Horticulture Innovation Australia

Final Report

Project Extension: Carton Management in the Banana Industry

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Kitchener Partners

Project Number: BA13019

BA13019

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CONTENTS

1. TABLE OF FIGURES 4

2. EXECUTIVE SUMMARY 6

3. TECHNICAL SUMMARY 7

4. PROJECT OBJECTIVES 8
4.1. Confidentiality and Conflict of Interest 9
4.2. Contact Details 9

5. PROJECT OUTPUTS 10

6. PROJECT BACKGROUND 10
6.1. Current Industry Status 11
6.2. Opportunity Assessment 11

7. METHODOLOGY 14
7.1. Project Reference Group 14
7.2. Stakeholder Engagement 14
7.3. 8-Per-Layer And 6-Per-Layer Cartons 15
7.4. Defintions of Fruit Damage 16
7.5. Overview of Current Research And Findings 16
7.5.1. Types of Fruit Damage 16
7.5.2. Liners and Bags 17
7.5.3. Fruit Cooling 17
7.5.4. Differences Between 1-Piece And 2-Piece Carton 18
7.6. Key Variables Influencing Carton Performance 19
7.7. Development of Minimum and Optimum Specifications 21
7.7.1. Scope Extension To Include Supply Chain Trials 22
7.7.2. Selection Process For Trial Variables 22
7.7.3. Final Selection Of Variables 24
7.7.4. Trial Methodology, Approach And Timelines 25
7.7.5. Data Analysis 26

8. RESULTS AND DISCUSSION 29
8.1. Carton Specifications 29
8.1.1. Carton Board Grade 30
8.1.2. Centre Post For Side-Wall Support 30
8.1.3. Interlocking Lugs 32
8.1.4. Carton Ventilation 32
8.1.5. Carton Construction Specification for 13kg Cartons (1-Piece) 34
8.1.6. Carton Construction Specification for 13kg Cartons (2-Piece) 35
8.1.7. Carton Construction Specification for 15kg Cartons (1-Piece) 36
8.1.8. Carton Construction Specification for 15kg Cartons (2-Piece) 37
8.1.9. External Dimensions 38
8.1.10. Internal Dimensions 38
8.1.11. Maximum Tray Weights 38
8.1.12. Pack Compression 38
8.1.13. Side-Wall Deformation 39
8.1.14. Lid Tightness 39
8.1.15. Base Sag 39
8.1.16. Optimal Ventilation for Cooling / Ripening. 40
8.2. Specification For Secondary Packaging And Packing Methodology 40

8.2.1. Differences Between Minimum and Optimum Specification 43
8.3. Results Of Supply Chain Trials 44
8.3.1. Secondary Packaging: 1-Piece 44
8.3.2. Packing Methodology: 1-Piece 49
8.3.3. Secondary Packaging: 2-Piece 53
8.3.4. Packing Methodology: 2-Piece 56
8.4. Pack Weight: 13kg Or 15kg 56
8.5. Benefits of 15kg 1-piece versus 13kg 2-piece 56
8.6. Implementation and Cost-Benefit Analysis 57
8.6.1. Packing Cost For Different Carton Configurations 57
8.6.2. Indicative Carton Costs 63
8.6.3. Cost-Benefit Analysis 65

9. RECOMMENDATION 67
9.1. Key Success Factors For The 15kg 1-Piece 67
9.2. Other Considerations And Potential Benefits 68
9.2.1. Re-Use Of Secondary Packaging For Delivery To Retailer DCs 68
9.2.2. Date Coding Cartons 69

10. BEST-PRACTICE GUIDELINES 70
10.1. Growers 70
10.1.1. Carton Management 72
10.2. Hauliers and Wholesalers 73
10.3. Ripeners 73
10.4. Retailers 74

11. COMMUNICATION AND EXTENSION 76
11.1. Additional Opportunities 77
11.1.1. Minimize time in DC Arrival Area 77
11.1.2. Forklift Pallet Protector Attachment 77
11.1.3. DC Repalletised Pallet Wrapping 77
11.1.4. Back Of Store Storage 78
11.1.5. Hauliers 79

12. CONCLUSION 80

13. REFERENCES 82

1. TABLE OF FIGURES

Figure 1: Key stakeholders within the banana supply chain 11
Figure 2: Annual banana waste cost-benefit analysis 12
Figure 3: List of stakeholders that were engaged during the project 15
Figure 4: Summary of key types of banana quality issues 16
Figure 5: Key differences between 1-piece and 2-piece cartons 18
Figure 6: Banana inspection record sheet 27
Figure 7: Visual defect chart with grading scale (adapted from Eckman, 2011) 28
Figure 8: Prototype banana carton used at the beginning of the trials 30
Figure 9: Example of carton with internal centre-post 31
Figure 10: Internal centre post at 62.5% (left) and 75% (right) of original size 31
Figure 11: Example of cross-stacking cartons with interlocking lugs 32
Figure 12: Example of uneven ripeness of fruit within the same carton 33
Figure 13: 4-way ventilation in the 1-piece carton *Figure 14: Diagram of end-to-end carton ventilation (as illustrated with 2-piece carton)* 33
Figure 15: Carton construction specification for 13kg 1-piece cartons 34
Figure 16: Carton construction specification for 13kg 2-piece cartons 35
Figure 17: Carton construction specification for 15kg 1-piece cartons 36
Figure 18: Carton construction specification for 15kg 2-piece cartons 37
Figure 19: Ideal base sag (straight pallet) 40
Figure 20: Hard board grade leading to an unstable pallet 40
Figure 21: Example of base-sag in carton after arrival at wholesale market (note white base of cartons being lifted off pallet with mechanical picker) 40
Figure 22: 1-piece secondary packaging and packing methodology specification developed and refined during the trials 43
Figure 23: Example of pallet with corner posts 45
Figure 24: Plastic poly-strapping *Figure 25: Stretch tape (for machine application)* 45
Figure 26: Example of pallet locking sheet 46
Figure 27: Examples of pallet caps to protect against fruit chilling (held in place with machine applied stretch-tape) 46
Figure 28: Interlocking lugs enables cross-stacking of cartons 47
Figure 29: Example of slitted bag 48
Figure 30: Example of plastic slip-sheet inserted between fruit rows 48
Figure 31: Example of sap paper applied between fruit rows 49
Figure 32: Packing methodology for 1-piece cartons 50
Figure 33: Example of second fruit row packed with the crown-end towards the flower-end of the bottom row 50
Figure 34: Example of bag-twisting packing technique to ensure fruit is held securely 51
Figure 35: Example of bag-liner packing technique 51
Figure 36: Example of fruit protruding above top of carton (which will settle in transit) 52
Figure 37: 2-piece carton specification (13kg and 15kg) 54
Figure 38: Benefits of a 1-piece carton over a 2-piece carton 57

Figure 39: Estimated packing cost for 15kg 1-piece carton, minimum and optimum recommended specification (including all labour and materials, excluding GST) 59
Figure 40: Estimated packing cost for 15kg 2-piece carton, minimum and optimum recommended specification (including all labour and materials, excluding GST) 60
Figure 41: Estimated packing cost for 13kg 2-piece, for typical current practices (including all labour and materials, excluding GST) 61
Figure 42: Summary of costing for all packing configurations 62
Figure 43: Comparison of packing costs for 15kg 1-piece and 15kg 2-piece carton configurations 63
Figure 44: Summary comparison of packing costs for different packing configurations 63
Figure 45: Indicative 2-piece carton costs (from Project BA13015, data from late 2013) 64
Figure 46: Cartons cost for 13kg and 15kg, and 1-piece and 2-piece cartons on a per kg basis 64
Figure 47: Price comparison between 13kg and 15kg carton (per kg fruit) 65
Figure 48: Use of a bag rather than a liner to avoid excessive fruit dehydration and friction (leading transit-rub and carton-rub) 71
Figure 49: Best-practice use of sap paper to preventing fruit staining 71
Figure 50: Packing fruit tightly and sealing doen the plastic bag helps prevent transit rub ... 71
Figure 51: Examples of memory tape and carton lugs to provide pallet stability 72
Figure 52: Recommended carton holding timings by supply chain stage 72
Figure 53: Examples of packaging used around pallets to provide additional support during transit 73
Figure 54: Fruit should only be handled by the crown 74
Figure 55: Bananas stacked on top of each other *Figure 56: Preferred retail shelf display* 74
Figure 57: Cling wrap used in retailer DCs to secure pallets 75
Figure 58: Damage to pallets that can be caused if a forklift 'pallet protector' is not used 77
Figure 59: Pallet with non-venting stretch wrap *Figure 60: Banana with signs of ventilation issues* 78
Figure 61: Storage with limited ventilation *Figure 62: Preferred option for greater ventilation* 78
Figure 63: *Temperature sensitive carton label used by UK retailers to prevent chilling injury* 79

2. EXECUTIVE SUMMARY

This project is an extension of Project BA13015, Scoping Study To Develop A Standardised Industry Banana Carton. Within this report specific recommendations have been made in regard to the banana carton configurations currently in use in Australia, with particular focus on carton construction, secondary packaging and the packing methodology, supported by detailed specifications and best-practice guidelines for the key stages within the banana supply chain. The intended output from this project is to support an increase in banana sales through improved fruit presentation on the retail shelf, and a reduction in fruit quality defects and therefore waste, whilst maximising cost efficiencies through the banana supply chain as a whole.

As the project progressed, it became apparent that the wide range of variables that affected carton performance and ultimately the quality of fruit received by retailers, needed to be tested and validated. It was agreed that engagement with the major retailers would be beneficial in testing core assumptions, through the use of their supply chains from growers through to retail stores, and trials were conducted with ALDI Stores. This enabled the relative importance of the key variables affecting carton performance and fruit quality to be better understood, and definitively prove which combinations of carton type, secondary packaging and packing methodology were most effective. It was also important to consider these factors collectively due to their high level of interdependancy.

Where possible specifications have been broken down into minimum and optimum components to allow supply chain stakeholders to select the specifications that are most appropriate for their business model, and understand which aspects are most relevant. The four main carton configurations currently used in the Australian market were assessed, namely the 13kg 2-piece carton, 15kg 2-piece carton, 13kg 1-piece carton and 15kg 1-piece carton, with the aim to identify the most cost effective configuration. The project confirmed that the 15kg 1-piece carton was the most cost effective means for transporting bananas whilst minimising fruit damage.

It is estimated that fruit waste at retail stores can be reduced from the current levels of 5-8% down to 2-5%. If waste can be reduced by 2.5%, then this presents industry with a potential annual saving of $22.79m based upon FY2014-15 Nielsen data, and the opportunity for this volume of fruit to transfer into additional retail sales.

Every part of the supply chain from growers through to retailers have an important role to play, and the project has compiled best-practice guidelines for each supply chain stage detailing the key aspects that can influence fruit quality.

3. TECHNICAL SUMMARY

Average waste across Australian retailers is approximately 5-8% of total volume sold, at a retail value between $45.57 million and $72.91 million per year. This is significantly higher than other international markets such as the UK and USA where waste is approximately 1.5-2% of sales. Through implementing the findings included within this report, it is estimated that fruit waste at retail stores could be reduced by 2.5%, equating to a saving of $55.35 per pallet, which can be transferred into retail sales, whilst also improving consumer satisfaction. This presents industry with a potential annual saving of $22.79m based upon FY2014-15 Nielsen data, and the opportunity for this volume of fruit to transfer into additional retail sales.

This project is an extension of Project BA13015, and has made specific recommendations in regard to the carton construction, secondary packaging and the packing methodology, supported by detailed specifications. Due to the delicate nature of bananas and the need to ripen fruit, there is a compromise needed between minimising the quantity of packaging for protecting fruit against physical damage whilst in transit, and optimising ventilation for evenness of ripening.

The four main carton configurations currently used in the Australian market were assessed, namely the 13kg 2-piece carton, 15kg 2-piece carton, 13kg 1-piece carton and 15kg 1-piece carton. The project developed specifications for each configuration and identified the 15kg 1-piece carton as the most cost effective means for transporting bananas, whilst minimising fruit damage, as long as the following conditions were met:

- The appropriate carton is used in terms of materials and construction (as specified in this report), with particular focus upon sidewall strength, moisture resistance and ability to be cross-stacked;
- The appropriate amount and type of secondary packaging is used, including corner posts, pallet strapping, slitted bags and sap paper;
- The appropriate packing methodology is employed, ensuring fruit is packed tightly to avoid rub marking and extra-large fruit in packed in the bottom row and placed on its side; and
- The ripening process is closely monitored and a minimum 6-day ripening cycle is used, with adequate venting post-ripening to ensure pulp temperatures are reduced to 13-15 degrees.

The carton itself, along with the secondary packaging and packing methodology have been considered holistically due to their interdependencies, and it is important that the specifications are implemented in their entirety, rather than in isolation. The recommendations have focused upon reducing rub marking that is common in the top carton layers on the pallet due to fruit ‘trampolining’ and not being firmly secured, and also compression bruising and neck damage that is common in the lower carton layers due to the physical weight from the cartons above. Close consideration of ventilation has been included due to the larger mass of fruit in the 15kg carton that can lead to higher respiration rates and the fact that fruit is packed more tightly which can reduce air circulation leading to higher temperatures and potentially over-ripe fruit.

Finally, it is important to stress that every part of the supply chain from growers through to retailers have an important part to play, and the project has compiled best-practice guidelines for each supply chain stage detailing the key aspects that can influence fruit quality.

4. PROJECT OBJECTIVES

The project objectives were in line with the proposal submitted and accepted by Horticulture Innovation Australia Ltd (Hort Australia) dated 28th February 2014. The proposal encompassed the implementation of practices that will improve the quality of fruit reaching the retailers' shelves, with the premise being that if the quality across the whole industry can be improved, then consumers are likely to respond favourably and demand for bananas should increase.

The activities included within this project consisted of two parts, broken down as follows:

- Minimum Specifications

  To identify and develop a minimum packing, secondary packaging and carton specifications for each of the four carton configurations namely 13kg 2-piece carton, 15kg 2-piece carton, 13kg 1-piece carton and 15kg 1-piece carton, to ensure fruit arrives at retailers in the best possible condition. The premise was to ensure all growers, retailers and other supply chain stakeholders, are aware of the need to utilise the appropriate type, quantity and combination of packaging and create awareness about the benefits of doing so. This will enable change to occur immediately and with minimal cost; and

- Best-Practice Guidelines

  To identify and develop optimum best-practice packing guidelines for each stage of the banana supply chain, from growers through to retailrers for the main carton configurations.

The focus of the project was weighted towards the delivery of minimum specifications, rather than the development of best-practice guidelines, since this presented the greatest potential benefits to industry. This is reflected in the structure of the report, and for ease of reading, the best-practive guidelines has been included in a separate section at the end of the report.

Providing specfications and best-practice guidelines for all packing combinations will allow growers to pack any carton configuration in line with requests from their retailer customers. Post the completion of the project, communication to growers will be facilitated through the National Extension Project (DEEDI QLD), as advised by the Hort Innovation Project Manager and the project refererence group; it should be noted that no communciation or extension activities have been included within the scope or budget of this project. Communication to industry will be important to ensure growers are aware of the need to utilise the appropriate type, quantity and combination of packaging and create awareness about the benefits of doing so. This will enable change to occur immediately and with minimal cost.

Furthermore, given the complexity and general reticence within the supply chain as a whole to use Returnable Plastic Crates (RPCs), it was agreed that RPCs should not be prioritised in the first instance and therefore have not been included within the scope of this project. However, it is important to note that learning in regard to 1-piece cartons, be it 13kg or 15kg, will have common principles that can be applied to RPCs. Nevertheless, when the time is right, RPCs should still be progressed, albeit more slowly and with caution, supported by rigorous analysis and assessment.

As detailed in the project proposal, key criteria have been met, including:

- *Output focus*: a focus upon practical implementation and NOT simply a situational analysis or an industry review;
- *Methodology*: a robust and detailed methodology;
- *Experience*: Suitably qualified and experienced team members that have a good understanding of the banana industry and supply chain (including both the major and independent retailers) in Australia, and proven experience in the relevant functional sectors, ideally including international experience;
- *Communication*: planning for appropriate communication to all stakeholders and interested parties; and
- *Progress Reports:* provision of progress reports and a Final Report (this report) upon completion of project.

Furthermore, it was important for there to be transparent alignment between all members of the banana supply chain, and particularly the major grocery retailers, to ensure the requirements of all parties are met and therefore maximise the chance for successful implementation of the project recommendations. Fully understanding the needs and current supply chain practices, particularly of the major grocery retailers, were critical to ensure the project recommendations were commercially relevant and could be readily applied, and close support and involvement was maintained throughout the project with key supply chain stakeholders. To enable this to occur the key skills required by the project team were:

- Commercial credibility and a thorough understanding of horticulture in Australia, and more specifically the banana industry;
- A comprehensive understanding of the supply chain for bananas; both the direct supply to the major retailers and the central markets that supply the independent retailers;
- A strong network of relationships within the banana industry; particularly within the supply chain and the major retailers; and
- A solid understanding of the banana industry from the growers' perspective.

4.1. Confidentiality and Conflict of Interest

Given the sensitivities around confidentiality, particularly by the retailers, and the desire of supply chain stakeholders to ensure impartiality, in order to alleviate all concerns, the Project Leader personally controlled all sensitive and confidential information. The Project Team view that there is no personal conflict of interest in relation to this study.

4.2. Contact Details

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5. PROJECT OUTPUTS

This project aims to make a meaningful difference to the banana industry through improving the quality of fruit available across all retailers in Australia, with a particular focus on the major retailers, namely ALDI, Coles, IGA and Woolworths. To ensure maximum impact, the project focused upon implementation and did not simply provide a situational analysis or industry review, and has expanded and developed upon the information and analysis completed in Project BA13015, Developing A Standard Industry Banana Carton.

The outputs delivered by this project include minimum and optimum specifications for use by the whole Banana Industry in Australia, as well as best-practice guidelines for the key supply chain stages. If these outputs are implemented, it will lead to an improvement in the quality of fruit in retail stores and an increase in consumer satisfaction, and in turn will increase demand. Furthermore, improving the management and supply chain practices currently in place, will in turn support a higher level of performance of the banana industry over the next 1-5 years.

6. PROJECT BACKGROUND

All the major retailers in Australia assert that they fail to receive consistently good quality fruit and largely attribute this to failings in the carton configurations currently being used. Given the highly concentrated retail market in Australia, and the fact that it is essentially the retailers that provide access to the end consumer, it is critical to partner with the major retailers in order to improve customer satisfaction and increase sales of bananas.

This means any solution proposed by industry must be aligned to the needs of the major retailers and take into consideration their supply chain requirements, and the major retailers are highly receptive to change and eager to partner with industry to improve the packaging configurations currently used to transport bananas. Currently it is only the premium and most capable independent retailers that are able to cherry-pick small volumes from the very best growers who have manageable waste levels, albeit they still expend additional resources in handling and sorting fruit on arrival at their stores.

Project BA13015 provided insight into the wide range of variables that can affect carton performance and therefore the quality of bananas received by retailers. This project also demonstrated the complexity in regard to the trade-offs and interdependencies between variables, and the importance to adopt a holistic approach that considers the entire supply chain from growers through to retailers. This view is supported by current literature, for example Eckman (2011) commented that significant differences in damage incidence and severity were found between different types of cartons, however, it was difficult to isolate variables and accurately attribute a particular quality defect with a specific carton type.

The danger in any project is that one can be distracted early on by the detail, the politics and the history of past attempts to solve the same ongoing issues. This creates a temptation to dive into solutions and tactics before clearly articulating, understanding and measuring the causal factors and therefore the relative attractiveness of different opportunities. Whilst past and current attempts to develop different carton configurations have been useful for generating learning, it was important to use this information with caution due to the commercial bias, mainly as a result of the existing sunk costs of the parties involved. The initial focus of Project BA13015 was to recommend a standard industry carton, be it 1-piece or 2-piece and 13kg or 15kg, however, the project actually recommended that it is better to implement practices that will improve quality first and

foremost, and in the immediate term *not* pursue a standard industry banana carton; if quality across the whole industry can be improved, then consumers are likely to respond favourably and demand for bananas should increase. Project BA13019 (this project) is the extension of Project BA13015.

6.1. Current Industry Status

Currently the banana industry is largely reliant on a 13kg 2-piece carton consisting of a separate base and lid, however, over the last 3-5 years greater interest has arisen in regard to a 1-piece, particularly as a 15kg carton. Project BA13015 identified significant quality and supply chain benefits in using an alternative 15kg 1-piece carton, including a reduction in waste, better on-shelf-availability, lower transport costs and an improved customer offering. This finding was important, since it demonstrated the strategic benefits in comparing the extremes of current packing configurations within Project BA13019 (see methodology).

There are a diverse range of variables that affect carton performance, and ultimately the quality of fruit arriving at stores. The key variables are:

1. *Carton Attributes*: including carton design, construction materials, laminates/glues, ventilation (for removing heat post-ripening as quickly as possible, and avoiding the need for 'air-stacking' in the back-room of stores);
2. *Secondary Packaging*: including the supporting packaging that is used in conjunction with the carton, particularly pallet strapping, pallet corner posts, bags, liners, sap paper etc.; and
3. *Fruit Packing Methodology*: including the packing configuration of the fruit within the carton, consisting of three layers of fruit of different lengths, protected by the appropriate secondary packaging.

It must be stressed that these variables are all mutually dependent upon one another and must be considered holistically. Furthermore, it is also important to note that Australia has a unique supply chain for bananas that is different to the larger and perhaps more mature supply chains that service the European and American markets. The past practices in Australia have largely been built upon legacy issues driven by practices that suit suppliers and growers, often with little supporting evidence or scientific rigour, and little consideration of the consumer. To this end, the trial has also leveraged global best-practice and worked closely with Fyffes Bananas UK that supplies 50% of the UK banana volume. Below is a diagram of the typical retailer banana supply chain in Australia.

Figure 1: Key stakeholders within the banana supply chain

6.2. Opportunity Assessment

One of the biggest drivers for instigating Project BA13015 actually arose from the major retailers. During this project the major retailers and independents were consulted in order to access data to enable waste (also know as shrink) to be assessed. The majority of retailers did not accurately measure waste at store level and a better gauge was to in fact calculate the 'discrepancy' or difference between the volumes of fruit out-loaded from distribution

centres versus the volume of fruit sold on an annualised basis. The difference between these two figures is a combination of:

1. *Waste*: fruit that is disposed of since it is unsaleable and offers no cost-recovery opportunity;
2. *Markdowns*: fruit that may be slightly marked but is still saleable but at a reduced price, although it should be noted that retailers have different policies in regard to markdowns (the majors often do not markdown product whilst independents will generally bag and sell marked fruit);
3. *Dehydration*: moisture loss from fruit whilst in transit or on display (this is likely to be minimal in comparison to points 1 or 2 and will be compensated by the over-pack; growers will over-fill cartons slightly in order to ensure the minimum net weight is met); and
4. *Theft*: fruit that is stolen from stores by customers (which is likely to be a relatively small contribution in the case of bananas since they are bulky and generally relatively low value).

Of these components of discrepancy, waste is by far the single biggest constituent for the banana category followed by markdowns, whilst dehydration and theft are likely to be negligible, and to all extents can be ignored as causal factors in the context of this project. Project BA13015 estimated that average waste across Australian retailers is approximately 5-8% of total volume sold, and based upon FY2013-14 and FY2014-15 figures, the current waste in the banana industry is likely to be between $45.57 million and $72.91 million per year, assuming:

- Average banana crop of 28.5 million cartons (average FY2013-14 and FY14-15);
- Average carton weight of 13kg net; and
- Average retail price of $2.46/kg (MAT 30th September 2015, Neilson Home Scan).

It is difficult to accurately quantify the amount of waste being caused by the current banana carton, albeit the majority of stakeholders attributed the single biggest cause as the carton and associated supply chain factors. Similarly other major international retailers have significantly lower waste at approximately 1.5-2% of sales. It can be conservatively estimated that an improved carton used in conjunction with best-practice packing, handling and transport could easily reduce waste by 2.5% (to between 2.5-5.5%), equating to a saving of $22.79 million per year. Furthermore, it could also be assumed that this loss could potentially be translated into sales generating extra industry revenue of $22.79 million per year, whilst also increasing consumer satisfaction and loyalty to the banana category.

No of Cartons/Yr	Av Retail Price/KG	Weight per Carton	Waste (min)	Waste (max)	Annual Waste Value Min ($)	Annual Waste Value Max ($)	Forecast Waste (min)	Annual Forecast Sales Increase ($)
28,500,000	2.46	13	5%	8%	$ 45,571,500	$72,914,400	2.5%	$ 22,785,750

Figure 2: Annual banana waste cost-benefit analysis

It should also be noted that the majority of 'discrepancy' consists of waste, yet retailers will also incur cost in removing and disposing of this waste (consisting of a labour component and the cost of physical disposal and dumping). Similarly, there is a significant labour cost to bag and markdown fruit and these costs would be reduced if quality were improved.

In summary:

- There are a huge number of variables and interdependencies that can affect carton performance and thus fruit quality; for example, a weaker carton can be compensated through using better taping, pallet sheets, bagging and packing methodology;
- It is difficult to attribute a weighting to all the different variables in regard to its influence on carton performance since there is such a large number of variables, that are all mutually interdependent;
- Many variables have not been definitively proved or disproved in regard to their influence on carton performance; and
- Some individuals and/or businesses have made significant investment in developing their own intellectual property and are undestandably reluctant to share the information with a wider audience that may include their competitors.

It should be noted that within the last 12-18 months, to varying extents, growers, wholesalers, suppliers and retailers have all increased their activity in trialing and assessing the performance of different cartons. Some are conducting trials in isolation and others in collaboration with supply chain partners, and this activity demonstrates that there is widespread dissatisfaction with the current solutions and that there is a strong appetite to improve the status quo. Hopefully this project will help to consolidate this activity and drive further collaboration within the supply chain to achieve swift change and wider adoption across the banana industry as a whole, and thus raise the bar in regard to quality of fruit reaching the retail shelf in general.

7. METHODOLOGY

In order for the outcomes of this project to be implemented and therefore deemed a success, there must be transparent alignment between all members of the banana supply chain, particularly in regard to the major grocery retailers. The needs of industry and supply chain stakeholders were identified and developed through one-on-one consultations and interviews as necessary, including input from international markets and particularly the UK, which has many similarities with the Australian market.

7.1. Project Reference Group

In order to provide ongoing guidance and helping steer the direction of the project, a Project Reference Group (PRG) was formed. Key members of the banana supply chain were invited to be part of the PRG (detailed below), and this provided an efficient means to rapidly collate information and experiences in regard to the banana carton, and help identify any pitfalls that could pose a risk to the project. It also helped to steer the strategic direction of the project. Engagement with the PRG members was largely on an individual basis, relative to individual sector expertise, but when necessary conference calls were also held. The PRG members were:

- Doug Philips, ABGC Chair;
- Chaise Pensini, Oakville Produce;
- Stewart Lindsay, QLD DAFF;
- Cameron Mackay, Mackay Bananas;
- David Chenu, Hort Innovation; and
- David Weisz and then Elisa King, Hort Innovation (Project Manager).

7.2. Stakeholder Engagement

The PRG confirmed the stakeholders within the banana supply chain that should be consulted, and relationships that were developed during Project BA13015 were leveraged; these individuals were knowledgable and experienced and able to provide opinions on behalf of all members for their specific stage of the supply chain. These stakeholders were used to help understand the concerns and needs in relation to the current banana cartons, secondary packaging and processes in use, capturing both positive and negative aspects, as well as recommendations for any improvements or considerations for potential solutions. The list of individuals and businesses consulted are listed below:

BUSINESS	NAME	POSITION
Project Reference Group		
Horticulture Innovation Australia Ltd	David Chenu	Gerneral Manager, Marketing
Horticulture Innovation Australia Ltd	David Weisz & Elisa King	Marketing Manager, Bananas
ABGC	Robet Mayers	R&D Sub-Committee Member
ABGC	Doug Philips	Chairman
ABGC	Cameron Mackay	R&D Sub-Committee Member
ABGC	Stuart Lindsay	R&D Sub-Committee Member
Growers		
Tropicana	Wayne McCarthy	Grower
Johnstone River Produce	Doug Philips	Owner
Merryport	Linda Davies	Owner
Camuglia Farms	Tony Camuglia	Owner
Camuglia Farms	Charles Camuglia	Owner
Mackay's Banana Marketing	Cameron Mackay	Owner
Transport Companies		
Blenners Transport	Les Blennerhassett	Owner
Lindsay Transport	Various staff	General Manager
Wholesalers		
Oakville Produce	Chaise Pensini	National Banana Category Manager
Archella	Harry Theoharous	General Manager, Bananas
PW Chews	Greg Bradshaw	Owner
Ripeners		
Archella	Rosa Archella	General Manager, Bananas
Harris Farms	David Vella	General Manager
Distribution Centres		
ALDI Stores	Phillip Kayrouz	QC Manager
Harris Farms	David Vella	Sydney Markets
Retailers		
ALDI Stores	Steven Hastings	Purchasing Director
ALDI Stores	Sarah McIntosh	Purchasing Director
Gumtree Good Food	Ray Mak	Owner
Fruits on Coventry	South Melbourne Markets	Owner
Packaging Companies		
Orora Fibre Packaging	Joe Stacey	New Product Development Manager
Orora Fibre Packaging	Andrew Russo	Regional Sales Manager QLD/NT
Orora Fibre Packaging	George Ganzenmuller	Innovation Manager
Visy Boxes and More N QLD	Barry Campagnolo	Regional Sales Manager QLD
Researchers		
Agri-Science Queensland, DAFF	Stuart Lindsay	Senior Development Horticulturist
Agri-Science Queensland, DAFF	Naomi King	Development Horticulturist
International Retailers and Suppliers		
Fyffes Bananas (UK)	John Clarke	National Account Manager
Fyffes Bananas (UK)	Mark Basinger	Operations Manager
Fyffes Bananas (UK)	Andrew Deham-Smith	Commercial Director

Figure 3: List of stakeholders that were engaged during the project

7.3. 8-Per-Layer And 6-Per-Layer Cartons

As detailed in Project BA13015, according to carton data supplied by the major carton manufacturers, growers on an annual basis use approximately 25 million cartons. Of this total approximately 22.70 million cartons (90.78%) are supplied as 6-per-layer cartons and 2.3 million cartons (9.23%) as 8-per-layer cartons. Lady Finger growers and those not supplying the major retailers mainly use the 8-per-layer cartons, and at least one major

retailer does not accept 8-per-layer cartons since the automatic pallet pickers within their DCs cannot handle them. For these reasons, and as agreed within the original project proposal, the 8-per-layer carton has been excluded from this study and consideration only given to the 6-per-layer carton.

7.4. Defintions of Fruit Damage

To ensure consistency in understanding, the types or damage that can occur to fruit have been classified in line with past reports and based upon current understanding and interpretation within the industry. Whilst not definitive the key types of damage are:

Key Issues	Defect Definition
Carton Rub *(see defect chart)*	Marks caused by the friction between the skin of the banana and the carton
Transport Rub *(see defect chart)*	Scuffing or rub marks between clusters and individual fingers, often showing as dark bown skin marking caused by fingers within a hand rubbing against each other during transport (underlying flesh is unaffected)
Compression Bruising *(see defect chart)*	Softened flesh, generally underlying a discoloured area on the skin
Neck Injury *(see defect chart)*	Black marking around all or part of the neck
Sap Burn	Dark staining on fruit skin
Chilling Injury	Grey skin or under-peel discolouration
Incorrect Ripening	Blotchy appeareance or green inside with external sugar spots
Other Defects	Cuts, splits and rots (neck or blossom end)

Figure 4: Summary of key types of banana quality issues

7.5. Overview of Current Research And Findings

As detailed in project BA13015, feedback to date from the major retailers has indicated a range of issues with the industry cartons being used currently, namely around damaged fruit arriving at stores, which is creating waste (shrink), requiring handling and sorting by store staff, creating a missed sales opportunity and ultimately dissatisfying consumers.

In order to achieve alignment and consensus, including the identification and articulation of the specific issues, a review of past research was conducted and the findings from Project BA13015 were built upon. Key researchers that have completed previous studies were also consulted as required, such as Stewart Lyndsay and Naomi King at Agri-Science QLD DAFF. This helped provide a list of key variables that influence carton performance and affect fruit quality, which was then validated with stakeholders, adjusted accordingly and tested through supply chain trials. As mentioned in Project BA13015, by way of background the key insights from existing reports are detailed below, and grouped by main variables for ease of reference.

7.5.1. Types of Fruit Damage

Eckman (2011) observed 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. A strong trend was evident for large fruit (oversize) being bruised or superficially marked compared to smaller (medium to large) fruit, however, considerable differences in sample numbers per category meant that results were not significant. 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 (1 or 2-piece). Pre-packed fruit was the best quality, the packaging presumably helping to protect smaller fruit from rubs and bruising'.

Eckman (2011) also observed that rub marking was the most common damage, and neck injury frequently the most severe damage. Her report confirmed that bruising, rub marking and neck injuries were all major issues, and decreased retail quality leading to reduced prices that consumers were willing to pay for bananas. Interestingly, approximately 6% of fruit had chilling injury, which most likely occurred after harvest.

Importantly, Eckman (2011) noted that bananas loaded on the top layers of pallets suffered significantly greater fruit rub than those in the centre of the pallet, which suffered virtually none. She also noted that the differences between the 1-piece and 2-piece cartons were minimal.

7.5.2. Liners and Bags

Eckman (2011) noted that packing bananas into bags rather than a slip-sheet with 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. This was consistent with feedback from wholesalers and retailers, and also from Fyffes Bananas in the UK.

While carton type had less effect on abrasion damage during transport overall than the other factors examined, there appeared to be an interaction between carton type and liner. Bananas in the 2-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 1-piece cartons, differences between the internal packing methods were less obvious. It should be noted that care should be taken due to the relatively low numbers of fruit evaluated and considerable differences between individual cartons.

7.5.3. Fruit Cooling

Eckman (2011) noted that flesh temperatures were generally lower for bananas in 1-piece cartons compared to those in 2-piece cartons, most likely due to better ventilation in this carton type. It also appeared that temperatures inside 2-piece cartons tended to rise slightly during low temperature storage, whereas those in 1-piece cartons remained constant. In regard to speed of cooling, the report also noted that bananas in 1-piece cartons cooled more quickly than those in 2-piece cartons and stayed cooler, on average, during transport and ripening.

Eckman (2011) also noted that the average flesh temperature of bananas in bags was effectively the same as those in lined cartons suggesting that bags have little effect on internal temperatures; in other words, packing bananas into bags instead of with a slip-sheet and liner did not appear to increase flesh temperatures during transport and ripening. 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). Although Eckman (2011) did not investigate the interaction between carton type and bag ventilation, it was thought that differences in temperature control between perforated and slitted bags were likely to be relatively slight, especially when compared to factors such as total vent area on the carton.

In addition to the above points, Eckman (2011) also highlighted that significant damage can occur to bananas, even during short supply chains, especially if they are not loaded securely on the delivery truck. Also the increase in damage once bananas are placed on retail display was significant; whilst customer handling is somewhat unavoidable, ensuring ease of unpacking cartons and merchandising by store staff is certainly important to minimise fruit damage.

7.5.4. Differences Between 1-Piece And 2-Piece Carton

Project BA13015 identified the main pros and cons in using a 1-piece or 2-piece carton, which are displayed below. It should be noted that this assessment has been based upon typical industry practices that are currently in place.

	1-Piece Carton		2-Piece Carton	
Variable	**Pros**	**Cons**	**Pros**	**Cons**
Cost		$0.20-30 premium; NB The extra cost for 1-piece cartons could be a reflection of the dominance of 2-piece cartons and sunk cost in production infrastructure. Should more growers request 1-piece cartons it is likely the costs will come down	No price premium	
Lid Application	Labour saving as no carton lid is required			Labour cost for lid to be applied
Ventilation	Better ventilation allows more uniform ripening and better temperature management within the supply chain	During winter may be increased likelihood of chill damage if pallets are not handled appropriately	Better able to handle external temperature variations	
Pallet Fill	Can pack with 15kg and achieve greater pallet weight of 900kg (60 cartons in 10 layers)			Lower pallet weight of 858kg (66 cartons in 11 layers)
Pallet Pickers	Straighter and stronger cartons sides facilitate Pallet Pickers	Lugs need to be tapered to ensure they can still be handled by Pallet Pickers		More variable carton strength and greater likelihood of minor compression bruising when lifted with pallet pickers
Manual Handling/ OH&S		Need to 'lift and place' in order for lugs to align rather than slide cartons, could lead to OH&S issues	Easier to stack as cartons will slide; less OH&S issues	
Glueing	No glue required			Glue required
Picking in DC		Harder to cross-stack with other products when being 'picked' in the DC; consideration should be given to a 1-piece with foldable flaps along the long edge of carton to allow cross-stacking	Easier to cross-stack with other products when being 'picked' in the DC	
Ripening	Straighter sided cartons and no cross-stacking allow the use of new generation ripening facilities, providing more uniform ripening and a lower cost of ripening			Often carton sides are bowed which disrupts air-flow and can lead to inconsistent ripening; limited opportunity to use tarpless ripeners
Store handling	Less reliance for air-stacking by retail store staff due to better ventilation			Need to air-stack at store to slow continued ripening of fruit
Store Merchandising		Fruit displayed in the carton crown downwards, requiring handling of hands to display on shelves (resulting in more skin marking)	Fruit displayed in the carton crown upwards, facilitating display on shelves (resulting in less handling and skin marking)	
Stacking	No cross-stacking results in less damage due to mid-layer compression on cross-stacked carton layer			Cross-stacked layer is often damaged by compression from cartons above

Figure 5: Key differences between 1-piece and 2-piece cartons

Since 1-piece cartons are less insulated and have greater air-flow, there is a greater risk of chilling injury, and Eckman (2011) recorded 6% of deliveries with chilling damage. Eckman (2011) also noted that 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. However, the increased ventilation of the 1-piece avoids the reliance on store staff to air-stack pallets in the back of store, which is beneficial for the major retailers that can sometimes struggle with store compliance. The shelf-life benefit from increase ventilation is likely to be approximately 0.5 days, and perhaps slightly more in stores located in locations with higher ambient temperatures.

An added complication for the major retailers is in regard to the pick cycle within the DC. Since bananas are a high volume line, they are often used to construct the base of the pallet and other products then stacked on top. With the 1-piece, the pick cycle needs to be altered to ensure other products are not stacked upon on the carton causing damage to fruit. However, since 1-piece 6-per-layer cartons are used for many other products such as stonefruit, mangoes and truss tomatoes, it is clearly possible for these changes to be made but ideally the 1-piece should have a lip on the top of the carton or supporting mechanisms such as lugs to enable cross-stacking of cartons (similar to the avocado carton).

7.6. Key Variables Influencing Carton Performance

Project BA13015 listed the following key variables than could influence carton performance:

- Packing method;
- Carton liner (slitted bag, perforated bag, slipsheet);
- Carton footprint (6-per-layer versus 8-per-layer);
- Carton type (1-piece versus 2-piece);
- Carton weight (13kg versus 15kg net weight);
- Stacking configuration (column-stacked versus cross-stacked);
- Pallet stabilization material (stretch tape, corner posts or string);
- Pallet stabilization method (around sides of pallet or around side *and* top of pallet with downward pressure on top layers);
- Pallet stabilization application method (hand strapped or machine strapped);
- Carton layer stabilization type (glue versus no-glue);
- Carton layer stabilization glue type (wood glue versus other types);
- Carton location on the pallet (top, center 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; and
- Seasonality (wet versus dry season, primarily for FNQ).

The project team used this list to identify and agree the variables for inclusion within the specifications. Certain variables were excluded since they were too far removed from the area of infuence within the project scope, for example packers skill, weather conditions

during growing or fruit size and condition (the effects of fertilizer and irrigation on fruit softness and shelf-life).

Project BA13015 identified a number of knowledge gaps that were felt to exert a significant influence on carton performance and banana quality, and were worthy of further investigation. Whilst some of the points listed had been considered to varying degrees within other reports, engagement with the supply chain demonstrated that many were not clearly understood or opinion was divided. The knowledge gaps formed a key component of assessments that were completed and validated in this project, and included:

- *Corner Posts*: Assess if there is a need for corner posts for long-distance freights and/or at certain times of the year and/or in combination with certain carton types (such as column stacked 2-piece cartons with no cross-stacking);
- *Pallet Strapping Material*: Benchmark the performance and cost-benefit of different pallet strapping materials;
- *Strapping Configuration*: Investigate other strapping alternatives that can extend over the top of the pallet to provide downward force;
- *Strapping Application Method:* Quantify the cost-benefit of hand versus machine applied and the benefit that machine strapping provides in terms of positioning around the pallet and tensioning;
- *Pallet Sheets*: Understand the performance and cost-benefit of pallet sheets versus other forms of supporting packaging;
- *Pallet Caps*: Assess the incidence of chill damage on the top carton layers and any benefit that a pallet cap provides, including pallet stability;
- *Carton Taping*: Understand the benefit of lid taping to reduce rub marking;
- *Bag and Liner Material*: Understand the performance and benefits of different bag plastics;
- *Fruit Size*: The retailers are willing to engage in further dialogue around fruit size. There is a need to compile consumer driven evidence around fruit size preference, supported by the potential improvement to fruit quality and supply chain efficiency that could be achieved through packing mixed-size cartons, such as the 'International Pack', consisting of smaller fruit on the bottom layer and larger fruit on the top layer;
- *Bag Closure:* Investigate the best method to seal bags as tightly as possible to provide stability whilst not over-compressing fruit and causing other issues that adversely affect fruit quality;
- *Glue Application*:
    - Identify and specify the minimum number of carton layers that require glue application;
    - Specify the optimum type and amount of adhesive to be used and optimum method of application; and
    - Confirm the benefit if a single spot application versus several application areas across the carton surface.
- *Pallet Stacking Configuration*: Assess the cost-benefit of cross-stacking in terms of pallet stability and ripening consistency;

- *Board Material (virgin or craft versus recycled card)*: Define optimum specification and tolerances for recycled verses craft content;
- *Board Grade Thickness*: Identify the optimum board thickness in relation to cost-benefit, and agree a minimum specification
- *Lid Type ('pop-up' lid versus glued/ taped)*: Understand the strength properties of taped versus glued lids;
- *Lid Tightness:* Agree a minimum specification for lid tightness;
- *Carton Height*: Identify the optimum height carton in conjunction with other variables;
- *Carton Coatings*: Understand moisture absorbency in relation to carton strength of different board materials during the wet and dry seasons, and also the quality, appropriateness and cost-benefit implications of using laminated card;
- *Carton Holding Times*: Agree a minimum specification for holding empty cartons, including type of storage area and season (wet or dry);
- *Temperature Receival at DCs*: Advise DC of the appropriate holding temperature for bananas (considered to be 13-15 degrees);
- *Pallet Tape in DCs*: Introduce protocols for handling pallet tape within DCs to ensure fork lifts are not hindered by tape wrapping around wheels;
- *Carton Stacking*: Engage with retailers to help them accommodate 1-piece cartons; and
- *Fruit Holding in Stores*: Engage with retailers to communicate the cost-benefit of installing warm-rooms in all stores; influence store renewal teams to include warm-rooms as a standard and encourage retailers to provide stores with temperature sensitive tray-end labels (or equivalent).

Whilst each criteria listed above could form the basis a specific project in its own right, which is clearly beyond the scope of this project, it was important to better understand the influence that these variables exert on carton performance and therefore fruit quality, as well as their respective interdependencies. The interdependencies add a huge level of complexity, which make detailed cost-benefit assessments difficult, but are an important consideration for developing specifications to improve fruit quality.

7.7. Development of Minimum and Optimum Specifications

Project BA13015 identified the variables associated with cartons and RPCs that can affect fruit quality from a packaging perspective, broken down by supply chain stage and activity, and also the many interdependencies that can affect carton performance.

The use of correct internal packaging practices is critical in the successful delivery of bananas to the end customer. Due to the nature of the product and the further requirement to ripen fruit before being sold through the supply chain, there is a compromise needed between minimising cost through the quantity and quality of packaging used, whilst also protecting fruit against physical damage; in addition ventilation has to be optimised to ensure evenness of ripening. Therefore, the use of suitable secondary packaging in conjunction with carton performance is a key dependency in order to deliver bananas to retail stores in the best possible condition for sale.

In addition, it is important to adopt a holistic approach, whereby all the interdependencies that can infuence carton performance throughout the supply chain from grower through to

retailer, including packing and packaging systems and processes, must be considered. This will ensure the suitability of any solutions or recommendations, and ensure that the specifications produced are applied and commercially practical.

The following section details the methodology for the development of the minimum and optimum carton, secondary packaging and packing methodology specifications for each of the four carton configurations.

7.7.1. Scope Extension To Include Supply Chain Trials

When this project was first proposed, the scope was agreed to only include collation and analysis of current industry practices and thinking, and no trials or testing of cartons, secondary packaging or packing methodology would be conducted in order to minimise the project cost. Much of initial analysis was conducted by engaging and interviewing key stakeholders within the banana supply chain, however, it quickly became apparent that 'legacy issues' and past history were a significant barrier in being able to accurately identify the most appropriate solutions; essentially there was often little alignment in the opinions of industry experts and therefore it was very difficult to confidently be able to make accurate recommendations. In many instances, variables had not been tested and comparisons had not been completed or not completed objectively. This was raised with the Project Reference Group, and it was agreed that engagement with the retailers would be beneficial, and in fact critical, in testing core assumptions, through the use of their supply chains from growers through to retail stores.

7.7.1.1. Retailer Selection For Trials

ALDI, Coles and Woolworths were approached, and ALDI confirmed their interest in supporting trials using their exisiting grower base and supply chain. ALDI acknowledged that information would be made available to industry and that the cost of trials would be covered by ALDI. The additional advantage of working with ALDI was that their supply chain was relatively simple in comparison to Coles and Woolworths due to their region-based distribution centres (DCs), and therefore, the assessment, collection and integrity of data would be easier and more accurate. Essentially, a single state could be assessed using two different DCs, one as test and the other as a control.

7.7.1.2. Carton Manufacturer Selection For Trials

In order to conduct the trials with a retailer, different sample cartons needed to be manufactured and supplied to the trial growers, in addition to the required secondary packaging. Furthermore, on-farm support was required to ensure growers understood how the cartons were different and to assist in developing the most appropriate packing methodology. Orora Fibre Products, and Joe Stacey in particular, provided this support and supplied growers with trial cartons at a price equivalent to the cost of their current cartons in order to ensure that the growers taking part in the trial were not financially disadvantaged or biased in any way.

7.7.2. Selection Process For Trial Variables

Certain variables are already well documented in regard to their influence upon carton performance and fruit quality, although no previous study has weighted the relative importance of different variables as detailed in the previous sections. The purpose of the

trial was to better understand the variables that were more contentious and had conflicting opinions from key supply chain stakeholders in regard to their relative importance.

In order to determine which variables should be tested within the trial, it was important to consider each variable in the context of the criteria listed below:

- The amount of information that is currently known and understood in regard to the key variables, and therefore the relative need to gather more data in order to make a more informed decision; and
- The degree of interdependencies between variables, both in terms of the carton construction and form, and also in conjunction with secondary packaging and the packing methodology.

Key supply chain stakeholders assessed the shortlist of variables. This process essentially involved developing draft minimum and optimum specifications for both the carton, secondary packing and packing methodology used for each of the four carton configurations, and validating these with key supply chain stakeholders, whilst removing any bias and anecdotal information or opinion. Findings and revised recommendations were then again validated with stakeholders until a definitive list of variables were identified and agreed upon.

7.7.2.1. Learning From International Markets

Project BA13015 primarily investigated the domestic market, however consideration was also given to learning from other international markets, particularly the UK, in regard to gaining a better understand of best-practice. It is important to note that the UK and USA markets have shorter supply chains than the Australian market, yet use more packaging to protect fruit to ensure it arrives at retail stores in the best possible condition. The benefits of these practices and resulting return on investment are perhaps best illustrated by the fact that banana waste and markdown at retail level in the UK is approximately 1.5-2% as opposed to 5-8% in Australia.

A comparison was made with established practices utilised internationally and in particular Fyffes Bananas in the UK. Since the project leader was in the UK, a meeting was held with Fyffes Bananas with senior commercial representatives at their headoffice and ripening centre in Basingstoke, UK. As detailed in Project BA13015, the UK market value is approximately £880 million per year (AUS$1.61 billion), and Fyffes currently supply and ripen almost 50% of this volume. Fyffes are the leading banana business in the UK, supplying fruit to all the major retailers, and ripen and sell approximately 230,000 cartons of 18.14kg per week.

Findings from these markets were included in developing the base assumptions in regard to selecting the variables that were considered of greatest importance in influencing banana quality. In general there is siginificantly more packaging used for protecting green fruit in the UK market than Australia, namely:

- No cardboard is in direct contact with fruit since it can lead to fruit dehydration (and make the skin more susceptable to marking);
- Plastic liners and paper slipsheets between *all* fruit layers (in loose *and* pre-packs, even though all flower-ends have been removed which are a main source of rub marking);

- There is less concern over high humidity conditions within the bags (in fact it is encouraged);
- Pallets and cartons are straight with no excessive leaning or damage to survive mechanical handling (breaking down and building pallets with automated machinery);
- Cartons have minimal side bulge to force air-flow through the cartons rather than around the sides to ensure even fruit ripening and venting (removing of heat post-ripening);
- Corner posts are used on all green fruit pallet loads;
- Corner posts are cut or snapped when pallets are split into half-pallets at ripening centers, so that the pallet is still supported with corner posts whilst within the packhouse and during delivery to the retailer DCs.
- Up to nine individuals plastic straps are used for a ten carton layer pallet for green fruit;
- Carton inventory is tightly managed to ensure they are used quickly to prevent weakening in the humid conditions;
- No glue is used between 2-piece carton layers; and
- Non-specialist hauliers are used to transport fruit.

A prototype carton was presented to Fyffes and feedback provided, which helped validate and direct the assumptions of the project team. This meeting was held at no additional cost to the project.

7.7.3. Final Selection Of Variables

The recommendations for the construction of the carton, in regard to materials and structure, was predominantly conducted with the major carton manufacturers, namely Orora Fibre Products and Visy, given their extensive expertise in this area. Manufacturers were encouraged to adopt a holistic approach, whereby consideration was given to the carton *in conjunction* with the secondary packaging and packing methodology; in other words, some de-engineering or simplification of the carton is possible if the appropriate type and quantity of secondary packaging is used in combination, since the desired performance is not solely reliant on the carton but also the secondary packaging. The 1-piece 15kg carton was selected as the configuration for assessment (as detailed in section 7.7.5).

The final variables that were agreed for inclusion within the trial are listed below.

7.7.3.1. Carton Attributes:

- Strengthened carton side-walls using internal centre posts mid-way along the long side to provide structural support (this was to enable cross-stacking of cartons at the DC, and ensure better air-flow for more uniform ripening);
- Increase ventilation to remove heat post-ripening and improve fruit condition in the back-room of stores (bananas should be held at 13-15^{0}C, yet fruit temperature in some stores can be considerable higher, potentially compromising shelf-life and increasing waste); and

- Laminates and glues to increase carton strength and reduce carton weight in order to maximise the pallet load (of up to 1,000kg/pallet), yet allow some 'base-sag' to avoid 'trampolining' in transit, which can lead to rub marking.

7.7.3.2. Secondary Packaging:

- Corner posts for ensuring pallet stability (corner posts are used in the majority of other countries, excluding Australia);
- Stretchable 'memory tape' around pallets that can flex and absorb energy whilst in transit to reduce compression bruising and rub marking;
- Pallet locking sheets located in the middle of the pallet to provide structural support and improve pallet stability;
- Cardboard caps over the top of the pallet to prevent chilling injury on the top layer of fruit;
- Slitted bags that can open and 'vent' as heat is built up; and
- Sap paper in sufficient quantities and applied correctly in order to absorb fruit sap, especially when sap-flow is high.

7.7.3.3. Packing Methodology

- Side-lying the bottom layer of extra-large fruit to prevent neck damage and reduce the fruit height in the carton to facilitate carton 'settling';
- Alternating the three fruit layer with crown-to-tip end packing;
- Twisting or taping the top two layers of cartons to prevent 'trampolining'; and
- Cross-stacking the top layer of cartons to provide additional pallet stability.

7.7.4. Trial Methodology, Approach And Timelines

A clear process for the trial was proposed and agreed with Purchasing Director for Prestons ALDI region, Steven Hastings, who is also responsible for the ALDI banana strategy. It was important to ensure the methodology took into consideration current practices within the ALDI supply chain, particularly in regard to the DCs and stores. Also to maximise the integrity of the data, it was important to minimise any variables or changes within the supply chain throughout the duration of the trial.

The trial included the two main banana suppliers to ALDI in NSW, supplied by 6-8 growers from Far North Queensland. The key growers and packers were visited in Innisfail and Tully on the 19th-20th March 2015, to ensure they understood the input that they were required to provide, and understand the key variables that were being assessed. In addition, a 'packing specification' was provided to all growers to help them better understand the required standard, and ensure compliance to the agreed specification. This was important to ensure the integrity of the trial data.

The trial was initially planned to run for a total of 8 weeks, commencing on the 6th April 2015. Since there were challenges in ensuring growers continued to pack fruit in line with the agreed packing specifications, the trial was extended for a further 8 weeks. This also enabled additional variables to be tested, and greater insights to be gathered.

7.7.5. Data Analysis

The ideal trial would involve testing the four carton configurations simultaneously with the same supply chain conditions. However, not only was this deemed impractical and overly complex, but the most accurate data collection set was at a regional (DC) level. In other words, if a single trial DC covering approximately 70 stores was transitioned to a single packing configuration for an extended period of time, this would enable the change in sales value, sales volume and waste to be monitored from before the trial started. At the same time, a similar DC was left unchanged and used as a control. This enabled the following data sets to be analysed and compared:

- Trial DC verses Control DC during the trial;
- Trial DC verses Trial DC compared year-on-year; and
- Control DC verses Control DC compared year-on-year

Given only one packing configuration could be tested, since the 13kg 2-piece carton is the most established configuration within the market place currently, it was decided that testing the direct opposite, namely the 15kg 1-piece carton would generate the most valuable data and insights. This was also the most preferred carton configuration, as recommended in Project BA13015.

The 1-piece 15kg configuration, was supplied exclusively into Prestons DC (NSW), whilst the Minchinbury DC (NSW) was the control and supplied predominantly with the 2-piece 13kg configuration (it was not possible to ensure that only this configuration was supplied to Minchinbury DC at all times due to existing business arrangements between ALDI and suppliers, and the impact on data was considered to be minimal).

Orora Fibre Products developed prototype cartons in line with the project team's recommendation, and supplied the required secondary packaging to an agreed specification. Growers were then trained in the new packing methodology, and asked to investigate alternative packing practices that could improve upon the suggested methodology. During the trial period all loads were inspected by the ADLI QC team in the ALDI distribution centre using an inspection record sheet developed by the project team (displayed below), together with a visual defect chart with grading scale (adapted from Eckman, 2011).

		ASSESSMENT INFORMATION					
	Assessment Number:	1	2	3	4	5	6
	Date:						
	Load Number:						
	Grower Name:						
	Assessor Name:						
Carton Quality	**AMBIENT (AIR) TEMP** Temperature in degrees						
	CARTON HEIGHT Measure 4 cartons and list min and max measurements						
	CARTON WEIGHT Measure 4 cartons and list min and max measurements						
	CARTON CONDITION 0 (good) - 4 (poor)						
	NEATNESS OF PALLET 0 (good) - 4 (poor)						
	EASE OF DE-STACKING PALLET 0 (easy) - 4 (hard)						
Fruit Quality	**RIPENESS** Colour Stage 2-7 (see defect chart)						
	PULP TEMPERATURE Temperature in degrees						
	NECK INJURY 0 - 4 (see defect chart)						
	COMPRESSION BRUISING 0 - 4 (see defect chart)						
	TRANSPORT RUB 0 - 4 (see defect chart)						
	CARTON RUB 0 - 4 (see defect chart)						
	OTHER DEFECTS E.g. chilling, sap burn, incorrect ripening, cuts/spilts						
	OVERALL QUALITY ASSESSMENT 0 - 4 (see defect chart and please also add comments)						

Figure 6: Banana inspection record sheet

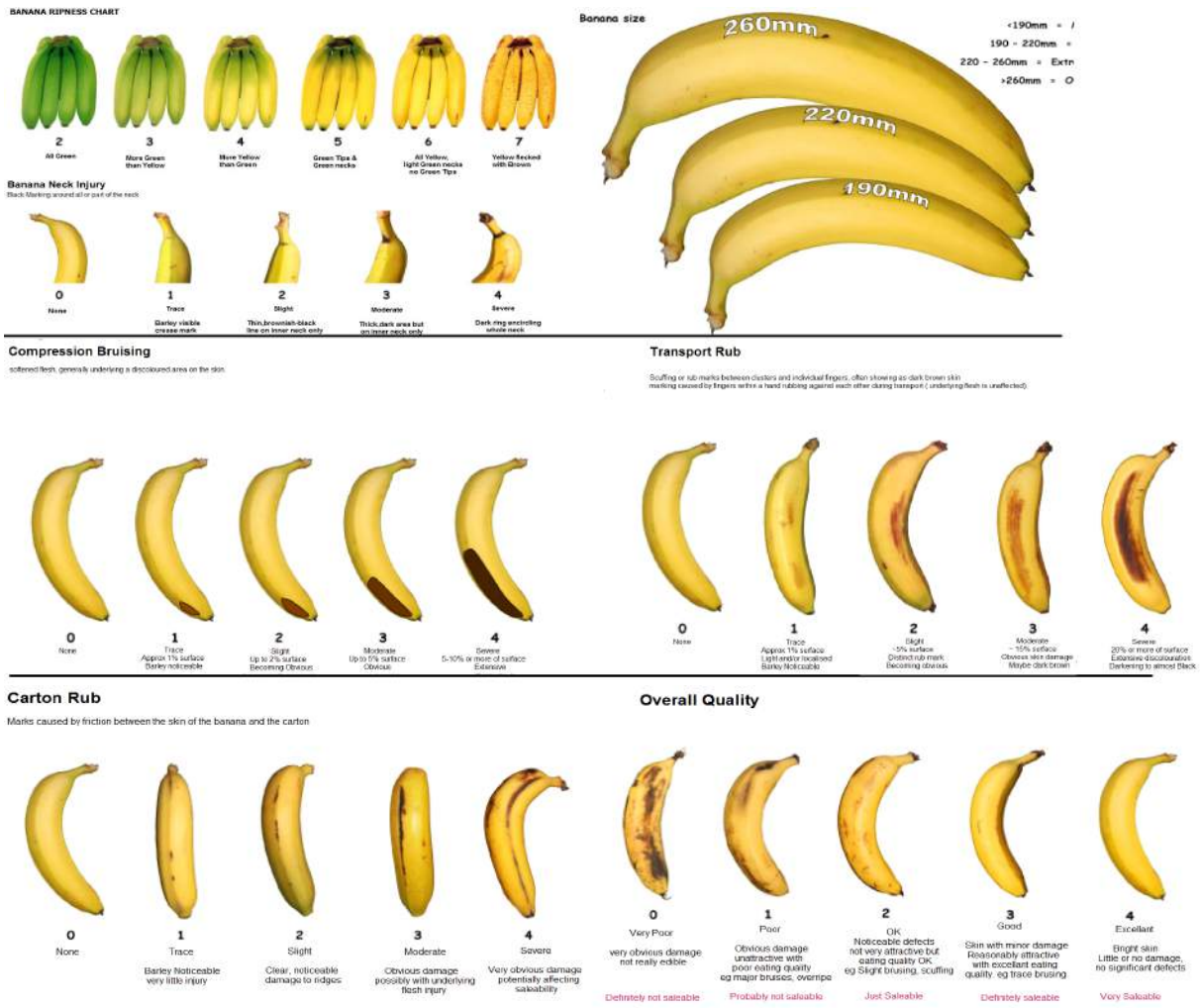

Figure 7: Visual defect chart with grading scale (adapted from Eckman, 2011)

In addition to the ALDI DC inspections by ALDI quality control staff, on a weekly basis Orora Fibre Products and/or the project team inspected deliveries in the Sydney markets (before and after ripening), key ALDI stores and the ALDI distribution centre. ALDI were hugely supportive and provided full access to their complete supply chain through to the back of stores. Cartons were inspected from the top, middle and bottom of randomly selected pallets for carton and secondary packaging integrity, and also for fruit quality, particularly fruit compression and rub marking.

Whilst every effort was made at the start of the trial to accurately identify and validate the key variables to assess, additional variables came to light that were not previously considered relevant. These were immediately included within the trial where possible.

8. RESULTS AND DISCUSSION

The objective of Project BA13019 was to develop minimum and optimum specifications taking into consideration carton construction and form, secondary packaging and packing methodology. Consideration was given to the main carton packing configurations, namely 13kg 2-piece carton, 15kg 2-piece carton, 13kg 1-piece carton and 15kg 1-piece carton.

When developing the trial specifications for the carton and secondary packaging, the recommendations identified in Project BA13015 were validated and built upon in order to select the appropriate combination of variables. The cost-benefit lay at the heart of all decisions in selecting which variables should be included, and which were deemed excessive in regard to the benefit generated relative to its cost.

After selecting the carton and second packaging variables it was important to give consideration to the packing methodology. The risk was that the benefits generated (and cost incurred) through using the packing options selected, would be negated or reduced in benefit if the trial growers did not adopt the correct packing methodologies. Whilst some basic packing practices were described in Project BA13015, particularly in regard to the correct use of internal packaging, it was important to work with growers to jointly identify the optimum methodology for extracting the full benefit from the trial deliveries. This was felt to be the best means for ensuring the successful delivery of fruit to the end consumer.

8.1. Carton Specifications

There were a large number of variables that had to be understood and measured along the supply chain, and changing the long established packing practices of growers took time. There was a ‘chicken and egg’ situation when it came to deciding if the carton construction and form, or the secondary packaging with packing methodology should be considered first. In reality, there was more accurate and proven information available in regard to the variables associated with carton construction and form, and therefore it was deemed appropriate to make some base assumptions regarding the carton and in the first instance focus upon the secondary packaging with packing methodology.

Therefore a carton was developed that was deemed appropriate based upon current understanding and information, in consideration with the preferred secondary packing needs. It was agreed that the carton should be moderately over-engineered to allow the secondary packaging and packing methodology variables to be isolated, tested and fully understood, with the view that the carton could then be de-engineered when it came to commercialisation if necessary (see below). As the trials progressed it became apparent that changes needed to be made to the carton, and these adjustments were generally made within a 2-week timeline, and reassessed in the trial.

Essentially the carton is a compromise between many competing variables, and almost every variable has trade-off implications. The carton must also take into account the need for the pallet stack height and weight, in order to fit within transport regulations and transit constraints, and it ultimately falls to the grower to ensure they maintain the ‘chain of responsibility’.

Figure 8: Prototype banana carton used at the beginning of the trials

Most criteria related to the carton design are detailed and explained within the carton specifications, however, the following points were contentious and therefore require further explanation. These are detailed below.

8.1.1. Carton Board Grade

The technical and product development experts at Orora Fiber Packaging were engaged to help develop the appropriate carton for use in the trial. The carton materials trialed included a Xitex flute-wrap containing hydro-shield papers on both sides consisting of recycled mediums, as well as an outer wrap of a C-flute semi-chem. The Xitex provides greater compression strength and also greater wet strength over the semi-chem medium, which allowed the carton to retain its strength longer through periods of high humidity and during the ripening process.

It was also important to be mindful of the weight of the carton, since the increased packed weight of 15kg carton could create potential worker handling issues. Therefore consideration was given to the use of lighter weight and higher strength materials using improved design construction (six posts) and hydro-shield papers. The trial carton was approximately 250 grams lighter than the other alternative 2-piece lidded cartons, which equated to 15kg per pallet or 360kg per 24-pallet trailer load. This is important when considering 'chain of responsibility' for ensuring the pallet weight is not above the Federal government legislated transport weights.

8.1.2. Centre Post For Side-Wall Support

Internal triangular corner posts mid-way along the long side of the carton were used to provide structural support for the carton stacked above to prevent it telescoping or collapsing into the carton below, whilst also enabling cartons to be cross-stacked. The 'centre posts' were triangular in shape and this provided the greatest amount of structural strength from an engineering perspective and proved highly effective in preventing sidewall deformation, as illustrated below.

Figure 9: Example of carton with internal centre-post

Early prototypes resulted in rub marking on bananas due to the posts digging into fruit and growers felt it also slowed down packing since it was tight to pack 15kg in the carton. Initial reactions were that the carton height should be raised, but this would have increased the risk of rub marking due to fruit not being help firmly and 'trampolining'. The final solution was a combination of reducing the size of the centre post and developing a packing methodology whereby clusters or even fingers were placed either side of the centre post. The only outstanding issue was packers complaining about scratching their wrist on the carton edges as fruit was placed into the carton. Packers generally developed solutions to minimise this by protecting the inside of their arms.

The initial corner post measured 50mm wide and extended 45mm into the carton, and further prototypes at 75% and 50% of this size were made and tested. Packers felt no restriction with the 50% center post, the clusters of bananas packed out straighter and lower than the 100%. The 75% was easier to pack but the bananas were packing higher in the carton. Side wall bulge greatly reduced going to 75%, and this balanced with the need for the support of the larger center post; in other words the greater the sidewall bulge the greater the size of the center post required and it can start to become a self defeating exercise.

Throughout the trials the importance of the center posts was evident with the appearance of the pallet neatness and reduction of neck damage and compression bruising compared to lidded cartons. The center posts allowed for the removal of the locating lugs on the sidewalls of the carton, which removed the DC and back of store handling issues associated with the lugged carton (pickers found it difficult to separate cartons since cartons needed to be lifted vertically before sliding, raising the risk of manual handling injuries). With the reduction of the sidewall bulge it allowed the size of the center posts to be reduced, whilst still allowing the center posts to support the carton above. The optimum between providing maximum support whilst also minimizing sidewall bulge, was between the 75% and 50%, and a center post size of 62.5% (60mm wide and extending 30mm into the carton) was trialed and proved to be successful.

Figure 10: Internal centre post at 62.5% (left) and 75% (right) of original size

8.1.3. Interlocking Lugs

Interlocking lugs are important to ensure cartons are properly aligned and pallet sides are straight as possible. This helps to achieve a more even ripening and adequate ventilation and/or cooling to remove heat. Whilst corners are a big factor in creating straight-sided pallets, the impact of lugs should not be underestimated.

The shape of the lugs is also important. Since many DCs are transitioning to automated machinery for de-palletising, and considering the need for good OH&S practices, using tapered rather than straight-sided lugs helps cartons to be de-stacked and stacked. Tapering also reduces the chance of lugs getting compressed or misaligned and helps the carton above locate into the correct position, thereby providing the maximum support possible. This is an important consideration, since pallets will often be appear unstable immediately after packing as fruit is sitting 25-35mm proud of the carton top. However, whist in transit fruit will settle and the cartons will locate into each other to form straight-sided pallets.

Figure 11: Example of cross-stacking cartons with interlocking lugs

8.1.4. Carton Ventilation

There is an array of information available in regard to carton ventilation. Respiration rates of bananas are high, and this can quickly lead to fruit getting warmer, which accelerates the release of ethylene, and fruit ripening, creating a positive feedback loop. Good ventilation is important at all stages of the life cycle of the packaged bananas, including pre-cooling once first packed, during transportation, during ripening and whilst being stored in the backroom of stores. At the same time over-ventilation, particularly in low humidity environments, can cause the bananas to dehydrate.

It is important for cartons to have ‘top-flow’ as well as vertical ventilation airflow to maximise forced air ventilation with minimal impact on tray performance**.** This includes end-to-end carton ventilation at >10% plus lateral ventilation, which is important post-ripening and for back of store temperature management. Furthermore, the greater the carton weight the greater the likelihood of accelerated heating and therefore adequate ventilation and cooling is critical; in other words, a 15kg carton will more prone to accelerated heating and over-ripe fruit than a 13kg carton that holds less fruit. For this reason it is even more important to ensure adequate ventilation with the 15kg carton.

The result of inadequate ventilation can be uneven ripeness of fruit (it is worth noting that over-ripe fruit is the single biggest cause of waste for the major retailers). At its worst, poor ventilation and ripening can lead to fruit splitting and being unsaleable, and at best shelf-life will be reduced.

Figure 12: Example of uneven ripeness of fruit within the same carton

The advantage of the 1-piece carton is that it has 4-way ventilation (as illustrated below), which allows heat to rise and escape through each side wall panel, and vent upwards through the stacked cartons. This is made easier by the fact there is no carton lid. Slitted bag liners further facilitate this process and are preferable to liners bags with holes.

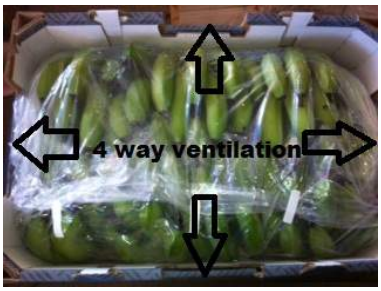

Figure 13: 4-way ventilation in the 1-piece carton

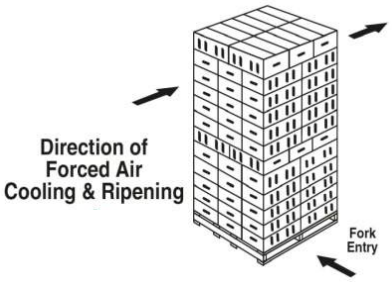

Figure 14: Diagram of end-to-end carton ventilation (as illustrated with 2-piece carton)

In essence, it is vital to ensure there is more rather than less ventilation, and an advantage of using thicker board material, good construction design, glues and laminates, is that the carton is stronger and this allows more ventilation holes to be cut into the carton without compromising strength. This is particularly important for 15kg cartons where respirations rates are higher and internal temperatures can quickly rise, leading to over-ripe fruit. Since hot air rises, holes were predominantly is the upper 30% of the carton to maximise venting.

The criteria listed above were considered important in terms of ensuring carton performance, and have been reflected in the final carton specifications where possible. Certain elements, such as internal centre posts, have not been specified within the carton specification but instead a tolerance has been provided for the issue it is trying to solve, in this case sidewall deformation. This also reflects the fact that different packaging companies will most likely have different solutions and tactics to fix the same issue.

The recommended specifications for the 1-piece and 2-piece cartons, for both 13kg and 15kg are displayed below. Within the specifications, comments have been included to provide context and explain the rational for deciding the upper and lower limits, and allow the specifications to be used as stand-alone documents. Further explanation is provided after the specifications regarding the factors that were considered most important.

8.1.5. Carton Construction Specification for 13kg Cartons (1-Piece)

		1-Piece		
Number	**Item**	**Lower Limit**	**Uper Limit**	***Comments***
1	**External Dimensions**	575mm x 380mm x 170mm (LxWxH)		*The critical external dimensions are the width and length, as these will dictate how well the carton fits onto the pallet; too big and cartons will overhang the pallet leading to impact damage, and too small will lead to the pallet swaying whilst in transit and also poor ripening since air will escape around the sides of the pallet instead of passing directly through the cartons. The external length and width dimensions must be designed to fill the Australian Standard Net Unit Load Size (NULS) of 1152mm x 1152mm to maximise practical pallet utilisation and minimise space/movement between carton stacks and pallets*
2	**Internal Dimensions (Height)**	165mm	175mm	*The critical internal dimension is the height, which must allow for 10-20mm headspace post-ripening. It is important to note that excessive internal height will lead to possible fruit bounce (transit rub) whereas insufficient internal height will lead to neck damage and compression bruising. The internal dimensions for width and length can vary depending on the wall thickness of the carton (e.g. some cartons have a double sided wall), however, typical length is 550 mm and width of 365 mm*
3	**Maximum Pack Weight**	750 grams (dry weight)		*Tray must have minimum 13.5kg net weight of bananas to allow for weight loss through the supply chain. Please check with your individual transport company for permitted gross pallet weight*
4	**External Material Water Absorptiveness (AS1301 Cobb Value)**	Use of treated papers on outside liner of the tray and high quality paper on the inside liner to protect the strength of the board from moisture uptake and damage (AS1301.411s Cobb Test Value <60gsm/30mins for the treated outside liner and <150gsm/30mins for the inside liner)		
5	**External Material Burst Strength (AS1301 Burst Value)**	>500kPa		
6	**ISO Pack Compression**	> 15,000N (18,000N Aim)		*Need complete stack compression strength (Nil load share with the fruit)*
7	**ISO Stack Compression (Two trays together)**	>12,000N		*With positive location features to prevent premature telescope failure (trays falling into each other)*
8	**Side Wall Deformation**	Side wall deformation under load of 14,000N to be less than 5mm		*Minimal side wall deformation/bulge is important in order to maintain airflow through the carton during forced ripening rather than allowing air to pass around the carton. Excessive side wall deformation will lead to neck damage and compression bruising*
9	**Base Sag (when stacked)**	10-20mm		*Some base sag/up-flex is needed to accommodate over packing of fruit, but excessive sag can escalate telescope failure of trays due to base deformation*
10	**Ventilation**	8%	12%	*Featuring standard mid-panel as well as top flow ventilation to allow warm air to rise and escape, and vertical vents in base also assist with removing hot spots within pack*
11	**Lid Tightness**	n/a		
12	**Interlocking Lugs**	Corner location features and recesses that allow for rows to be cross-stacked		*Cross-stacking selected rows provides additional pallet stability. To enable this to occur, lugs should be tappered to allow mechanical stacking/de-stacking in DCs*

Figure 15: Carton construction specification for 13kg 1-piece cartons

8.1.6. Carton Construction Specification for 13kg Cartons (2-Piece)

		2-Piece		
Number	**Item**	**Lower Limit**	**Uper Limit**	***Comments***
1	**External Dimensions**	575mm x 380mm x 170mm (LxWxH)		*The critical external dimensions are the width and length, as these will dictate how well the carton fits onto the pallet; too big and cartons will overhang the pallet leading to impact damage, and too small will lead to the pallet swaying whilst in transit and also poor ripening since air will escape around the sides of the pallet instead of passing directly through the cartons. The external length and width dimensions must be designed to fill the Australian Standard Net Unit Load Size (NULS) of 1152mm x 1152mm to maximise practical pallet utilisation and minimise space/movement between carton stacks and pallets*
2	**Internal Dimensions (Height)**	158mm	165mm	*The critical internal dimension is the height, which must allow for 10-20mm headspace post-ripening. It is important to note that excessive internal height will lead to possible fruit bounce (transit rub) whereas insufficient internal height will lead to neck damage and compression bruising. The internal dimensions for width and length can vary depending on the wall thickness of the carton (e.g. some cartons have a double sided wall), however, typical length is 550 mm and width of 365 mm*
3	**Maximum Pack Weight**	900grams (dry weight)		*Tray must have minimum 13.5kg net weight of bananas to allow for weight loss through the supply chain. Please check with your individual transport company for permitted gross pallet weight.*
4	**External Material Water Absorptiveness (AS1301 Cobb Value)**	Use of high quality papers on outside liner of the lid and both liners of the inner to protect the strength of the board from moisture uptake and damage (AS1301.411s Cobb Test Value <150gsm/30mins)		
5	**External Material Burst Strength (AS1301 Burst Value)**	>500kPa		
6	**ISO Pack Compression**	>10,000N		
7	**ISO Stack Compression (Two trays together)**	n/a		
8	**Side Wall Deformation**	Side wall deformation under load of 14,000N to be less than 5mm (see comment)		*Minimal side wall deformation/bulge is important in order to maintain airflow through the carton during forced ripening rather than allowing air to pass around the carton. Excessive side wall deformation will lead to neck damage and compression bruising. It is difficult to set a minimum specification for a 2-piece carton due to the variability in carton and lid inter-dependencies, and if deformation is an issue then additional secondary packaging such as strapping and memory tape can be used as an alternative to re-engineering the carton or lid, although not a comprehensive solution*
9	**Base Sag (when stacked)**	10-20mm		*Some base sag/up-flex is needed to accommodate over packing of fruit, but excessive sag can escalate telescope failure of trays due to base deformation*
10	**Ventilation**	8%	12%	*Featuring standard mid-panel as well as top flow ventilation to allow warm air to rise and escape, and vertical vents in base also assist with removing hot spots within pack*
11	**Lid Tightness**	Lid should require firm downward force to be applied on to base, and require base to be held in order to slide off the lid		*The lid should be as tight as possible without excessively compromising ability to place the lid over the base and thus slowing down packing*
12	**Interlocking Lugs**	n/a		

Figure 16: Carton construction specification for 13kg 2-piece cartons

8.1.7. Carton Construction Specification for 15kg Cartons (1-Piece)

		1-Piece		
Number	**Item**	**Lower Limit**	**Uper Limit**	***Comments***
1	**External Dimensions**	575mm x 380mm x 180mm (LxWxH)	575mm x 380mm x 182mm (LxWxH)	*The critical external dimensions are the width and length, as these will dictate how well the carton fits onto the pallet; too big and cartons will overhang the pallet leading to impact damage, and too small will lead to the pallet swaying whilst in transit and also poor ripening since air will escape around the sides of the pallet instead of passing directly through the cartons. The external length and width dimensions must be designed to fill the Australian Standard Net Unit Load Size (NULS) of 1152mm x 1152mm to maximise practical pallet utilisation and minimise space/movement between carton stacks and pallets*
2	**Internal Dimensions (Height)**	175mm	177mm	*The critical internal dimension is the height, which must allow for 10-20mm headspace post-ripening. It is important to note that excessive internal height will lead to possible fruit bounce (transit rub) whereas insufficient internal height will lead to neck damage and compression bruising. The internal dimensions for width and length can vary depending on the wall thickness of the carton (e.g. some cartons have a double sided wall), however, typical length is 550 mm and width of 365 mm*
3	**Maximum Tray Weight**	800 grams (dry weight)		*Tray must have minimum 15.5kg net weight of bananas to allow for weight loss through the supply chain. Please check with your individual transport company for permitted gross pallet weight.*
4	**External Material Water Absorptiveness (AS1301 Cobb Value)**	Use of treated papers on outside liner of the tray and high quality paper on the inside liner to protect the strength of the board from moisture uptake and damage (AS1301.411s Cobb Test Value <60gsm/30mins for the treated outside liner and <150gsm/30mins for the inside liner)		
5	**External Material Burst Strength (AS1301 Burst Value)**	>500kPa		
6	**ISO Pack Compression**	> 15,000N (18,000N Aim)		*Need complete stack compression strength (Nil load share with the fruit)*
7	**ISO Stack Compression (Two trays together)**	>12,000N		*With positive location features to prevent premature telescope failure (trays falling into each other)*
8	**Side Wall Deformation**	Side wall deformation under load of 14,000N to be less than 5mm		*Minimal side wall deformation/bulge is important in order to maintain airflow through the carton during forced ripening rather than allowing air to pass around the carton. Excessive side wall deformation will lead to neck damage and compression bruising*
9	**Base Sag (when stacked)**	10-20mm		*Some base sag/up-flex is needed to accommodate over packing of fruit, but excessive sag can escalate telescope failure of trays due to base deformation*
10	**Ventilation**	8%	12%	*Featuring standard mid-panel as well as top flow ventilation to allow warm air to rise and escape, and vertical vents in base also assist with removing hot spots within pack*
11	**Lid Tightness**	n/a		
12	**Interlocking Lugs**	Positive location features and recesses that allow for rows to be cross-stacked		*Cross-stacking selected rows provides additional pallet stability. To enable this to occur, lugs should be tapered to allow mechanical stacking/de-stacking in DCs*

Figure 17: Carton construction specification for 15kg 1-piece cartons

8.1.8. Carton Construction Specification for 15kg Cartons (2-Piece)

		2-Piece		
Number	**Item**	**Lower Limit**	**Uper Limit**	***Comments***
1	**External Dimensions**	575mm x 380mm x 185mm (LxWxH)	575mm x 380mm x 195mm (LxWxH)	*The critical external dimensions are the width and length, as these will dictate how well the carton fits onto the pallet; too big and cartons will overhang the pallet leading to impact damage, and too small will lead to the pallet swaying whilst in transit and also poor ripening since air will escape around the sides of the pallet instead of passing directly through the cartons. The external length and width dimensions must be designed to fill the Australian Standard Net Unit Load Size (NULS) of 1152mm x 1152mm to maximise practical pallet utilisation and minimise space/movement between carton stacks and pallets*
2	**Internal Dimensions (Height)**	175mm	185mm	*The critical internal dimension is the height, which must allow for 10-20mm headspace post-ripening. It is important to note that excessive internal height will lead to possible fruit bounce (transit rub) whereas insufficient internal height will lead to neck damage and compression bruising. The internal dimensions for width and length can vary depending on the wall thickness of the carton (e.g. some cartons have a double sided wall), however, typical length is 550 mm and width of 365 mm*
3	**Maximum Tray Weight**	1,000grams (dry weight)		*Tray must have minimum 15.5kg net weight of bananas to allow for weight loss through the supply chain. Please check with your individual transport company for permitted gross pallet weight.*
4	**External Material Water Absorptiveness (AS1301 Cobb Value)**	Use of high quality papers on outside liner of the lid and both liners of the inner to protect the strength of the board from moisture uptake and damage (AS1301.411s Cobb Test Value <150gsm/30mins)		
5	**External Material Burst Strength (AS1301 Burst Value)**	>500kPa		
6	**ISO Pack Compression**	>10,000N		
7	**ISO Stack Compression (Two trays together)**	n/a		
8	**Side Wall Deformation**	Side wall deformation under load of 14,000N to be less than 5mm (see comment)		*Minimal side wall deformation/bulge is important in order to maintain airflow through the carton during forced ripening rather than allowing air to pass around the carton. Excessive side wall deformation will lead to neck damage and compression bruising. It is difficult to set a minimum specification for a 2-piece carton due to the variability in carton and lid inter-dependencies, and if deformation is an issue then additional secondary packaging such as strapping and memory tape can be used as an alternative to re-engineering the carton or lid, although not a comprehensive solution*
9	**Base Sag (when stacked)**	10-20mm		*Some base sag/up-flex is needed to accommodate over packing of fruit, but excessive sag can escalate telescope failure of trays due to base deformation*
10	**Ventilation**	8%	12%	*Featuring standard mid-panel as well as top flow ventilation to allow warm air to rise and escape, and vertical vents in base also assist with removing hot spots within pack*
11	**Lid Tightness**	Lid should require firm downward force to be applied on to the base, and require the base to be held in order to slide off the lid		*The lid should be as tight as possible without excessively compromising ability to place the lid over the base and thus slowing down packing*
12	**Interlocking Lugs**	n/a		

Figure 18: Carton construction specification for 15kg 2-piece cartons

8.1.9. External Dimensions

The critical external dimensions are the width and length, as these will dictate how well the carton fits onto the pallet; too big and cartons will overhang the pallet leading to impact damage, and too small will lead to the pallet swaying whilst in transit and also poor ripening since air will escape around the sides of the pallet instead of passing directly through the cartons. The external length and width dimensions must be designed to fill the Australian Standard Net Unit Load Size (NULS) of 1152mm x 1152mm to maximise practical pallet utilisation and minimise space/movement between carton stacks and pallets.

8.1.10. Internal Dimensions

The critical internal dimension is the height, which must allow for 10-20mm headspace post-ripening. It is important to note that excessive internal height will lead to possible fruit bounce/'trampolining' (transit rub) whereas insufficient internal height will lead to neck damage and compression bruising. The internal dimensions for width and length can vary depending on the wall thickness of the carton (e.g. some cartons have a double sided wall).

This was perhaps one of the most contentious issues within the project. Growers would often provide feedback that cartons were packed too proud and pallets were unstable. The challenge was that growers did not necessarily witness the settling process and were keen to increase the internal height of the carton in order to ensure fruit sat level with the top of the carton, and also to speed up packing. Trials were completed with cartons with internal heights up to 182mm and there was significantly greater rub marking due to fruit not be held securely whilst in transit and 'trampolining', which confirms the need to ensure cartons are packed slightly proud and have some base-sage so that the carton above provides some downward force on the fruit below.

8.1.11. Maximum Tray Weights

Due to their larger size in order to hold more fruit, the 15kg cartons are heavier than the 13kg cartons, and the 2-piece cartons are heavier than 1-piece cartons since they consist of a base carton and also a lid.

To maximise freight efficiencies it is ideal for gross pallet weight to be at or just below the 1,000kg maximum legislative requirement, and ideally reach 66 trays/pallet for 13kg cartons and 60 trays/pallet for 15kg cartons. The gross pallet weight needs to also take into account the pallet weight of 20-40kg (depending on soft wood or hard wood pallets) and also the fruit over-pack (usually around 0.5kg/carton). This can result in the total pallet weight getting close to the legal maximum of 1,000kg/pallet, and therefore the weight of the carton is important and using a lighter carton could potentially enable an additional layer of fruit to be carried on the pallet, significantly improving transport efficiencies. (Please note that it is clearly not in the scope of this project to provide guidance on permitted gross pallet weights, and it is best to check with individual transport companies in this regard).

Given the importance of minimising the carton weight, the use of treated papers on the outside liner of the tray and high quality paper on the inside liner to protect the strength of the board from moisture uptake and damage, become worthwhile investments.

8.1.12. Pack Compression

The ideal is for approximately 90% of the fruit load to be carried by the carton and 10% to be carried by the fruit. It is important that some of the load is carried on the fruit in order to hold

fruit in place and prevent 'trampolining' whilst in transit, leading to rub marking. In the 2-piece carton the lid provides additional support, hence the need for the 1-piece carton walls needing to be stronger in order to hold a greater vertical load.

The other consideration for the 1-piece carton is the risk of 'telescoping' (trays falling into each other), due to the walls of a lower carton failing or misaligning with the carton above. The use of 'positive location features' helps to prevent premature telescope failure. In addition, positive location features and recesses allow for rows to be cross-stacked, which provides additional pallet stability. To enable this to occur, lugs should be tapered to allow mechanical stacking/de-stacking in DCs.

8.1.13. Side-Wall Deformation

Minimal sidewall deformation or bulge is important in order to maintain airflow through the carton during forced ripening rather than allowing air to pass around the carton. Excessive sidewall deformation will lead to neck damage and compression bruising. It is difficult to set a minimum specification for a 2-piece carton due to the variability in carton and lid inter-dependencies, and if deformation is an issue then additional secondary packaging such as strapping and memory tape can be used as an alternative to re-engineering the carton or lid, although this is not a comprehensive solution.

In the trial cartons a surface laminate was used (Surefresh), which increased the moisture resistance of the carton and helped reduce sidewall weakness and excessive base sag. The alternative to using a water resistant laminate to ensure adequate sidewall strength is to increase the board thickness. However, this can lead to other undesirable trade-offs:

- Firstly, increased carton wall thickness will reduce the internal volume of the carton and this can lead to slower packing, and can also increase the chance of compression bruising if fruit is forced into the carton; and
- Secondly, thicker board grade will increase the weight of the carton. It is important for the carton not to exceed 1kg in weight as it could lead to breaching of the permitted gross pallet weight.

In summary, the use of card laminates was considered a worthwhile investment in order to avoid the trade-offs listed above.

8.1.14. Lid Tightness

In regard to lid tightness for 2-piece cartons, the lid should be as tight as possible without excessively compromising the ability to place the lid over the base and thus slowing down packing. Ideally the lid should be tight enough to require firm downward force to be applied for it to slide on to the base, and require the base to be held in order to slide off the lid.

8.1.15. Base Sag

Some base sag (or up-flex) is needed to accommodate over-packing of fruit, but excessive sag can escalate telescope failure of trays due to base deformation. The ideal is between 10mm and 20mm. The opposite extreme to too much base sag is when the board grade is too hard, as this can cause compression damage to the fruit as over-packed cartons cannot settle and pallets then become unstable. This is illustrated below.

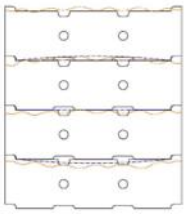

Figure 19: Ideal base sag (straight pallet)

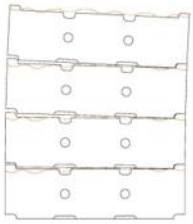

Figure 20: Hard board grade leading to an unstable pallet

Figure 21: Example of base-sag in carton after arrival at wholesale market (note white base of cartons being lifted off pallet with mechanical picker)

8.1.16. Optimal Ventilation for Cooling / Ripening.

Cartons should ideally have dual 'top flow' and vertical ventilation patterns in order to maximise forced air ventilation with minimal impact to tray performance**.** For six per layer cartons for forced-air cooling and ripening, end to end ventilation must be >10% of end panel surface area with a reinforced hand hole of at least 80mm x 20mm and at least 120mm x 20mm 'overflow ventilation'.

In addition, for post ripening temperature management, at least two sets of 40mm x 20mm side-wall 'overflow ventilation' per length panel, plus at least 2% lateral ventilation (base) for post ripening / back of store temperature management is necessary. This allows hot air to rise and escape.

8.2. Specification For Secondary Packaging And Packing Methodology

The use of suitable secondary packaging in conjunction with carton performance is critical in order to deliver better quality fruit to the retail stores ready for sale. Due to the nature of the product and the arduous supply chain, there is a compromise needed between minimal packaging, stabilising pallet loads and optimising ventilation. As detailed in Project BA13015, the following secondary packaging was specified for use within the carton:

- Plastic bags rather than liners;
- Slitted bags rather than perforated bags (or bags with holes); and

- Paper and slip-sheets between clusters.

Similarly, the use of the correct palletisation practices is critical to ensure the successful delivery of bananas to the end customer. Palletisation also needed to take into account the stack height and weight of pallets, in order to comply with transport regulations and chain-of-responsibility requirements. The following secondary packaging was specified for palletisation:

- Corners protectors/posts on all four pallet corners;
- Plastic strapping or stretch net-wrap/memory tape (and ensuring cartons are not damaged by over-tensioning);
- A locking sheet included within the pallet to minimise stack rocking; and
- Cross-stacking to minimise stack rocking.

Based upon the variables that were considered most important in regard to affecting carton performance and fruit quality, a packing specification was developed and issued to packers and growers (displayed below). As detailed in the methodology, the specification was only for the 1-piece 15kg configuration, which was supplied exclusively into Prestons DC (NSW), whilst the Minchinbury DC (NSW) was the control and supplied predominantly with the 2-piece 13kg configuration.

It should be noted that there are a number of different packing methodologies currently in practice in Australia. The 13kg pack generally has two basic packing methodologies in the form of a two and three row carton depending on size of the fruit. The 15kg is generally packed as a three-row carton, and for the trials the 'international pack' configuration was used. The conventional 'international pack' configuration was adopted initially, consisting of a single bottom row of large fruit and the middle and top rows of extra-large fruit, albeit this configuration was altered during the trial to place the large fruit in the top layer. In the past retailers have often commented that 'consumers prefer uniform sized fruit' and therefore their specifications have generally reflected a uniform size of fruit. However, the project team felt there was little evidence that supported this theory and specialist independent retailers strongly felt that different customers have different needs and therefore having mixed size fruit within the same carton was in fact preferable. The project team agreed with this finding. Additional benefits to adopting the 'international pack' was that it enabled more of the growers' crop to be utilised and allowed the 15kg carton to be packed more tightly, which greatly reduced the chance of 'trampolining' and subsequent rub marking.

Since each of the trial growers already had established processes, practices and infrastructure for packing bananas, different packing options for the 'international pack' were tested within the trial across different growers. This not only provided a broader learning base for the project team but also minimised the disruption caused to growers. Within the specification certain variables were considered essential, whilst others such as the gauge of the plastic bag and the method of strapping the pallet (plastic straps or instead memory tape requiring a pallet taping machine) had clear preferences, but were not deemed essential. Therefore the specification included a 'minimum' and 'optimum' specification for all variables. Growers were asked to sign the specification and tick each variable within the specification to confirm they would meet it in full; this was to avoid a grower changing practices midway through the trial and potentially corrupting the integrity of the data.

It is important to stress the interdependencies across all variables, in that changing any individual variable will create a series of knock-on events. For example, reducing the

strength of the construction material used to make the carton base could lead to increased side-wall bulge, however, this can be offset by changing other variables such as the use of a centre corner-post midway along the long-side of the carton, or by increasing the use of secondary packaging such as additional pallet strapping. The final specification was developed and agreed after continued trials and assessment of results, including feedback from growers and suppliers.

Growers transitioned 100% of their ALDI supply volume to the new specification, which enabled packing speeds and commercial practicalities to be better understood. Needless to say, there was an initial learning curve whilst growers transitioned from long established practices to the new cartons, secondary packaging and packing methodology. Furthermore, during the trial there were factors at work that could not be controlled such as environmental conditions and the impact that these can have on fruit quality, however, for the duration of the trial there were no events that were considered of such great significance that it disrupted the validity of the data produced.

			1-Piece Carton Specification		*Grower to complete:* Please tick each box below, in regard to the specification you will pack to	
Supply Chain Item	**Item No**	**Carton Variables**	**Minimum Specification**	**Optimum Specification**	**Minimum**	**Optimum**
Palletising	1	Corner Posts	All pallets must have Corner Posts, with minimum corner widths of 50mm x 50mm, thickness of 5mm and length of 2040mm or 2080mm (depending on pallet height). The corner posts must extend down past the bottom layer cartons and onto the pallet, as this will help lock the pallet to the cartons above			
	2	Pallet Strapping	Straps of 15mm Poly Strapping running horizontally at rows 2, 4, 6, 8 & 10, applied using a Strap Binder (to ensure adequate tension)	3M 8886 Stretchable Tape or equivalent, starting at the bottom layer of cartons and applied in a cross hatched pattern, with stretchable tape looping over 4 top corners of pallet and banding at layer 9		
	3	Locking Sheet	Inner locking sheet on Layer 5			
	4	Pallet Caps	Cardboard pallet cap placed across top of pallet to protect against fruit chill			
	5	Carton Stacking	Column stack layers with carton end panels facing the non-entry side of pallet. In addition, rotate the top carton layer by 90 degrees (cross stacking)			
Fruit Secondary Packaging	6	Bag Type	*Bag-With-Holes*: LDPE 25µm with 4 holes per 100mm2, with 8mm hole diameter	*Slitted Bag*: LDPE 25µm with 23 slits per 100mm2, with 15mm length slits		
	7	Slip-Sheet	380mm x 650mm between 40-75µm LDPE			
	8	Sap Paper	Plain newsprint paper 350mm- 450mm x 550mm-650mm			
Packing Methodology	9	Fruit Packing (International Pack)	**Fruit Size**: Bottom row extra-large (220-280mm), middle row extra-large (220-280mm) and top row large/premium (180-220mm). Bottom row is to be packed on its side, second row is to be packed with crown-end towards the flower-end of the bottom road, and top row is to be packed in the same direction as the bottom row			
			Total net fruit weight on receival: 13kg or 15kg			
	10	Pre-Cooling	Bananas need to be pre-cooled to 13-15 degree before loading			
	11	Packing Methodology	*The top 2 carton layers* are to be packed with the plastic bag tensioned in order to prevent fruit movement, using either the '**Bag-As-Liner Technique**' or '**Bag Twisting Technique**'; see below for descriptions of respective techniques	*All cartons* are to be packed with the plastic bag tensioned in order to prevent fruit movement, using either the '**Bag-As-Liner Technique**' or '**Bag Twisting Technique**'; see below for descriptions of respective techniques		
			'**Bag-As-Liner Technique**': Only slitted bags should be used. A slip sheet must be placed between the bottom and second row of fruit and the bag then folded between the second and top layer of fruit, before folding the other side of the bag over the top layer of fruit and sticking down (with tape) or tucking under the bottom layer, to ensure minimal movement			
			The '**Bag Twisting Technique**' is where the bag is pulled together and twisted, and then tied off keeping the fruit held firmly; a slip sheet must be inserted between the bottom and second rows			
	12	Fruit Height in Carton	Fruit to protrude no more than 35mm above top of carton (accounting for fruit settling in transit and 20mm base-sag from base of carton above)			
	13	Slip Sheet	One slip sheet between the *bottom and second row* of fruit to protect from rub marking and compression bruising, and allows the clusters in *slide into each* other as the packed carton settles during transit			
	14	Sap Paper	One sheet of absorbent sap paper to be placed flat on the bottom of the carton *inside the bag/liner* (as the sappy water passes through the liner the sap residue sticks to the paper rather the bananas preventing sap stain and residual water passes into the carton board). A second piece of sap paper is to be scrunched up and placed at the crown end of the second row, and a third piece of sap paper scrunched up at the crown end of the top layer; it is important that the sap paper is scrunched up at the crown-ends, and not simply placed between the fruit layers			

Figure 22: 1-piece secondary packaging and packing methodology specification developed and refined during the trials

8.2.1. Differences Between Minimum and Optimum Specification

The project originally set out to provide both minimum and optimum specifications. However, as the specifications were developed it became apparent that the majority of variables could not be separated and either had to be included in their entirety, for example corner posts, or alternatively excluded altogether. All secondary packaging items and packing methodology requirements were subjected to cost-benefit validation and only those items that had a

benefit that exceeded their cost were included. This has meant that the final minimum and optimum specifications are actually not that different from each other.

8.3. Results Of Supply Chain Trials

Given the sensitivity of sharing commercially sensitive information, it is not possible to include ALDI's actual sales volume, sales value and waste levels in this report, and therefore, only the interpretation and learning from the trials will be discussed in relation to the variables being assessed. The recommended overall specification for the 1-piece carton is displayed above, and the specification of each variable will be discussed in turn, followed by an explanation of the rationale relevant to the variable. Variables have been grouped into secondary packaging and then the packing methodology.

8.3.1. Secondary Packaging: 1-Piece

Based on the results of the trial, a definitive specification was developed for the 1-piece 15kg carton in regard to the secondary packaging and packing methodology. Whilst the trials were conducted on a 15kg tray weight, the same principles apply for a 13kg tray weight. Variables that are specific for the 1-piece carton are considered first, followed by variables that are specific to the 2-piece carton.

In summary, fruit should be packed into a slitted bag, which will allow airflow, maintain humidity and avoids rub marking at the short ends of the carton. A slip sheet should be placed between the bottom and second layers of fruit and the bag folded between the second and top layer of fruit, before folding the other side of the bag over the top layer of fruit and sticking down or tucking under the bottom layer; alternatively bags should be tied using a method that ensures the fruit is firmly compressed and cannot move. An absorbent paper liner should be placed inside the bag under the bottom layer of fruit. As a minimum, cartons on the top three layers of the pallet should have twisted bags and/or tied to hold the fruit tightly together to prevent movement leading to rub marking, or be firmly taped in order to minimise movement (essentially 'trampolining' leading to rub marking). In terms of pallet stacking configuration, column stacking is necessary to ensure the carton walls carry the load, and just the top carton layer should be cross-stacked to provide additional pallet stability.

Each of the key variables that exerted a significant influence on carton performance and fruit quality will be considered in turn, starting firstly with the secondary packaging and then secondly the packing methodology, followed by the carton construction.

8.3.1.1. Corner Posts

Specification: All pallets must have Corner Posts, with minimum corner widths of 50mm x 50mm, thickness of 5mm and length of 2,040mm or 2,080mm (depending on pallet height). The corner posts must extend down past the bottom layer cartons and over the corners of the pallet, as this will help lock the pallet to the cartons above.

Rationale: This is single most important type of secondary packaging and vital in order to ensure pallet stability. Australia is one of the few markets globally that does not use corner posts, and this goes against global best-practice.

Figure 23: Example of pallet with corner posts

8.3.1.2. Pallet Strapping

*Specification (minimum): S*traps of 15mm poly strapping running horizontally at rows 2, 4, 6, 8 & 10, ideally applied using a strap binder (to ensure adequate tension).

Rationale: The ideal method for securing pallets is 15mm poly strapping that is tightened and crimped with metal clasps, with a minimum of 5 straps per 10 or 11 layer pallet. It is better if straps are tightened using a strap binder (with care being taken to ensure straps are not over tightened causing the corner of cartons to collapse) and not simply hand tightened with clasps, since these can work loose in transit (NB: if straps are hand-tightened without a strap binder, then it is important that metal clasps are used as inferior plastic clasps, whilst a few cents cheaper, are prone to breaking and working loose in transit). No additional memory tape, string or other forms of strapping are necessary;

Specification (optimum): 3M 8886 Stretchable Tape or equivalent, starting at the bottom layer of cartons and applied in a cross hatched pattern, with stretchable tape looping over 4 top corners of pallet and banding at layer 9.

Rationale: 3M-memory tape (or equivalent) has a memory and maintains tension to help hold the cartons together on the pallet. Machine application is preferred since it ensures consistency in positioning around the pallet and optimum tensioning. It is also highly beneficial to have strapping extending over the top of the pallet, which provides downward force, and ideally this tape must have 'memory tension' to compensate for cartons settling in transit (rigid strapping will often work loose in transit) and 3M memory tape is preferred for this reason.

Memory tape was also preferred due to its increased speed of application relative to hand strapping, and therefore lower labour cost. A taping machine costs approximately $17,000 (excluding GST) and for high-volume packhouses the payback period in not likely to be excessive; for average volume packhouses the payback was estimated to be 12-18 weeks.

Figure 24: Plastic poly-strapping

Figure 25: Stretch tape (for machine application)

8.3.1.3. Locking Sheet

Specification: Inner locking sheet on Layer 5.

Rationale: Locking sheets often consist of an inner and outer part that can be separated, and often empty cartons are delivered with a locking sheet that can be re-used to save cost. The inner of the locking sheet is beneficial to use halfway up the pallet to lock the columns together and help prevent pallet movement. The outer part of the locking sheet can be used on the top of the pallet, however, since the top layer of cartons are rotated the additional advantage of a locking sheet is minimal, hence this has not been specified.

Ideally a Tuff3 mini locking sheet should be used. This is specifically designed for this purpose and is constructed out of moisture resistant thickened card, which provides additional strength and lateral pallet stability.

Figure 26: Example of pallet locking sheet

8.3.1.4. Pallet Caps

Specification: Cardboard pallet cap placed across top of pallet to protect against fruit chilling.

Rationale: Protecting the top layer of cartons is important to protect against chilling injury. This is most likely to occur whilst fruit is in transit, particularly for pallets located close to the cooling units, and in cartons that are located on the top layers of the pallet. Even though fruit is packed within plastic bags, this provides little protection against chilling injury in comparison to cardboard, and any conditions where fruit is exposed to temperatures below 13 degrees can be detrimental to fruit quality.

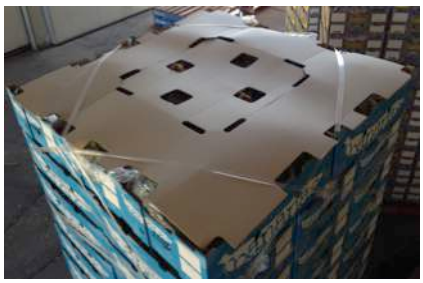

Figure 27: Examples of pallet caps to protect against fruit chilling (held in place with machine applied stretch-tape)

8.3.1.5. Carton Stacking

Specification: Column stack layers with carton end panels facing the non-entry side of pallet. In addition, rotate the top carton layer by 90 degrees (cross stacking).

Rationale: Column stacking cartons is the best means to achieve straight-sided pallets, which optimises airflow and uniform ripening. Ideally the top layer of cartons would not be rotated but the trade-off is considered worthwhile since it helps to lock columns together and improve pallet stability.

Whilst cross-stacking cartons results in the corner lugs of the cartons on the second-from-top layer digging into the bases of the cartons on the top layer, during the trials no damage was caused to fruit. This is because the lugs will collapse slightly and there is only a small load from a single layer of cartons. External lugs will locate into the slots as demonstrated below.

Figure 28: Interlocking lugs enables cross-stacking of cartons

8.3.1.6. Bag type

Bag-With-Holes Specification (minimum): LDPE 25µm with 4 holes per 100mm^2, with 8mm hole diameter, or

Slitted Bag Specification (optimum): LDPE 25µm with 23 slits per 100mm^2, with 15mm length slits.

Rationale: Fruit should ideally be packed using a bag, rather than a liner, since it helps to maintain humidity and protects the short ends of the carton, which are prone to rub marking when a liner is used. Fruit in bags generally create conditions with higher humidity and condensation, and lessens the risk of dehydrated fruit that can become more prone to rub marking and scuffing, both during and after ripening.

A slitted bag is preferable to a bag-with-holes since it allows the fruit to breathe more easily since the splits can expand as required (self-regulate), and humidity is retained to prevent against dehydration. Holes tend to less effect than slits since they are static in nature and can often be blocked when located directly against fruit.

It should be noted that there is also a variation in the functionality and performance of slitted bags; the thickness and material type can affect the ability of the slits to open and vent. A thicker gauge plastic will give less ventilation, with LDPE being the preferred material. It is important for the gauge of plastic to be low (25µm ideally) to enable the plastic to stretch more easily and allow the slits to open and vent the fruit, yet still be strong enough to not tear too easily. Slitted bags were inspected that were made from a higher gauge plastic, and slits did not open as easily due to the rigidity of the plastic. Similarly the physical length of the slits is important as slits less than 15mm in length failed to open adequately.

Figure 29: Example of slitted bag

8.3.1.7. Slip-Sheet

Specification: 380mm x 650mm between 40-75µm LDPE.

Rationale: Plastic slip-sheets allow fruit to slide and minimise rub marking, as the plastic sheet rather than the skin of the banana absorbs the energy caused through friction.

Figure 30: Example of plastic slip-sheet inserted between fruit rows

8.3.1.8. Sap Paper

Specification: Plain newsprint paper 350mm- 450mm x 550mm-650mm.

Rationale: A paper liner should be used in the base of the carton (inside the bag) and extra paper placed under the crown ends when sap flow is high during summer months. This will help avoid sap stain. It is important that the sap paper absorbs moisture, and therefore newsprint paper is ideal but high-sheen magazine paper is not appropriate since it will not absorb moisture.

It was also noted that clusters, which were cut with a knife rather than broken by hand, had less sap staining and also presented better on the retail shelf. In addition, replacing the water in the wash tank in the packhouse can help reduce sap stain on fruit. Fyffes Bananas are particularly stringent in this regard, and ensure all their packhouses frequently change the wash tank water.

Bottom Row ***Middle Row*** ***Top Row***

Figure 31: Example of sap paper applied between fruit rows

8.3.2. Packing Methodology: 1-Piece

It is important to ensure the correct packing methodology is used when packing into a 1-piece carton. The danger is that often the carton can be blamed for not performing adequately when in fact it is the packing methodology, or other processes along the supply chain such as ripening, that are the problem.

During the trials a number of different methodologies were tested, and growers were extremely helpful in identifying, testing and validating the each part of the packing process. This enabled the best parts of all practices to be combined into the best possible solution.

8.3.2.1. Fruit Packing

Fruit Size Specification: The bottom row should be extra-large (220-280mm), middle row extra-large (220-280mm) and top row large/premium (180-220mm). The bottom row should be packed on its side, the second row packed with the crown-end towards the flower-end of the bottom row, and the top row packed in the same direction as the bottom row; total net fruit weight on receival must be a minimum of 15kg plus over-pack allowance (approximately 500g).

The bottom row must be a full row of fruit extending right across the base of the carton and packed tightly in order to act as a 'spine' to support the two rows of fruit above. It is important to not leave any space since it will lead to neck bruising on the second row of fruit, as it will be unsupported. As the middle layer of fruit is placed on top of the bottom row, the bottom row must be slid away from the crown ends of the second row; this is to ensure the crowns of the middle row are in contact with the base of the carton and not simply on top of the bottom layer fruit and potentially causing bruising. It also helps to ensure the top row can easily fit into the carton without requiring downward pressure to be applied that can lead to compression bruising.

Bottom Row
(packed on side)

Middle Row
(crown to flower-end of bottom row)

Top Row
(crown to flower-end of middle row)

Figure 32: Packing methodology for 1-piece cartons

Rationale: Initially attempts were made to specify the weight of fruit for each layer, but this actually proved to be highly inaccurate and in fact served little benefit, since the most important factor is how well the fruit is packed (tight but not damaged by surrounding fruit). Specifying the weight per layer does not help achieve this end goal and can in fact become a distraction, not to mention slowing down the packers. Instead it was better to ensure the bottom two rows are tightly packed so that fruit cannot move.

The typical International Pack configuration was initially used, with extra-large (220-280mm) packed in the top two rows and large/premium (180-220mm) packed on the bottom row. As the trial progressed this was reversed with the top row being large/premium and the bottom row extra-large, and on its side. Whilst at first this may seem counter-intuitive it actually resulted in less compression bruising and neck damage in the bottom row and less rub marking in the top row. In addition, this change was not found to affect the consistency of ripening throughout the carton.

The trial cartons showed little signs of transit rub, even in the top carton layers, which typically experience more transit rub issues since fruit is prone to increased movement and 'trampolining'. However, it should be noted that transit rub is generally worse during the summer months from October through to February, and this trial was conducted outside this period. It was felt that a combination of increased volume (2kg), a consistent tight bottom row (giving a better spine to the pack) and packing the bottom row on its side, which provided a lower pack height, collectively contributed to a reduction in transit rub issues.

Figure 33: Example of second fruit row packed with the crown-end towards the flower-end of the bottom row

8.3.2.2. Pre-Cooling

Specification: Bananas need to be pre-cooled 13 to 15 degree before loading.

Rationale: If heat is not removed prior to loading, fruit will start to ripen and inconsistent quality will result. This is absolutely critical, since once pallets are loaded on to trucks no further cooling will occur; refrigeration systems on trucks are designed to hold product temperature but have less cooling effectiveness than forced-air systems. It was interesting to note that some growers felt trucks had a greater ability to cool fruit whilst in transit than they actually do.

8.3.2.3. Bag Sealing

Specification: As a minimum, the top two carton layers should be packed with the plastic bag tensioned in order to prevent fruit movement since these layers are most prone to rub

marking, using either the 'Bag-As-Liner Technique' or 'Bag Twisting Technique'. Ideally all cartons should be packed in this way. Descriptions for each technique are detailed below:

- *'Bag-As-Liner Technique'*: To optimise the use of this technique, only slitted bags should be used. A slip sheet must be placed between the bottom and second row of fruit and the bag then folded between the second and top layer of fruit, before folding the other side of the bag over the top layer of fruit and sticking down (with tape) or tucking under the bottom layer, to ensure minimal movement; and
- *'Bag Twisting Technique':* This is where the bag is pulled together and twisted, and then tied off or taped in order to keep the fruit held firmly; a slip sheet must be inserted between the bottom and second rows. Whilst some growers used a specifically designed turning table operated by a foot lever, other growers simply used a clear area on the rollers as cartons were moving towards the palletising area, firmly grabbed and lifted the bag in order to take the majority of the weight off the carton, and with the other hand then spun the carton 3-4 times before sealing down the bag.

Rationale: The bag should be sealed as tightly as possible to firmly hold the fruit to prevent vibration during transit, which can lead to rub marking. The Bag Twisting Technique is the preferred method since it holds the fruit more tightly, and using the rollers on the conveyor belt meant no additional cost was incurred apart from the 4-5 seconds taken to complete the action. However, it does lift the height of the fruit and care should be taken to ensure fruit does not extend more than 35mm over the top of the carton since it can increase the chance of compression bruising, although fruit will settle in transit.

Figure 34: Example of bag-twisting packing technique to ensure fruit is held securely

Figure 35: Example of bag-liner packing technique

8.3.2.4. Fruit Height In Carton

Specification: Fruit to protrude no more than 35mm above top of carton (accounting for fruit settling in transit and 20mm base-sag from the base of the carton above).

Rationale: As detailed previously, fruit will settle whilst in transit, and there is a trade off between fruit extending above the top of the carton and potentially being compression bruised, verses not being held securely enough and incurring rub marking whilst in transit (due to trampolining and vibration). Setting a specification of 35mm was considered an appropriate compromise between both these competing factors.

When stacking the pallet, due to fruit being proud of the top of the carton, columns may be unstable when stacked (especially as the pallet gets higher). It is best for the pallet to be stacked by orientating the cartons so that the top row of fruit within the carton is to outside of the pallet, so that the carton column leans inwards, rather than outwards, of the pallet; the fruit will settle in transit and the pallet will flatten out. This is another advantage of using memory tape rather than rigid strapping.

Figure 36: Example of fruit protruding above top of carton (which will settle in transit)

8.3.2.5. Slip-Sheet

Specification: One slip-sheet should be placed between the bottom and second row of fruit to protect from rub marking and compression bruising, and allow the clusters in slide into each other as the packed carton settles during transit.

Rationale: The slip-sheet simply allows fruit to slide and minimise rub marking, as the plastic sheet rather than the skin of the banana absorbs the energy caused through friction, and therefore only a single sheet is required.

8.3.2.6. Sap Paper

Specification: One sheet of absorbent sap paper should be placed flat on the bottom of the carton inside the bag or liner (as the sappy water passes through the liner the sap residue sticks to the paper rather the bananas preventing sap stain and residual water passes into the carton board). A second piece of sap paper should be scrunched up and placed at the crown end of the second row, and a third piece of sap paper scrunched up at the crown end of the top layer; it is important that the sap paper is scrunched up at the crown-ends, and not simply placed between the fruit layers, in order to increase the surface area available for holding sap.

Rationale: Further information regarding the use of sap paper has been provided under the secondary packaging section. Needless to say, sap stain is purely a visual deterrent for consumers, and to not be able to sell perfectly good quality fruit simply due to sap marking is a huge frustration for retailers.

8.3.3. Secondary Packaging: 2-Piece

The criteria listed above under the 1-piece, are equally as relevant for the 2-piece carton. Again the weight of the carton, be it 13kg or 15kg does not change the specification and are equally as relevant to both configurations. The final specification is detailed below followed by an explanation of the variables that are different to those already explained under the 1-piece specification.

It is important to stress the importance of using corner posts and strapping for securing the pallet, and as detailed below, this can help then avoid the need for glue between cartons, cross-stacking and locking sheets.

			2-Piece Carton Specification (13kg and 15kg)	
Supply Chain Item	**Item No**	**Carton Variables**	**Minimum Specification**	**Optimum Specification**
Palletising	1	Corner Posts	All pallets must have Corner Posts, with minimum corner widths of 50mm x 50mm, thickness of 5mm and length of 2040mm or 2080mm (depending on pallet height). The corner posts must extend down past the bottom layer cartons and onto the pallet, as this will help lock the pallet to the cartons above	
	2	Pallet Strapping	Straps of 15mm Poly Strapping running horizontally at rows 2, 4, 6, 8 & 10, applied using a Strap Binder (to ensure adequate tension)	3M 8886 Stretchable Tape or equivalent, starting at the bottom layer of cartons and applied in a cross hatched pattern, with stretchable tape looping over 4 top corners of pallet and banding at layer 9
	3	Carton Stacking	Column stack layers with carton end panels facing the non-entry side of pallet. There is no need to rotate (cross-stack) the mid layer of the top carton layer to provide additional pallet stability, as the corner posts and pallet strapping will suffice	
Fruit Secondary Packaging	4	Bag Type	*Bag-With-Holes*: LDPE 25µm with 4 holes per 100mm2, with 8mm hole diameter	*Slitted Bag*: LDPE 25µm with 23 slits per 100mm2, with 15mm length slits
	5	Slip-Sheet	380mm x 650mm between 40-75µm LDPE	
	6	Sap Paper	Plain newsprint paper 350mm- 450mm x 550mm-650mm	
Packing Methodology	7	Fruit Packing (International Pack)	**Fruit Size**: Bottom row extra-large (220-280mm), middle row extra-large (220-280mm) and top row large/premium (180-220mm). Bottom row is to be packed on its side, second row is to be packed with crown-end towards the flower-end of the bottom road, and top row is to be packed in the same direction as the bottom row	
			Total net fruit weight on receival: 13kg or 15kg	
	8	Pre-Cooling	Bananas need to be pre-cooled to 13-15 degree before loading	
	9	Packing Methodology	*The top 2 carton layers* are to be packed with the plastic bag tensioned in order to prevent fruit movement, using either the **'Bag-As-Liner Technique**' or '**Bag Twisting Technique**'; see below for descriptions of respective techniques	*All cartons* are to be packed with the plastic bag tensioned in order to prevent fruit movement, using either the **'Bag-As-Liner Technique**' or '**Bag Twisting Technique**'; see below for descriptions of respective techniques
			Bag-As-Liner Technique': Only slitted bags should be used. A slip sheet must be placed between the bottom and second row of fruit and the bag then folded between the second and top layer of fruit, before folding the other side of the bag over the top layer of fruit and sticking down (with tape) or tucking under the bottom layer, to ensure minimal movement	
			The '**Bag Twisting Technique**' is where the bag is pulled together and twisted, and then tied off keeping the fruit held firmly; a slip sheet must be inserted between the bottom and second rows	
	10	Fruit Height in Carton	Fruit to protrude no more than 35mm above top of carton (accounting for fruit settling in transit and 20mm base-sag from base of carton above)	
	11	Slip Sheet	One slip sheet between the *bottom and second row* of fruit to protect from rub marking and compression bruising, and allows the clusters in *slide into each* other as the packed carton settles during transit	
	12	Sap Paper	One sheet of absorbent sap paper to be placed flat on the bottom of the carton *inside the bag/liner* (as the sappy water passes through the liner the sap residue sticks to the paper rather the bananas preventing sap stain and residual water passes into the carton board). A second piece of sap paper is to be scrunched up and placed at the crown end of the second row, and a third piece of sap paper scrunched up at the crown end of the top layer; it is important that the sap paper is scrunched up at the crown-ends, and not simply placed between the fruit layers	
	13	Carton Taping	The top 2 carton layers to have their lids taped to the base (any type of tape can be used)	

Figure 37: 2-piece carton specification (13kg and 15kg)

8.3.3.1. Carton Taping:

Specification: The top 2 carton layers to have their lids taped to the base (any type of tape can be used).

Rationale: For 2-piece cartons lid taping is recommended, particularly for the top two carton layers, since it provides additional stability (the top layers on the pallet are most prone to rub marking caused by vibrations).

8.3.3.2. Practices No Longer Necessary

There are also a number of practices that can be avoided based on the implementation of the recommended specification. These obviously provide an immediate cost saving, or at least will go towards offsetting any additional costs associated with implementing other aspects within the specification. These are detailed below.

Gluing Between Cartons

Prior to the use of corner posts, the recommendation for 2-piece cartons was for every carton to have glue applied; usually just on the carton lid, but some growers were also applying glue to the sides of cartons (on the sides that were internal on the pallet, and avoiding glue on the external sides of the pallet). The premise was that the glue helped to hold cartons in place and increase pallet stability, and the glue was designed to come apart easily without tearing or requiring excessive force (the glue should ideally be 'tacky' and not too sticky, and specialist palletising or hot-melt glue is used). However, with the use of corner posts and an appropriate amount of strapping, there is no need to use glue.

Pallet Caps

Since the fruit within 2-piece cartons are covered there is no need for a pallet cap to protect against chilling injury.

Carton Stacking Configuration

Generally 2-piece cartons are column stacked with the carton end panels facing the non-entry side of pallet, and then the 6th or 7th carton layer and top carton layer are rotated by 90 degrees (cross-stacking) to provide additional pallet stability.

Cross-stacking helps to provide additional pallet stability, however, the trade off is that cross-stacked carton do not vent as well due to their orientation and are prone to over-ripeness. In addition, the cross stacked layer is prone to collapsing along the long side of the carton, due to the weight of the load above pressing the carton on to the corner of the carton below. When corner posts and strapping are used it actually negates the need to cross-stack cartons. This will save the handling costs associated with rotating cartons and reduce the waste caused by fruit that is compression damaged and/or over-ripe. It should be noted that this was not tested in the trial.

Locking Sheet

There are mixed views in regard to the need for a locking sheet placed mid-way up the pallet to help reduce lateral movement of the pallet. Generally 2-piece cartons need to be column stacked for at least the bottom five layers before the single cross-stacked mid layer, and then in order to maximise the load bearing capacity of the carton, a full locking sheet is used below the rotated layer to help prevent carton collapse that ofter occurs along the long edge

of the rotated cartons. However, as long as the pallet is supported by corner posts and is adequately strapped, the project team believes there is no need for cross-stacking cartons and therefore, there is no need for a locking sheet. It is important to stress that this was not physically tested within the trial. Comments were made that a locking sheet is used to provide additional support and avoid the need to have a rotated carton layer, and is therefore more relevant to the 15kg rather than 13kg configuration.

8.3.4. Packing Methodology: 2-Piece

There are no other variables within the packing methodology that are different to what has already been detailed for the 1-piece carton.

8.4. Pack Weight: 13kg Or 15kg

As detailed in Project BA13015, in Australia, the decision regarding carton weight has largely been dictated by OH&S legislation and the internal policies of the major retailers designed to ensure workers are not exposed unnecessarily to risks arising from manual handling. Whilst the UK and USA market have a well established 18.14kg (40lb) carton, this would be challenging to introduce into Australia and the major retailers are unwilling to increase their maximum manual handling limit above 15kg nett weight as it would expose their staff to excessive risk of injury. This only leaves the 13kg and 15kg as viable options, acknowledging there are significant sunk costs within supply chains. Challenging legislation and existing OH&S rules would be complex and challenging objective that has a high unlikelihood of failure.

An advantage of the 15kg carton is that a greater net weight per pallet (900kg) can be achieved, whereas for the 13kg the net weight per pallet is only 858kg. Since growers are generally paying per pallet space, rather than the weight of the pallet, there are efficiencies to be gained through using a 15kg carton.

In addition, due to the tighter pack, there is less over-pack relative to the 13kg carton; the typical over-pack in a 15kg is only 400-500g (or approximately 3%), whereas in the 13kg it was 700-800g (or approximately 5.8%). Whilst this is beneficial for growers since they are ‘giving away’ less fruit, it can result in retailers receive slightly less fruit on a pro-rated basis if they transition to a 15kg carton.

8.5. Benefits of 15kg 1-piece versus 13kg 2-piece

There are a number of tangible and intangible benefits through transitioning to a 1-piece carton. Whilst some of these can be monetised and the benefits calculated, albeit the benefits will be specific to the individual businesses, others are largely intangible, but nevertheless provide a saving.

	Supply Chain Stage	Positive/Negative	Who captures the benefit?
1	Nearterm increase in cost of 1-piece	Negative	All but grower is likely to pay
2	Less labour required to pack equivalent volume	Positive	Grower
3	Freight Saving (from grower to capital cities)	Positive	Grower
4	Freight Saving (from DCs to stores)	Positive	Retailer
5	DC Saving (pick fewer cartons)	Positive	Retailer
6	Fewer pick-slots/space required in DCs	Positive	Retailer
7	Reduced Carton Disposal Cost	Positive	Retailer
8	Less Cardboard Disposal In-Store	Positive	Retailer
9	Improved Ripening Quality	Positive	All
10	Less Need for Air-Stacking In-Store	Positive	Retailer
11	In-Store Availability Improvement	Positive	All
12	Improved Customer Satisfaction	Positive	All

Figure 38: Benefits of a 1-piece carton over a 2-piece carton

8.6. Implementation and Cost-Benefit Analysis

Project BA13015 proposed that if no other packing configurations were currently in use, the preferred option would be a 15kg 1-piece carton (over a 13kg 1-piece carton, 13kg 2-piece carton or a 15kg 2-piece carton), since this would present the lowest packing cost per carton and maximum fruit weight on a per pallet basis. These calculations were based upon what was largely a desk-based study without the completion of trials to more accurately assess and quantify the potential savings. Project BA13019 has enabled the assumptions adopted in Project BA13015 to be further analysed and refined.

8.6.1. Packing Cost For Different Carton Configurations

It is critical that the correct combinations of variables are used, and therefore the proposed specification must be implemented in its entirety, and simply cherry picking only certain criteria will not provide the desired result.

Given the significant variation between grower practices it is difficult, and perhaps also an over-simplification, to assume a ‘typical’ or ‘average’ amount, type and method of packaging used by growers. The project team has a high level of confidence that the recommended specifications are necessary in order to ensure fruit reaches the retail shelf in the best possible condition, as evidenced by the trial for 1-piece cartons and the control consisting of 2-piece cartons; in determining the amount, type and quality of each piece of secondary packaging that should be used, the cost-benefit has continually been weighed up.

The recommended specifications have been fully costed, based upon the appropriate amount, type and method of packing that growers *should* ideally use, including both the cost of materials and labour. This will then allow growers to compare their activities individually against the proposed specifications, and assess what changes are appropriate to make in order to meet the needs of their retailer customers. Similarly, retailers (and other supply chain stakeholders) can engage with their grower base in regard to implementing the recommended specifications.

The tables below detail the costs associated with implementing the recommended packing specification detailed above, including all materials and labour, with labour costed at $30 per hour including superannuation and payroll costs (grower reported paying labour rates ranging from $27 to $32 per hour and therefore an average of $30 was assumed). Calculations have been completed for:

- 15kg 1-piece carton, minimum and optimum recommended specification;
- 15kg 2-piece carton, minimum and optimum recommended specification; and
- 13kg 2-piece carton, single specification

In order to provide an indication of the additional cost moving to either of the recommended packing specifications for the 15kg 1 or 2-piece cartons, a cost analysis was also completed for the 13kg 2-piece carton, which was representative of typical practices currently employed and witnessed during the trials. All prices detailed are estimates and exclude GST.

	Item	Material and Labour Cost	Cost Assumption	Minimum Specification: Cost Per Pallet (60 cartons/ pallet)	Minimum Specification: Cost Per Carton (15kg/ carton)	Optimum Specification: Cost Per Pallet (60 cartons/ pallet)	Optimum Specification: Cost Per Carton (15kg/ carton)
Pallet Secondary Packaging	Corner Posts	Material Cost	$1.22 per corner post, with 4 posts per pallet	$ 4.88	$ 0.081	$ 4.88	$ 0.081
		Labour Cost	3 min per pallet	$ 1.50	$ 0.025	$ 1.50	$ 0.025
	Pallet Strapping	Material Cost	15mm poly-strapping tape at $20 per 1,000m (5m per strap) and metal clips for crimping with a strap binder at $0.015 each, or less preferable are hand-tightened fastening clip/clasp at $0.04 each, for 5 straps per pallet	$ 0.58	$ 0.010	Not required if using automatic palletizer with stretch tape	
		Labour Cost	50 sec labour per strap for 5 straps in total	$ 2.08	$ 0.035		
	Pallet Stretch Tape	Material Cost	Roll at $79 per 500m, with 45 pallets per roll on automated machine	Not required if using hand-applied poly strapping		$ 1.76	$ 0.0293
		Labour Cost	10 sec to place pallet on machine and start wrapping process			$ 0.08	$ 0.0014
	Pallet Locking Sheet	Material Cost	Cost $0.46 each (1 per pallet), for mini locking sheet	$ 0.46	$ 0.008	$ 0.46	$ 0.008
		Labour Cost	10 sec labour to place on layer 5 over internal corners and side lugs	$ 0.08	$ 0.001	$ 0.08	$ 0.001
	Pallet Cap	Material Cost	Cost $0.65 each (1 per pallet)	$ 0.65	$ 0.011	$ 0.65	$ 0.011
		Labour Cost	10 sec labour to place over top layer	$ 0.08	$ 0.001	$ 0.08	$ 0.001
Carton Secondary Packaging	Bag (Slitted)	Material Cost	Minimum Specification: *Bag-With-Holes* at $0.18 each for 1 bag per carton (LDPE 25µm with 4 holes per 100mm2, with 8mm hole diameter); Optimum Specification: *Slitted Bag* at $0.18 each for 1 bag per carton (LDPE 25µm with 23 slits per 100mm2, with 15mm length slits)	$ 10.80	$ 0.180	$ 10.80	$ 0.180
		Labour Cost	8 sec to place in carton	$ 4.00	$ 0.067	$ 4.00	$ 0.067
	Slip-Sheets	Material Cost	380mm x 650mm LDPE at 50µm at $55/1000 roll, with 1 slip-sheet per carton	$ 3.30	$ 0.055	$ 3.30	$ 0.055
		Labour Cost	5 sec to place in carton	$ 2.50	$ 0.042	$ 2.50	$ 0.042
	Sap Paper	Material Cost	$32 per 20kg pack (1800 sheets) at $0.0178 per sheet, with x3 pieces per carton	$ 3.20	$ 0.053	$ 3.20	$ 0.053
		Labour Cost	5 sec to place in carton	$ 2.50	$ 0.042	$ 2.50	$ 0.042
Packing Methodology	Bag Closure	Material Cost	Minimum Specification: *Bag-As-Liner Technique* only additional cost is taping bag down for all cartons (with x2 10cm tape per carton at $20 per 1000m); Optimum Specification: *Bag Twisting Technique* twisting and sealing bags for all cartons (with x1 10cm tape per carton at $20 per 1000m)	$ 0.240	$ 0.004	$ 0.120	$ 0.002
		Labour Cost	Minimum Specification: 3 sec to apply tape to each carton; Optimum Specification: 10 sec per carton to twist bag and 3 sec to apply tape to each carton	$ 1.50	$ 0.025	$ 6.50	$ 0.1083
	Cross-Stack Top Layer	Material Cost	No cost	$ -	$ -		
		Labour Cost	No additional cost as cartons still have to be stacked on pallet	$ -	$ -		
		Total Material Cost		$ 24.11	$ 0.40	$ 25.17	$ 0.42
		Total Labour Cost		$ 14.25	$ 0.24	$ 17.25	$ 0.29
		Grand Total		**$ 38.36**	**$ 0.64**	**$ 42.42**	**$ 0.71**
		Total cost to pack per KG		**$**	**0.0426**	**$**	**0.0471**

NB: Additional item is Pallet Cap

Figure 39: Estimated packing cost for 15kg 1-piece carton, minimum and optimum recommended specification (including all labour and materials, excluding GST)

				Minimum Specification		Optimum Specification	
	Item	**Material and Labour Cost**	**Cost Assumption**	**Cost Per Pallet** (60 cartons/ pallet)	**Cost Per Carton** (15kg/ carton)	**Cost Per Pallet** (60 cartons/ pallet)	**Cost Per Carton** (15kg/ carton)
Pallet Secondary Packaging	Corner Posts	Material Cost	$1.22 per corner post, with 4	$ 4.88	$ 0.081	$ 4.88	$ 0.081
		Labour Cost	3 min per pallet	$ 1.50	$ 0.025	$ 0.03	$ 0.000
	Pallet Strapping	Material Cost	15mm poly-strapping tape at $20 per 1,000m (5m per strap) and metal clips for crimping with a strap binder at $0.015 each, or less preferable are hand-tightened fastening clip/clasp at $0.04 each, for 5 straps per pallet	$ 0.58	$ 0.010	Not required if using automatic palletizer with stretch tape	
		Labour Cost	50 sec labour per strap for 5 straps in total	$ 2.08	$ 0.035		
	Pallet Stretch Tape	Material Cost	Roll at $79 per 500m, with 45 pallets per roll on automated machine	Not required if using hand-applied poly strapping		$ 1.76	$ 0.0293
		Labour Cost	10 sec to place pallet on machine and start wrapping process			$ 0.08	$ 0.0014
	Pallet Locking Sheet	Material Cost	No cost as card left over from delivery of empty cartons, (1 per pallet)	$ -	$ -	$ -	$ -
		Labour Cost	10 sec labour to place on layer 5 over internal corners and side lugs	$ 0.08	$ 0.001	$ 0.08	$ 0.001
Carton Secondary Packaging	Bag (Slitted)	Material Cost	Minimum Specification: *Bag-With-Holes* at $0.18 each for 1 bag per carton (LDPE 25µm with 4 holes per 100mm2, with 8mm hole diameter); Optimum Specification: *Slitted Bag* at $0.18 each for 1 bag per carton (LDPE 25µm with 23 slits per 100mm2, with 15mm length slits)	$ 10.80	$ 0.180	$ 10.80	$ 0.1800
		Labour Cost	8 sec to place in carton	$ 4.00	$ 0.067	$ 4.00	$ 0.067
	Slip-Sheets	Material Cost	380mm x 650mm LDPE at 50µm at $55/1000 roll, with 1 slip-sheet per carton	$ 3.30	$ 0.055	$ 3.30	$ 0.055
		Labour Cost	5 sec to place in carton	$ 2.50	$ 0.042	$ 2.50	$ 0.042
	Sap Paper	Material Cost	$32 per 20kg pack (1800 sheets) at $0.0178 per sheet, with x3 pieces per carton	$ 3.20	$ 0.053	$ 3.20	$ 0.053
		Labour Cost	5 sec to place in carton	$ 2.50	$ 0.042	$ 2.50	$ 0.042
Packing Methodology	Bag Closure	Material Cost	Minimum Specification: *Bag-As-Liner Technique* only additional cost is taping bag down for all cartons (with x2 10cm tape per carton at $20 per 1000m); Optimum Specification: *Bag Twisting Technique* twisting and sealing bags for all cartons (with x1 10cm tape per carton at $20 per 1000m)	$ 0.24	$ 0.004	$ 0.12	$ 0.002
		Labour Cost	Minimum Specification: 3 sec to apply tape to each carton; Optimum Specification: 10 sec per carton to twist bag and 3 sec to apply tape to each carton	$ 1.50	$ 0.0250	$ 6.50	$ 0.1083
	Placing Lid on Carton	Material Cost	Included in carton cost	$ -	$ -	$ -	$ -
		Labour Cost	4 sec per carton	$ 0.03	$ 0.0006	$ 0.03	$ 0.0006
	Taping Carton Lid to Base	Material Cost	x2 30cm of tape @ $20 per 1000m to seal lid to base for top 3 layers of pallet (18 cartons)	$ 0.22	$ 0.0036	$ 0.22	$ 0.0036
		Labour Cost	10 sec labour	$ 1.50	$ 0.0250	$ 1.50	$ 0.0250
	Cross-Stack Top Layer	Material Cost	No cost	$ -	$ -		
		Labour Cost	No additional cost as cartons still have to be stacked on pallet	$ -	$ -		
		Total Material Cost		$ 23.22	$ 0.39	$ 24.28	$ 0.40
		Total Labour Cost		$ 15.70	$ 0.26	$ 17.23	$ 0.29
		Grand Total		**$ 38.92**	**$ 0.65**	**$ 41.50**	**$ 0.69**
		Total cost to pack per KG		$ 0.0432		$ 0.0461	

NB: additional items are placing lid on carton and taping carton lid to base. No pallet cap is required

Figure 40: Estimated packing cost for 15kg 2-piece carton, minimum and optimum recommended specification (including all labour and materials, excluding GST)

	Item	Material and Labour Cost	Cost Assumption	Cost Per Pallet (66 cartons/ pallet)	Cost Per Carton (13kg/ carton)	Differences
Pallet Secondary Packaging	Corner Posts	Material Cost	$1.22 per corner post, with 4	$ -	$ -	Not used
		Labour Cost	3 min per pallet	$ -	$ -	
	Pallet Strapping	Material Cost	15mm poly-strapping tape at $20 per 1,000m (5m per strap) and metal fastening clip at $0.035/each, for 2 straps per pallet	$ 0.27	$ 0.004	2 straps instead of 5 straps, often using string rather than poly-strapping
		Labour Cost	50 sec labour per strap for 2 straps in total	$ 0.83	$ 0.013	
	Pallet Stretch Tape	Material Cost	Roll at $79 per 500m, with 45 pallets per roll on automated machine			Not used
		Labour Cost	10 sec to place pallet on machine and start wrapping process			
	Pallet Locking Sheet	Material Cost	Cost $0.46 each (1 per pallet), for locking sheet			Not used
		Labour Cost	10 sec labour to place on layer 5 over internal corners and side lugs			
Carton Secondary Packaging	Bag (Slitted)	Material Cost	Minimum Specification: *Bag-With-Holes* at $0.18 each for 1 bag per carton (LDPE 25µm with 4 holes per 100mm2, with 8mm hole diameter)	$ 10.80	$ 0.164	No change, although some growers are using a liner instead of a bag
		Labour Cost	8 sec to place in carton	$ 4.40	$ 0.067	
	Slip-Sheets	Material Cost	380mm x 650mm LDPE at 50µm at $55/1000 roll, with 1 slip-sheet per carton	$ 3.30	$ 0.050	No change
		Labour Cost	5 sec to place in carton	$ 2.75	$ 0.042	
	Sap Paper	Material Cost	$32 per 20kg pack (1800 sheets) at $0.0178 per sheet, with x3 pieces per carton	$ 3.20	$ 0.049	No change
		Labour Cost	5 sec to place in carton	$ 2.75	$ 0.042	
Packing Methodology	Bag Closure	Material Cost	Minimum Specification: *Bag-As-Liner Technique* no tape used; Optimum Specification: *Bag Twisting Technique* no tape used	$ -	$ -	It is estimated that 60% of the industry is using the Bag-As-Liner Technique and 40% is using the Bag Twisting Technique (but only for the top 3 layers, 18 carton, and no tape is used
		Labour Cost	Minimum Specification: 60% of industry, no additional cost; Optimum Specification: 40% of industry, 10 sec per carton to twist bag for top 3 carton layers (18 cartons)	$ 0.58	$ 0.009	
	Placing Lid on Carton	Material Cost	Included in carton cost	$ -	$ -	No change
		Labour Cost	4 sec per carton	$ 2.20	$ 0.033	
	Taping Carton Lid to Base	Material Cost	x2 30cm of tape @ $20 per 1000m to seal lid to base for top 3 layers of pallet (18 cartons)	$ 0.216	$ 0.003	No change
		Labour Cost	10 sec labour	$ 1.50	$ 0.023	
	Cross-Stack Top Layer	Material Cost	No cost	$ -	$ -	Also cross-stacking the middle layer (layer 6 or 7)
		Labour Cost	No additional cost as cartons still have to be stacked on pallet	$ -	$ -	
	Glueing (all cartons on pallet)	Material Cost	$135 per 20 litre palletising glue (with c. 8,000 cartons per 20 litres) at $0.01625 per carton	$ 1.07	$ 0.016	Glue applied to lid of all cartons
		Labour Cost	2 sec per carton	$ 1.10	$ 0.017	
		Total Material Cost		$ 18.86	$ 0.29	
		Total Labour Cost		$ 16.11	$ 0.24	
		Grand Total		**$ 34.97**	**$ 0.53**	
		Total cost to pack per KG		$	0.0408	

NB: additional items are placing lid on carton and taping carton lid to base. No pallet cap is required

Figure 41: Estimated packing cost for 13kg 2-piece, for typical current practices (including all labour and materials, excluding GST)

Item	Material and Labour Cost	15kg 1-Piece Carton				15kg 2-Piece Carton				13kg 2-Piece Carton	
		Minimum Specification		Optimum Specification		Minimum Specification		Optimum Specification		Estimated Average Packing Specification	
		Cost Per Pallet (60 cartons/ pallet)	Cost Per Carton (15kg/ carton)	Cost Per Pallet (60 cartons/ pallet)	Cost Per Carton (15kg/ carton)	Cost Per Pallet (60 cartons/ pallet)	Cost Per Carton (15kg/ carton)	Cost Per Pallet (60 cartons/ pallet)	Cost Per Carton (15kg/ carton)	Cost Per Pallet (66 cartons/ pallet)	Cost Per Carton (13kg/ carton)
Corner Posts	Material Cost	$ 4.88	$ 0.081	$ 4.88	$ 0.081	$ 4.88	$ 0.081	$ 4.88	$ 0.081	$ -	$ -
	Labour Cost	$ 1.50	$ 0.025	$ 1.50	$ 0.025	$ 1.50	$ 0.025	$ 0.03	$ 0.000	$ -	$ -
Pallet Strapping	Material Cost	$ 0.58	$ 0.010	Not required if using automatic palletizer with stretch tape		$ 0.58	$ 0.010	Not required if using automatic palletizer with stretch tape		$ 0.27	$ 0.004
	Labour Cost	$ 2.08	$ 0.035			$ 2.08	$ 0.035			$ 0.83	$ 0.013
Pallet Stretch Tape	Material Cost	Not required if using hand-applied poly strapping		$ 1.76	$ 0.029	Not required if using hand-applied poly strapping		$ 1.76	$ 0.029	Not used	
	Labour Cost			$ 0.08	$ 0.001			$ 0.08	$ 0.001		
Pallet Locking Sheet	Material Cost	$ 0.46	$ 0.008	$ 0.46	$ 0.008	$ -	$ -	$ -	$ -	Not used	
	Labour Cost	$ 0.08	$ 0.001	$ 0.08	$ 0.001	$ 0.08	$ 0.001	$ 0.08	$ 0.001		
Pallet Cap	Material Cost	$ 0.65	$ 0.011	$ 0.65	$ 0.011					Not required	
	Labour Cost	$ 0.08	$ 0.001	$ 0.08	$ 0.001						
Bag (Slitted)	Material Cost	$ 10.80	$ 0.180	$ 10.80	$ 0.180	$ 10.80	$ 0.180	$ 10.80	$ 0.180	$ 10.80	$ 0.164
	Labour Cost	$ 4.00	$ 0.067	$ 4.00	$ 0.067	$ 4.00	$ 0.067	$ 4.00	$ 0.067	$ 4.40	$ 0.067
Slip-Sheets	Material Cost	$ 3.30	$ 0.055	$ 3.30	$ 0.055	$ 3.30	$ 0.055	$ 3.30	$ 0.055	$ 3.30	$ 0.050
	Labour Cost	$ 2.50	$ 0.042	$ 2.50	$ 0.042	$ 2.50	$ 0.042	$ 2.50	$ 0.042	$ 2.75	$ 0.042
Sap Paper	Material Cost	$ 3.20	$ 0.053	$ 3.20	$ 0.053	$ 3.20	$ 0.053	$ 3.20	$ 0.053	$ 3.20	$ 0.049
	Labour Cost	$ 2.50	$ 0.042	$ 2.50	$ 0.042	$ 2.50	$ 0.042	$ 2.50	$ 0.042	$ 2.75	$ 0.042
Bag Closure	Material Cost	$ 0.240	$ 0.004	$ 0.120	$ 0.002	$ 0.24	$ 0.004	$ 0.12	$ 0.002	It is estimated that 60% of the industry is using the Bag-As-Liner Technique and 40% is using the Bag Twisting Technique (but only for the top 3 layers, 18 carton, and no tape is used	
	Labour Cost	$ 1.50	$ 0.025	$ 6.50	$ 0.1083	$ 1.50	$ 0.025	$ 6.50	$ 0.108	$ 0.58	$ 0.009
Placing Lid on Carton	Material Cost	Not required		Not required		No change		No change		No change	
	Labour Cost					$ 0.03	$ 0.001	$ 0.03	$ 0.001	$ 2.20	$ 0.033
Taping Carton Lid to Base	Material Cost	Not required		Not required		$ 0.22	$ 0.004	$ 0.22	$ 0.004	$ 0.22	$ 0.003
	Labour Cost					$ 1.50	$ 0.025	$ 1.50	$ 0.025	$ 1.50	$ 0.023
Cross-Stack Top Layer	Material Cost	$ -	$ -			$ -	$ -			$ -	$ -
	Labour Cost	$ -	$ -			$ -	$ -			$ -	$ -
Glueing	Material Cost	Not required		Not required		Not required		Not required		$ 1.07	$ 0.016
	Labour Cost									$ 1.10	$ 0.017
Total Material Cost		$ 24.11	$ 0.40	$ 25.17	$ 0.42	$ 23.22	$ 0.39	$ 24.28	$ 0.40	$ 18.86	$ 0.29
Total Labour Cost		$ 14.25	$ 0.24	$ 17.25	$ 0.29	$ 15.70	$ 0.26	$ 17.23	$ 0.29	$ 16.11	$ 0.24
Grand Total		**$ 38.36**	**$ 0.64**	**$ 42.42**	**$ 0.71**	**$ 38.92**	**$ 0.65**	**$ 41.50**	**$ 0.69**	**$ 34.97**	**$ 0.53**
Total cost to pack per KG		**$ 0.0426**		**$ 0.0471**		**$ 0.0432**		**$ 0.0461**		**$ 0.0408**	

Figure 42: Summary of costing for all packing configurations

A comparison of the costs for the main carton configurations is displayed above in Figure 39. Excluding the carton cost, the costing for the optimum specification, including all packing materials and labour, for a 15kg 1-piece carton is between $38.36 (minimum specification) and $42.42 (optimum specification) per pallet, a difference of $4.06 or 11%. For a 15kg 2-piece carton the costing is $38.92 (minimum specification) and $41.50 (optimum specification) per pallet, a difference of $2.59 or 7%. It is $0.56 *cheaper* per pallet to pack the 15kg 1-piece carton for the minimum specification than the 2-piece carton, but $0.92 per pallet *more expensive* for the optimum specification. Needless to say, the difference between the minimum and optimum specifications is insignificant, at only $0.36 per pallet.

				Minimum Specification			Optimum Specification			Difference (on per KG basis)	
Carton Weight	Configuration	Cartons Per Pallet	Weight Of Fruit Per Pallet	Cost Per Pallet	Cost Per Carton	Cost Per KG of Fruit	Cost Per Pallet	Cost Per Carton	Cost Per KG of Fruit	$	%
15kg	2-piece	60	900	$ 38.92	$ 0.65	$ 0.0432	$ 41.50	$ 0.69	$ 0.0461	$ 0.0029	6.64%
	1-piece	60	900	$ 38.36	$ 0.64	$ 0.0426	$ 42.42	$ 0.71	$ 0.0471	$ 0.0045	10.59%
Typical current 13kg	2-piece	66	858	$ 34.97	$ 0.53	$ 0.0408	n/a				n/a

Figure 43: Comparison of packing costs for 15kg 1-piece and 15kg 2-piece carton configurations

In order to compare the indicative cost of packing in line with the recommended specifications for the 15kg 1-piece and 15kg 2-piece carton, estimated industry costs were calculated for packing the typical industry carton configuration, namely the 13kg 2-piece. The estimated cost for the 13kg 2-piece carton was $34.97 per pallet. If this is used as a benchmark in order to approximately quantify the additional cost to pack in line with the recommended specifications, then the difference in comparison to the 15kg 1-piece carton is $1.60 or 4.57% (minimum specification) and $5.47 or 15.64% (optimum specification) per pallet, and the difference in comparison to a 15kg 2-piece carton is between $2.13 or 6.08% (minimum specification) and $4.59 or 13.13%(optimum specification) per pallet.

				Minimum Specification				Optimum Specification			
Carton Weight	Configuration	Cartons Per Pallet	Weight Of Fruit Per Pallet	Cost Per Pallet	Cost Per Carton	Cost Per KG of Fruit	Difference (%)	Cost Per Pallet	Cost Per Carton	Cost Per KG of Fruit	Difference (%)
Difference between 15kg 1-piece and 15kg 2-piece		60	900	-$ 0.56	-$ 0.01	-$ 0.0006	-1.45%	$ 0.92	$ 0.02	$ 0.0010	2.17%
Difference between 15kg 2-piece and typical current 13kg 2-piece		Pro rated for a 13kg carton at 858kg pallet weight		$ 2.13	$ 0.03	$ 0.0025	6.08%	$ 4.59	$ 0.07	$ 0.0054	13.13%
Difference between 15kg 1-piece and typical current 13kg 2-piece		Pro rated for a 13kg carton at 858kg pallet weight		$ 1.60	$ 0.02	$ 0.0019	4.57%	$ 5.47	$ 0.08	$ 0.0064	15.64%

Figure 44: Summary comparison of packing costs for different packing configurations

The additional cost of packing for the recommended specifications need to be considered in conjunction with the carton cost, and then collectively compared to the benefit that can be generated. These calculations can be used as the basis to quantify the likely benefit, in terms of reduced fruit waste due to better protection of fruit whilst in transit (see section 8.6.3).

8.6.2. Indicative Carton Costs

Growers often perceive the carton as the singlest largest cost that they can readily influence, but often overlook the fact that the carton is highly technical in terms of construction and composition. It is important to stress that there is a wide range of cartons currently in use, including many cheap cartons of sub-standard quality that are not adequately protecting fruit. The key driver for the use of sub-standard cartons is the perceived cost saving; whilst it is true that a grower may be saving up $0.30 per carton, it is likely that the retailer will

experience much higher waste levels due to fruit that is bruised and/or compression damaged.

As discussed previously, in regard to the ability of the carton and fruit to share the load bearing, the view was that a carton should split the carton load from above as 90% carton and 10% fruit, whilst for sub-standard cartons the split was 70% carton and 30% fruit, which significantly increases the likelihood of compression damaged fruit. Growers are understandably cost conscious, and many are far removed from their end market and may not fully appreciate the impact that cheaper cartons can cause in terms of higher waste levels for their customers.

The recommended specifications within this project have been developed in conjunction with packaging companies and the findings identified by the project team, and based on cost-benefit of the key variables that exert an influence on carton performance and therefore fruit quality. The suggestion is that industry should promote and educate growers in regard to the need to adhere to at least a minimum carton specification.

The volume purchased heavily influences the cost of the carton and existing business relationships with packaging manufacturers, and the cost of cartons are highly variable. It is difficult to obtain accurate data given the commercial sensitivities but best estimates were provided in Project BA13015 for the 2-piece carton based upon the size of farm (as an indication of quantity of fruit grown and packed), and is detailed below. The weighted industry average carton cost was estimated to be around $2.35 per carton for a 2-piece.

Farm Size	**Lower limit** (cost per carton)	**Upper Limit** (cost per carton)	
50-100 acre farms	$ 2.36	$ 2.42	
100-250 acre farms	$ 2.30	$ 2.32	
250+ acre farms	$ 2.32	$ 2.25	Justifies full truck loads and the potential for machine erecting on site

Industry Average	**$ 2.35**

Figure 45: Indicative 2-piece carton costs (from Project BA13015, data from late 2013)

These estimates above were collated in late 2013, and since then the gap between the 1-piece and 2 piece cartons has reduced with little pricing difference between the 15kg 1-piece and 15kg 2-piece cartons. This has probably occurred due to the manufacturing scale benefits from increased demand. Carton pricing has been revised and current estimates (in late 2015) for both the 1-piece and 2-piece cartons are displayed below.

				Carton Cost ($ per carton)			**Carton Cost ($ Per KG of Fruit)**		
Carton Weight	**Configuration**	**Cartons Per Pallet**	**Weight Of Fruit Per Pallet**	Min	Max	Av	Min	Max	Av
15kg	2-piece	60	900	$2.25	$2.55	$2.40	$0.150	$0.170	$ 0.160
	1-piece	60	900	$2.29	$2.55	$2.42	$0.153	$0.170	$ 0.161
13kg	2-piece	66	858	$2.10	$2.50	$2.30	$0.162	$0.192	$ 0.177
	1-piece	66	858	$2.29	$2.55	$2.42	$0.176	$0.196	$ 0.186

Figure 46: Cartons cost for 13kg and 15kg, and 1-piece and 2-piece cartons on a per kg basis

Price Difference Between 13kg Vs 15kg	
2 -piece	9.57%
1-piece	13.33%

Figure 47: Price comparison between 13kg and 15kg carton (per kg fruit)

It should be noted that on a per kg basis, due to extra weight of fruit that can be packed in a 15kg carton, the 15kg carton is lower in cost in comparison to the 13kg carton (9.57% cheaper for the 2-piece and 13.33% cheaper for the 1-piece).

8.6.3. Cost-Benefit Analysis

In order to understand the full cost-benefit position in transitioning to a 15kg 1-piece carton the proposed additional cost of packing as well as the cost of the carton need to be considered collectively. These calculations can be used as the basis to quantify the likely benefit, in terms of reduced fruit waste due to better protection of fruit whilst in transit, and these calculations are detailed below.

8.6.3.1. Cost-Benefit For The 15kg 1-Piece Carton

If a grower/packer transitions from the current typical industry configuration of a 13kg 2-piece carton, as detailed in section 8.4.1, including all packing materials and labour the additional cost of packing a 15kg 1-piece carton is $1.60 (minimum specification) and $5.47 (optimum specification) per pallet. This equates to an additional packing cost of $0.0018 per kg of fruit (minimum specification) and $0.0061 (optimum specification) per kg of fruit. However, when the reduced cost of the 15kg 1-piece carton is included (at an average saving of $0.016 per kg), the final outcome is a *saving* of $0.014 per kg or $12.69 per pallet for the minimum specification. The optimum specification incurs a *saving* of $0.01 per kg or $8.64 per pallet. Therefore, the cost of transitioning to a 15kg 1-piece carton is, to all intents and purposes, is largely insignificant and actually slightly cost positive.

8.6.3.2. Cost-Benefit For The 15kg 2-Piece Carton

If a grower/packer transitions from the current typical industry configuration of a 13kg 2-piece carton, as detailed in section 8.4.1, including all packing materials and labour the additional cost of packing a 15kg 2-piece carton is $2.13 (minimum specification) and $4.59 (optimum specification) per pallet. This equates to an additional $0.003 per kg of fruit (minimum specification) and $0.005 (optimum specification) per kg of fruit. When the reduced cost of the 15kg 2-piece carton is included (at an average saving of $0.017 per kg), the final outcome is a *saving* of $0.015 per kg or $13.05 per pallet for the minimum specification. The optimum specification incurs a *saving* of $0.012 per kg or $10.44 per pallet. Therefore, the cost of transitioning to a 15kg 2-piece carton is, to all intents and purposes, is also insignificant and in fact slightly cost positive.

8.6.3.3. Final Cost-Benefit Outcome

When the cost for additional packaging (secondary packaging and packing in line with the specified packing methodology) is considered in conjunction with the reduced carton cost for the 15kg carton (1-piece and 2-piece), then the difference in net cost is insignificant, and in fact generates a small saving. Clearly the purchase cost of the carton is the determining factor, whilst the additional cost of packing and secondary packaging is less significant.

To calculate the definitive cost-benefit outcome, consideration must be given to the reduced retail waste that will result from the use of the recommended specifications. A pallet of 15kg cartons will hold a total net fruit weight of 900kg. Average retailer waste is currently 5-8%, therefore the retail value of waste at an average retail price of $2.46/kg (MAT 30th September 2015, Neilson Home Scan) is $110.70 to $177.12 per pallet. Through using the recommended specifications detailed in this report, waste should easily be able to be reduced by 50% of current levels. If the more conservative lower limit of 5% waste is taken, and assuming a waste reduction of 2.5% is achievable, then at least $55.35 per pallet can be saved and transferred into retail sales.

Whilst there may be some 'transition costs' for growers and retailers to change long established processes, and perhaps a degree of risk that needs to managed, in the purest sense, a transition to a 15kg carton in line with the recommended specifications can generate a saving of $55.35 per pallet, and in fact could generate savings of up to approximately $10 per pallet if the recommended specifications are utilised.

Given the additional costs incurred in packing fruit in line with the recommended specifications, retailers, growers, packers and wholesalers will need to redesign and agree new business models that are able to fairly absorb and share the burden of these costs, relative to the respective benefit captured by each stage of the supply chain. Simply expecting growers and/or packers to absorb the additional costs with no benefit in the price they receive for their fruit, or through additional orders that can provide increased scale benefits, may not be enough to deliver an ongoing and sustainable behaviour change. Needless to say, the supply chain stakeholders that can align their interests for mutual benefit will be best placed to capture the first-move advantages.

9. RECOMMENDATION

This project has recommended the 15kg 1-piece carton as the most preferred packing configuration, in preference to either the 15kg 2-piece, the 13kg 1-piece or 13kg 2-piece configurations. The supply chain trials helped to identify key dependencies that must be adhered to, and greatly supported the development of the recommended specifications for the carton, secondary packaging and packing methodology.

9.1. Key Success Factors For The 15kg 1-Piece

Whilst the need for adopting a holistic solution (due to the high degree of interdependencies) has been stressed, it is worth noting the following key success factors:

- *Carton Sidewall Strength*: Ensuring the strength of the long side of the carton was important in order to reduce the risk compression bruising and neck damage. This was achieved through using an internal center post;
- *Fruit Tightness In Carton*: Packing an extra 2kg of fruit into the carton resulted in a tighter pack and helped to reduce 'trampolining' and fruit movement leading to transit rub, which was a problem particularly prevalent in the top carton layers; a tightly packed bottom row was particularly important as it acted as a 'spine' and provided additional rigidity. The internal carton height was intentionally kept to a maximum of 175mm (excessive internal height will lead to possible fruit bounce and transit rub, whereas insufficient internal height will lead to neck damage and compression bruising). Whilst this initially slowed down fruit packing, once packers became accustomed and adapted their processes, there was no change in packing speed;
- *Packing Methodology:* Packing the bottom row of fruit on its side provided a lower carton height and contributed to a reduction of compression bruising and neck damage;
- *Carton Ventilation:* Since the 1-piece carton is open, it facilitates ventilation and allows better air circulation during transit (particularly when used in conjunction with the slitted bag). In addition, this provides ripeners with greater control over temperature management with open tray cartons during ripening, compared to 2-piece cartons; and
- *Fruit Ripening:* The ripening stage is critical, and a minimum of a six-day cycle is recommended, with fruit probing between 13-15 degrees before being delivered to retailers.

However, whilst with the 15kg 1-piece was the preferred packing configuration, the trials also demonstrated that there is considerably less room for error in comparison to the 13-kg carton, be it a 1-piece or 2-piece carton. For supply chain members that have difficultly in controlling their supply chain, particularly in regard to temperature management, the 15kg 1-piece carton can present some significant risks, for the following reasons:

- *Respiration Rates:* The higher respiration rates in the 15kg carton in conjunction with the tighter pack can decrease the ease of air circulation and ventilation. In addition, the larger mass of fruit can quickly start a feedback loop with increased temperatures leading to the production of ethylene. This can lead to over-ripe or uneven ripeness of fruit if cartons are not adequately vented and cooled. It is important that the cool-down cycle post-ripening has reduced the pulp fruit temperature to 13-15 degrees, and the role of the ripener should not be underestimated;

- *Colour Staging:* It was beneficial for the colour stage of fruit to be held back slightly to a stage 3 to 3.5 for arrival into DC, with stage 4 only if necessary. Fruit at stage 4 rapidly accelerates in speed of ripening (due to higher respiration rates and temperature, leading to a positive feedback loop as described previously) and is difficult to control once underway. Whilst the back of store ambient temperature does contribute to accelerated ripening, it is the heat being generated by the banana itself that has a far greater influence. There is perhaps a trade off between fruit on the retail shelf being at a slightly greener stage than ideally desired, verses riper fruit that has less shelf-life and is likely to lead to more store waste;
- *Fruit Over-Pack*: Due to the tighter pack, there is less over-pack in the 15kg carton relative to the 13kg carton; the typical over-pack in a 15kg is only 400-500g (or approximately 3%), whereas in the 13kg it was 700-800g (or approximately 5.8%). Whilst this is beneficial for growers since they are 'giving away' less fruit, it can result in retailers receive slightly less fruit on a pro-rated basis. This can lead to a data discrepancy when comparing scanned sales to DC outgoings, and an initial adverse result suggesting waste levels have increased after having transitioned to the 15kg carton. The temptation for the retailer will be to either revert back to the 13kg carton or increase the internal height of the 15kg 1-piece in order to allow more over-pack of fruit (to the advantage of the retailer but not necessarily the grower). Increasing the over-pack in the 15kg carton needs to be treated with caution since hauliers have strict allowances in regard to the total pallet weight, which must not exceed 1,000kg per pallet, and it could also lead to more rub marking. In essence, once the retailer has made the transition to the 15kg 1-piece carton, in time, once the transition period has been cycled through, then the difference caused by the over-pack will be nullified; and
- *Grower Mindset:* In regard to growers, the 1-piece allows less room for error and requires more stringent handling with the use of specific secondary packaging and the correct packing methodology. If the recommended specifications are not implemented in their entirety, but instead just certain aspects adopted, then the results achieved are unlikely to be satisfactory. Therefore the 1-piece is probably most suitable for growers that are prepared to take the additional time, care and attention and work collaboratively with their retailer customers to adopt the recommended specifications, to ensure quality issues do not arise. The same principles can also be applied to the ripeners, wholesalers and other supply chain stakeholders that handle the 15kg 1-piece carton, as aspects such as strict cool chain management are critical.

9.2. Other Considerations And Potential Benefits

There are a number of other benefits that can be developed further based upon the recommendations within this project, including:

9.2.1. Re-Use Of Secondary Packaging For Delivery To Retailer DCs

The majority of loads are transported as green loads and generally ripened at third party sites in either the central markets or another facility. Loads are then delivered into retailer DCs, which are often up to an hour away from the ripening centers. Since green load pallets are generally broken down to comply with retailer pallet height requirements (the top layer of cartons are removed), it often results in all the secondary packaging being removed, and insecure and poorly stabilized loads being delivered to the DCs. (Whilst trucking companies will stabilize pallets from the growing regions with a combination of plywood, foam, metal

bars and air bags, there is virtually no support being provided for delivering ripened loads to the retailer DCs).

During the trial, growers and suppliers were asked to remove the minimum amount of packaging possible, and cut the strapping and cardboard corner posts at the highest level necessary in order to retain the integrity of the pallet lower down. This essentially meant that pallets were ripened with corner posts and pallet strapping in place (without compromising ventilation and the ripening process) and provided greater stability whilst pallets were being moved around the ripening facility, loaded and off-loaded onto trucks and delivered to the retailers DCs.

It is important to stress, that secondary packaging was selected which did not reduce carton ventilation; for example, the corner posts do not cover carton holes and pallet strapping is a maximum of 15mm wide only. In addition, in instances when the top layer of cartons were removed, new pallets were built which had corner posts and strapping applied, ensuring pallets were then stabilized in transit from the ripening center to the retailer DCs. Corner posts are usually not used with ripened fruit out-loading from retailer DCs to stores, and this is an opportunity to further reduce fruit damage whilst in transit if secondary packaging is retained and left on the pallet. This may be difficult for smaller stores that only receive a small number of cartons in a single delivery, but the majority of retail stores will be selling 20-30 cartons a day (larger stores can often receive minimum order quantities in excess of half a pallet a day).

9.2.2. Date Coding Cartons

In the UK, Fyffes manufacture all their cartons in Dorset (UK) for both the Fyffes branded cartons and also their retailer customers, and transport flat packed cartons out to the tropics where they are assembled and glued before use. Fyffes control the carton process end-to-end to ensure that stock levels and inventory are closely managed and used quickly to prevent cartons weakening in the humid conditions, essentially a first-in-first-out approach. Cartons are date coded with a pre-determined shelf-life to help with inventory management and it is recommended that the same practices are adopted in Australia. The shelf-life can be adjusted during the year to take into account chaging climatic conditions in relation to the effect upon the carton; for example, in humid months the carton shelf-life could be reduced to avoid excessive moisture absorption leading to weakening of cartons and potential exceedence of maximum pallet weights.

10. BEST-PRACTICE GUIDELINES

Assessment of the current supply chain from growers through to retailers has identified significant opportunities to improve current practices in regard to the carton construction, secondary packaging and packing methodologies. The second part of the project focused upon the development of best-practice guidelines, in order to improve the understanding and awareness of practices that can be used along the banana supply chain to improved quality, and in turn build upon the minimum specifications recommended in this report. The objective of Project BA13019 was to also develop best-practice guidelines for key parts of the banana supply chain, including growers, packers, hauliers, wholesalers, ripeners, distribution centres and retail stores (both majors and independents), for the main carton configurations.

Improving the understanding and awareness along the banana supply chain provides an immediate means to address some of the main causes of fruit damage and variable quality that is received at store level, and is a simple and cost-effective means to instigate change and improve the status quo. Guidelines have been developed by building upon the findings of Project BA13015 and through seeking input from key industry experts, many of whom have been involved in the trials and assessments completed in this project.

The approach has been to not conduct detailed scientific analysis due to limitations within the budget, but rather focus on the most important ‘pinch points’ within each stage of the supply chain; the Pareto Principle most likely applies in that 80% of the improvement benefits will be made from the top 20% of issues identified. In line with this premise, the approach has been to focus upon the variables that are the main contributors to poor carton performance and fruit quality, rather than trying to weight the relative importance of all variables.

The key variables for each supply chain stage have been considered in turn and are detailed below. If a variable is in relation to a particular carton configuration then this has been specified.

10.1. Growers

This report is largely aimed at improving the practices employed by growers and packers, particularly in regard to packing bananas in line with the carton, secondary packaging and packing methodology specifications recommended in this report. However, the key variables for attention by growers are reiterated below:

- Cut clusters with a knife rather than break them by hand, since it will create less sap staining and present better on the retail shelf;
- Frequently replace the water in the wash tank in the packhouse to help reduce sap stain on fruit;
- Use a bag liner rather than a carton liner for higher moisture retention and fruit coverage at carton ends, to help reduce rub marking;

Figure 48: Use of a bag rather than a liner to avoid excessive fruit dehydration and friction (leading transit-rub and carton-rub)

- Use sap paper to absorb sap, and use additional paper when sap flow is high;

Figure 49: Best-practice use of sap paper to preventing fruit staining

- Pack cartons tightly to ensure they are full and fruit is held firmly;
- Tension the bag liner by either twisting or using tape (fruit should not protrude more than 35mm above top of carton);
- Ensure at least the top three carton layers are particularly well secured, by taping down lids or using stretchable palletising tape that extends over the top corners of the pallet creating downward force;

Figure 50: Packing fruit tightly and sealing doen the plastic bag helps prevent transit rub

- Use stretchable palletising tape (the tape has a memory and keeps constant pressure on the whole pallet preventing cartons moving independently); and
- Use side wall or corner locating features, in combination with layer locking pads, to prevent (1-piece) cartons moving independently of each other.

Figure 51: Examples of memory tape and carton lugs to provide pallet stability

10.1.1. Carton Management

If cartons are not stored properly their performance can become compromised and lead to carton failure whilst in the transit, which can then result in fruit damage. In large packing sheds cartons are either delivered on a daily basis or erected on site, whilst in small packing sheds cartons are generally delivered on a weekly basis. If stock is rotated according to delivery date then erected cartons should not be older than two weeks. Below is a schematic demonstrating the ideal holding times across the supply chain for unused (new) cartons.

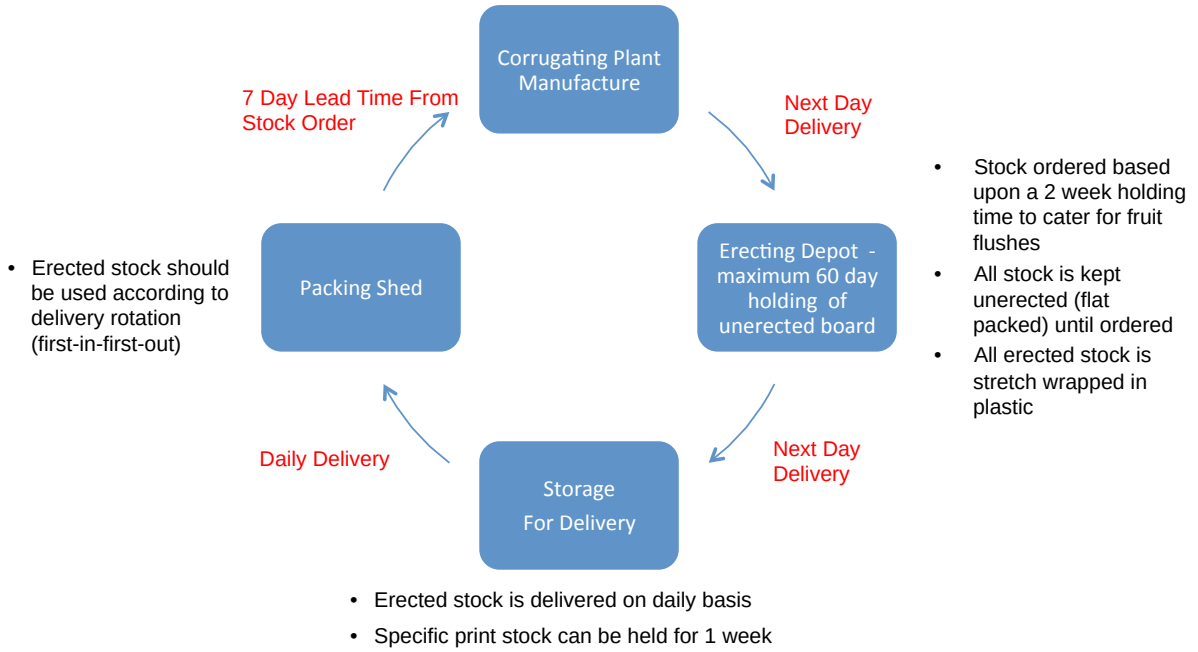

Figure 52: Recommended carton holding timings by supply chain stage

The key recommendations for carton storage were:

- *Delivery*: Cartons must be delivered to packhouses wrapped in plastic stretch wrap;
- *Holding Times*: Un-erected stock (whether inners or lids) can be kept for up to 2 years if wrapped in plastic and stored in a dry cool area not exposed to direct sunlight or humidity;
- *Stock Control*: Cartons must be used on a first-in-first-out basis (ideally cartons should be stamped with the date of manufacture); and
- *Storage*: Cartons must not be stored in direct sunlight or near external shed walls, since walls can radiate enough heat to cause glue to melt and reduce carton strength.

10.2. Hauliers and Wholesalers

The key variables for attention by hauliers are:

- Hold fruit in high-humidity cool rooms between 13-15 degrees (according to industry sources, currently only 5% of cool rooms have humidifiers);
- Ensure trucks are pre-cooled and cleaned before loading;
- Ensure fruit is only loaded if internal pulp temperature is between 13-15 degrees;
- Ensure cool-chain is maintained when cross-docking;
- Ensure pallets are secured in place using air-bags and/or ply/foam/polystyrene padding (see below);
- Any 'leaning' pallets to be loaded with lean against the external sides of the truck;
- Ensure drivers slow down on rough roads, and use vibration sensors and experienced drivers where possible; and
- Use horizontal crossbars every fourth row from the front and back of the trailer to provide support when truck breaks/slows.

Figure 53: Examples of packaging used around pallets to provide additional support during transit

10.3. Ripeners

The key variables for attention by ripeners are:

- Ensure pallet sides are as straight as possible to ensure uniform air-flow and maximise venting to remove heat post-ripening;

- Use a minimum of a 6-day ripening cycle; and
- Ensure the cool down cycle fully removes the heat from the fruit to 13 degrees before removing the fruit from the ripeners.

10.4. Retailers

The key variables for attention by retailers (majors and independents) in store are:

- Air-stack in the back of store (or at least tear bags through carton ventilation holes or handle holes to allow airflow);
- Hold fruit at a temperature of 13-15 degrees and avoid locating bananas near refrigeration or near chilled products. Cartons need to be ventilated as much as possible, and it is recommended to hold fruit close to the access door of the retail floor and away from potential hot spots, such working refrigeration motors or in congested areas with limited ventilation;
- Handle by crown only to avoid bruising and skin marking;

Figure 54: Fruit should only be handled by the crown

- Cut clusters with a knife rather than break them by hand, since it will create less sap staining and present better on the retail shelf (3-5 fingers are preferred by consumers);
- Ideally clusters of bananas should not be stacked on top of each other as this can cause unnecessary bruising and lead to further damage from customers trying to access fruit from underneath.

Figure 55: Bananas stacked on top of each other

Figure 56: Preferred retail shelf display

- Provide in-store training regarding how to handle bananas.

The key variables for attention by retailers (majors only) in DCs are:

- Avoid using cling-wrap around pallets as it will not allow venting and can lead to build up of heat and accelerated ripening of fruit (see below);
- In DCs, bananas should be picked and stacked in full carton layers in order to avoid stacking other products on top, particularly heavy produce such as potatoes and products in crates that can dig into the carton. This particularly relevant for 1-piece cartons that have no top protection (even when the carton has cross-stacking ability); and
- Ensure holding temperature of 13-15 degrees (below 13 degrees can lead to chill damage, and above 15 degrees will lead to forward fruit with reduced shelf-life/poor quality). Often pallets are left in the receival area, which can be as low as 4-6 degrees before being relocated to pick slots and this presents a risk of chill damage, particularly for higher-venting 1-piece cartons.

Figure 57: Cling wrap used in retailer DCs to secure pallets

11. COMMUNICATION AND EXTENSION

It is important for the information in this report to be compiled into a format that can be easily and simply communicated to growers, in both hard and soft copy form. Growers will then be able to compare their activities with the recommended specifications and decide how to implement the changes.

In order to facilitate uptake and adoption by the supply chain, a 'push-pull' strategy could be used, whereby growers are engaged to 'push' the benefits of the minimum specifications and retailers are engaged to explain the benefits to their grower-base i.e. 'pulling'. Targeting both ends of the supply chain will help drive the required change in processes and behaviours in the shortest period of time.

Consideration should also be given to additional means of communication to the different parts of the supply chain to maximise adoption, including:

- Presentations and information sessions at regional grower meetings, and other industry meetings;
- Extension of communication activity; for example extending the activity previously being conducted by Naomi King (QLD DAFF);
- Banana Newsletter; and
- Banana Congress 2017 (albeit a long time away).

Whilst many businesses have developed relationships that extend along the length of the supply chain, it is important to ensure a wide communication base with as many touch-points as possible to maximise the likelihood of adoption and positive action. Furthermore, given the influence of the major retailers, it would be well worthwhile meeting with each individually to explain the benefits and the need for their support, and also the support that industry could provide to them in return.

Ideally the communication strategy should be led and controlled by the ABGC or a party that is unbiased, as there is the risk that other commerical entities with a vested interest will attempt to influence growers which could potentially jeopardise the process.

It is important that industry is encouraged to adopt and implement the recommended guidelines to ensure change occurs. Communication and extension of the best-practice guidelines is not within the scope of the project scope (as requested by the PRG), but could simply consist of a double-sided A4 sheet with a mix of text and pictures to describe the activities that should or should not be completed. This could be easily circulated both electronically and in hard copy form, and presentations given at relevant industry forums.

11.1. Additional Opportunities

A number of additional opportunities for improving the quality of fruit arriving at retail stores have been identified within the trials conducted in this project, including:

11.1.1. Minimize time in DC Arrival Area

It is important to minimise the amount of time that bananas are exposed to temperatures <13^{0}C as it causes the breakdown of the cell structure of the banana skin leaving the banana with a dull grey appearance commonly referred to as 'under peel chill'. DC arrival areas run at 4^{0}C, and DCs have been informed to hold bananas for a maximum of 15 minutes in the receival area, and to swiftly move fruit into the picking area.

11.1.2. Forklift Pallet Protector Attachment

Forklifts often hit pallets with excessive speed causing impact damage to the bottom 6 cartons layers of fruit, and also damaging the pallet itself, which can lead to further fruit damage. 'Pallet protectors' ensures the contact point of the forklift is at the strongest point of the pallet preventing forks tines hitting cartons of bananas or damaging the leading pallet board and leaving cartons of bananas on the base layer unsupported. These can be fitted to all forklifts (cost is c. $120/forklift).

Figure 58: Damage to pallets that can be caused if a forklift 'pallet protector' is not used

11.1.3. DC Repalletised Pallet Wrapping

Bananas continuously produce a self-ripening gas that, and if not ventilated, causes the bananas to heat up and 'cook' the bananas making them inedible. When re-palletising cartons in the DC for sending to stores, it is important to use wrapping material which will allow ventilation. Currently non-venting stretch wrap is used, and this should be replaced with stretch tape, which will allow venting of fruit.

Figure 59: Pallet with non-venting stretch wrap

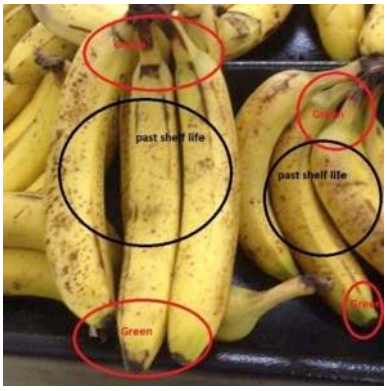

Figure 60: Banana with signs of ventilation issues

11.1.4. Back Of Store Storage

Back-room temperatures in stores can be well in excess of 20 degrees, particularly in summer months, when the optimum holding temperatures is 13-15^{0}C. Cartons need to be ventilated as much as possible, and it is recommended to hold fruit close to the access door of the retail floor and away from potential hot spots of working refrigeration motors or in congested areas with limited ventilation.

Figure 61: Storage with limited ventilation

Figure 62: Preferred option for greater ventilation

Store staff should air-stack bananas on arrival but compliance is very low in this regard across all the major retailers. Stores generally do not have 'warm rooms' or designated banana rooms in the back of store and fruit is held in an ambient holding area, with temperatures often in excess of 20^{0}C. The concern is that once heat in cartons builds up, it creates a positive feedback loop and unless cartons are placed back into forced-air cool rooms this heat can not be removed, and fruit will rapidly become overripe. This ultimately leads to increased waste and consumer dissatisfaction due to poor quality fruit and reduced home-life.

The UK retailers have adopted a realistic approach in regard to the capabilities of stores and are continually assessing methods for simplifying in-store tasks. During winter months ambient holding areas can get below 8 degrees and tools have been implemented to assist stores with temperature management of fruit including:

- *Temperature Sensitive Carton Labels*: some UK retailers are using cartons with an end label with the word 'COLD' written in temperature sensitive ink (see below), which will appear when the carton is exposed to temperature below 10 degrees. Stores use this an early warning sign to indicate that fruit is held in an area that is not suitable for bananas and should be moved to a warmer location. Once the fruit is placed back in the correct temperature the sensitive ink showing 'COLD' will disappear. This has helped reduce the incidence of chilling injury.

Figure 63: *Temperature sensitive carton label used by UK retailers to prevent chilling injury*

Whilst the main concern regarding temperatures in the UK is that holding areas are too cold, the concern in Australia is mainly that holding temperatures are too warm. Developing temperatures sensitive labels that can indicate temperatures in excess of 15 degrees would be beneficial, and help stores recognise non-compliant conditions before they become a problem.

11.1.5. Hauliers

In the UK, no packaging or additional support are used within trucks, and hauliers are often not banana specialists unlike Australia where generally specialist banana handlers are performing the majority of fruit movements. If practices are established whereby pallets are secured appropriately, then the banana industry in Australia would be less reliant on just the current transport providers and there would be greater competition with the use of non-specialist hauliers, perhaps leading to reduced freight rates for growers and suppliers.

12. CONCLUSION

The issues tackled within this trial are complex and if successful will create a step-change in the supply chain practices of the banana industry in Australia. Retailers that adapt the project findings will capture these benefits through reduced waste within stores, and improved on-shelf availability and fruit quality, leading to increased sales and customer satisfaction.

Needless to say, improving upon the status quo and insitigating change will rely upon an adjustment in behaviours through every stage of the banana supply chain, with close engagement and communication from growers through to retailers. It important that unbiased and accurate information is relayed to key stakeholders, and particularly growers, to enable them to make an informed decision that will address their specific business needs. This should now be a key focus for Hort Innovation and the ABGC.

All the major retailers are eager to reduce the level of waste their currently experience within their stores, and are receptive to engaging in further activities to jointly overcome the challenges. Industry should assist the retailers in building business cases to address the individual needs of each retailer, and help address the change management hurdles that they will need to be overcome internally. Developing ongoing collaborative partnerships with the retailers will be highly beneficial for the whole industry and facilitate rapid change with the minimum cost.

Throughout this project a commercially pragmatic approach has been adopted. As agreed with the PRG, in order to make the most appropriate recommendations, it was necessary to consider more than just the attributes of the carton itself, since there were many interdependencies that can affect the performance of any given carton and subsequently the resultant fruit quality. Similarly, there are a large number of variables across the supply chain that influence carton performance, some, which can be approximately monetised, but others which are essentially intangible and therefore difficult to attach an accurate value. Rather, it is perhaps more appropriate to broadly acknowledge that a benefit exists, and the estimated scale of the benefit, but not attempt to spend funds conducting complex and costly analysis to prove what is largely already known.

All businesses within the supply chain will have specific preferences in regard to the pack weight (13kg or 15kg), carton form (2-piece carton or 1-piece carton), in their respective combinations. In reality, the greatest influence on deciding which combination is preferred will most likely arise from the retailer customer, and then secondly growers, and in all likelihood the supply chain partners will adapt accordingly. Nonetheless, the ABGC is well placed to assist and guide all members of the banana supply chain, through providing the necessary information to optimise the packing and transportation of fruit in the range of packing configurations available, and ensure retail stores receive the best quality fruit possible. Notwithstanding this, it is important that all members of the banana supply chain take on the responsibility for implementing actions based upon this information.

Industry should avoid trying to find the single ‘perfect’ solution in which to invest, but rather spread the risk across a number of solutions. In reality every solution is partially right and partially wrong, and innovation often arises at the intersection where different ideas collide. The success of any solution will rely upon bringing businesses together at different parts of the supply chain to test ideas and learn from the limitations of any single solution and figure out how to overcome them. This will require trust and patience. Whilst the ‘fail fast’ approach is favoured by many industries, there is a risk in trying to move too quickly without properly considering the details associated with execution, and thereby disengage key partners and stakeholders.

Finally, it is important to note that even the most successful organisations fail to innovate. This is because they are built to optimize their current business model, and leverage existing sunk costs, and this in itself becomes a noose around their necks. Instead focus should be given to assessing the opportunity to create different business models, where ideas can be tried and tested, most can be allowed to fail, but others can quickly be supported and allowed to flourish, and perhaps even disrupt long established practices that are no longer relevant to todays market needs.

13. REFERENCES

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