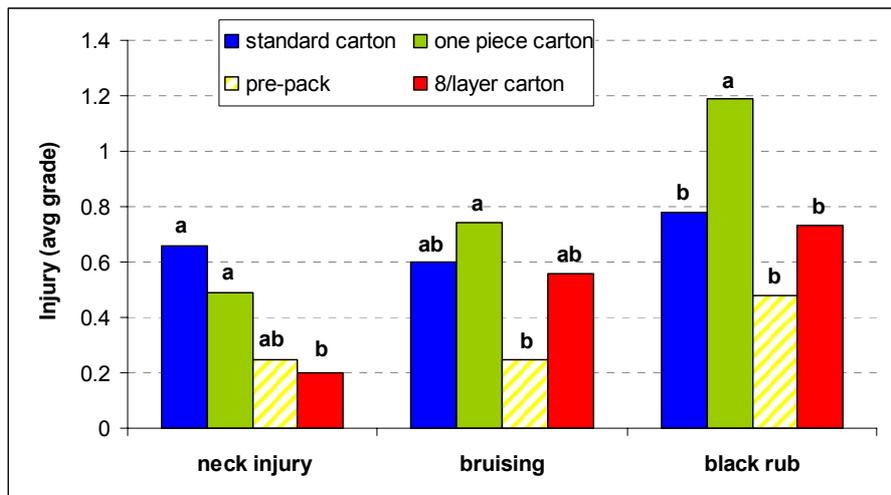
Figure 2.5 - Effect of carton type on damage, expressed as average severity grade. Letters indicate values that are significantly different (p<0.05)

A strong trend was evident for large fruit (oversize) being bruised or superficially marked compared to smaller (medium – large) fruit. However, considerable differences in sample numbers per category meant that results were not significant.

2.3.4 Quality of retail fruit

Despite the levels of damage observed, only 4% of fruit were graded unacceptable (quality <2). Average quality was 3.2 (good) while 47% of bananas sampled were rated as "excellent". Overall quality was closely associated with bruising (figure 2.6), superficial skin damage having less influence on the fruit overall appeal.
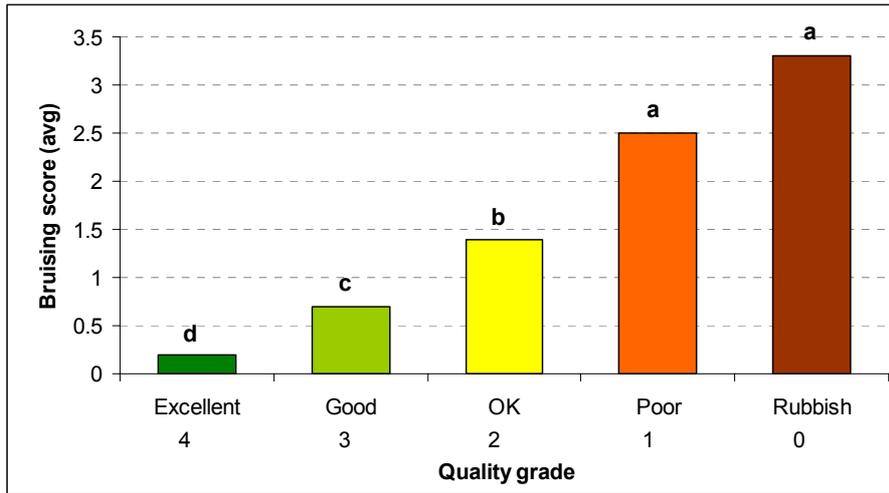
Figure 2.6 - Relationship between bruising score and quality grade. Average bruising severity in excellent quality fruit was 0.2, compared to 3.3 in the poorest quality bananas. Letters indicate means which are significantly different (p<0.05)

Banana quality varied significantly (p<0.01) between different retailers (figure 2.7). Quality of sampled fruit was best from the major retailers and lowest from the smaller supermarket chains. Independent grocers were intermediate. Consumer surveys consistently indicate that most shoppers believe that produce quality is superior at fruit and vegetable stores (Ekman, 2008). However, these results suggest that this is may not be the case for bananas.
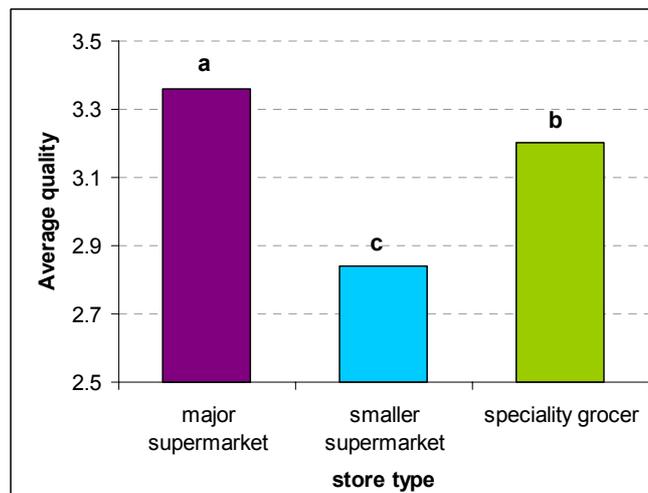
Figure 2.7 - Average quality of bananas purchased from different types of retail outlet. Letters indicate means which are significantly different (p<0.05)

As previously noted, it is not possible to draw strong conclusions based on carton type, due to problems collecting this information. Despite the differences in sample size between carton types, overall quality was significantly better in the traditional 8/layer carton than either of the 6/layer cartons (one or two piece). Pre-packed fruit was the best quality, the packaging presumably helping to protect these smaller fruit from rubs and bruising.

Fruit quality appeared to be somewhat related to price, at least at the lower prices paid (figure 2.8). This suggests that, at least to some extent, buyers of bananas get what they pay for. It seems possible that reducing bruising damage, thereby raising retail quality, could help ensure that consumers are willing to pay a consistent price for bananas.
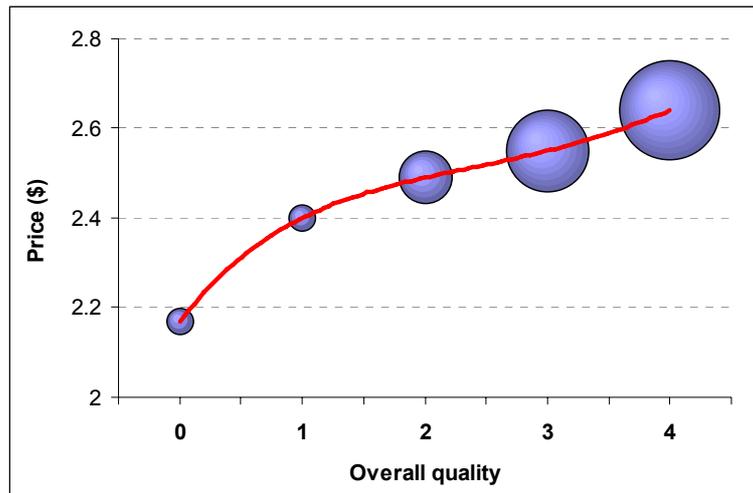
Figure 2.8 - Average price paid for bananas ranging in quality from very poor (0) to excellent (4), showing a slight positive relationship between price and quality. The size of each circle indicates the number of measurements in the category.

2.4   Key points

★   A pictorial grading scale was developed to help classify types of damage to bananas and ensure grades were allocated consistently between assessors and over time.

★   Samples of 20 bananas were sampled from 55 retail stores and individually assessed.

★   Prices ranged from $1.25 to $4.00 and both green (stage 3) and overripe (stage 7) bananas were sampled. The average banana was x-large in size, cost $2.57 and was ripeness stage 5.7.

★   Half of the fruit sampled (50%) had significant (grade >1) damage of some kind, while 20% of fruit had moderate to severe injury

★   Rubs were the most common damage, but neck injury was the most frequently severe.

★   Approximately 6% of fruit had chilling injury, which most likely occurred after harvest.

★   Quality was best at the major retailers and was higher when prices were at least $2.50 / kg.

★   The results indicate that bruising, rubs and neck injury are major issues. Factors that decrease retail quality may reduce the price consumers are willing to pay for bananas.

3.0 Consumer Research

3.1 *Background*

The objective of the consumer research aspect of the project was to gain insights into the impact of physical damage on consumer purchasing. A method for understand consumer buying behaviour is to measure self-reported buying behaviours and attitudes. However, disparity between consumer self-perceptions and actual purchase behaviour are an established phenomenon.

An experimental research method used to understand actual behaviour as well as consumers' willingness to accept food products is the experimental auction. Experimental auctions involve individuals exchanging real money for real goods in an active market and have been used to understand how genetic modification (Lusk et al., 2001), organic production (Conner & Christy, 2004) and country of origin (Umberger et al., 2002) amongst other factors can influence the buying process.

Surveys measuring stated behaviours and attitudes to blemish and experimental auctions were conducted to understand if, and to what degree, consumers devalue typical supply chain defects in bananas.

3.2 *Method*

Research designed to measure consumer attitudes to supply chain blemishes was conducted on November 2010 and May 2011 at DEEDI sensory laboratories at the Health and Food Sciences Precinct, Coopers Plains, Brisbane.

Trial 1 was a pilot study consisting of 100 government employees. Trial 2 was a small study consisting of 20 recruited consumers undertaken to provide a comparison to the results from trial 1. All participants were regular banana eaters.

3.2.1 Trial 1 - November 2010

An initial study was conducted on Thursday 25th and Monday 29th November 2010 using Queensland and Federal government employees working at the Coopers Plains site. A shortlist of nine samples of blemish and level of blemish likely to be experienced by consumers when buying bananas was developed by referencing the banana grading scale previously described in this report (Appendix A). Given the large number of samples under investigation the trials were conducted over two days to avoid participant fatigue (table 3.1).

Fifty consumers participated on day one and a further 50 consumers participated on day two. All bananas used in this trial were sourced from and graded by La Manna, a commercial banana wholesaler at Rocklea Markets, Brisbane. Examples of the bananas supplied by LaManna are shown in figure 3.1.

Table 3.1 - Banana defect and level investigated in trial 1

Thursday 25th November (day 1)	Monday 29th November (day 2)
Bruising grade 1	Blackened rub grade 1
Bruising grade 3	Fruit rub grade 2
Blackened rub grade 2	Banana bruising grade 2
Fruit rub grade 1	Neck injury grade 2
Neck Injury grade 2	

Figure 3.1 - Bananas with scuffing level 1 (a) or neck injury level 2 (b)

Respondents participated in a short survey and an experimental auction. Participants were provided with a pencil and paper questionnaire (Appendix B) including questions on:

* demographics (marital status, income etc)

* banana buying behaviour

* general attitude to fruit

* acceptability of blemished bananas used in the experimental auction

* auction data

Influences on banana purchase were measured with a ranking exercise. A list of factors that influence the consumer decision to buy bananas was developed based on literature and discussion amongst team members. The list was submitted to participants who were asked to indicate the three most, and the three least important factors that impact on their decision to buy bananas. They were also asked to indicate the single most and single least important factor. These included:

* size

* colour

* ripeness

* price

* blemish

* place of purchase

* growing process.

General attitudes to banana blemishes were measured by asking consumers to indicate how well each of ten statements described them, ranging from 1 – does not describe me at all, to 5 – describes me well. These statements were:

> ★   I will only eat bananas if they have no skin marks

> ★   I tend to accept minimal amount of skin marks on the banana I buy

> ★   I will only eat bananas if they look perfect

> ★   I believe most skin marks on bananas are superficial & don't affect eating quality

> ★   I take a lot of care when choosing bananas to buy

The acceptability of the external appearance of best quality and blemished bananas used in the experimental auction process was measured on a hedonic scale (figure 3.2). Participants were asked to rate the appearance of the bananas on these scales and answers were converted to a score out of ten. Samples that scored over 5 were interpreted as acceptable for the consumer. Samples with scores close to 10 were considered desirable while those rated below 5 were interpreted as unacceptable to consumers.

Please find Round **X** bananas

Considering appearance, what is your opinion of this cluster of bananas? You can indicate your answer anywhere along the line.

Totally unacceptable appearance	Satisfactory appearance	Exceptional appearance

Figure 3.2 - Acceptability scale for whole fruit

Experimental auction

The objective of the experimental auction was to determine if, and how much, consumers devalued blemished bananas. To do this, participants were asked to bid on exchanging blemished bananas for defect free bananas.

On each day, participants were asked to visually inspect a carton of 'Bidding Bananas' placed at the front of the room, and rate the fruit for overall acceptability. Bidding bananas were those bananas graded as blemish free and were divided into cluster sizes similar to those displayed in supermarkets and grocers. Each participant was also provided with plain white trays of clusters of blemished bananas. The blemished banana trays were presented to consumers in randomised order. Each tray represented a single defect and a grade of defect according to those to be examined for that day (figure 3.3). Each indicative sample was given a bidding round number and this was displayed on each white tray. Participants were also provided with a bidding sheet (Appendix C), and were provided the following scenario:

> *"Round X bananas have cost you $1.95. Use the round X bid form to indicate how much more you would pay per kilo to exchange round X bananas with the bidding bananas. "*
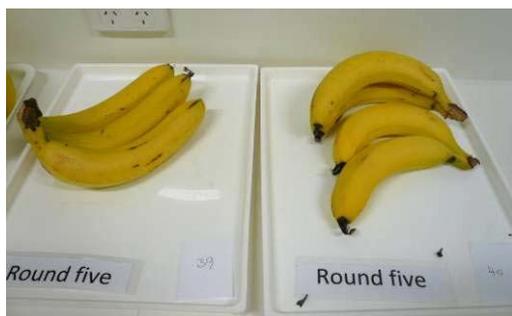
Figure 3.3 - Trays of bananas typical of neck damage grade 2, trial 1

3.2.2 Trial 2 - May 2011

A second trial was conducted on 18th May 2011. Two groups of ten consumers were recruited by an external agency. The method used in trial 1 was altered slightly due to the high prices and low availability of bananas post Cyclone Yasi.

Fruit

Five cartons of bananas were purchased for the trial from LaManna wholesalers, Brisbane Markets. Commercially graded fruit used in the initial study had been somewhat inconsistent. The aim for this stage of the study was to obtain blemish free fruit then damage them in a standard manner to create bruising, superficial scuffing and neck injury. This method provides more uniform samples of fruit to present to consumers.

Unfortunately, the fruit received for the trial (although the best available) already had significant bruises and skin marking. This can likely be attributed to the unusual market post-Yasi.

The bananas were therefore sorted to obtain samples that were as uniform as possible. All care was taken to choose fruit which only reflected the defect of interest. For example, samples typical of bananas with neck injury were chosen only if they were free of black rubs and bruising. This was difficult for superficially damaged fruit, which often had small bruises in addition to rub or scuff marks.

Unlike trial 1, where fruit used in the auction also underwent assessment for acceptability, separate samples were used for the assessment phase and the auction process. Fruit samples undergoing assessment for acceptability of external appearance took the form of single bananas placed on a tray and identified by a unique three-digit code (figure 3.4). These included:

* Major bruising
  o One grade 3 bruise per fruit
  o Deep bruise with softened flesh under the area
  o Eating quality definitely reduced by significant bruise

* Superficial marking
  o Max grade 3, minimum grade 2 (cumulative) fruit rub, black rub or scuffing.
  o Obvious external damage
  o No significant bruising, underlying flesh generally firm

* Minor bruising

       o Small bruise grade 1-2 on each fruit
       o Underlying flesh generally firm
       o Eating quality unlikely to be affected

★ Neck Injury
       o Minimal scuffs or marks
       o Neck injury grade 3

★ Best quality
       o Minimal scuffs or marks
       o No bruises
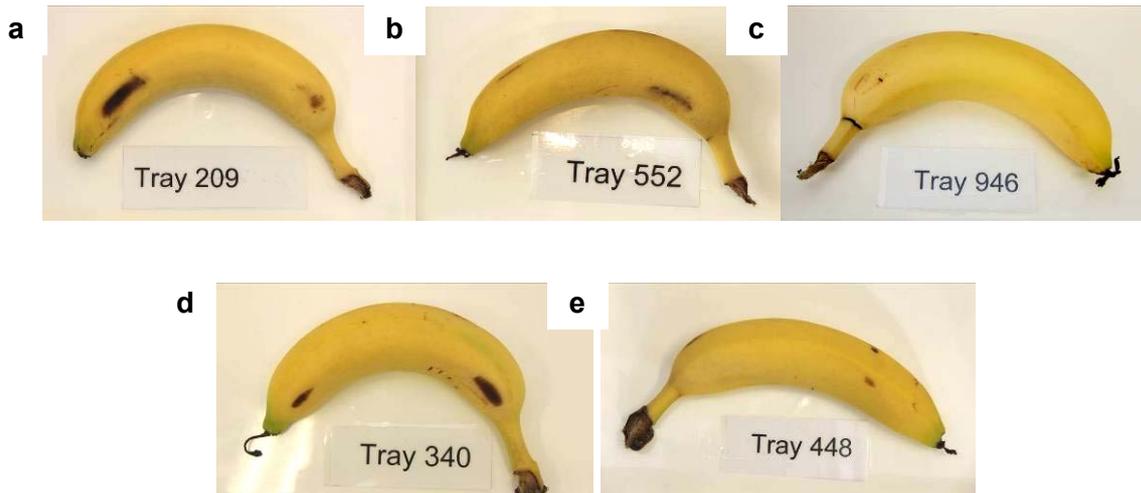
Figure 3.4 - Typical examples of bananas presented to consumers, showing major bruising (a), minor bruising (b), neck injury (c), superficial marking (d) and best quality (e)

Bananas used in the auction process were presented as a three fruit cluster on small white trays identified with the label *Auction Bananas*, or *Round A, B* or *C* according to blemish type (figure 3.5). Parameters for each type of tray were as follows:

Auction bananas

★ All 3 fruit on the cluster with minimal skin damage and no bruises

★ Maximum 1 fruit with neck injury grade 2

Round A - Neck injury

★ All 3 fruit on the cluster with grade 3 neck injury

Round B - Bruising

★ All 3 fruit on the cluster with some bruising

★ At least 1 fruit with grade 3 bruising

★ At least 1 other fruit with grade 2 bruising

Round C - Superficial marking

★ All 3 fruit with either black rub, fruit rub or scuffing

★ At least 2 fruit with grade 2 black rub or scuffing

★ At least 1 fruit with grade 2 fruit rub
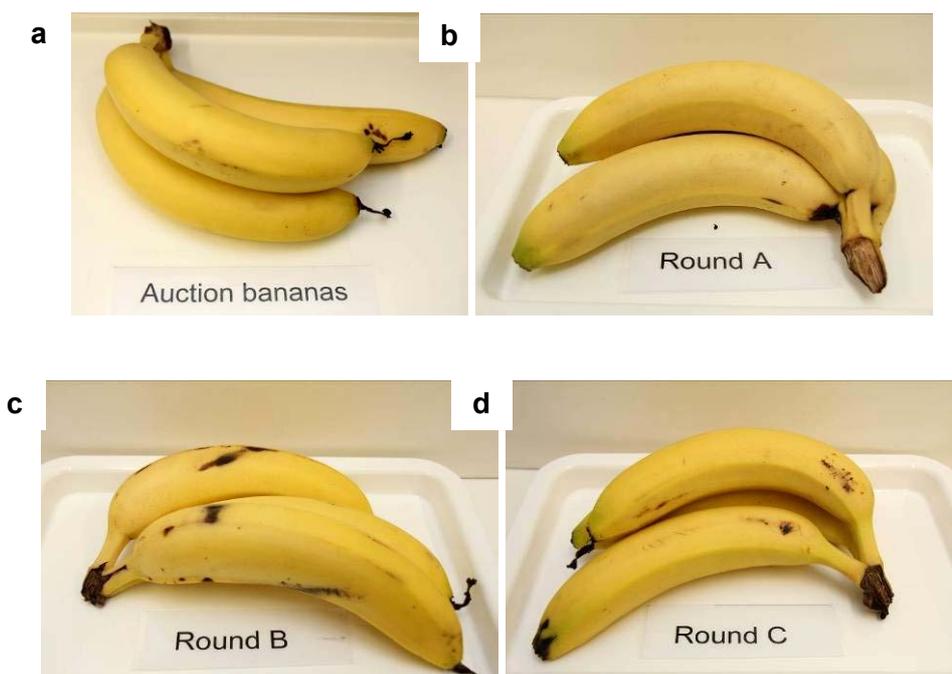
Figure 3.5 - Typical examples of bananas presented to consumers during the auction process showing the best quality fruit (a), neck injured (b), bruised (c) and marked (d)

Participant Instructions

On arrival, participants were invited to sit 2-3 at each of 4 tables. Each place was set with a red and a blue mug, a packet of crackers and a packet of chips, a numbered set of assessment sheets and a pencil. The assessment sheets stipulated the order in which each participant examined the banana samples, this order being randomised among the group.

The group was taken through a practice auction where they were asked to write down how much they would pay to exchange their red mug for the blue one, or the crackers for the chips. The highest bid would get to keep the blue mug or chips, lower bids would simply keep their red mug or crackers.

It was then explained that they would be asked to make a similar 'bid' on bananas. They were asked to look carefully at the samples provided – pick them up, touch and smell them etc. They were further instructed to imagine themselves pre-Yasi, when bananas were $1.95kg, rather than the current situation.

Similar instructions were given in respect to the appraisal of individual bananas, with participants urged to take care in their assessments. Finally they were asked to ensure that all parts of the assessment sheets were completed at the end.

Banana Auction

The study participants were each given $5 cash with which to bid in the auction (in addition to normal expenses). Four white trays were placed on each table, each with a cluster of 3 bananas labelled "Auction bananas", "Round A", "Round B" or "Round C" (figure 3.5).

Participants were instructed;

"Please find the tray labelled 'Round X' bananas.

Consider the following scenario:

You have purchased 'Round X' bananas for $1.95/kg. Indicate in the space below how much more, if anything, you would pay per kg to swap your 'Round X' bananas with the Auction bananas."

The participants examined the three samples of bananas in a random order, recording their bid as they did so.

At the end of the session, the assessment sheets were collected. One round (A, B or C) was chosen randomly to act as the "standing round". The highest bidder on this round paid what they bid to swap their blemished bananas with the cluster of "Auction bananas" using the $5 provided for this purpose.

The remaining participants at each table were allowed to each keep one of the lower quality clusters of fruit. This was decided by each participant picking a card; the person with the highest value card chose first. The cluster picked first was observed for each table.

Banana Quality Assessment

For trial 2, quality assessment was performed on single bananas rather than clusters. Participants collected single bananas with the appropriate 3 digit code assigned to their seat number. They then evaluated the samples on the acceptability scale developed for the initial trials and shown in figure 1. As with the initial trial, participants were asked to rate the appearance of the bananas on these scales and answers were converted to a score out of ten. Samples that scored >5 were interpreted as acceptable for the consumer. Samples with scores close to 10 were considered desirable. Conversely, samples rated <5 were interpreted as unacceptable.

Defect bananas examined for both groups were limited to three general types:

* neck injury
* bruising
* superficially marked.

Similar to trial 1, participants were provided with a pencil and paper questionnaire (Appendix D) including items measuring:

* demographics of participants
* banana buying behaviour
* general attitude to fruit.

Attitudes and buying behaviours

Survey questions measuring attitudes to banana blemish were the same as trial 1. The original number of items included in the rating of factors affecting the purchase decision were reduced for trial 2 with a single item termed colour as an indication of ripeness replacing the three previous colour items (ie. green/yellow, light yellow, deep yellow).

Analysis

Quantitative data was analysed with PASW package 18. A number of techniques were used including between-group and within-group ANOVA, cluster analysis and logistical regression. Appropriate non-parametric techniques were conducted where warranted.

3.3   Results

3.3.1 Trial 1

Demographic and behaviour data

A relatively even split of gender was evident on day one, with more females present on day two. The majority of participants were 41 years of age or older, living in a permanent relationship with children at home. Over half of the participants had incomes between $40 001-80 000 per year. However, most households were dual income. This sample population was well educated with 80-90% attaining some type of university degree (table 3.2).

Table 3.2 - Demographic information, trial 1

	Day one %	Day two %
Gender		
Female	52	62
Male	48	36
Age		
18-30	4	18
31-40	12	16
41-50	12	30
>50	24	32
Marital status		
Perm/live in relationship?		
Yes	72	74
No	28	20
Children at home		
Yes	48	38
No	52	58
Individual income		
$0-40 000	3	2
$ 40 001 – 80 000	59	58
>$80 000	38	38
Household income		
Single	35	22
Double	62	72
Other	3	2
Education		
High school	3	4
Trade/technical	7	8
University undergraduate	45	42
University postgraduate	45	42

Around half of all participants were the sole purchaser of bananas, and most preferred to buy bananas which would ripen within 1-2 days (table 3.3). Many participants preferred to buy a mixture of bananas, with some bananas ready to eat and others ripe in a few days.

A number of factors that influence the consumer decision to buy bananas were examined (table 3.4). Cost was considered by an average of 58% of respondents to be an important factor when buying bananas, followed by a preference for medium sized bananas (46%). The presence of skin marks was the third most cited factor at 41%. The presence of marks on skin was cited by 16% of participants as one of the least influential factors.

Table 3.3 - Buying behaviour, trial 1

	Day one	Day two
	%	%
Banana Purchase		
Me	58	46
My partner	2	6
Shared activity	38	48
Buying ripeness		
Ripe immediately	10	10
Ripe 1-2 days	36	50
Ripe 3 or more days	14	16
Other	38	24

Table 3.4 - Factors considered when buying bananas, trial 1

	Mean %
Most Important	
Price per kilo	58
Size (medium)	46
Presence of marks	41
Colour (green/yellow)	33
Colour (light yellow)	24
Size of cluster	21
Colour (deep yellow)	17
Colour (bright yellow)	14
Shape	11
Previous retail experience	7
Girth	9
Least Important	
Growing process	60
Size of cluster	56
Shape	45
Previous retail experience	45
Girth of banana	42
Price per kilo	13
Marks on skin	16

Participants were asked to consider the single most and single least important factor in purchasing bananas. While price was the most important factor influencing banana purchases (28%), 28% of participants also considered ripeness stage very important. The presence of marks on bananas was cited by 41% of respondents as an important factor, but only 13 per cent of participants named skin blemishes as the most important factor to consider when buying bananas.

The least important factor was the growing process at 25% (table 3.5).

Table 3.5 - The single most and single least important factors considered when buying bananas, trial 1

	Mean%
Most Important	
Price per kilo	28
Colour (green/yellow)	14
Colour (deep yellow)	14
Presence of marks	13
Colour (light yellow)	6
Least Important	
Growing process	25
Size of cluster	23
Previous retail experience	19
Shape	10
Girth	12

Acceptability data

Participants were asked to rate the external appearance of the whole fruit 'bidding bananas' and the nine defect bananas. For the hedonic scales, samples that score over 5, towards 10, are interpreted as acceptable for the consumer for external appearance. Samples rating below 5, toward 0, are interpreted as unacceptable to consumers.

No differences were found in the acceptability of the bidding bananas for the two days. Overall, no banana clusters were found to have average scores that were in the unacceptable range for the participants (table 3.6)

Table 3.6 - Average acceptability of bananas with different types of damage, trial 1

Day and samples	Average scores * <5 = unacceptable appearance ≥5 = acceptable appearance	
Day one		
Bidding bananas	8.2	a
A. Banana bruising 1	6.5	b
B. Blackened rub 2	7.2	b
C. Fruit rub 1	6.0	b
D. Banana bruising 3	6.3	b
E. Neck injury 2	6.3	b
Day two		
Bidding bananas	7.8	a
A. Blackened rub 1	7.3	ab
B. Banana bruising 2	6.9	b
C. Fruit rub 2	6.9	b
D. Neck injury 3	6.6	b

* Letters indicate means which are significantly different for each group

All banana samples were found to be acceptable. On day one, a significant difference in acceptability was found between the bidding bananas and all other bananas indicating that a

difference between the defect free sample and all other bananas was detected by participants. No difference was found between the two grades of Bruising. Fruit rub was perceived as the least acceptable to consumers but this was not significant.

On day two, a difference was perceived between the bidding bananas and all bananas except bananas with Blackened Rub 1.

Consumer attitudes to banana blemish

A number of items measuring attitudes to banana blemishes were included. Participants were asked to indicate how well a set of statements described them with a score of 1 - does not describe at all to 5 - describes me well. Scores over 3 are considered an affirmation to the statement.

Overall, participants' self-reports indicate they accept a minimal amount of skin marks, they believed that most skin marks on bananas were superficial, but took care when choosing bananas to buy (table 3.7).

Table 3.7 - Consumer attitudes to banana blemish trial 1

Statement	**Average Scores** 1= does not describe me at all 5 = describes me well
I will only eat bananas if they have no skin marks	2.2
I tend to accept minimal amount of skin marks on the banana I buy	3.8
I will only eat bananas if they look perfect	1.5
I believe most skin marks on bananas are superficial & don't affect eating quality	3.6
I take a lot of care when choosing bananas to buy	3.8

Auction data

Auction bid data was divided into four categories:

1. Tolerant - $0 bid

2. Mostly tolerant - Up to .50c bid: a decrease in value of up to 26%

3. Fairly intolerant - .51 to $1 bid: a decrease in value of up to 51%

4. Intolerant - over $1 bid: a decrease in value of over 51%

Overall, around 33% of participants were regularly willing to pay more than 50 cents per kilo to exchange their blemished bananas for the high quality bananas. This devalue equates to over a 51%. Around 36% of participants were unwilling to exchange bananas for any price. On day one, over 30% of participants were intolerant (over $1 bid) of Fruit Rub. However this trend was not repeated on day two for Fruit rub level 2. On day two a greater number of consumers were intolerant of defects (16-27%) (table 3.8).

Table 3.8 – Auction bids trial 1

	Bruising 1	Blackened Rub 2	Fruit Rub 1	Bruising 3	Neck Injury 2
Day one					
Tolerant ($0 bid)	34	46	28	42	28
Mostly tolerant (<.50c	34	36	28	32	38
Fairly intolerant (.51 to $1)	20	18	22	18	20
Intolerant (> $1)	12	10	32	8	14
		Blackened Rub 1	Fruit Rub 2	Bruising 2	Neck Injury 3
Day two					
Tolerant ($0 bid)		38.8	42	43.8	29.2
Mostly tolerant (<.50c		32.7	30	25	39.6
Fairly intolerant (.51 to $1)		8.2	12	4.2	10.4
Intolerant (> $1)		20.4	16	27.1	20.9

Segmentation of participants

A segmentation of participants was performed to understand if clusters of people existed with different bidding behaviours. Two distinct groups were found for both days. For both days, the pattern of data shows that group one (N =31-32) were either unlikely to want to pay to swap any of the blemished bananas for the bidding bananas or were willing to spend only a small amount (less than .50 cents). Inspection of the buying behaviours questions show they were influenced in their purchase by the colour of bananas. Group two (N= 16-19) were more likely to pay a larger amount of money to swap their bananas for the 'bidding bananas'. Group two were also less accepting of bruising but described themselves as less concerned with skin markings and cost was a greater factor to impact their decision to buy bananas.

Values for auction bids were calculated for the two groups. This was also estimated as a devalue amount by calculating the percentage the bid is to the $1.95 consumers were told they had purchased the blemished bananas for. Average bids and devalue amounts for blemished bananas are provided in table 3.9. Average bids show that group one devalued blemished bananas at between 7- 23 %. Group two devalued blemished bananas at between 41 – 89%. Bidding for group two, day two is considerably higher than for day one.

Table 3.9 – Auction bids by group membership trial 1

	Group one bid	devalue	Group two bid	devalue
Bruising level 1	$0.30	15%	$0.90	46%
Blackened rub level 2	$0.13	7%	$1.01	52%
Fruit rub level 1	$0.44	23%	$1.31	66%
Bruising level 3	$0.23	12%	$0.79	41%
Neck injury level 2	$0.29	15%	$1.08	55%
Blackened rub level 1	$0.19	10%	$1.48	76%
Banana bruising level	$0.19	10%	$1.67	86%
2 Fruit rub level 2	$0.25	13%	$1.74	89%
Neck injury level 3	$0.24	12%	$1.68	86%

3.3.2 Trial 2

Demographic and behaviour data

Gender split was relatively even for the 20 participants. Age was skewed to an older demographic and most were in a permanent relationship (table 3.10). Participants belonged to a low – mid income bracket and education was relatively evenly spread amongst categories.

Table 3.10 Demographic information, trial 2

	No of participants
Gender	
Female	11
Male	9
Age	
30-39	3
40-49	3
50-59	8
>60	6
Marital status	
Perm/live in relationship	
Yes	16
No	4
Children at home	
Yes	4
No	16
Individual income	
$0-40 000	9
$ 40 001 – 80 000	6
>$80 000	4
Household income	
Single	8
Double	9
Other	3
Education	
Some high school	2
High school	5
Trade/technical	6
University undergraduate	3
University postgraduate	4

Almost all participants were the sole purchaser of bananas or shared in the shopping activity. The majority preferred to buy bananas which would ripen within 1-2 days (table 3.11).

Cost was considered by over half of the respondents to be the most important factor when buying bananas, followed by colour as an indication of ripeness (table 3.12). The presence of skin marks was the most important factor considered in the buying process by two people. However skin markings were an important consideration with eight people citing it as the third most important factor in buying bananas. The presence of skin markings was the least or second least important factor in buying bananas for six out of the ten people.

Table 3.11 - Banana purchase and ripeness preferences, trial 2

	No of participants
Banana Purchase	
Me	14
My partner	1
Shared activity	5
Buying ripeness	
Ripe immediately	2
Ripe 1-2 days	12
Ripe 3 more days	6
Other	0

Table 3.12 - Three factors considered important / not important when buying bananas, trial 2

	Number of respondents		
	1st	2nd	3rd
Most Important			
Price per kilo	11	4	2
Colour as an indication of ripeness	5	7	4
Size of individual bananas	1	7	4
Presence of marks	2	0	8
Size of cluster	0	1	3
Growing process	1	1	0
Least Important			
Previous experience of retailer	8	8	2
Growing process	6	4	3
Size of cluster	4	3	7
Presence of marks	2	4	0
Price per kilo	0	0	8
Size of individual bananas	0	2	3
Colour as an indication of ripeness	0	0	2

Acceptability data

Participants were asked to rate the external appearance of whole fruit manipulated to typify five defects; Best quality, Minor bruising (Bruise grade 1-2), Neck injury grade 3, Superficial marking (Fruit/Black rub grade 2-3) and Major bruising (Bruise grade 3). Samples were graded on scales, where samples that score over 5, towards 10, are interpreted as acceptable in appearance for the consumer. Samples rated below 5, toward 0, may be interpreted as unacceptable to consumers.

Participants found the sample typical of Major Bruise to be unacceptable (table 3.13). The best quality sample received the highest scores, but these were not that different for scores for Minor Bruising. Samples typical of Superficial Marking received an acceptable score but this was quite low. Scores for Superficial Marking were highly variable.

Table 3.13 – Averages for acceptability data, trial 2

Day and samples	Average scores <5 = unacceptable appearance ≥5 = acceptable appearance
Best quality	6.9
Minor bruising	6.7
Neck injury grade 3	6.0
Superficial marking	5.4
Major bruising	4.2

Consumer attitudes to banana blemish

In a repeat of the initial study, a number of items measuring attitudes to banana blemishes were included. Participants were asked to indicate how well a set of statements described them with a score of 1 - does not describe at all to 5 - describes me well. Scores over 3 are considered an affirmation to the statement.

Participants described themselves as accepting of skin marks, felt that most marks on bananas were superficial and scored high on the statement 'I take a lot of care when choosing bananas (table 3.14).

Table 3.14 – Consumer attitudes to banana blemish, trial 2

Statement	Average Scores 1= does not describe me at all 5 = describes me well
I will only eat bananas if they have no skin marks	2.4
I tend to accept minimal amount of skin marks on the banana I buy	4.0
I will only eat bananas if they look perfect	2.2
I believe most skin marks on bananas are superficial & don't affect eating quality	4.0
I take a lot of care when choosing bananas to buy	4.4

Auction data

As with the initial study, auction bid data was divided into four categories:

1. Tolerant - $0 bid (no decrease in value apparent)

2. Mostly tolerant - Up to .50c bid (a decrease in value of up to 26%)

3. Fairly intolerant - 51 to $1 bid (a decrease in value of between 26- 51%)

4. Intolerant - over $1 bid (a decrease in value over 51%)

Around seven of the 20 people were regularly unwilling to pay to swap their blemished bananas for the best quality bananas (table 3.15). Around the same number (5-8 people) were willing to pay up to 50 cents (a decrease in value of up to 26%) a kilo to swap blemished bananas for best quality. More people were fairly intolerant of banana bruising. One or two people were intolerant of blemish.

Table 3.15 – Auction bids, trial 2

	Type of damage		
	Skin markings	*Bruising*	*Neck injury*
Tolerant ($0 bid)	7	7	6
Mostly tolerant (<.50c	7	5	8
Fairly intolerant (.51 to $1)	4	7	4
Intolerant (> $1)	2	1	1

Segmentation of participants

A segmentation of participants was performed to understand if clusters of people existed with different bidding behaviours. Similar to the initial study, two groups were found with different patterns of behaviour and this was reflected in both the acceptability data as well as the bidding data (table 3.16). Group one were more willing to accept blemishes and bidding was markedly lower with a devalue of between 16-19%. Group two devalued blemished bananas by 30-32%.

Table 3.16 – Auction bids by group membership, trial 2

	Group one bid	Devalue	Group two bid	Devalue
Neck injury	$.38	19%	$.62	32%
Bruised	$.36	18%	$.63	32%
Marked	$.31	16%	$.58	30%

3.4   Discussion and Key points

The objective of this research was to gain insight into the impact of physical damage on consumer purchasing. The physical damage investigated within this research were bruising, blackened rub, fruit rub and neck injury. Various levels of damage were also investigated. Research was undertaken in November 2010 (trial 1) and May 2011 (trial 2). Trial 1 was a pilot study consisting of 100 government employees. Trial 2 was a small study consisting of 20 recruited consumers undertaken to provide a comparison to the results from trial 1. All participants were regular banana eaters.

There is often an inconsistency between what consumers think they do and their actual behaviour. For this reason trials included both self-report items where consumers were simply asked to indicate their answers to questions, as well as an auction process where actual behaviours could be measured.

The influence of skin blemish on banana buying

Consumers were asked to indicate the importance of different factors on their purchase of bananas. Trials 1 and 2 reveal similar results for consumers' perception of how skin marks affect their decision to purchase bananas:

* ★ overall, skin marks were the third most influential factor for consumers in buying bananas

* ★ skin marks are *the* most important purchase factor for 13 % of participants in trial 1, and 8/20 for trial 2

> ✷ skin blemishes were one of the least important factor for 16% of participants in trial 1 and 6/20 in trial 2

> ✷ 60% of participants in trial 1 and half of trial 2 believed skin marks on bananas did not affect their purchase process

> ✷ consumers believed they were tolerant of banana blemishes, but also felt they took a lot of care when purchasing them.

Other influences on banana buying

Price was the primary influence for buying bananas for over half the participants in both trials.

Other influences on purchase were size, with almost half the consumers in the first trial preferring a medium sized banana. Colour as an indication of ripeness was also considered important. The majority of participants preferred to purchase bananas that would ripen in 1-2 days. Many participants preferred to buy a mixture of bananas, with some bananas ready to eat and others ripe in a few days.

The growing process, described as organic production or Eco bananas was the least important factor in buying bananas for these groups of consumers as was the previous experience with the retailer.

Acceptability of banana blemish type and level.

Participants were asked to rate the acceptability of bananas used in the trials. A fair amount of variability was found in the bananas typical of blemish and level of blemish in trial 1. This can be seen in the acceptability levels for bananas. No real differences in scores were shown for Bruising level 1 and bruising level 2. Fruit rub level 1 was also found to have been less acceptable than all other bananas, but this was not repeated for fruit rub level 2. To avoid this in trial 2, bananas were damaged by hand in a consistent manner.

> ✷ major bruising where the eating quality of the banana is affected was unacceptable to consumers in trial 2

> ✷ consumers in both trials could not always detect a difference in minor blemishes such as Bruise Grade 1-2 or Blackened Rub 1and the Best Quality bananas

> ✷ all other blemishes such as neck damage and rub were perceived as acceptable in appearance but lower in acceptability to Best Quality.

Segmentation and auction results

Consumers took part in an auction process. Participants were asked to bid on how much they would pay to exchange the various defect bananas with a cluster of defect free bananas.

Trends in data for both trials were similar. Overall, a greater number of people were Tolerant (defined as bid nothing) or Mostly Tolerant (defined as a bid of < .50cents) toward skin blemishes in bananas. However, a smaller group of consumers did show Fairly Intolerant (defined as bid ≥.50cents - $1) to Intolerant (defined as bid over $1) behaviours toward blemished bananas.

> ✷ Tolerant - trial 1:around 36% consumers, trial 2: around 7/20

> ✷ Mostly tolerant - trial 1:around 33% consumers, trial 2: around 7/20

★ Fairly intolerant - trial 1: around 15% consumers, trial 2: around 5/20

★ Intolerant - trial 1: around 18% consumers, trial 2: 1-2/20 consumers.

This indicated that two groups of people with different bidding behaviours existed and a segmentation analysis confirmed this. Group one, called *Forgiving*, was relatively tolerant of blemishes and numbered around two thirds of the participants of trial 1 and around half of the participants in trial 2. On average, the *Forgiving* group devalued blemished bananas between 7-15% (trial 1), and 16-19% (trial 2) in price.

Group two, called *Fanaticals*, was both price sensitive and intolerant of banana blemishes. When averaged, the *Fanatical* group devalued blemished bananas between 41-89% (trial 1), and 30-32% (trial 2) in price. This group consistently scored all 'blemished' bananas in the acceptability testing as less acceptable than the participants belonging to the *Forgiving* group. It is interesting to note that the *Fanatical* group believed they were not influenced by skin markings. This reveals that for some people, their perceptions of themselves and their actual behaviour is sometimes contradictory.

The high acceptability of bananas with superficial blemishes and the low levels of devalue placed on them by the *Forgiving* group suggests that for many of the consumers in this study, slight blemishes are not an obstacle to purchase. However, the low acceptability scores, high devalue amounts and high price sensitivity of the smaller *Fanatical* group means that dissatisfaction with blemished product will be an issue for some. Most participants would like to believe that blemishes hold little effect on their purchase decision.

4.0 Initial Supply Chain Study

4.1 Background

Before conducting major supply chain studies, we needed to determine a suitable method. This meant deciding what factors were most important and the best method of evaluating their effects. For example,

*   ★ How many fruit need be examined to make a representative sample from a treatment?

*   ★ Where should they be taken from on the pallet?

*   ★ Should they be sampled randomly from cartons (eg 20 fruit) or did every banana in the carton need to be checked?

*   ★ How to manage different numbers of fruit / carton and time required

Costas Banana Exchange were interested in damage during transport and the effects of packaging and generously offered an opportunity to use some of their fruit and facilities for an initial study. They arranged to place data loggers in some pallets of bananas being delivered from North Qld to their Sydney ripening facility, and then track some of these consignments through to local Woolworths stores. This would help develop the method, act as a "proof of concept" and potentially provide initial results which could be built on in larger trials.

NOTE : These results are from one small trial. The study must be repeated to verify whether observed differences are due to the applied treatments.

4.2 Method

CostaExchange pack-house staff constructed one full pallet each of;

1. 1 piece carton + slip sheet and liner

2. 1 piece carton + bag (perforated)

3. 2 piece carton + slip sheet and liner

4. 2 piece carton + bag (slitted)

Temperature and humidity data loggers were included in four cartons: two were in the top pallet layers, the others in the bottom layer (1 per pallet). An additional 4 temperature loggers with probes were used to monitor banana flesh temperatures in the bottom layers of each pallet.

The fruit were pre-cooled before shipping direct to the Banana Exchange facility in Flemington, where they were ripened to stage 3-4 over the course of a week. On removal from the ripening room, the pallets were re-stacked so as to remove the cartons from the bottom third of each pallet. These were despatched to the Woolworths DC for immediate re-supply to stores within the nearby Sydney Metropolitan area.

Fruit remaining at the ripening facility were assessed for symptoms of transport damage later that same day. To do this, each cluster was removed the sample carton and the number of fingers counted. The number of fingers with each type of injury was then recorded (eg total fingers = 5, 2 with neck injury grade 1, 1 with neck injury grade 3, 1 with basal bruise grade 2). Injury severity was graded using the original pictorial grading scale, as shown in figure 2.1.

The following morning the marked cartons originally on the base layers of each pallet were assessed in the same way while in the service area of each of the four retail stores.

This assessment method recorded the total number of fingers inside each carton as well as the total number with bruising, rubs, neck damage or scuffs along with the severity and types of these injuries. Rather than a random subsample, this method enabled accurate calculation of the percentage of fruit with each type and grade of injury. A total score per carton was calculated by multiplying the number of fruit in each category by grade. This score therefore reflected both the percentage of fruit affected by each type of injury and severity of that injury.

4.3   Results

4.3.1 Effect of carton location

As only cartons from the bottoms of each pallet were assessed at retail, it is not possible to determine whether differences were due to carton position or the additional transport between the ripening rooms and retail store. However, it seems clear that carton position is a critical factor, particularly with regard to superficial skin markings (figure 4.1). Fruit inside cartons at the top of each pallet can vibrate more than those lower in the stack, which are stabilised by the weight of those above. The observed damage is the likely result.

The greater number of rub marks on fruit originally at the base of each pallet, compared to those in the pallet centre, may be related to the restacking of these cartons for distribution. Although transport distances during distribution were obviously far less than the original travel to Sydney, lack of pallet stabilisation during this process may have significantly increased transport injury.
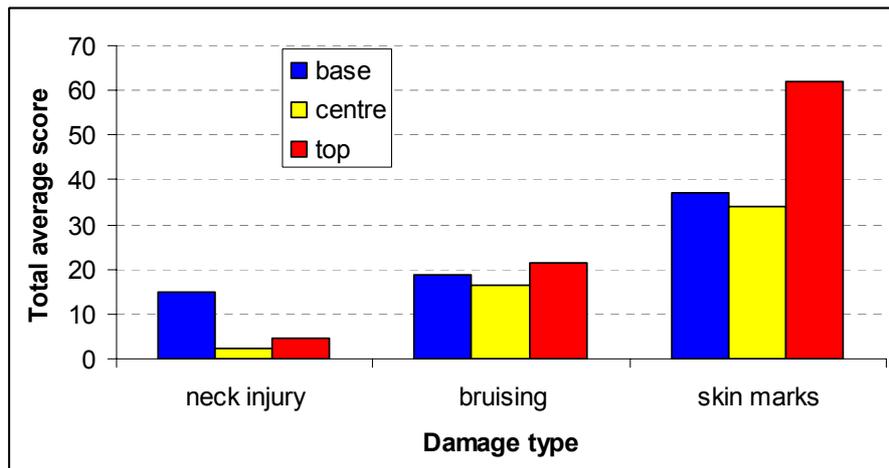
Figure 4.1 - Differences in incidence and severity of damage by carton location at the base, centre or top of each pallet

Location in the top part of the pallet not only increased the number of fruit with rub marks, but also the severity of those rubs. While only 1.2% and 0% of fruit in the pallet base and centre respectively had a moderate to severe rub mark, 7.6% of fruit at the top of the pallet had this injury. However, location at the bottom of the pallet may also have negative effects; neck injury was increased in these fruit, although in most cases injury was slight.

4.3.2 Effect of packaging method and carton type

In this trial, packing bananas into bags rather than a slip sheet + liner reduced average total fruit rub from 13% to 5.4%. The bags also appeared to reduce bruising caused by banana tips impacting fruit lower on the same cluster and nearly halved the incidence of neck injury.

While carton type had less effect on transport damage overall than the other factors examined, there appeared to be an interaction between carton type and liner. Bananas in the two piece cartons with liners had more rub marks and skin damage than fruit in the same cartons in bags. While a similar effect was noted on the one piece cartons, differences between the internal packing methods were less obvious (figure 4.2).

While these results indicate interesting areas for future research care should be taken due to the relatively low numbers of fruit evaluated and considerable differences between individual cartons.
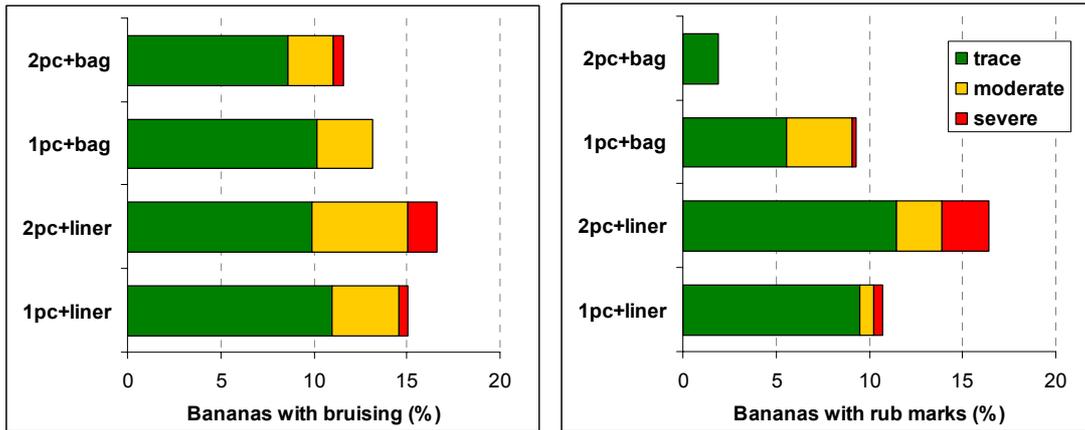
Figure 4.2 - Total incidence of bruising (L) and skin marking (R), showing the percentage of fruit graded as trace, moderate or severe, for each combination of carton type and internal packaging.

4.3.3 Temperature and humidity control

The fruit was cooled rapidly after harvest and packing, flesh temperatures falling to between 13 – 14.5^{o}C within 24 hours and remaining between 14.3 – 15.5^{o}C during transport (figure 4.3). Temperatures fell at one point during ripening, with flesh temperatures falling to 12°C, normally regarded as a chilling temperature for bananas. Low temperatures were maintained for 2 days before they returned to 16-17°C. This was evidently not long enough to induce chilling injury, as none was observed in the fruit.

The rapid fall in temperatures during distribution is another concern. In this case the time was too short to damage the fruit. It could be useful to monitor a longer chain, as such falls in temperatures could potentially induce chilling injury if bananas remain cold for any length of time. This could explain the chilling injury at retail which was observed in the benchmarking survey.
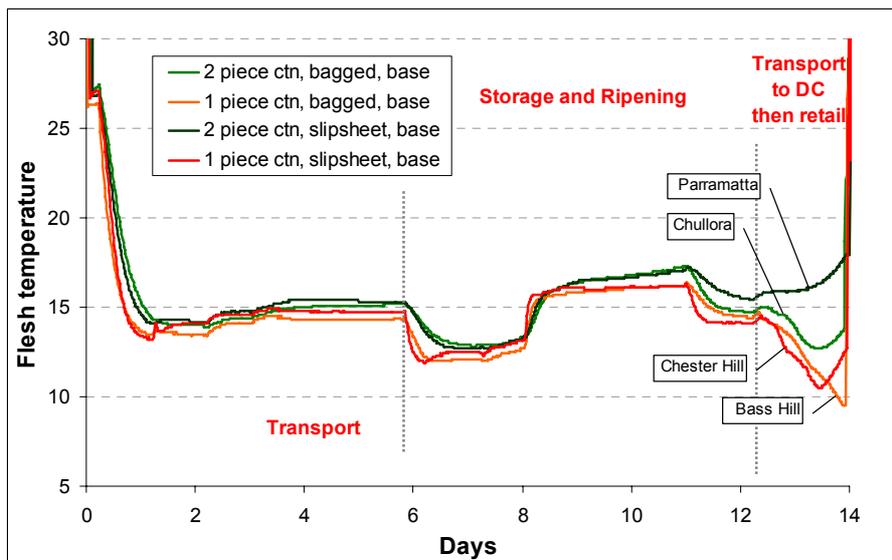
Figure 4.3 - Banana temperatures during packing, transport, ripening and distribution

During cooling, internal air temperatures fell quickest in the 1 piece carton with liner, and slowest in the 2 piece carton with bagged fruit, potentially reflecting differences in ventilation

rates between these two systems (figure 4.4). Flesh temperatures were generally lower for bananas in 1 piece cartons compared to those in 2 piece cartons, which could also be related to better ventilation in this carton type (figure 4.5). It also appears that temperatures inside 2 piece cartons tended to rise slightly during low temperature storage, whereas those in 1 piece cartons remained constant.

It had been suspected that bagged fruit would stay warmer during ripening than fruit in slipsheets and carton liners. In this trial, the average flesh temperature of bananas in bags was effectively the same as those in lined cartons (Figure 4.5), suggesting that bags have little effect on internal temperatures. In addition, no consistent temperature differences were observed between the top and base of the pallets.

It had also been thought that air temperatures might change more slowly in perforated bags (used in the 1 piece cartons) than slitted bags (used in the 2 piece cartons). This trial did not investigate the interaction between carton type and bag ventilation. However the results suggest that differences in temperature control between perforated and slitted bags are likely to be relatively slight, especially when compared to factors such as total vent area on the carton.
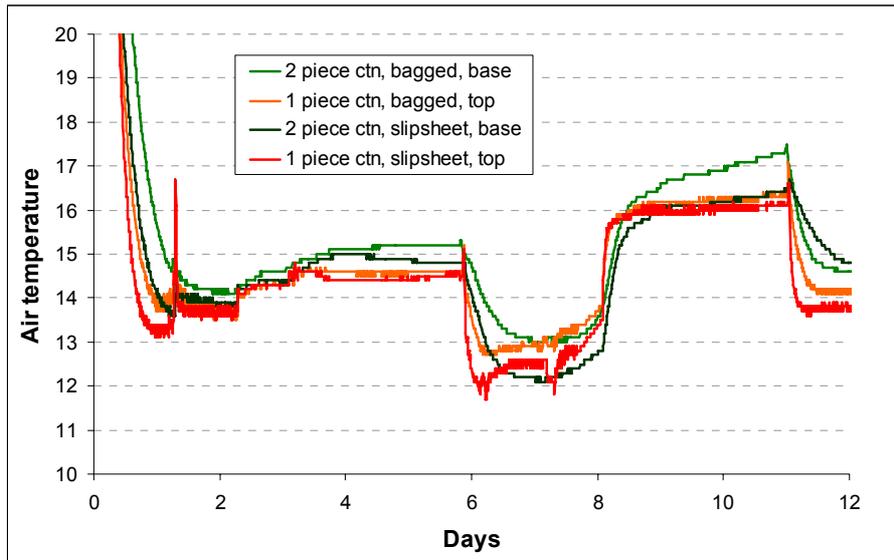
Figure 4.4 - Air temperatures inside cartons of bananas packed in either a bag or with a slipsheet + liner in a 2 piece or 1 piece carton.
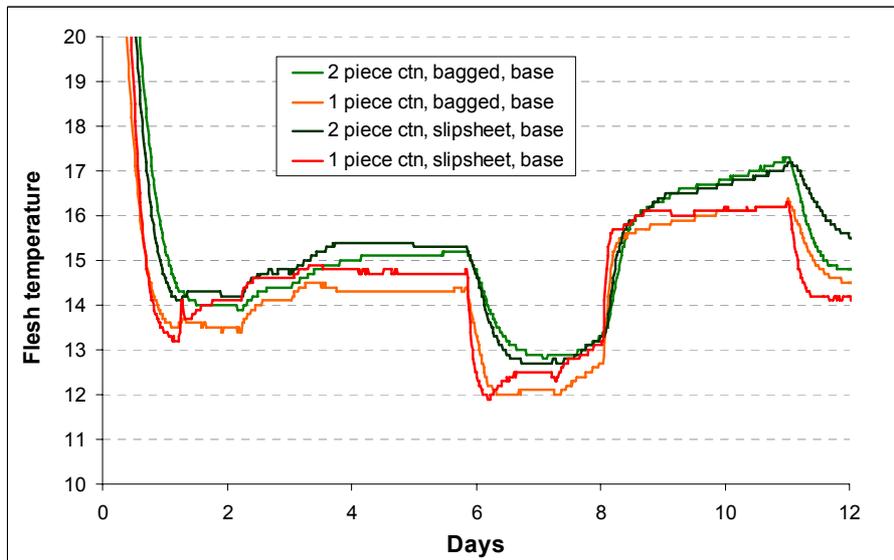
Figure 4.5 - Flesh temperatures inside cartons of bananas packed in either a bag or with a slipsheet + liner in a 2 piece or 1 piece carton.

One possible difference between perforated and slitted bags may be their control of relative humidity (RH). For both bagging types, RH rose to 100% within 30 minutes of packing the fruit. During pre-cooling, however, RH inside the slitted bag fell to 70%, taking 2 days to return to ~100%. In contrast, RH inside the perforated bag maintained 100% throughout, despite being in a more highly ventilated carton. This observation is consistent with the easier movement of water vapour molecules through a large hole, such a as a slit, than multiple small holes such as perforations, even though the total open area may be similar. Perforated plastic is therefore an effective barrier to moisture loss.

Flesh temperatures were more stable than air temperatures. Where flesh and air temperatures were measured within the same carton, values tracked closely with minimal lag. For example, 7/8 cooling was reached 1 or 2 hours later in the flesh, compared to the air temperature, in the bagged and lined cartons respectively. All fruit were 7/8 cooled within 24 hours of the start of packing.

4.4 Discussion

The results from this trial suggest that it is definitely possible to significantly reduce damage to bananas occurring during transport, ripening and distribution. The differences between bags and slipsheets particularly appeared worthy of further investigation. Also, interactions between carton type and factors such as temperature control during ripening and incidence of neck injury could prove significant in a larger study. Practices which stabilise the top layers of pallets should also be tested, the increase in fruit rub in the top carton layer being the strongest effect observed during this trial.

The method which was developed to assess full cartons of fruit proved an efficient and replicable way of determining the incidence and severity of damage within a carton. Variability between cartons was such that at least 3 cartons / layer need to be assessed from the top, center and bottom layers of each pallet, both after ripening and following distribution to retail stores, to accurately estimate damage. This method will be used in subsequent supply chain studies.

4.5 Key Points

* Bananas were packed either in bags or with slipsheets + liners in either a one piece or two piece carton on farm in Nth Qld. One pallet of each combination (total = 4 pallets), including data loggers, was transported to Sydney.

* Cartons from the centre and top of each pallet were assessed after ripening, cartons from the base were assessed after distribution to local Woolworths stores.

* Bananas loaded on the top layers of pallets suffered significantly greater fruit rub than those in the pallet centres – which suffered virtually none.

* Packing the fruit in bags instead of the traditional liner + slipsheet appeared to greatly reduce fruit rub and skin markings generally.

* Differences between the 1 piece and 2 piece cartons were minimal.

* Low temperatures were recorded during ripening and particularly during distribution.

* Bananas in 1 piece cartons cooled more quickly than those in 2 piece cartons and stayed cooler, on average, during transport and ripening.

* Packing bananas into bags instead of with a slipsheet + liner did not appear to increase flesh temperatures during transport and ripening.

5.0   Northern NSW Supply Chains

5.1   Background

Plans for studies of a number of supply chains were well underway when, on February 3rd, most of Australia's banana crop was destroyed by Cyclone Yasi. This created extraordinary market conditions and banana prices increased rapidly.

One production area that remained unaffected by the disaster is centred around Northern NSW. It was decided to conduct a small study of two local supply chains operating in this market. Not only could this provide some comparative data to North Queensland, but also act as a "test run" for our assessment method.

Two short supply chains were studied:

* ✶ Farm A is a small Cavendish plantation near Alstonville in NSW. The bananas are ripened at the farm and then supplied directly to local fruit and vegetable retailers by small delivery truck. Under normal market conditions fruit rarely travels >100km from the farm.

* ✶ Farm B is a ladyfinger banana grower north of Mullumbimby in NSW. Fruit is consolidated with other products and trucked to a wholesaler / ripener on the Gold Coast, Qld. After ripening, it is either supplied directly into Woolworths supermarkets in Brisbane or sold through the Brisbane Markets to local retailers.

5.2   Method

5.2.1 Farm A

Fruit samples were taken immediately after harvest. Around 20 bananas were packed carefully into bubble wrap lined boxes and taken to the nearby Alstonville Research station for ripening. The fruit were assessed for damage and graded once they reached ripeness stage 6.

After the remaining fruit was trimmed and packed, air temperature loggers were placed inside two cartons. The cartons were placed in a cool room and ripened over the course of around 9 days. On removal, fruit quality was examined in three cartons from the top, middle and base of the pallet. The cartons were then loaded onto a small truck for delivery to the retail stores. The assessors met the truck when it arrived at the furthest point from the farm – in this case, Evans Head. Cartons from the top, middle and bottom of the pallet were again assessed for signs of damage. In addition, 20 fruit (from the same grower) were purchased from the retail display for later assessment.

Bananas quality was assessed using the methods previously described in this report (Appendix A). The total number of fingers with each defect was used to calculate the total % fruit affected in each carton.

5.2.2 Farm B

As with farm A, fruit samples were taken immediately after harvest. Around 20 bananas were packed carefully into bubble wrap lined boxes and taken to the nearby Alstonville Research station for ripening. The fruit were assessed for damage and graded once they reached ripeness stage 6.

Data loggers were placed inside two cartons before palletisation (6 layers high, 8/layer cartons) and transport to the ripening facility at Labrador, Qld. The fruit was ripened over the course of a week. Three cartons each from the top and base of the pallet were then assessed before dispatch to retail stores. Unfortunately it was not possible to follow the fruit to specific stores as planned due factors beyond the researchers control.

5.3 Results

5.3.1 Farm A

Temperatures of the bananas were stable around 14-15°C during ripening, but fell prior to distribution, perhaps because of low ambient temperatures once the room had been opened (figure 5.1).
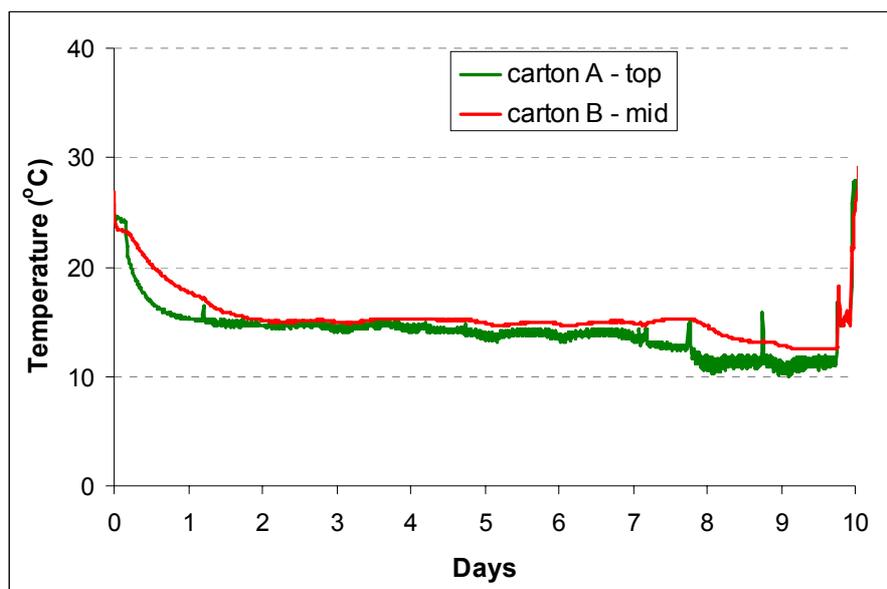
Figure 5.1 - Temperatures recorded during ripening and transport local retail stores for fruit from farm A.

Even this short supply chain resulted in an increase in bruised and scuffed fruit between the farm and the retail store (figure 5.2). All types of bruising were recorded, although all but two fruit were scored as 1 – trace only. Black rub and skin scuffing were likewise generally trace markings. Given the results of the consumer survey, such markings would be unlikely to affect the value of the fruit or reduce its acceptability to consumers.

However, the fruit which were actually on retail display had severe damage. The display had been overfilled, resulting fruit being squeezed into it (figure 5.3). Of the 15 fruit which were bruised, 5 were graded as slight or moderate bruises which could affect fruit saleability.

Similarly, black rub was graded as slight to moderate on 5 of the 7 fruit; these markings would be obvious to consumers.
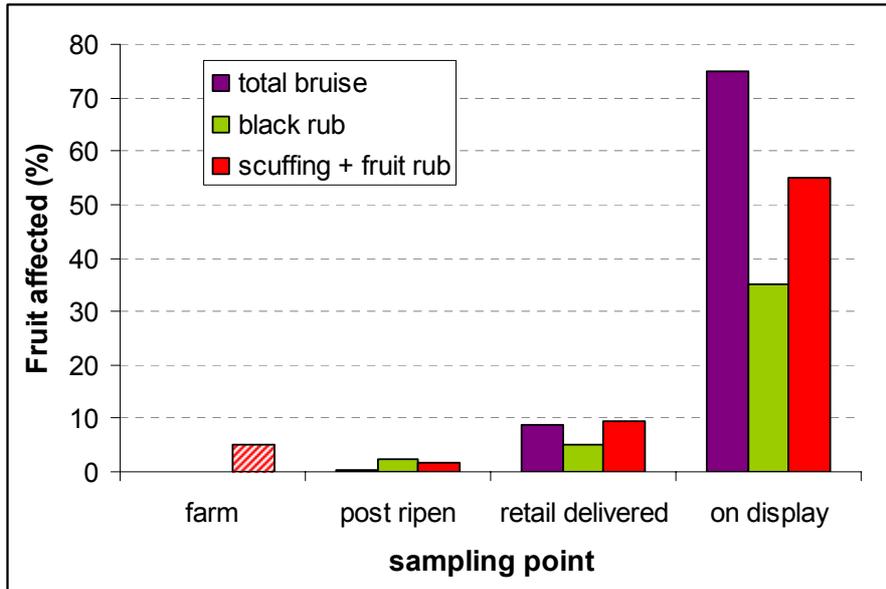
Figure 5.2 - Damage recorded to farm A bananas showing initial values recorded on the farm (20 fruit only), after ripening and delivery to retail (mean values from 3 cartons, whole carton assessed) and finally sampled from retail display (20 fruit only).

Figure 5.3 - Retail display at Evans Head

5.3.2 Farm B

There was significant lag between temperature changes in the top carton and the carton at the base of the pallet (figure 5.4). Air temperature inside the top carton fluctuated rapidly between 13.5 and 14.8°C for much of the time during ripening, whereas at the base of the pallet temperature was quite stable around 15°C.
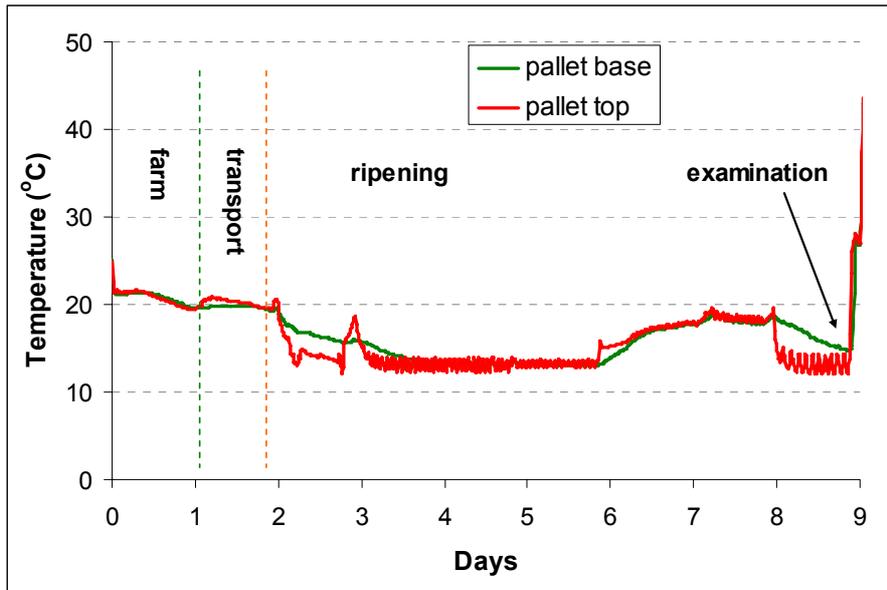
Figure 5.4 - Temperatures recorded during transport from the farm to the banana ripening rooms near Brisbane, then during ripening for bananas from farm B.

Although, it was not possible to follow fruit all the way to retail there were clear increases in damage due to transport from the farm to the ripening rooms (figure 5.5). It appeared that another pallet had been loaded on top of the fruit we were examining – several top layer cartons had clear marks where nail heads had dug into them from above. This had resulted in some damage to the cartons, and the fruit underneath (figure 5.6).

The additional weight may also have contributed to the increased bruising we observed in the base layer of the pallet. Most of this bruising was either at the basal end of the fruit, or was an impact bruise somewhere else on the fruit. Little "tip" or "shoulder" bruising was observed. Black rub was split fairly evenly between the bottom and top of the pallet, while skin scuffs were concentrated at the top and fruit rubs were in only one group of fruit in a single carton.
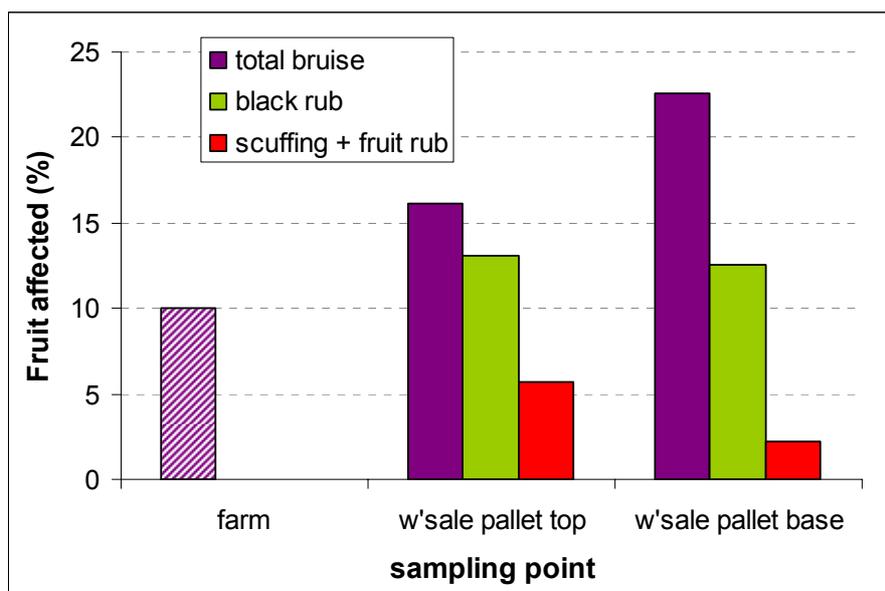
Figure 5.5 - Damage recorded to farm B Ladyfinger bananas showing initial values recorded on the farm (20 fruit only) and after ripening (mean values from 3 cartons, whole carton assessed) from the top and base of the pallet..

Figure 5.6 - Damage to the top carton of Ladyfinger bananas, apparently caused by another pallet loaded on top

Key Points

★ Significant damage can occur to bananas, even during short supply chains, especially if they are not loaded securely on the delivery truck.

★ The extreme increase in damage once bananas are placed on retail display was a particularly interesting result, showing the value of investigating retail display methods.

★ Identifying strategies to reduce damage at retail could maintain value of bananas, potentially improving returns to all supply chain members.

6.0   Major supply chain study – Qld to Central Coast

6.1   Background

Fruit for the major supply chain studies was sourced from the Atherton Tablelands region of north Queensland because of the destruction of the coastal banana industry in February 2011 by Tropical Cyclone Yasi. This fruit was generally equivalent, in terms of size, packing method, distance travelled etc., to that normally supplied from north Queensland.

There are a large number of different factors which can effect the level of damage to bananas between harvest and retail. Some potential factors suggested by industry members included;

   ★   weather

   ★   fruit size and condition (effects of fertiliser, irrigation on fruit softness)

   ★   packing method and packers skill

   ★   carton liner (slitted bag, perforated bag, slipsheet)

   ★   carton type and strength (6/layer, one piece, 8/layer, board strength)

   ★   type of pallet used (Chep or Loscam)

   ★   pallet stabilisation (stretchy tape, corner posts, string)

   ★   orientation of the carton on the pallet, position at top, centre or base of pallet

   ★   truck type (short or long wheelbase)

   ★   position in the truck (A or B trailer, front or back of trailer)

   ★   road condition combined with driver ability and carefulness

   ★   number of pallet movements between farm and retail

Clearly it was not possible to examine all of these factors within one, short project, particularly given the very limited volume of fruit available. After some discussion it was decided that important factors we could examine in this trial were;

   ★   carton strength

   ★   carton position on the pallet

   ★   differences between layers of fruit packed inside the cartons

   ★   differences between position on the truck

The fruit would be supplied from the Mareeba area, ripened at the Wyong distribution centre on the NSW Central Coast and finally traced through to local retail stores.

6.2   Method

All fruit was packed on 6 April 2011. Three equivalent pallets of fruit were prepared. Data loggers recording temperature and relative humidity were included in 3 marked sample

cartons in each of the three pallets. These cartons were placed in standard positions in each pallet – bottom row + corner, centre row + middle, top row + corner.

A number of higher strength cartons were obtained for the trial. These cartons are reported to be more resistant to collapse under high humidity. To compare their integrity during transport and ripening with standard 6 per layer cartons, three of each type were placed in the bottom layer of each of the three pallets.

The three pallets were intended to be loaded in the truck in standard positions – front, middle and back – to provide an assessment of the influence of position in the truck. However the short fruit supply meant that trucks were not fully loaded and the pallet positions could not be prescribed. This factor was therefore not included in the later analysis.

A standard sample of 3 cartons of fruit per treatment was assessed for physical damage, using the scale previously described (Appendix A), at a standard ripeness stage of colour stage 4 or 5. The total number of fingers per cluster was counted, and the number and types of damage on each cluster recorded. This allowed calculation of the total number of affected fruit from each layer in each carton.

Fruit from the same day's packing was assessed at four different points along the supply chain:

1. In the packing shed after removal from the bunch but before packing (1 carton)

2. After packing but before palletising – this fruit sample was ripened at a commercial banana ripening facility in Tully (3 cartons)

3. At the retail chain distribution centre (DC) after fruit was ripened (10 cartons x 3 pallets = 30 cartons)

4. At the back of retail stores after transport from the DC (6 cartons x 3 stores = 18 cartons)

6.3 Results

6.3.1 Temperature

In general, temperature variations between different parts of each pallet were greater than differences between pallets. However, reduced fruit supply meant that cool rooms and trucks were not necessarily full during the study; under more challenging conditions it is possible that greater differences between pallets would be observed (figure 6.1).

The top layer of each pallet cooled faster and fell lower than cartons in other positions, particularly during consolidation at the transport company facilities. This reflects a top air delivery system, possibly running significantly lower than the average room temperature, and may indicate that circulation between and around the pallets was less than optimal.

Air temperature inside the top cartons on pallet 3 fell to 12.6^{o}C during this time, which is close to a chilling temperature. According to UC Davis data, approximately 48 hours at 12.6^{o}C is sufficient to induce moderate chilling injury in mature green bananas. Had the temperature continued to fall to 12°C, only 12 hours exposure would have damaged the fruit (Perishables handling 88, 11/1996).

a

b
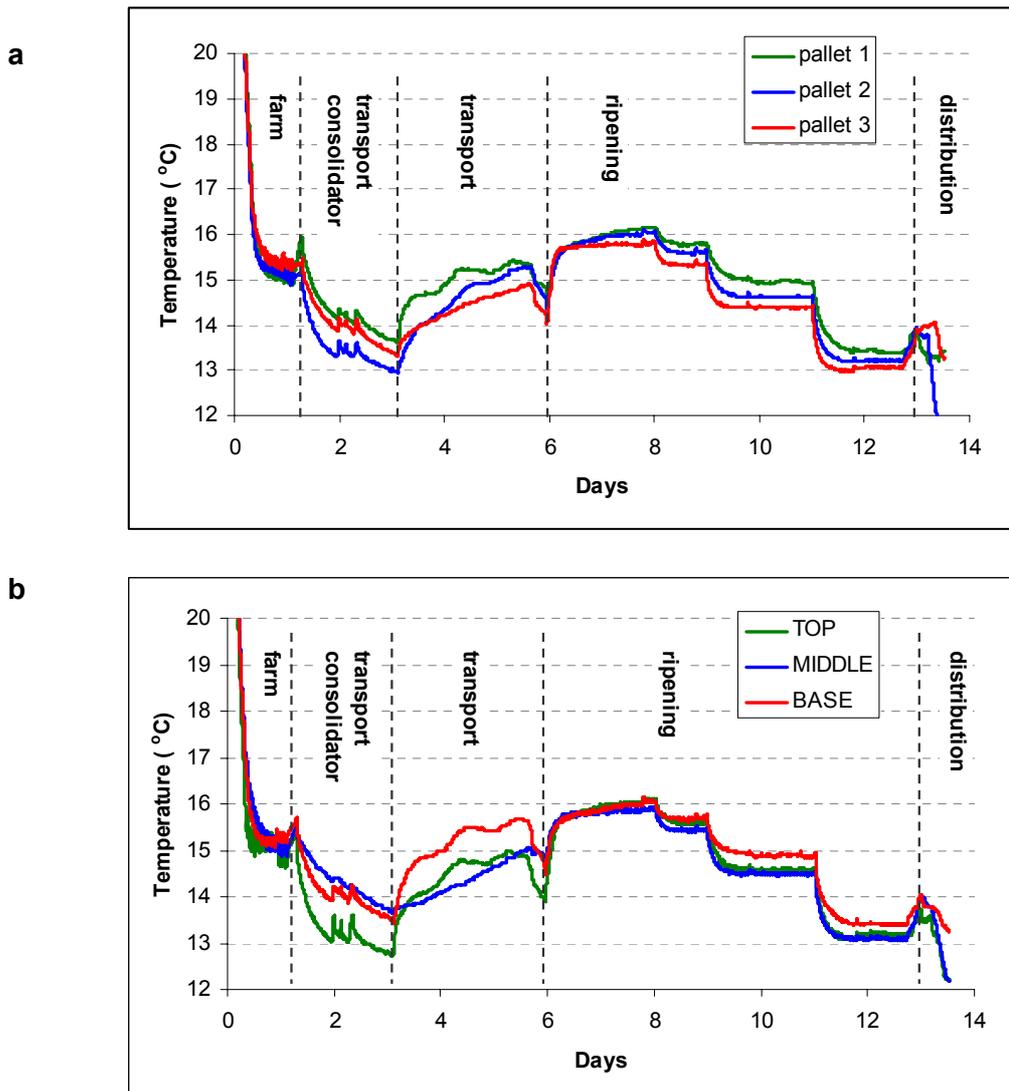
Figure 6.1 - Air temperatures recorded during transport from North Qld to the NSW Central Coast and subsequent ripening, showing differences between three pallets (average of top, middle and base) (a) and differences between cartons on the top, middle and base of pallets (average of three pallets) (b).

The risk of chilling injury was even greater during distribution to retail stores. Truck cooling systems are set to provide a low temperature suitable for most commodities. Unfortunately, this can mean that bananas are exposed to damaging temperatures, especially if transport distances are far or if fruit are loaded onto trucks well before they are due to be delivered.

In this trial, bananas consigned to Gosford had cooled to 10.4°C by the time they were delivered into the back of the store (figure 6.2). Under normal supply conditions this may be less of an issue – retail stores would normally receive half a pallet of bananas, the thermal mass of which could slow down cooling inside the truck. Temperature may have changed relatively quickly in the 6 cartons of bananas which stores were allocated during this trial.

Nevertheless, it seems possible that the chilling injury observed during the benchmarking survey (Section 2) could have occurred during distribution to retail stores. Insulating cartons with a thermal blanket could be a useful strategy to reduce this damage.
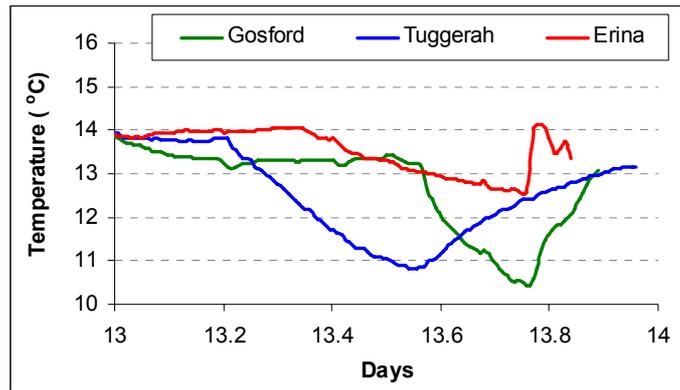
Figure 2 - Temperatures recorded inside cartons of bananas during distribution to retail stores in Gosford, Tuggerah and Erina on the NSW Central Coast.

6.3.2 Differences between carton types

It had been suggested that increasing carton strength would be a key factor in reducing transport damage to bananas. The difference in carton strength was obvious when the pallets were inspected at the DC, (figure 6.3). While the standard cartons had developed a distinct bulge, indicating a moderate degree of collapse, the stronger grade cartons retained their integrity.

Figure 6.3 - Carton condition after ripening, showing the difference in carton integrity between standard (black) cartons and the stronger grade (white) cartons on the base of each pallet.

Despite this, bananas packed in either carton type appeared to be similar (figure 4). There were no significant differences between bananas packed in the standard and stronger grade cartons in terms of ripeness stage, neck injury, bruising, black rubs, superficial injury or any other factor measured.

Figure 6.4 - Condition of bananas packed in a standard (a) or stronger grade (b) carton following transport and ripening. Damage incidence and severity was similar for both carton types

6.3.3 Differences between positions on the pallet

Types of bruising recorded as well as bruising severity and incidence were not affected by where the carton was located on the pallet. However, there were significant differences in neck injury and skin markings. Bananas on the top layer of the pallet had significantly more skin markings than those in the centre or base of the pallet (p<0.001). This was mainly due to black rub, the incidence of which was nearly doubled on the top layer of the pallet compared to the base (p<0.001). In this trial, most of these marks were 'trace' so had only a minor effect on quality (figure 6.5).

Nevertheless, the result suggests that the pallets were not fully stabilised. Cartons at the top of the pallet moved during transport, whereas those at the base are stabilised by the weight of those above. This results in increased rubbing and scuffing in the top layers of the pallet. This same effect was observed in the initial supply chain study conducted from Sydney to Qld (Section 4).
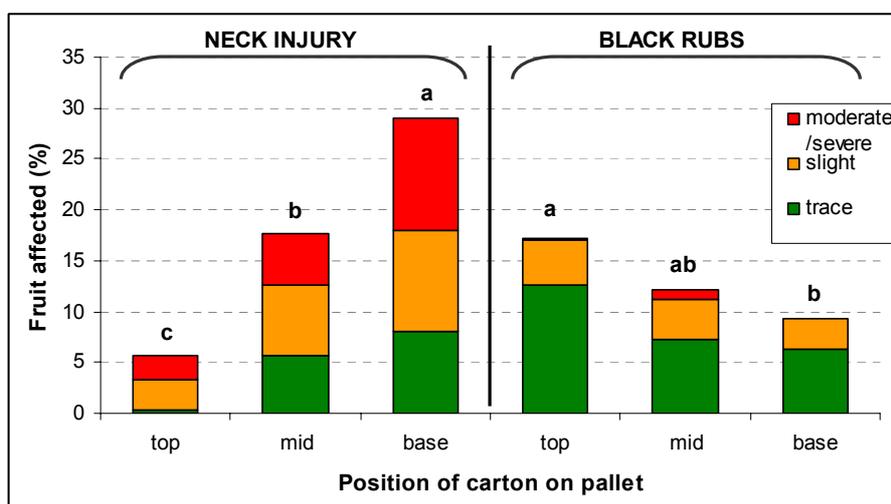
Figure 6.5 - Effect of carton location at the top, middle or base of the pallet on the percentage of fruit with trace, moderate or severe neck injury (L) or black rubs (R). Values are means from 18 cartons (base) or 6 cartons (mid and top). Letters indicate means (total affected) which are significantly different (p<0.05).

In contrast, bananas at the bottom of the pallet suffered significantly more neck injury (p<0.001) than those above. Not only did placement at the base of the pallet increase the total number of fruit affected (p<0.001), but it also increased the percentage of fruit with

moderate or severe damage (p<0.001). This confirms that the bananas were resting, at least partially, on fruit below, rather than being supported fully by the carton. This weight may be concentrated through the banana necks, putting the force through a small cross sectional area. The result is the increased neck damage observed at the pallet base.

6.3.4 Differences between layers inside the carton

Bananas packed into normal 6/layer cartons are usually packed in three separate layers, each composed of a number of clusters (figure 6.6). Damage on each layer of fruit was recorded separately, allowing the differences between the layers to be analysed separately.
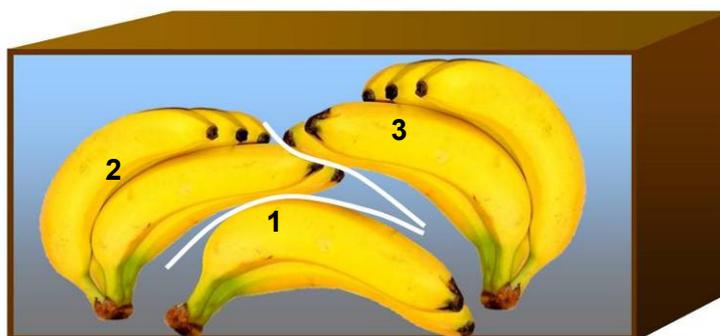
Figure 6.6 - Layers of bananas packed into a 6/layer carton

The largest differences were in neck injury. The top layer inside each carton (layer 3) consistently suffered more frequent and more severe neck injury than the other layers (p<0.001). The fruit on the bottom of the carton (layer 1) had the least neck injury (figure 6.7).
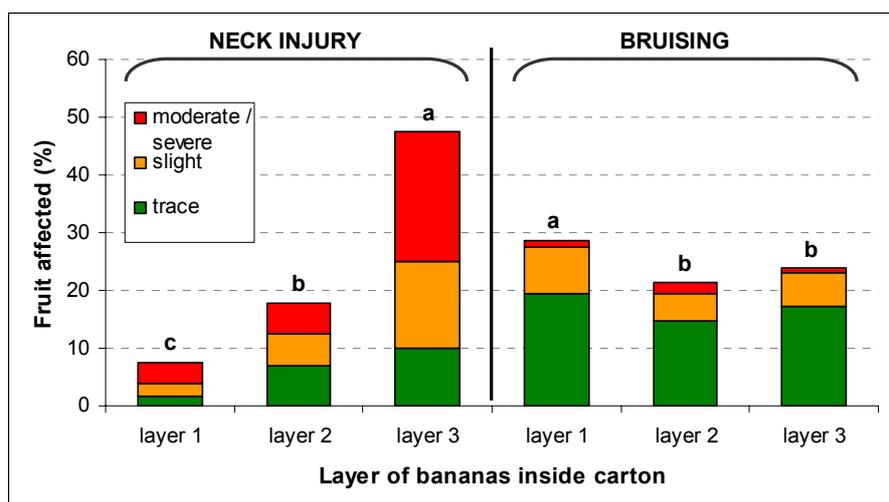
Figure 6.7 - Effect of packing into the 1st, 2nd or 3rd layer inside a carton on the percentage of fruit with trace, moderate or severe neck injury (L) or bruising (R). Mean values calculated from 48 cartons assessed at the DC or at retail. Letters indicate values which are significantly different (p<0.005).

It had been thought that fruit on the base layer of the carton might have more bruising or skin markings, caused by fruit above it. Bruising was significantly increased on the bottom layer of the carton compared to the middle and top layers (p=0.032) (figure 6.7), although the numerical difference was small. In contrast, black rubs and skin markings were reduced in

the bottom layer compared to the top layer (p=0.046), presumably due to the bananas being kept firmly in place by the fruit above.

6.3.5 Damage occurring between farm and retail

Damage to bananas was assessed at the farm, after ripening and on delivery to retail stores. Some of the assessments conducted on farm were more thorough than those conducted later – bruises and marks recorded as "trace" (grade 1) on farm may not have been recorded under the greater time and volume pressure at the DC and retail stores. Moreover, it could not be certain whether minor injuries could have occurred during transport to the Tully ripening facility, rather than actually on farm, due to the distance the fruit had to travel in the car. For this reason, only more significant injuries (grade 2 or more) were considered in the analysis of this data as these were considered to have been assessed similarly at each location.

Damage increased significantly between the farm and the DC, then again between the DC and retail store (figure 6.8). All types of damage increased by 50-75% between the DC and retail. The increase in neck injury was particularly important. Only 2% of bananas sampled had neck injury ≥2 on farm, but this increased to 16% after transport to the DC then to 28% by the time fruit reached the retail store.
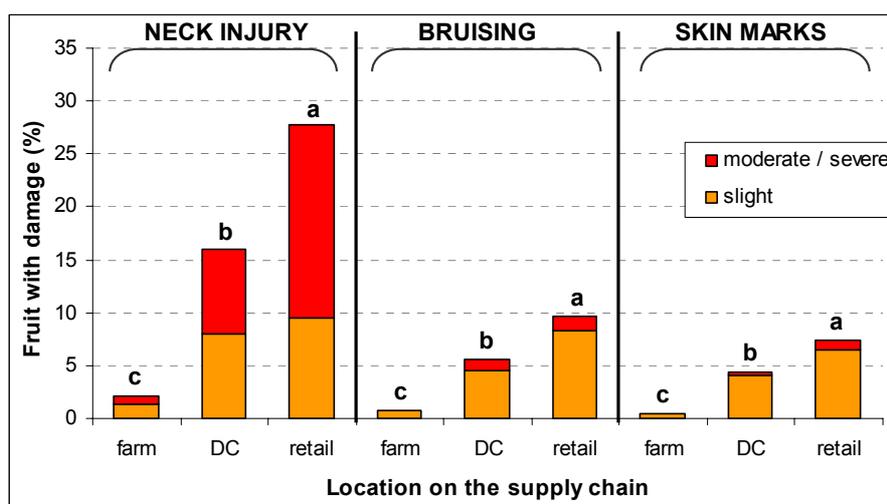
Figure 6.8 - Percentages of bananas with slight, moderate or severe neck injury, bruising or skin marks when assessed on farm, after ripening, and on delivery to retail stores on the NSW Central Coast. Mean values calculated from 4 (farm), 30 (DC) or 18 (retail) cartons, letters indicate values which are significantly different

It is interesting to note that damage increased nearly as much during distribution to retail stores, a distance of <25km, as it did during transport >2,200km from north Queensland. This suggests that much of the damage may be caused by the actual stacking, loading, unloading etc., rather than during transport itself.

It is also possible that, although short, more damage occurs during the short trip to retail due to lack of pallet stabilisation. At this stage in the chain, cartons are loaded onto pallets with other products and may not form a stable, cohesive unit. This may be less of an issue during normal fruit supply, when stores receive half a pallet instead of a few cartons. Despite this, distribution could be an area where there is an opportunity for improvement. Ensuring that pallets are handled gently at all times, and are stable and unified before they leave the DC in

particular, could reduce transport damage and improve retail quality. This should be further investigated under normal supply conditions.

6.4   Key points

★   Three pallets of Mareeba bananas, packed into standard and improved strength cartons, were assessed for incidence and severity of damage at the farm, after ripening and on delivery to retail stores on the NSW Central Coast.

★   Temperatures fell low during ripening, and even lower during distribution to retail stores. Longer exposure to these temperatures would have caused chilling injury in the fruit.

★   Although the improved strength cartons retained their shape and integrity better than standard cartons, no differences were found in damage levels in the fruit.

★   Fruit in cartons at the base of the pallet had significantly more neck injury than those in the top layer, with fruit from central cartons intermediate. In contrast, skin marking was greater at the top of the pallet than in the middle or base layers.

★   There were major differences between the three layers of fruit inside each carton. Neck injury was significantly more common and more severe in the top layer of fruit. These bananas also had more rub marks. Bruising was slightly increased in the bottom of the carton.

★   Damage levels were low after harvest but increased significantly at each stage of the supply chain. While the number of fruit with bruises, black rubs and other skin markings increased, both the number of neck damaged fruit and severity of injury greatly increased between the DC and retail store.

★   It seems likely that improved methods of handling cartons and better stabilisation of pallets could improve retail quality of bananas.

7.0   Major supply chain study – Qld to Melbourne

7.1   Background

Following the trial examining the supply chain from Qld to the NSW Central Coast, a second, similar study was conducted to the even more distant market of Melbourne. This increased the distance between the farm and DC to nearly 3,000km. Comparing the results from this trial with those from the Central Coast could help indicate how much damage was due to vibration and movement during transport, compared to the damage caused by loading and unloading. It also effectively acted as a second replication of treatments tested in the initial trial.

7.2   Method

Fruit for this assessment was packed on 28 April 2011. The sampling pattern and procedure was the same as described in Section 6.2 and shown in Appendix A, for the consignment sent to the NSW Central Coast. The comparison of standard and higher strength cartons was repeated, placing three of each carton type on the base of the pallets.

Air temperature loggers were again included in marked sample cartons. These cartons were placed in standard positions in each pallet – bottom row + corner, centre row + middle, top row + corner. In addition, a number of temperature loggers with probes were used to monitor flesh temperature. These were located in the same cartons as the air loggers, in the centre and bottom row of each pallet. The probes were inserted into additional, single bananas so that the measuring tip was in the centre of the fruit core and packed into the middle of the carton.

For this shipment 3 different carton liners were trialled –

  ✱ standard plastic liner

  ✱ perforated bag liner

  ✱ slitted bag liner

This comparison aimed to investigate claims that bag liners, twisted and pulled tight, reduced fruit movement and hence damage caused by vibration, when compared to the standard plastic sheet liner. Two cartons packed using each method (4 cartons /treatment) were placed in the top 2 layers of the pallet; this is where fruit damage caused by vibration is most likely to cause damage. The remaining cartons on each pallet were packed using the standard plastic carton liner.

Fruit damage was assessed at the farm (after ripening to stage 4-5), at the DC in Melbourne, and after delivery to retail stores. Assessments at the DC were conducted using one carton / treatment from each of the top two layers, two cartons from the centre of the pallet, and two standard and two extra strength cartons from the base layer (total = 12 cartons / pallet). Once the cartons were delivered to retail stores, the remaining cartons from each of the original pallet layers were assessed. That is, one carton / treatment from each of the top two layers, one carton from the centre of the pallet, and one standard and one extra strength cartons from the base layer (total = 6 cartons / pallet). All cartons were numbered and

marked to ensure that none was assessed twice. This ensured that any damage observed was the result of transport, rather than handling during previous assessments.

As previously mentioned, it had been planned to place the three pallets at the front, centre and rear of the truck trailer for transport. While this was done, unfortunately the position of specific pallets was not recorded so this factor could not be included in the analysis.

Data was analysed using CoStat statistical software.

7.3   Results

7.3.1 Temperature

Unlike the previous trial, where fruit cooled as low as 13°C, fruit remained at around 15°C during pre-cooling and consolidation before transport. The air temperature in the top layer of pallet 2 stabilised at 13.3^{o}C during transport. The warmest records during transport were from the base and mid levels of pallet 1. Most temperatures were between 14.5 – 16°C. The temperature records therefore suggest that pallet 2 was closest to the delivery air and pallet 1 near the door, although this cannot be confirmed (figure 7.1).

As reported previously (Section 6), temperatures in the top layers of each carton fell more quickly during cooling and were generally lower than in the rest of the pallet. It is noticeable that temperatures were kept low for several days after arrival in Melbourne, slowing the ripening process.
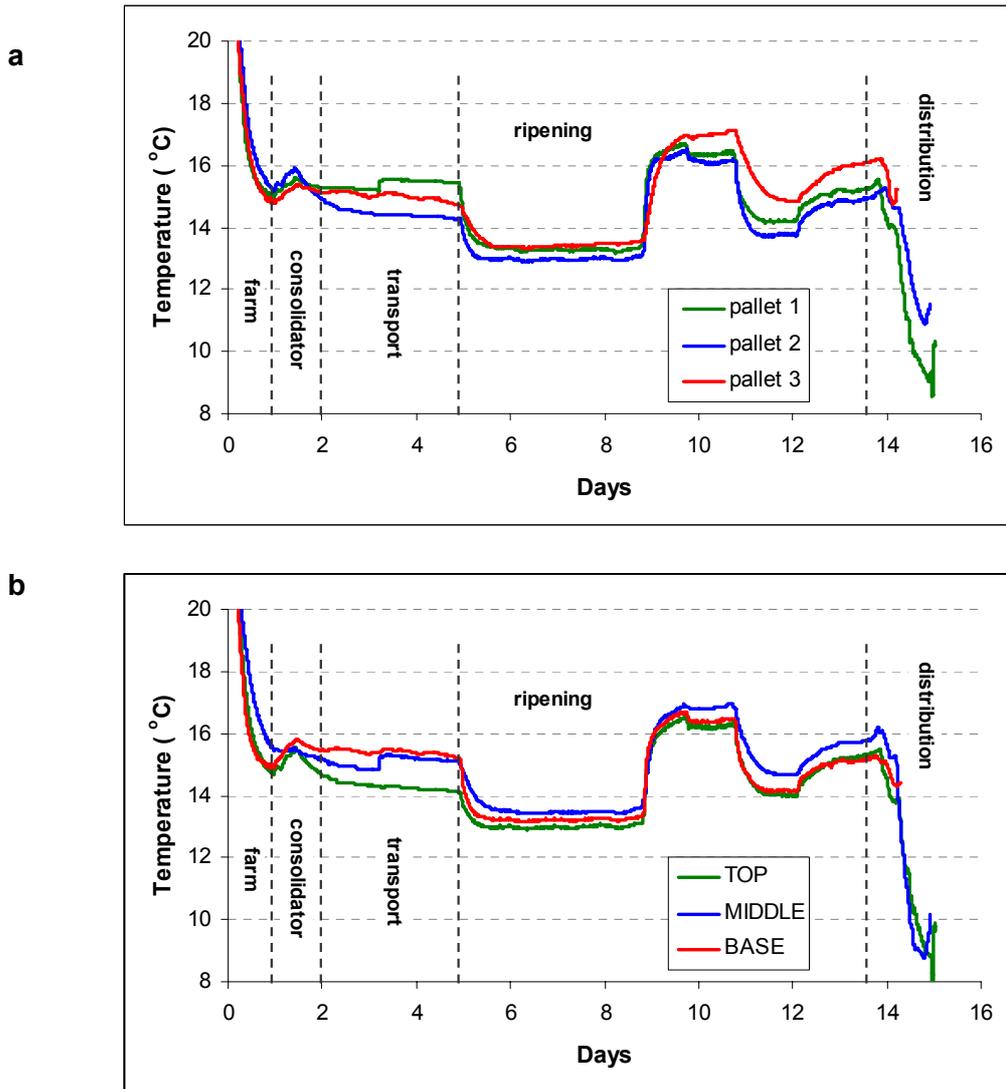
Figure 7.1 - Air temperatures recorded during transport from North Qld to Melbourne and subsequent ripening, showing differences between three pallets (average of top, middle and base) (a) and differences between cartons on the top, middle and base of pallets (average of three pallets) (b).

As expected, flesh temperatures (recorded by the probe loggers) lagged slightly behind air temperatures and were generally more stable (figure 7.2). However the results indicate that air temperatures (which are generally easier and cheaper to record) provide a good indication of what is happening in the fruit flesh.
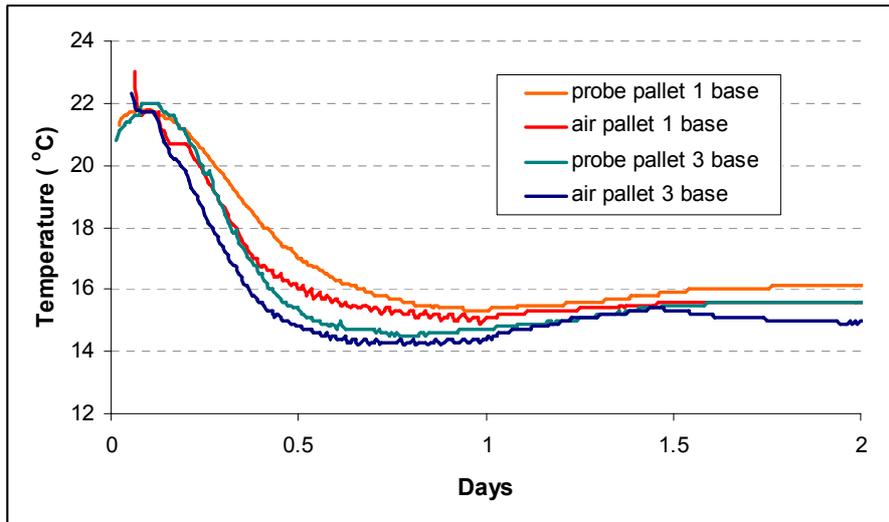
Figure 7.2 - Example of air temperatures and corresponding fruit flesh temperatures inside cartons of bananas. The probes, which measured flesh temperature, lagged behind air temperature and showed less variability.

In the previous trial, temperatures fell to 10.5^{o}C during distribution from the DC to retail stores. In this case temperatures fell even lower, with one consignment below 6.5^{o}C by the time it was offloaded into the store loading area (figure 7.3). Two of the three consignments spent more than 12 hours at temperatures low enough to initiate chilling damage in the fruit. As noted previously, cooling during distribution to retail may be slower under normal supply conditions, when a larger volume of fruit would provide increased thermal mass. However, preventing this from occurring would seem a relatively simple way to improve retail quality.
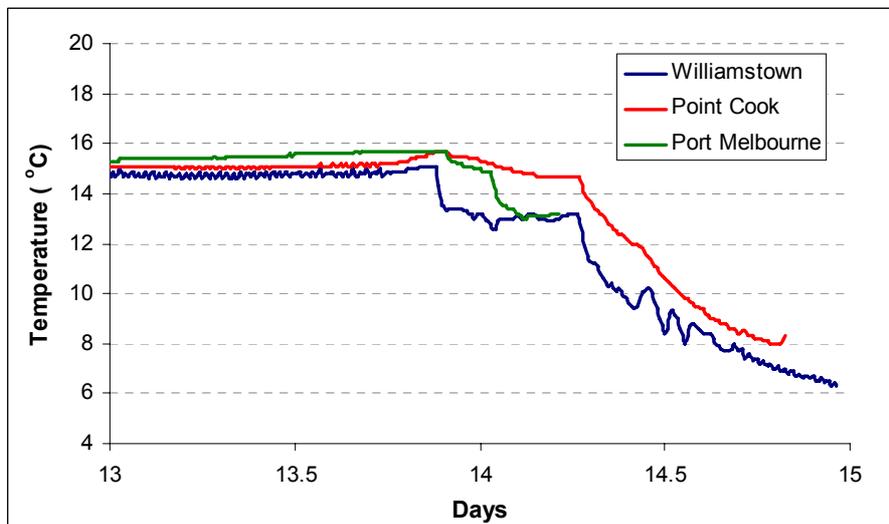
Figure 7.3 - Temperatures during distribution to Melbourne retail stores

7.3.2 Differences between carton types

As found previously, when the pallets were inspected after ripening there was a clear difference between the standard and stronger grade cartons. The stronger cartons retained their shape and integrity, not developing the bulge that was evident in the standard cartons.

As a result, it was noted that the vents on the standard cartons had become misaligned, reducing air circulation, whereas those on the stronger cartons remained open (figure 7.4).

Vents blocked

Vents open

Figure 7.4 - Carton condition after ripening, showing the difference in carton integrity between standard (black) cartons and the stronger grade (white) cartons on the base of each pallet.

Despite this, the quality of fruit in both types of cartons appeared similar when the cartons were opened. There was no significant effect of carton type on bruising, black rubs or skin scuffs or ripeness stage (figure 7.5). A trend to increased ripeness in the stronger cartons was observed, but differences were not significant.

a   **b**
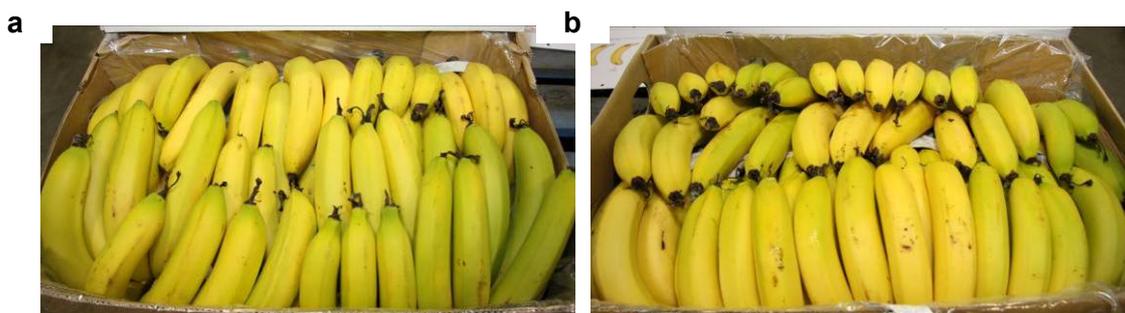
Figure 7.5 - Condition of bananas packed in a standard (a) or stronger grade (b) carton following transport and ripening.

Although the higher strength cartons did not reduce bruising or skin damage, there was a small but significant reduction of neck injury in these cartons. Most of this difference was in the moderate and severe neck injury categories, where the stronger cartons reduced damage from 17 to 11%. By reducing the severity of neck injury – especially in the top layer of fruit, where damage was reduced by 10% – the stronger cartons did provide a measurable advantage over the standard cartons. Greater differences could be observed under wetter conditions, or during periods when banana necks are elongated and more prone to this type of damage.

7.3.3 Differences between carton liners

It had been expected that packing bananas inside bags instead of with a standard slip sheet would reduce skin markings and possibly other damage. This was observed in the initial trial (section 4). The affect on ripening was also of interest, as it was expected that bags would reduce ventilation rates.

In this trial there were no significant differences between the two types of bags and normal slipsheet in terms of neck damage, skin marks or bruises (figure 7.6). While there was a

trend to reduced rub marks in the perforated bag, fruit in the slit bag more closely resembled that packed with the standard slip sheet. Ripeness was unaffected by liner type.

Figure 7.6 - fruit packed inside a perforated bag (a) or slitted bag (b) as an alternative to the standard slip sheet.

The effectiveness of bags in reducing rubs is likely to relate to how tightly they can bind the packed fruit. The tightness of the bag seal can be increased by spinning the carton before tying off, or using other mechanical aids to ensure bags are as tight as possible. The cartons in this trial were packed by people unfamiliar with these materials, and were not mechanically assisted. More experienced packers may have achieved different results.

7.3.4 Differences between positions on the pallet

As previously discussed, position of the carton on the pallet significantly affected neck injury. In this trial, neck injury was just as severe in the middle of the pallet as in the top layers (figure 7.7), both being significantly more than the top layers of the pallet ($p < 0.001$). Fruit in the top layer had significantly more fruit rub marks than those at the pallet base ($p = 0.02$), however differences in black rubs and scuffing were not significant. Although there was a trend to increased bruising at the base of the pallet, this was also not significant.
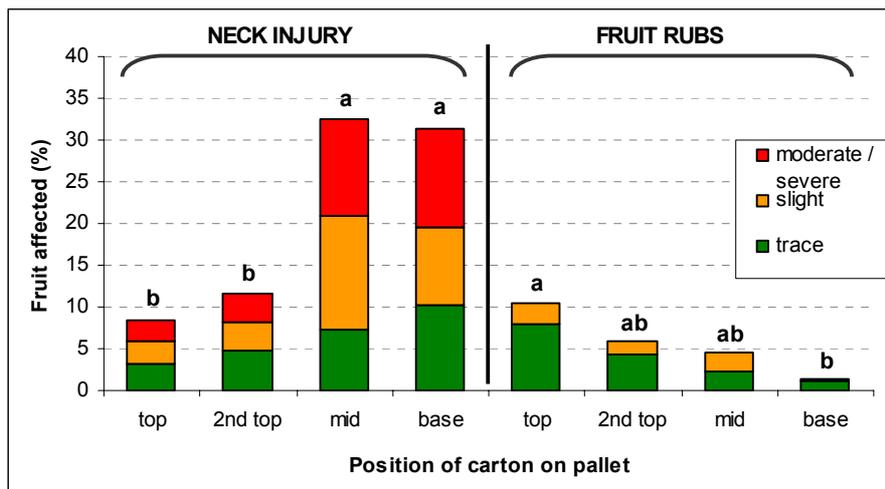

Figure 7.7 - Effect of carton location in the top, 2nd top middle or base layer of the pallet on the percentage of fruit with trace, moderate or severe neck injury (L) or fruit rubs (R). Values are means from 6-12 cartons. Letters indicate means (total affected) which are significantly different ($p < 0.05$).

7.3.5 Differences between layers inside the carton

There were significant differences between the 3 layers of packed fruit inside the cartons (figure 7.8). The fruit at the base of each carton (layer 1) had significantly more bruising than those above ($p < 0.001$). Neck injury was most frequent, and often severe, in the top fruit (layer 3). Layer 3 also suffered more skin marking than the other fruit, but this only became significant after distribution to retail – which will be discussed later in this report. These results are similar to those found in the previous study (section 6).
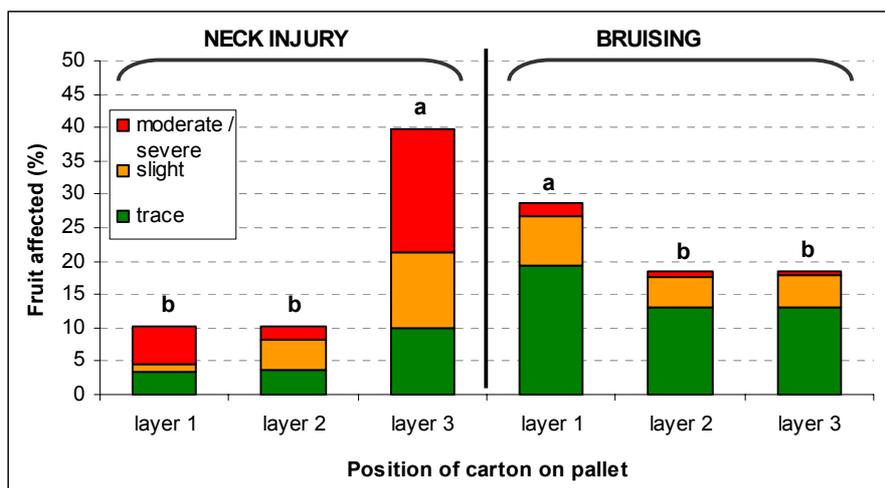
Figure 7.8 - Effect of packing into the 1ˢᵗ, 2ⁿᵈ or 3ʳᵈ layer inside a carton on the percentage of fruit with trace, moderate or severe neck injury (L) or bruising (R). Mean values calculated from 48 cartons assessed at the DC or at retail. Letters indicate values which are significantly different ($p < 0.005$).

7.3.6 Damage occurring between farm and retail

As explained in section 6, it was not possible to include damage recorded as "trace" on farm due to inconsistencies with how the data was recorded as well as the possibility of damage occurring during travel from the farm to the ripening facility used. Only moderate / severe injuries were used in the analysis, as these were considered to have been assessed similarly at each location.

In this trial, neck injury primarily occurred between the farm and the DC, although severity increased during distribution to retail (figure 7.9). As in the trial to the NSW Central Coast, neck injury affected close to 15% of fruit when assessed after ripening. However, whereas injury increased to close to 30% in the previous trial, in this study the increase during distribution was relatively small. This difference could be due to the stacking and handling techniques used at each DC, or the amount of product placed on top of the banana boxes for transport to the retail stores.

In contrast, bruising and skin marks hardly changed between the farm and the DC, despite the long distance fruit were transported. This result further supports the observation that much of the damage which occurred between farm and DC was likely to be due to packing, pallet stacking and loading. Damage occurring during transport, at least for these trials, is likely to be less important.
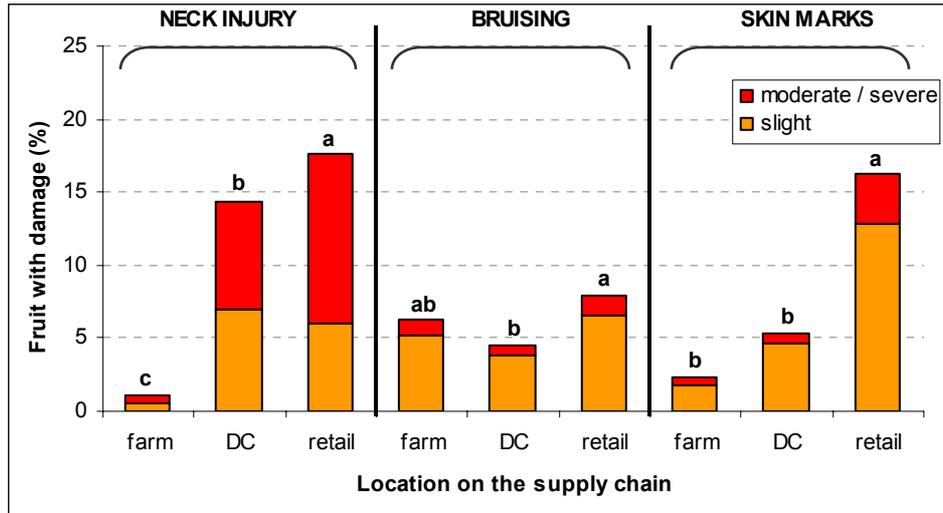
Figure 7.9 - Percentages of bananas with slight, moderate or severe neck injury, bruising or skin marks when assessed on farm, after ripening, and on delivery to retail stores in Melbourne. Mean values calculated from 3 (farm), 36 (DC) or 18 (retail) cartons, letters indicate values which are significantly different

The major increase in skin markings which occurred between DC and retail in this trial is of particular interest. On further analysis of the data, it is evident that marks increased nearly three times as much during delivery to one retail store as the other two stores (figure 7.10).
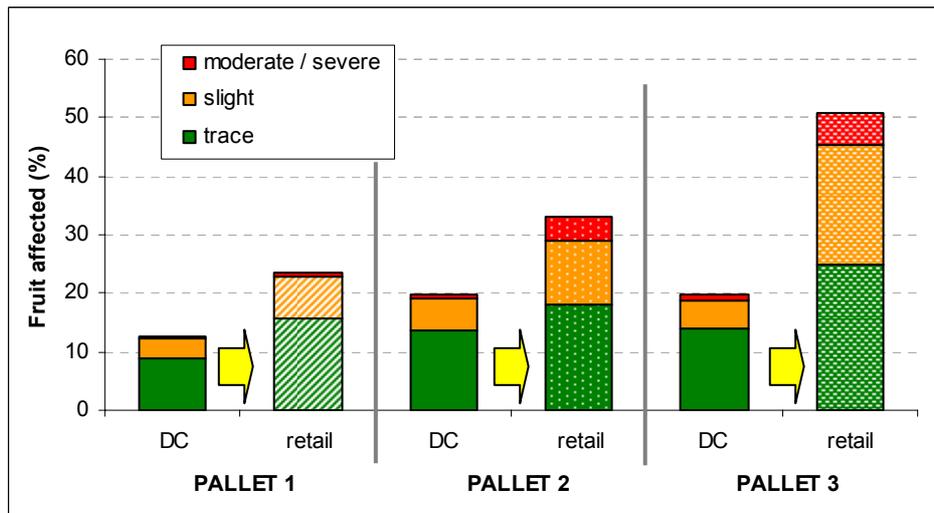
Figure 7.10 - Total skin markings recorded before after delivery to retail stores in Melbourne. Damage increased by 30% during delivery to one store, compared to 10-12% increases for other stores.

One possible reason for this difference is that the cartons were stacked differently on the pallets for delivery. For two stores, the base layer of banana cartons had been left on the original pallet, and other items stacked on top. For the third store cartons were restacked into a column (figure 11). It was thought that this would avoid the fruit being crushed by heavy stock placed on top. However, the method actually had the opposite effect, the unstabilised cartons moving during transport and resulting in the observed damage. During normal supply pallet stacking is less likely to be an issue. However, the result emphasises the importance of stabilising pallets before delivery, even if distances are short.

a

b

Figure 11 - Cartons stacked for delivery to retail stores. Skin damage was increased in the column stacked fruit (a) compared to cartons laid flat under other products (b).

7.4   Key points

★ Three pallets of Mareeba bananas, packed into standard or improved strength cartons, lined with a standard slipsheet, perforated bag or slitted bag, were assessed for incidence and severity of damage at the farm, after ripening and on delivery to retail stores in Melbourne.

★ Chilling temperatures occurred during distribution to retail stores, with one consignment's temperature falling below $7^{o}C$.

★ The improved strength cartons slightly reduced neck injury, but had no effect on bruising or skin marking

★ Despite a trend to reduced skin marking in bananas packed into perforated bags, there were no significant differences in damage or ripeness between the different types of liner tested.

★ Neck injury was more severe as well as more frequent at the base and centre of each pallet, while fruit rubs were increased in the top layers.

★ Neck injury mainly occurred between the farm and the DC. Four times as many fruit from the top layer inside each carton had neck injury compared to the remainder.

★ While all types of damage increased significantly between the DC and retail stores, the largest increase was in skin markings. Cartons column stacked onto pallets instead of flat stacked under other products appeared to suffer the worst damage.

★ Many of the results in this trial were similar to those previously found for bananas delivered to NSW Central Coast stores.

8.0   Technology Transfer

8.1   Banana Supply Chain Workshop background

One of the objectives of the current project was to communicate findings to key members of the banana On Wednesday 1st June a half day workshop was held in conjunction with the 9th Australian Banana Industry Congress. The purpose of the workshop was to;

★   Brief key industry members on the results obtained in project BA10016 – Improved handling in banana supply chains.

★   Discuss the key types of damage occurring in banana supply chains and possible causes of this damage.

★   Recommend priorities for future investment and investigation by the banana industry to reduce damage and improve retail quality of bananas.

8.2   The workshop process

The workshop was designed in 2 parts, to define the fruit quality issues and their possible causes and then to identify practices or improvements that might address the quality issues. Findings on fruit damage and incidence from BA10016 were also presented to the workshop to provide some quantitative data on fruit damage in banana supply chains.

The workshop was attended by 37 industry members representing growers, wholesalers, transport companies, packaging providers, retailers and marketers. Seating was arranged so as to distribute representatives from each part of the supply chain around 5 tables. A copy of the agenda is included as Appendix E and a list of attendees is included in Appendix F. Samples of Ladyfinger and Cavendish bananas were placed on the tables for use illustrating specific types of damage.

8.2.1 Group record of quality issues

After introductions, the first group activity was a "brain dump" by each table on what they considered to be the main quality issues with bananas (Figure 1). Table 1 shows the results from this activity, sorted into categories and including the number of tables which nominated each issue.

Figure 8.1 - workshop participants discuss their ideas about the causes of quality loss in bananas

All groups nominated transport related damage as a significant quality issue for bananas (table 8.1). Four of the five groups also nominated issues relating to ripeness. Neck damage, bruising and issues relating to size and grade of fruit were also important, and were nominated by 3 groups.

Table 8.1 - Quality issues with bananas

Quality Issue	No. groups nominating
Neck damage	4
Ripening / colour	4
Over-ripe	3
Under-ripe	1
Uneven ripening	1
Shelf life too short	1
Lack of colour stages	1
Marks	3
Transport rubs	1
Bruising	3
Skin spots	2
Disease (crown end rot)	2
Mould	1
Size / grade	3
Skin splits and cuts	3
Underpeel chilling injury	3
Cluster count	2
Sap residues	2
Presentation at retail	2
Taste	1

The participants were then asked to think about the causes of damage. Again, each group recorded several major quality issues and then listed potential causes of this damage that could occur at different points within the supply chain. Three main types of damage were analysed by most of the groups;
- bruising / marking,
- ripeness issues and
- neck injury.

One group also listed some causes of dull skin colour. The combined outcomes from all groups are summarised in figure 8.2a – d.

Dehanding cuts
Inappropriate packing materials
Pallet height
Unloading technique
Palletising
Packing shed
Trailer type and position
Environmental conditions
Fruit – fruit rub
Rough handling
Strength
Overmature fruit
Carton collapse
Wetness
Harvest
Trailer padding
Transport
Trans-shipping
Rough roads / in field transport
Distance
Bruising / Marking
Poor roads
No. of turns
Stops and starts
Leaf / bag rubbing
Packaging rub
Pallet height and stability
Inappropriate display unit
Wholesale / retail
Poor presentation
Poor stock rotation
Rummaging by customers
Lack of staff training
Display overfilled
Wrong cluster sizes
Number of pallet movements
Rough handling

Poor temperature management
Excess nitrogen during growth
Transport
Overmature fruit
Fruit variability
Ripening too fast
Farm
No pre-cooling
Ripeness
Ripener
Over-ordering
Immature fruit
Slow sales
Poor temperature control
Retail
Poor stock management
Differences between customer requirements
Poor temperature management

Figure 8.2 - Factors affecting bruising / marking (a), ripeness issues (b), neck injury (c) and dull skin colour (d) in bananas, according to workshop participants.

8.2.2 Presentation of BA10016 results

The next part of the workshop involved presentations on the results of the retail quality benchmarking survey, consumer research and supply chain studies which have been completed by the project team. Key points were;

* Although most bananas sampled from retail stores were graded as good to excellent quality, many (approximately 50%) had noticeable rubs, marks, bruises or neck injury

* There appeared to be differences between packaging types and retailers

* Best quality fruit tended to have the highest retail prices

* The results from a simulated "auction" with randomly selected consumers indicated that consumers were willing to pay significantly more for bananas which didn't have neck injury or severe bruising.

* While large bruises affecting flesh quality had the greatest effect on consumer evaluations of banana quality, for some panel members superficial markings also significantly devalued fruit. This suggested two distinctly different levels of quality perception within the groups.

* Neck injury mainly occurred between the farm and the distribution centre.

* Bruises and skin marks could occur anywhere on the supply chain, but increased markedly between the DC and the retail store.

✳   Neck injury was most severe in the base row of the pallet and the top layer inside each carton

✳   Fruit rub was worst in the top row of the pallet.

✳   Bruising was slightly increased in the bottom layer inside each carton

✳   Temperatures fell below the desired minimum during distribution to retail stores; readings down to $7^{o}C$ were recorded

This stimulated further discussion among the workshop participants. Some of these comments are summarised as follows;

Packaging

✳   Some wholesalers suggested that there is considerable private research supporting use of the one piece carton – some participants believed these cartons are better able to take the mechanical weight of the stack.

✳   The combination of a one piece carton and bag was suggested by some as the best answer to transport damage.

✳   Others suggested that using a lidded carton but with higher wall – so that the fruit does not touch the lid – and always packing 3 layers of fruit would reduce damage.

✳   There was interest in a new 15kg carton. The increased height of this carton has been reported to reduce neck damage and transport rub. Other issues discussed were implications for workplace health and safety, pallet weights and load capacity for transport (60 ctns/pallet approaches maximum pallet weight of 1 tonne).

✳   Although there has been significant private research on packaging materials, much of this is not publicly available. Also, different evaluation methods have been used, making it difficult to compare results.

Transport / Wholesale

✳   There can be problem with fruit loaded onto trucks while still hot – the trucks don't cool hot fruit, so ripening can start en-route.

✳   Better communication and information about different batches of fruit would help ripeners produce a more consistent quality.

Retail

✳   The retailers present generally agreed that store losses are $\leq$ 10% when banana ticket prices are around $2.99. This is an efficient price for bananas – people will buy large quantities at this price and are not overly concerned about damage.

✳   Damage incurred while fruit are green becomes more noticeable when bananas ripen. This mainly shows up at retail, especially as bananas ripen further on the display. Ripe fruit also mark more easily so handling and display at retail is very important.

✳   Consumers may say one thing and do another, particularly when it comes to size preferences.

✳   Many consumers still don't understand the difference between Ladyfinger and Cavendish – more consumer education would help.

✳   Chilling injury can be caused by seasonal effects, but eating quality is still OK – need to educate consumers about this.

8.2.3 Identifying future supply chain R,D&E needs

The final stage of the workshop involved determining potential solutions to the quality issues that had been identified and discussed through the afternoon. Each group was given one issue to work on, based on what had been done already. These were

1. Ripening,

2. Bruising and other internal defects,

3. Merchandising and retail

4. Neck injury

5. Size of bananas

The solutions each group developed were reported back to the whole workshop, and additional comments were incorporated. In some cases multiple solutions were considered to be similar, and were grouped together. The workshop participants were then invited to mark each option with coloured dots indicating whether they

- ● Agreed that the solution could reduce damage

- ● Disagreed that the solution would reduce damage

- ● Were unsure about whether it would work or not – perhaps more research required…

During workshop planning this exercise had seemed like an effective way to gather the views of all workshop participants. However, in practice the logistics of each workshop participant voting on every solution resulted in not every participant casting a vote. Nevertheless, some useful insights were gained. The full results of the exercise are shown in Appendix G. The most strongly supported options are shown in table 8.2.

Table 8.2 - Supported management options relating to banana quality

Key quality issue	Suggested management options
Ripening	• Standardise ripening procedures (eg pre-cooling) • improve temperature monitoring and management through the chain
Internal defects	• In-store education on handling, • Role of transport damage, • Carton types • Packing methods
Retail/merchandising	• Standardised retail handling procedures and training, • Improved temperature management at the retail outlet • Develop specialised display unit
Neck damage	• Carton and liner type and design
Size of bananas	• Develop alternative outlets for small and large fruit • Sustainable returns to grow the correct size – pay the same wholesale price for large and ex-large

As not all delegates voted on each topic, the results should be treated as an indication of possible management options. However, it is interesting to note that there were more votes relating to banana size and neck damage than the other issues, possibly suggesting that these were the issues participants felt most strongly about.

8.3   Conclusion and Recommendations from workshop

The workshop was well attended by representatives of most sectors of the supply chain and provided the first opportunity for many to raise issues and contribute to potential answers across the whole supply chain. While not all participants voted on all the issues in the priority setting activity, the results are a useful guide when taken in conjunction with the findings of BA10016 and other privately conducted quality loss investigations. Key activities and recommendations are as follows;

* Participants identified a range of types of damage occurring to bananas, and possible causes of this damage.

* There was strong interest in the results from the benchmarking of retail quality, consumer evaluation of damage to bananas and, in particular, the differences in damage associated with position inside the carton, row of carton on the pallet, type of packaging used, and stage within the supply chain.

* Much of the discussion among participants related to the costs / benefits of different packaging types. Although many companies have run private trials, there was no clear agreement on which carton or liner was "best".

* Communication and product knowledge within the supply chain emerged as a key issue for all value chain members.

* More benchmarking of quality losses in chains is needed under normal market supply conditions - discussion during and after the workshop suggested that the data collected by BA10016 was a useful starting point but warned against drawing too many conclusions from a small number of observations under the restricted supply resulting from TC Yasi. Detailed observation of transport practices in particular were not possible because of the small volumes being marketed. The short project time frame also made it impossible to assess the effect of seasonal conditions on quality loss.

* Investigating the affect of different packaging options and packing methods – this issue was strongly identified by all the groups. The impact on neck injury and ripening is of particular interest.

* One suggestion from the participants for further investigation was to identify superior quality fruit at retail then follow back through that chain. This would help find factors for success.

* The influence of temperature management on fruit quality – this was identified as a possible contributor in the merchandising/retail quality issues, particularly transporting fruit at damaging cold temperatures.

* The need to develop standardised ripening procedures, especially with regard to temperature management during ripening and subsequent transport.

* Developing best practice handling and display guidelines for retail – the workshop identified that there is a lack of information and training available for the retail sector on temperature management, handling and displaying fruit to minimise quality loss.

8.4   Other extension activities

The key results from the project, as well as the outcomes from the supply chain workshop, were presented during the core presentation sessions at the 2011 Banana Congress. This was to an audience of 200-300 people from all sectors of the banana industry. Individual debriefing meetings have been held with a number of the key participants involved in the project. In particular, discussions have been held with north Queensland packaging providers, key cooperating producers and 3 major grower / wholesaler businesses. A presentation was also provided at the Cassowary Coast Banana Producer Association meeting in August. It is planned to continue these meetings with major retailers.

In addition, a defect poster is under preparation using some of the photographs generated during the project. The poster would replace one which is several years old and due for reprinting (figure 8.3). Despite its age, the original poster is still in demand and used as a reference by many in the banana supply chain.

The new poster is not yet complete as it needs to include a ripening scale. It is not possible to use those previously printed by Chiquita or others, partly because high resolution files are not available, and also because some in the industry feel there is a need to slightly revise the existing scale. For example, current Chiquita ripeness grade 7 is overmature with sugar spots. It has been suggested that stage 7 should be full yellow, without spotting, to better reflect market requirements.

The lack of high quality, typical fruit due to cold growing conditions over winter as well as lack of fruit generally means that the poster could not be completed by the end of this project. However, a draft with most of the photographs required has been prepared (figure 8.4). This will be sent to key industry representatives for comment on defects shown and terminology. Work on this will continue with completion expected within the next 2 months.
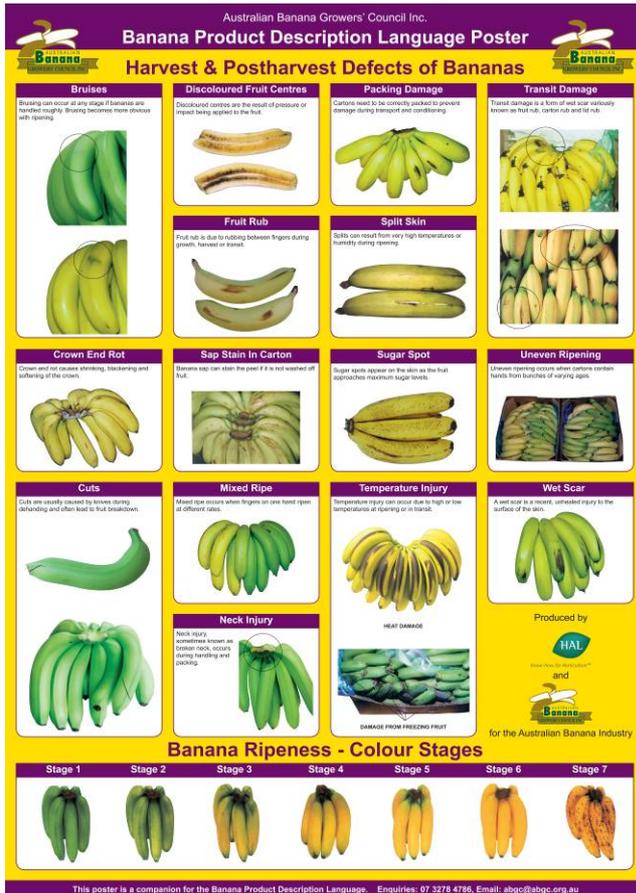
Figure 8.3 - Existing postharvest defects poster

Figure 8.4 - Draft of revised defects poster (still under construction)

9.0 References

Allen, C., 2008. Banana consumer research BA05010. Australian banana promotions company Ltd. Horticulture Australia final report.

Conner, D.S. & Christy, R.D., 2004. The Organic Label: How to reconcile its meaning with consumer preferences, Journal of food distribution, 35: 40-43.

Dangar, E., 2009. Banana qualitative research workshops BA08029. Dangar Research. Horticulture Australia final report.

Ekman, J.H., 2008. Improving market access for Asian vegetables DAN230A. RIRDC final report.

Lemin, C., Lindsay, S., & Boyle, G., 1999. Improved fruit handling systems FR95031. QDPI&F. Horticulture Australia final report.

Lusk, J.L., Daniel, M.S., Mark, D., & Lusk, C.I., 2001. Alternative Calibration and Auction Institutions for Predicting Consumer Willingness to Pay for Non-genetically Modified Corn Chips, Journal of Agricultural and Resource Economics, 26.

Pritchard, J. 1999. Banana consumer research FR99049. Deborah Wilson Consulting Services and Horticulture Australia Ltd.

Umberger, W.J., Feuz, D.M., Calkins, C.R. & Killinger-Mann, K., 2002. U.S. consumer preference and willingness-to-pay for domestic corn-fed beef versus international grass-fed beef measured through an experimental auction, Agribusiness, 18: 491-504.

Appendices

Appendix A - Banana grading scale

Grading scale v5 - 14/03/2011

Banana Ripeness Chart

2	3	4	5	6	7
All green	More green than yellow	More yellow than green	Green tips & green necks	All yellow, light green necks no green tips	Yellow flecked with brown

Banana Neck Injury

0	1	2	3	4
None	Trace	Slight	Moderate	Severe
	Barely visible crease mark	Thin, brownish-black line on inner neck only	Thick, dark area but on inner neck only	Dark ring encircling whole neck

Grading scale v5 - 14/03/2011

Banana size

260mm
220mm
190mm

<190mm = Medium
190 – 220mm = Large
220 – 260mm = Extra large
>260mm = Oversize
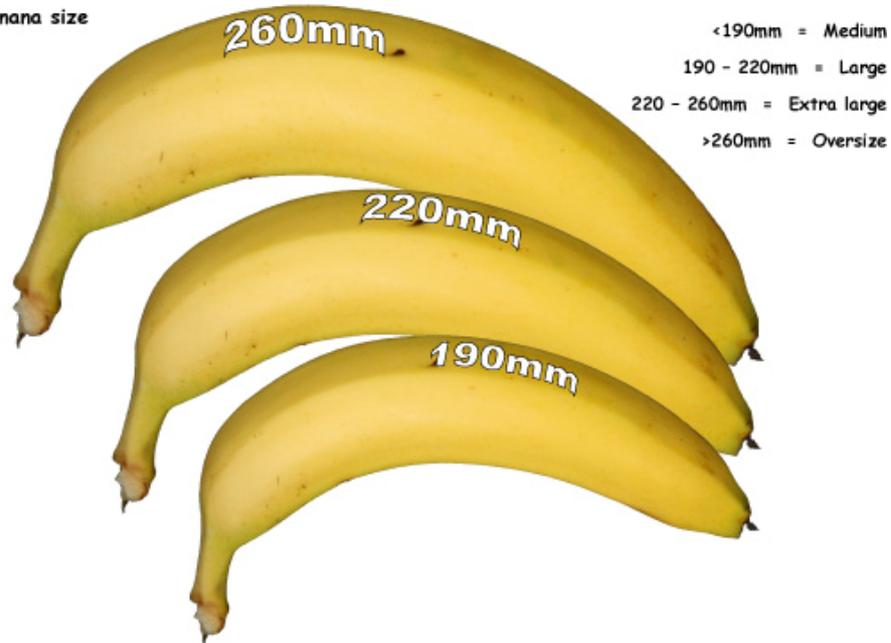
Grading scale v5 - 14/03/2011

Banana Bruising

Bruising is defined as softened flesh usually, but not always, underlying a discoloured area on the skin. It is best detected by gently feeling the fruit.

Percentage area affected by bruising is cumulative, so if two bruises are present the total area affected should be calculated

0	**1**	**2**	**3**	**4**
None	Trace	Slight	Moderate	Severe
	Approx 1% surface	Up to 2% surface	Up to 5% surface	5-10% or more of surface
	Barely noticeable	Becoming obvious	Obvious	Extensive
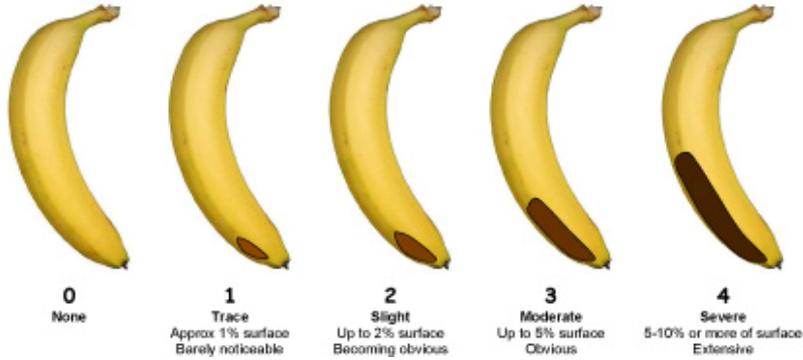
Grading scale v5 - 14/03/2011

Banana Bruising cont....

The location of the bruising could help indicate its cause.

For the purposes of this study, bruising may be classified into four broad types;

Basal	**Shoulder**	**Tip rub**	**Impact**
Caused by compression of the blossom end	Caused by compression of the neck end	Caused by banana tips pushing into the fruit below	Caused by impacts anywhere else on the fruit
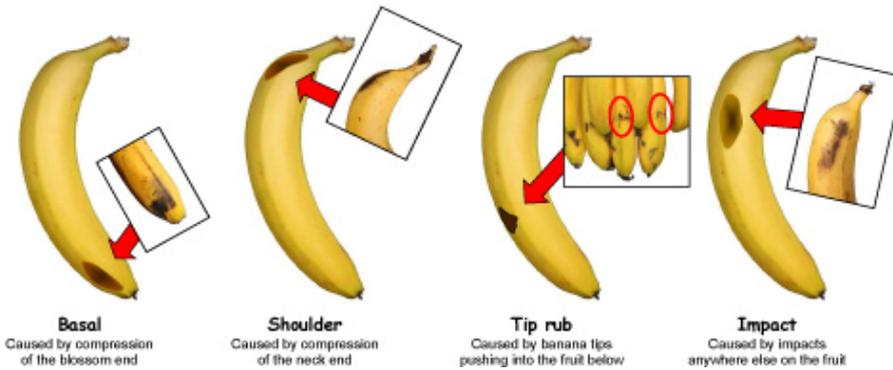
Grading scale v5 - 14/03/2011

Banana Fruit Rub

Fruit rub is caused by fingers within a hand rubbing against each other during transport. It generally results in a dark brown, flattened area with a distinct margin. Despite its appearance, the underlying flesh seems to be rarely bruised.

0	**1**	**2**	**3**	**4**
None - Trace	Slight	Moderate	Severe	Very Severe
<0.5cm^2	1 – 2cm^2	2 – 3cm^2	3 – 4cm^2	> 4cm^2
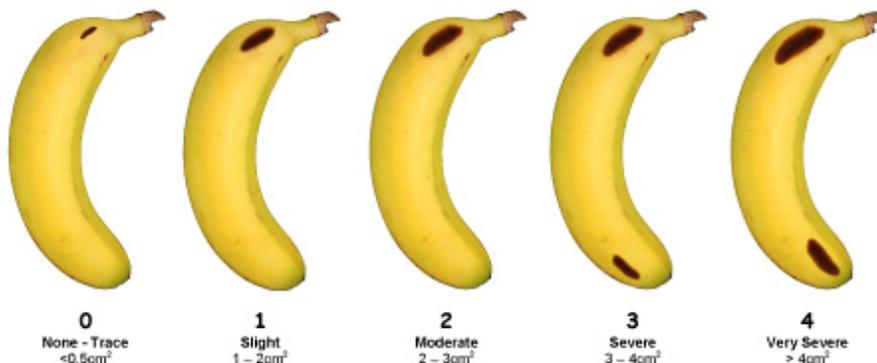
Grading scale v5 - 14/03/2011

Banana Superficial Scuffing

Superficial skin damage includes rub marks from other fruit or the carton itself as well as abrasions which could have occurred during packing and transport.

They are defined as discoloured light brown to dark brown marks on the skin which are superficial in that the underlying flesh is unaffected. "Sugar spotting" associated with advanced ripeness is not included.

0	**1**	**2**	**3**	**4**
None	Trace	Slight	Moderate	Severe
	Approx 1% surface	~ 5% surface	~ 15% surface	20% or more of surface
	Light and/or localised	Distinct rub mark	Obvious skin damage	Extensive discolouration
	Barely noticeable	Becoming obvious	May be dark brown	Darkening to almost black

Grading scale v5 - 14/03/2011

Banana Blackened Rubs (Transit injury etc)

While still superficial, these rubs are mainly along the fruit ridges (especially the outside curve) and tend to be black rather than dark brown. The clearly defined black areas are distinctly sunken.

0	**1**	**2**	**3**	**4**
None	Trace	Slight	Moderate	Severe
	Barely noticeable, very little injury	Clear, noticeable damage to ridges	Obvious damage possibly with underlying flesh injury	Very obvious damage potentially affecting saleability
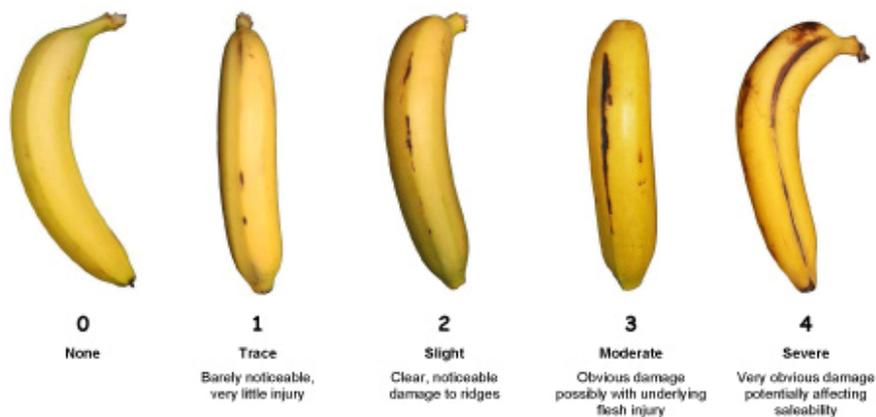
Grading scale v5 - 14/03/2011

Overall Quality

4	3	2	1	0
Excellent	**Good**	**OK**	**Poor**	**Very poor**
Bright skin	Skin with minor damage	Noticeable defects	Obvious damage	Very obvious damage
Little or no damage, no significant defects	Reasonably attractive with excellent eating quality eg trace bruising	Not very attractive but eating quality OK eg slight bruising, scuffing	Unattractive with poor eating quality eg major bruises, overripe	Not really edible
Very saleable	*Definitely saleable*	*Just saleable*	*Probably not saleable*	*Definitely not saleable*

Grading scale v5 - 14/03/2011

Banana – Other defects

Cuts	**Splits**	**Rots**
> 2cm long	>2cm long	Neck or blossom end
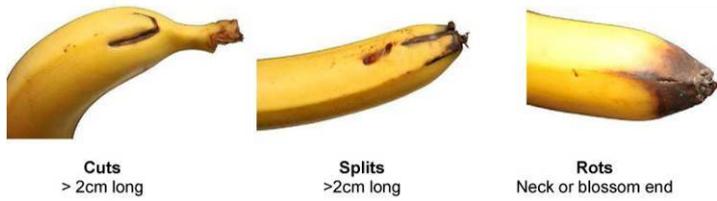
Chilling Injury (CI)

Grey skin discolouration

Incorrect Ripening (IR)

Blotchy appearance

OR

Green yet with sugar spots

Appendix B - Consumer research questions trial 1

Department of Employment, Economic Development and Innovation

Round two

Banana auction
BA10016

Toward Q | Queensland Government

Thank you for taking part in this experimental auction. This research is being conducted by Innovative Food Technologies on behalf of Horticulture and Forestry Services, DEEDI and the banana industry. The results will help us to understand the decision making process for banana purchase. If you have any concerns please do not hesitate to contact Katrina Gething on 3276 66014.

A full explanation of the auction process will be provided. The following pages contain some questions on your attitudes toward fruit and bananas, a series of scales for you to indicate your opinion on bananas for auction, and a few short questions about yourself.

You should also have in front of you five bidding slips marked round 1-5, an envelope, and a laminated number. You will need to keep this number for the second day of auction. Please write your number on the front of this answer booklet now.

Section A – About buying bananas

1. Who buys the bananas in your household?

☐ Me   ☐ My partner   ☐ It's a shared activity   ☐ Other → _____

2. When buying bananas, how ripe do you prefer them to be?

☐ Ripe to eat immediately   ☐ Ripe to eat in a day or two   ☐ Ripe to eat in three or more days

☐ Other → _____

Insert report title here Insert subtitle here   2

3. Please tick the three most important factors that impact on your decision to buy Cavendish bananas:

☐ Size of banana cluster
☐ Size of individual bananas (preference for large bananas)
☐ Size of individual bananas (preference for medium bananas)
☐ Size of individual bananas (preference for small/lunchbox size bananas)
☐ Typical banana shape
☐ Colour as an indication of ripeness (green/yellow)
☐ Colour as an indication of ripeness (light yellow)
☐ Colour as an indication of ripeness (deep yellow)
☐ Colour as an indication of quality (bright yellow)
☐ The price of bananas per kilogram
☐ The presence of marks on fruit skin
☐ My previous experience with the place of purchase
☐ The growing process (ie Organic, Eco etc)
☐ The girth (thickness) of the bananas
☐ Other → _____

4. Of the three most important factors you consider when purchasing bananas, which is the most important? _____

5. Please tick the three least important factors that impact on your decision to buy Cavendish bananas:

☐ Size of banana cluster
☐ Size of individual bananas (preference for large bananas)
☐ Size of individual bananas (preference for medium bananas)
☐ Size of individual bananas (preference for small/lunchbox size bananas)
☐ Typical banana shape
☐ Colour as an indication of ripeness (green/yellow)
☐ Colour as an indication of ripeness (light yellow)
☐ Colour as an indication of ripeness (deep yellow)
☐ Colour as an indication of quality (bright yellow)
☐ The price of bananas per kilogram
☐ The presence of marks on fruit skin
☐ My previous experience with the place of purchase
☐ The growing process (ie Organic, Eco etc)
☐ The girth (thickness) of the bananas
☐ Other → _____

Insert report title here Insert subtitle here   3

6. Of the three least important factors you consider when purchasing bananas, which is the least important?

_____
_____

Section B – Your thoughts about fruit

7. Please indicate how well the following statements describe you by circling the appropriate number.

1 Does not describe me at all	2 Is rather unlike me	3 Unsure	4 Is rather like me	5 Describes me well

I will only eat bananas if it has no skin marks or blemishes 1 2 3 4 5

In general, eating fruit is easy for me because I like the taste.................1 2 3 4 5

I buy only organic fruit...1 2 3 4 5

I tend to accept a minimal amount of skin marks on the bananas I buy......1 2 3 4 5

I eat fruit at least once a day...1 2 3 4 5

I will only eat bananas if they looks perfect...1 2 3 4 5

I am concerned with food miles...1 2 3 4 5

I believe most skin marks on banans are superficial & don't affect eating quality 1 2 3 4 5

I take a lot of care when choosing banans to buy..................................1 2 3 4 5

I have to make a conscious effort to include fruit in my diet....................1 2 3 4 5

Insert report title here Insert subtitle here   4

Section C – Banana auction

Day two :

Bidding bananas

Bidding Bananas – feel free to inspect the bidding bananas. We ask that you refrain from talking to other participants.

Considering the appearance, what is your opinion of this cluster of bananas? You can indicate your answer anywhere along the line.

Totally unacceptable appearance	Satisfactory appearance	Exceptional appearance

Your bananas

1. Round five bananas

Please consider the Round five bananas

Considering the appearance, what is your opinion of this cluster of bananas? You can indicate your answer anywhere along the line.

Totally unacceptable appearance	Satisfactory appearance	Exceptional appearance

Round five bananas have cost you $1.95. Use the Round five bid form to indicate how much more you would pay per kilo to exchange Round five bananas with the bidding bananas.

2. Round four bananas

Please consider the Round four bananas

Considering the appearance, what is your opinion of this cluster of bananas? You can indicate your answer anywhere along the line.

Totally unacceptable appearance	Satisfactory appearance	Exceptional appearance

Round four bananas have cost you $1.95. Use the Round four bid form to indicate how much more you would pay per kilo to exchange Round four bananas with the bidding bananas.

3. Round three bananas

Please consider the Round three bananas

Considering the appearance, what is your opinion of this cluster of bananas? You can indicate your answer anywhere along the line.

Totally unacceptable appearance	Satisfactory appearance	Exceptional appearance

Round three bananas have cost you $1.95. Use the Round three bid form to indicate how much more you would pay per kilo to exchange Round three bananas with the bidding bananas.

4. Round two bananas

Please consider the Round two bananas .

Considering the appearance, what is your opinion of this cluster of bananas? You can indicate your answer anywhere along the line.

Totally unacceptable appearance	Satisfactory appearance	Exceptional appearance

Round two bananas have cost you $1.95. Use the Round two bid form to indicate how much more you would pay per kilo to exchange Round two bananas with the bidding bananas.

5. Round one bananas

Please consider the Round one bananas.

Considering the appearance, what is your opinion of this cluster of bananas? You can indicate your answer anywhere along the line.

Totally unacceptable appearance	Satisfactory appearance	Exceptional appearance

Round one bananas have cost you $1.95. Use the Round one bid form to indicate how much more you would pay per kilo to exchange Round one bananas with the bidding bananas.

About you

1. What is your gender   ☐   Female   ☐   Male

2. What year were you born?   19 ☐ ☐

3. Are you living in a permanent relationship?   ☐   Yes   ☐   No

4. Do you have children living at home?   ☐   Yes   ☐   No

5. Where on the following scale would you place your individual income? Please tick anywhere on the scale.

Low - mid income (0 – $40 000 per year)	Mid income ($40 000-80 000)	Mid -high income (over $80 000)

6. How would you describe your household?

    ☐   Single income

    ☐   Double income

    ☐   Other

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

    ☐   Some primary

    ☐   Some high school

    ☐   High school

    ☐   Trade/technical

    ☐   University undergraduate

    ☐   University postgraduate

Thank you

Appendix C - Bidding sheet

Round one bid

$_____ per kilo

Round two bid

$_____ per kilo

Round three bid

$_____ per kilo

Round four bid

$_____ per kilo

Round five bid

$_____ per kilo

Appendix D - Consumer research questions trial 2

Department of Employment, Economic Development and Innovation

Participant number _____

Sheet 1

Banana auction
BA10016

Toward Q | Queensland Government

The following pages contain some questions on your attitudes toward fruit and bananas, a few short questions about yourself, a series of scales for you to indicate your opinion on bananas for auction.

Section A – About buying bananas

1. Who buys the bananas in your household?

☐ Me   ☐ My partner   ☐ It's a shared activity   ☐ Other → _____

2. When buying bananas, how ripe do you prefer them to be?

☐ Ripe to eat immediately   ☐ Ripe to eat in a day or two   ☐ Ripe to eat in three or more days

☐ Other → _____

3. Please indicate the three most important factors that impact on your decision to buy Cavendish bananas, with 1 being the most important, 2 being the next most important and 3 being the third most important factor :

☐ Size of banana cluster
☐ Size of individual bananas
☐ Colour as an indication of ripeness
☐ The price of bananas per kilogram
☐ The presence of marks on fruit skin
☐ My previous experience with the place of purchase
☐ The growing process (ie Organic, Eco etc)
☐ Other → _____

4. Please indicate the three least important factors that impact on your decision to buy Cavendish bananas, with 1 being the least important, 2 being the next least important and 3 being the third least important factor :

☐ Size of banana cluster
☐ Size of individual bananas
☐ Colour as an indication of ripeness
☐ The price of bananas per kilogram
☐ The presence of marks on fruit skin
☐ My previous experience with the place of purchase
☐ The growing process (ie Organic, Eco etc)
☐ Other → _____

Section B About you

1. What is your gender   ☐   Female   ☐   Male

2. What year were you born? 19 ☐ ☐

3. Are you living in a permanent relationship?   ☐   Yes   ☐   No

4. Do you have children living at home?   ☐   Yes   ☐   No

5. Where on the following scale would you place your individual income? Please tick anywhere on the scale.

(0 – $40 000 per year)	($40 000-80 000)	(over $80 000)

6. How would you describe your household?

☐   Single income
☐   Double income
☐   Other

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

☐   Some primary
☐   Some high school
☐   High school
☐   Trade/technical
☐   University undergraduate
☐   University postgraduate

Section C – Banana bunch auction

Round B Bananas

Please find the tray labelled Round B bananas.

Please consider the following scenario:

You have purchased Round B bananas for $1.95 a kilo. Indicate in the space provided below how much more, if any, you would pay per kilo to swap Round B bananas with the Auction Bananas.

I would pay _____ per kilo to swap my Round B bananas with the Auction Bananas.

Round C Bananas

Please find the tray labelled Round C bananas.

Please consider the following scenario:

You have purchased Round C bananas for $1.95 a kilo. Indicate in the space provided below how much more, if any, you would pay per kilo to swap Round C bananas with the Auction Bananas.

I would pay _____ per kilo to swap my Round C bananas with the Auction Bananas.
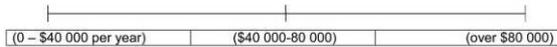
Round A Bananas

Please find the tray labelled Round A bananas.

Please consider the following scenario:

You have purchased Round A bananas for $1.95 a kilo. Indicate in the space provided below how much more, if any, you would pay per kilo to swap Round A bananas with the Auction Bananas.

I would pay _____ per kilo to swap my Round A bananas with the Auction Bananas.

Please continue onto the next page

Section D – Single banana rating

There are a number of single bananas on trays in front of you. Each tray has a three digit code. The following questions will ask you to find a particular sample. When finding a sample, please take the whole tray so that bananas are not misplaced.

1. Please find tray 946

Considering the appearance of the fruit only, what is your opinion of this banana? You can mark your answer anywhere along the line.

| Totally unacceptable appearance | Satisfactory appearance | Exceptional appearance |

What if anything did you like about sample 946?...

……………………………………………………………………………………………

What if anything did you dislike about sample 946?..

……………………………………………………………………………………………

2. Please find tray 448

Considering the appearance of the fruit only , what is your opinion of this banana? You can mark your answer anywhere along the line.

| Totally unacceptable appearance | Satisfactory appearance | Exceptional appearance |

What if anything did you like about sample 448?...

……………………………………………………………………………………………

What if anything did you dislike about sample 448?..

……………………………………………………………………………………………

3. Please find tray 209

Considering the appearance of the fruit only , what is your opinion of this banana? You can mark your answer anywhere along the line.

| Totally unacceptable appearance | Satisfactory appearance | Exceptional appearance |

What if anything did you like about sample 209?...

……………………………………………………………………………………………

What if anything did you dislike about sample 209?..

……………………………………………………………………………………………

4. Please find tray 340

Considering the appearance of the fruit only , what is your opinion of this banana? You can mark your answer anywhere along the line.

| Totally unacceptable appearance | Satisfactory appearance | Exceptional appearance |

What if anything did you like about sample 340?...

……………………………………………………………………………………………

What if anything did you dislike about sample 340?..

……………………………………………………………………………………………

4. Please find tray 552

Considering the appearance of the fruit only , what is your opinion of this banana? You can mark your answer anywhere along the line.

| Totally unacceptable appearance | Satisfactory appearance | Exceptional appearance |

What if anything did you like about sample 552?...

……………………………………………………………………………………………

What if anything did you dislike about sample 552?..

……………………………………………………………………………………………

Please continue onto the next page

Section E

Please indicate how well the following statements describe you by circling the appropriate number.

1	2	3	4	5
Does not describe me at all	Is rather unlike me	Unsure	Is rather like me	Describes me well

I will only eat a banana if it has no skin marks or blemishes 1   2   3   4   5

In general, eating fruit is easy for me because I like the taste..................1   2   3   4   5

I prefer to buy organic fruit...1   2   3   4   5

I tend to accept a minimal amount of skin marks on the bananas I buy......1   2   3   4   5

I eat fruit at least once a day..1   2   3   4   5

I will only eat bananas if they look perfect.............….....................….....1   2   3   4   5

I am concerned with how far my food has to travel to get to
me..1   2   3   4   5

I believe most skin marks on bananas are superficial
& don't affect eating quality 1   2   3   4   5

I take a lot of care when choosing bananas to buy.................................1   2   3   4   5

I have to make a conscious effort to include fruit in my diet....................1   2   3   4   5

Thank you

Appendix E - Supply chain workshop agenda

Banana Supply Chain Workshop

Meeting Agenda

Workshop facilitator – Tristan Kitchener

12:00 - 1:00pm	Lunch
1:00 - 1:20pm	Welcome, introductions and workshop purpose *Project outline and purpose – Stewart Lindsay, DEEDI*
1:20 – 1:50pm	What are the quality issues with bananas? – Group activity
1:50 – 2:30pm	What are the causes of these quality issues? – Group activity
2:30 – 2:50pm	Benchmarking survey of banana retail quality – *presentation by Jenny Ekman, NSW DPI*
2:50 - 3:10pm	Consumer perceptions of banana damage – *presentation by Katrina Gething, DEEDI*
3:10 – 3:30pm	Preliminary banana supply chain studies – *presentation by Naomi King, DEEDI and Jenny Ekman, NSW DPI*
3:30 - 3:50pm	Afternoon Tea
3:50 – 4:50pm	Banana supply chain priorities setting

   ★   How can we solve quality issues with bananas?

   ★   How confident are we regarding these solutions?

   ★   What research, development and extension activities are required?

   ★   Actions, timelines and responsibilities

4:50 – 5:00pm	Closing discussion

Appendix F - Workshop Participants

Name	Organisation
Adrian Crema	
Anieta Lusk	Coles (Maroochydore)
Barry Compagnolo	Visy
Cameron Mackay	Mackays
Chaise Pensini	Moraitis
Christopher Foster	Howes Bananas
David Chenu	HAL
David Weisz	HAL
Dennis Hoy	Chep
Derek Pregl	
Dom Arcella	Arcellas
George Ganzenmuller	Amcor
Greg Bradshaw	Wholesalers Assoc
Harry Theoarous	Moraitis
Ian Exintaris	Haacks transport
James Howe	Howes Bananas
Jeff Jackson	Moraitis
Jenny Ekman	NSW DPI
Jodie Campbell	DEEDI
Joe Ekman	Frontline Services
Joe Stacey	Joes Cartons
John Durst	Wholesalers Assoc
John Sipinkas	Coles
John Tyas	HAL
Jonathan Eccles	ABGC
Katrina Gething	DEEDI
Kris Gosper	Coles
Les Blenner	Blenners Transport
Marc Darvenisa	
Matthew Whittle	
Mel Luke	IGA
Naomi King	DEEDI
Patrick Arcella	Arcellas
Patrick O'Grady	Amcor
Paul Johnston	Coles
Peter Hofman	DEEDI
Peter Molenaar	
Peter Sillcock	De Luca
Richard Clayton	Mackays
Simon Johnson	Chep
Stewart Lindsay	DEEDI
Tom Rafferty	Supply Chain STO
Tony DeLuca	De Luca
Tristan Kitchener	AXS Partners

Appendix G - Results of voting at supply chain workshop.

Quality Issue	Influenced By	Solutions	Yes	No	Not sure
Ripening	Infrastructure	Right Designed room	7		11
	Cool Chain Management	Industry cool chain procedures through supply chain, pre cool –maintain- ripen	11	1	7
		Temperature Logging			
	Ripening	Industry ripening standards			
		Education on ripening process through chain		4 (all against "control supply")	
		Control Supply (reduce the need to hasten ripening)	7		12
		Better supply management			
		Qualified ripeners (green tag)			
	Carton/packaging	Carton quality and design			
		Design of liners and bags	8	6	7
		Quality control			
Bruising, Splits and other Internal Defects	Carton		7		2
	Packing Skills	Carton Packing	11		8
		Staff training in handling			
	Ripening process (splitting)			1	10
	Fruit over girth and maturity		13		4
	Transport damage		13		1
	In store education		15		
Merchandising and retail	Order process and pricing		6	3	2
	Training and procedures (handling)		21		2
	Pre packs		7	3	2
	Display Unit		11	2	6
	Consumer Education		13	3	5
	Cooling	Temperature control	14		4
		Back of Store stacking and cooling			
	Deliver the right product to the store – quality and cluster size		3	3	6

Quality Issue	Influenced By	Solutions	Yes	No	Not sure
Neck Damage	Packaging/carton bag	One piece carton 8 per layer carton 175 mm 2 piece carton Carton height One piece carton & bag	26	4 (2 x 8 per layer & 2 x 2 piece 175mm)	
		Bag liner	13		2
	Postharvest Handling		12	1	6
Size of Bananas	Farm	Density Growers will produce for maximum yield	15	2	5
	Variety	Grand Nain variety	2	17	5
	Retail	Sustainable returns to grow the right size Cluster pre-packs Singles at Starbucks etc Same wholesale price for large and exlarge	31		2