Future Orchards COG: Final Report

Title:	What is limiting quality of long-term storage of apples in Tasmania?
Region:	Tasmania
FLA: AgFirst:	Sophie Folder (Pear Consulting) Jonathan Brookes (AgFirst)
Host orchards:	RW Squibb and Sons, Paramatta Creek Orchards, Montague Legana and AAAW Legana
Project question:	What factors are limiting quality in long-term storage of Gala, Jazz, Ambrosia and Kanzi apples in Tasmania?
Project time frame:	October 2021 – December 2022

Outline and method

Project outline
A monitoring trial was undertaken by four northern Tasmanian Orchardists who are members of the Tasmanian Active Community Orchard Group (ACOG) to investigate issues relating to long-term storage of apples. The monitoring program was designed to address the following question.

Project question: What factors are limiting quality in long-term storage of Gala, Jazz™ Ambrosia™ and Kanzi™ apples in Tasmania?

Project method
The trial monitored the fruit from nine orchard blocks across four northern Tasmanian Orchards through the 2021–22 growing season and post-storage in November 2022. Each grower selected both a Gala block and either a Jazz, Ambrosia or Kanzi block for the monitoring program. The growers monitored the fruit in the orchard and at harvest collected a sample of 100 fruit from each block to be stored until November 2022 to simulate a long-term storage program.

The intent of the monitoring program was not to compare orchards, but to use each block as a case study to further understand and identify the limiting factors for each variety for long-term storage. Table 1 lists the block and varieties included in the monitoring program. Block names and orchards have been coded (A–I) to maintain confidentiality of the orchards involved.

Table 1: Orchard blocks involved in the Tas ACOG monitoring trial.

Block code	Variety
A	Gala
B	Gala
C	Gala
D	Gala
E	Jazz
F	Jazz
G	Ambrosia
H	Ambrosia
I	Kanzi

Growing season monitoring

Throughout the growing season each grower recorded and monitored crop load and fruit size. These results were entered into OrchardNet and the results were discussed at ACOG meetings in December 2021 and February 2022. Growers kept records of the total nutrients applied to each block during the growing season.

Harvest monitoring

Fruit nutrients (dry ash) were analysed at harvest. A sample of 10 fruit per block was sent for dry ash analysis at AgVita Analytical laboratory in Devonport. Fruit maturity, including Brix, starch, pressure and colour, was assessed by the growers at harvest.

Storage

After harvest, a storage fruit sample of 100 fruit per block was delivered to RW Squibb and Sons at Spreyton. Samples were put in a coolstore until all the trial fruit samples had arrived and they were put into a controlled atmosphere cool room at the end of April until 31 October 2022. The fruit was removed from cool storage on 10 November 2022 and stored at ambient temperature to simulate a retail environment for seven days prior to the sensory taste panel assessment on 17 November 2022.

Post-storage monitoring

Post-storage maturity (Brix, pressure and fruit weight) and fruit defects were assessed on 15 November 2022. The defect analysis recorded the incidence of storage rots and other fruit quality issues, including bruising, discolouration, russeting, insect damage, lenticel blotch and mechanical damage/stem punctures.

Sensory taste panel

A sensory taste panel was undertaken one week after removal from the coolstore at the Tasmanian Future Orchards® walk on 17 November 2022. Taste panellists were provided with a cut segment fruit from each block and asked to provide a rating of the fruit texture, juiciness, sweetness, flavour and chance of purchasing again, as shown in Figures 1 and 2. They also ranked the fruit from most preferred to least preferred and gave reasons why.

Figure 1: Fruit taste panel samples and score sheet.

Figure 2: Taste panellists scoring fruit.

Data analysis

The monitoring results were analysed to identify the limiting factors impacting fruit quality after long-term storage for each variety. The ACOG group met in December 2022 to discuss results, provide insight and their thoughts. This report lists the limiting factors identified as topics for further investigation for future studies to build further understanding for managing late-marketed Tasmanian apples.

Results summary

Eating quality

Fruit eating quality was measured using the sensory taste panel after storage in November 2022. Figure 1 shows the taste panel results for texture, juiciness, sweetness, flavour and chance of repurchase for each block.

Overall different varieties scored differently in the taste panel which can be attributed to personal eating quality preferences. The Jazz fruit scored highly in the taste panel, particularly for texture, juiciness and flavour. Different blocks of the same variety scored differently highlighting differences in eating quality of fruit harvested from different blocks. For example, D - Gala stood out as having a high scoring taste preference compared to the other three Gala blocks. H - Ambrosia was preferred over G - Ambrosia.

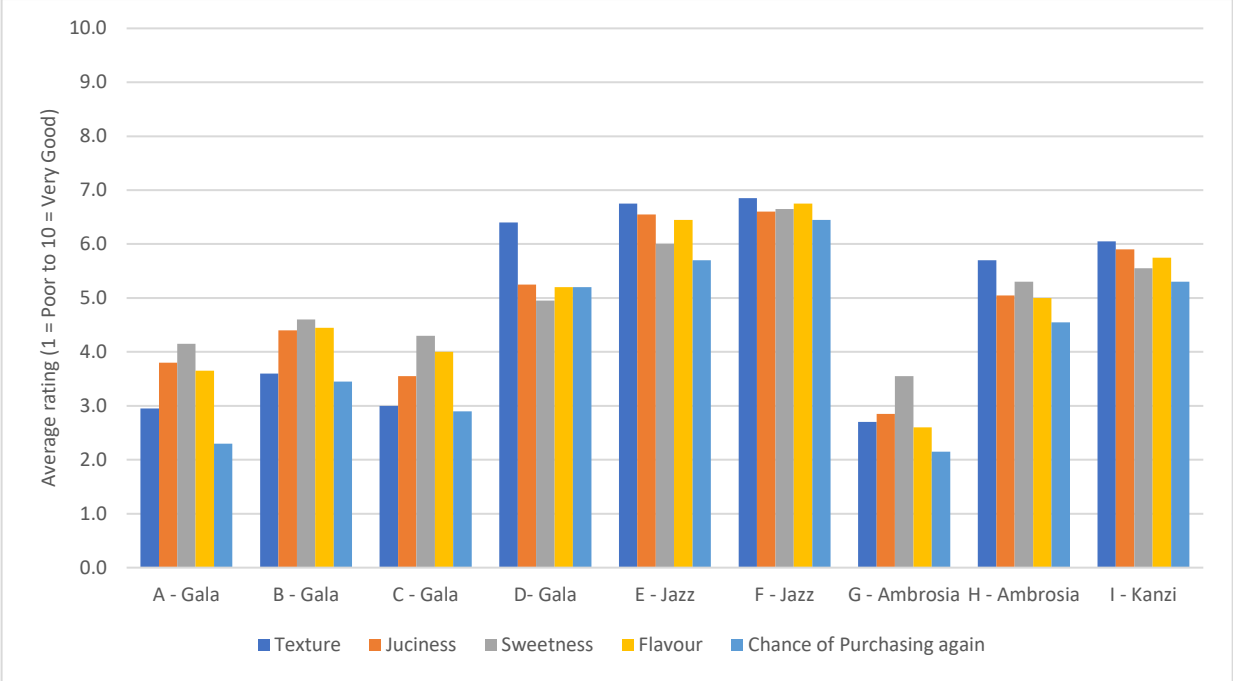

Figure 3: Taste panel average ratings for texture, juiciness, sweetness, flavour and chance of purchasing again.

The fruit texture and chance of purchasing again were closely related. Fruit with low texture scores were least preferred overall as evidenced in blocks Gala blocks A, B and C and G - Ambrosia. This is supported by the words used to describe the most preferred and least preferred apples, shown in Table 2. Texture, firmness, crunch, flavour, sweetness and juicy are listed frequently for preferred apples and lack of texture, soft, floury and poor taste are listed reasons for the least preferred apples.

Table 2: Words describing why an apple was the most or least preferred.

Most preferred apple	Least preferred apple
Texture, taste	Texture, taste
Crunchy, nice balance of flavours, texture, snappy	Soft pear-like texture, lacking defined flavour
Flavour	Floury, soft
Sweetness, sharpness, good juiciness, very good texture	Just bad in every category
Crunch, texture is firm, sweet, flavour	Bad texture, off taste
Crispy, sweet, juicy	Poor texture, poor flavour
Good texture and flavour	Too floury
Nice, crunchy	Soft, tasteless
Firm, juicy	Soft
Crunch	Floury, lacking crunch and juice
Texture	Soft
Some crunch, reasonable flavour	
Crisp, balanced	

Defect analysis

The incidence of post-storage fruit quality defects for each block is shown in Figure 3. Storage rots were present across all varieties, lenticel blotch was an issue in Kanzi and Jazz and russeting in Gala. Mechanical damage from stem punctures occurred in all blocks except one Ambrosia block and bruising from picking occurred in three Gala and one Ambrosia block.

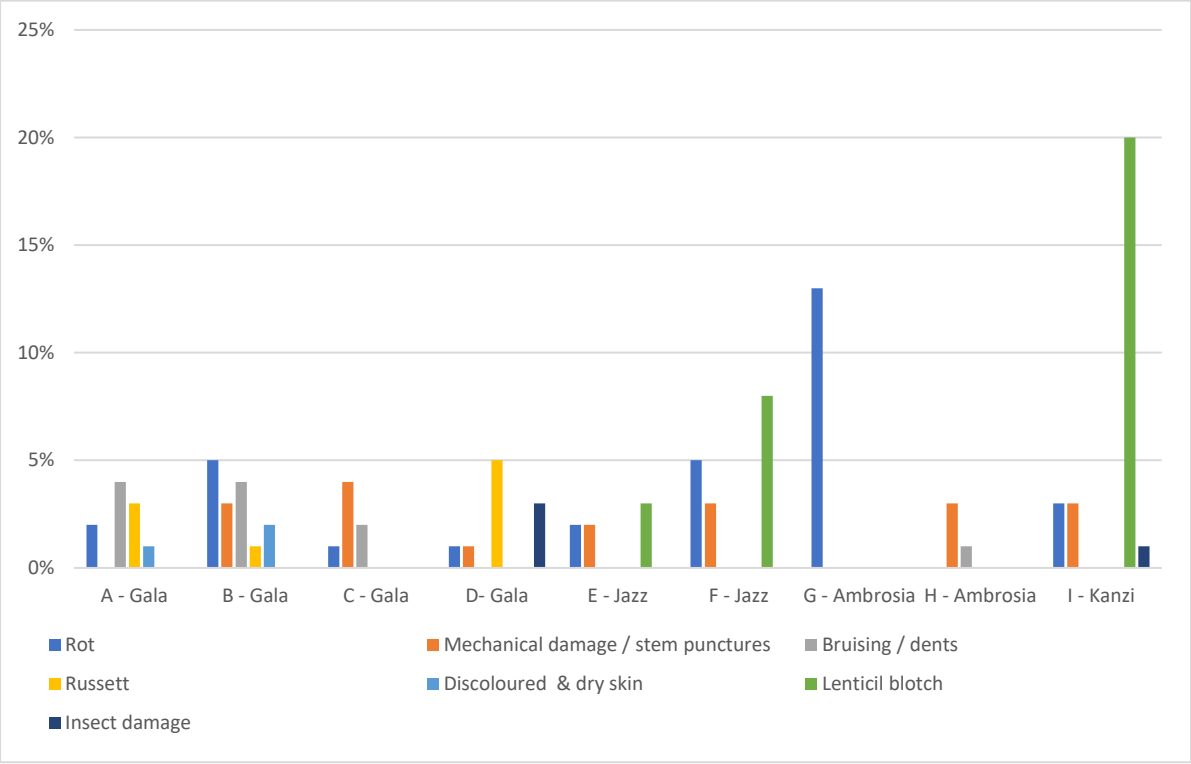

Figure 4: Percentage of fruit quality defects post-storage.

Photos of fruit defects found in the post-storage assessment are shown in Figures 5 to 8.

Figure 5: Insect damage, storage rot, stem puncture and russet, D - Gala.

Figure 6: Storage rot, G - Ambrosia.

Figure 7: Lenticel blotch, rot and stem punctures, F – Jazz.

Figure 8: Lenticel blotch and rot, I - Kanzi.

Fruit maturity

Fruit firmness (pressure) was measured at harvest by the orchardist and then again after storage on 15 November 2022, shown in Figure 9. All Gala blocks were above minimum market specifications of being above or equal to 6.5kg pressure at harvest and post-storage. Some blocks dropped pressure in storage a lot more than others including G - Ambrosia and three Gala blocks, this was also reflected in low texture scores in the fruit taste panel. The Jazz blocks, Kanzi, D - Gala and H - Ambrosia all had higher fruit pressures than the other blocks post-storage.

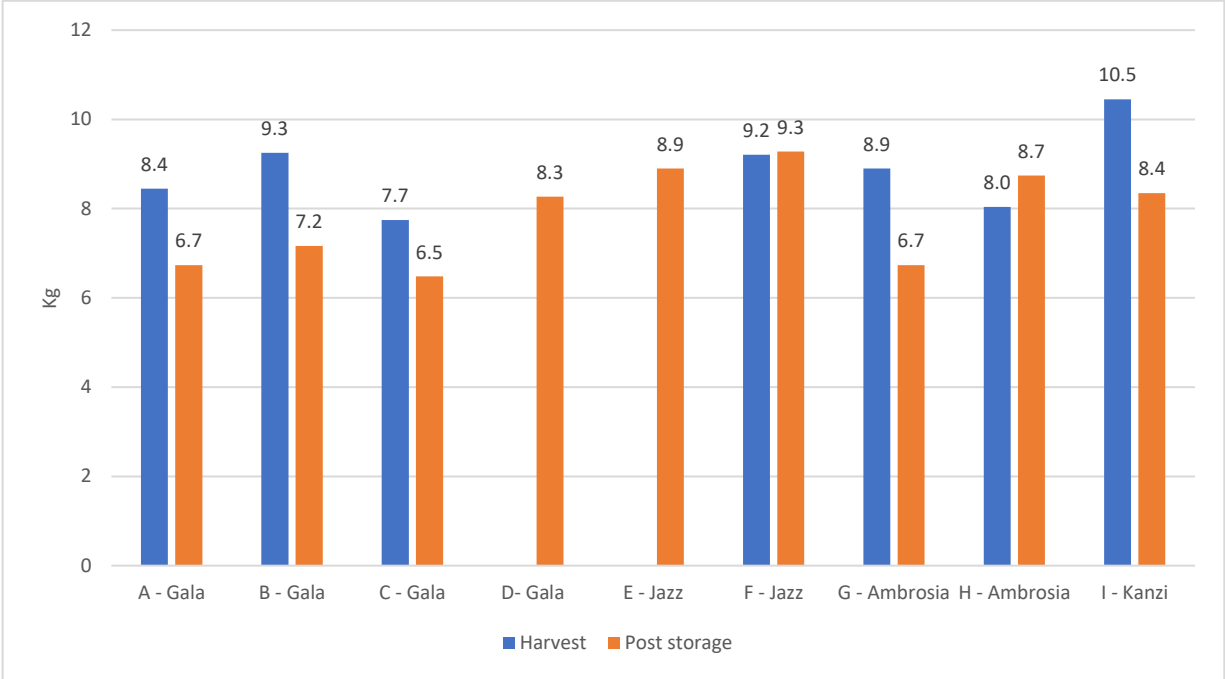

Figure 9: Fruit pressure (kg) at harvest and post-storage.

Fruit Brix (total soluble sugars) was measured at harvest by the orchardist and then again after storage on 15 November 2022, shown in Figure 10. Brix increased during storage as the starch that was accumulated in the growing season converted to sugars. Three of the Gala blocks (A, C and D) and Kanzi were below the minimum market specifications for Brix of 12 (Gala) and 13 (Kanzi) at the time of harvest and therefore storage was necessary to increase Brix prior to marketing. The Ambrosia and Jazz blocks recorded the highest Brix.

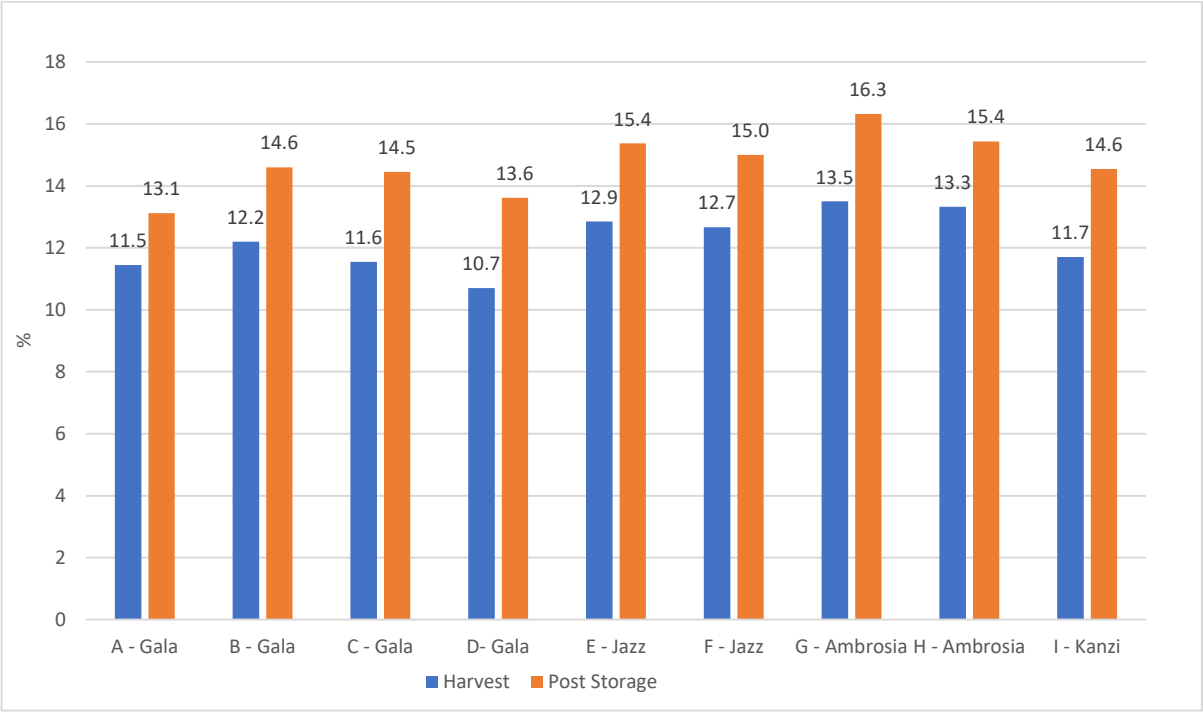

Figure 10: Fruit Brix (total soluble sugars) at harvest and post-storage.

Fruit dry matter

Fruit dry matter can often be used as an indicator of potential storage ability and fruit eating quality with higher dry matter being preferred. The dry matter results of this trial shown in Figure 11, supported this assumption for E - Jazz, F - Jazz, H - Ambrosia and I - Kanzi but not for G - Ambrosia or C - Gala which had high dry matter percentage but was rated poorly by fruit taste panellists. The Ambrosia blocks were higher in dry matter than the other varieties in the trial and on average the Gala blocks had the lowset dry matter percentages.

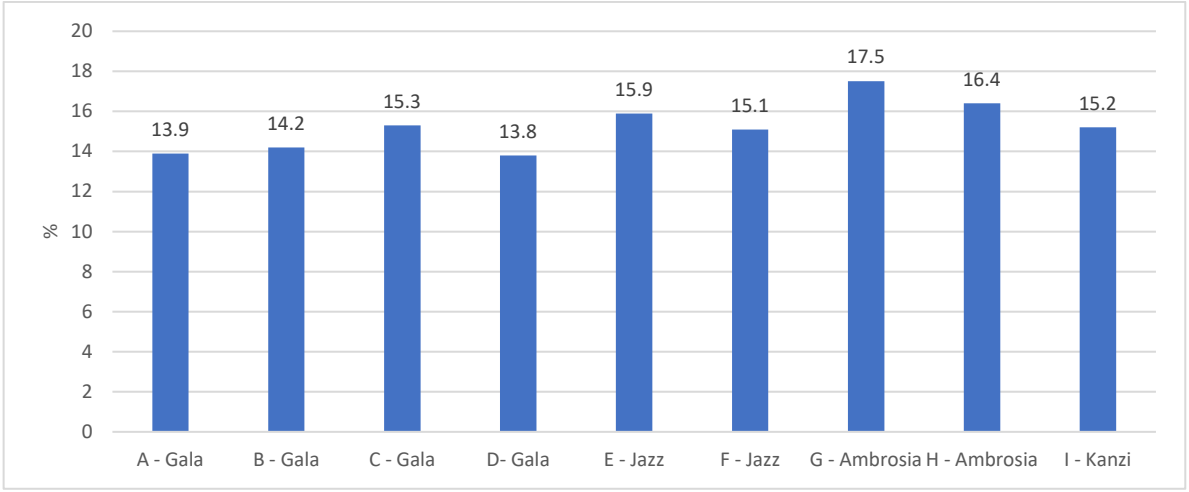

Figure 11: Fruit dry matter percentage at harvest.

Fruit nutrients

Growers recorded fertiliser, fertigation and foliar nutrients applied to each block and the units of each nutrient applied for the growing season up until harvest was calculated, see Table 3.

Table 3: Units of nutrient applied to blocks during the growing season.

	Units of nutrient applied					
Block	Nitrogen N	Phosphorous P	Potassium K	Sulphur S	Calcium Ca	Magnesium Mg
A -Gala	35.8	7.5	81.0	91.4	40.0	5.6
B - Gala	85.8	49.5	224.2	70.9	32.6	5.6
C - Gala	41.0	0	43.7	21.3	23.6	7.3
D - Gala	18.4	1.8	137.0	50.3	9.7	1.1
E - Jazz	33.3	31.5	3.8	13.0	38.6	0.2
F - Jazz	85.8	49.5	182.0	49.4	28.3	5.6
G - Ambrosia	87.6	49.7	183.6	49.7	28.3	5.8
H - Ambrosia	41.0	0	54.2	25.8	23.6	7.3
I - Kanzi	35.8	7.5	28.5	46.2	41.8	2.3

Harvest fruit samples were analysed by dry ash analysis for total nutrient content, results are shown in Table 4.

Table 4: Fruit nutrients at harvest from dry ash analysis.

Block	Nitrate N %	Phosphorous P %	Potassium K %	Sulphur S %	Calcium Ca %	Magnesium Mg %
A -Gala	3.4	0.07	0.82	0.02	0.05	0.04
B - Gala	0.6	0.08	0.83	0.04	0.05	0.04
C - Gala	4.3	0.06	0.72	0.02	0.04	0.03
D - Gala	7.9	0.08	0.88	0.02	0.06	0.04
E - Jazz	1.3	0.06	0.67	0.02	0.02	0.03
F - Jazz	10	0.06	0.7	0.02	0.03	0.04
G - Ambrosia	3.5	0.06	0.72	0.02	0.03	0.03
H - Ambrosia	7.4	0.06	0.7	0.02	0.03	0.03
I - Kanzi	23.5	0.06	0.71	0.02	0.03	0.04

Despite large differences in the units of nutrients applied to the blocks, there were not large differences in fruit nutrient content at harvest. The exception was fruit nitrate, with I - Kanzi recording significantly higher nitrate despite an average nitrogen input through the growing season.

There was little variation in Phosphorus between the blocks. Fruit potassium was higher in the Gala blocks at harvest than the other varieties – being a red variety potassium is important in Gala for colour development. D - Gala recorded the highest calcium and was the block which had the highest pressure of the Gala blocks post-storage. The Jazz, Ambrosia and Kanzi blocks recorded lower fruit calcium than the Gala blocks.

Discussion and implications

The fruit taste panel results highlighted that fruit from the Jazz, Kanzi and Ambrosia blocks were better suited to long-term storage than the Gala blocks as the fruit was firmer and texture was rated more favourably than the Gala.

Fruit texture in Gala

Gala eating quality was hampered by poor texture and reduced fruit firmness after storage. It should be noted that the lack of post-harvest treatments, such as SmartFresh™, may have influenced this result in the trial. In a previous Tasmanian COG trial conducted in 2020, harvest date was shown to have a high influence on Gala fruit maturity and texture at marketing. In the 2020 trial, late-picked Gala was less firm at marketing and texture was rated poorly in the sensory taste panel. The use of a plant growth regulator was shown to delay the commercial harvest date by 10 days, allowing for greater red colour development in the fruit without detriment to eating quality (Folder et al. 2020).

The take home messages from the 2020 Tasmanian COG trial are relevant to managing Gala texture and were:

1. Focus on harvesting Gala at the optimum maturity and if maturity is slipping or labour resources are limited then consider the use of a PGR such as Harvista™.
2. If starch pattern index is above 2.5 then the consumer eating experience may be impacted post-storage (Folder et al. 2020).

Further investigation and improved knowledge on maintaining texture in late-marketed Gala would have high industry relevance, as Gala is a widely grown variety in Tasmania.

Managing lenticel breakdown and blotch

Lenticel breakdown and blotch was identified as a post-storage quality issue in the Kanzi and Jazz blocks. This is a known disorder for both these varieties. The incidence of lenticel blotch in Jazz was comparative with commercial pack out reports for 2022 season fruit reported by the growers. The high incidence of lenticel blotch in the Kanzi trial fruit was not reflected commercially, with only minimal lenticel spot reported by the packhouse, although the fruit was marketed earlier in the season (June) than the trial fruit (November).

Blakey (2018) listed factors known to increase the risk of lenticel disorders including unbalanced nutrition, rapid changes in weather and growth, advanced maturity and post-harvest management, listed in Table 4. Given that the fruit in the trial did not undergo any post-harvest treatments, sorting or packing, the pre-harvest factors would be most relevant in identify possible causes of lenticel breakdown and blotch found in this trial. The Kanzi block for example was shown to have high harvest nitrate, low harvest calcium and moderate harvest potassium, suggesting nutrition may have been the cause. The long storage duration for this trial may also have increased the risk of lenticel disorders being expressed.

Table 5: Factors for increasing and reducing the risk of lenticel breakdown.

Factors known to increase the risk of lenticel breakdown	Factors known to reduce the risk of lenticel breakdown
1. Unbalanced nutrition, specifically high (K+Mg):Ca and N:Ca ratios. 2. Rapid changes in weather resulting in rapid fruit growth. 3. Advanced maturity – especially with poor colouring strains when growers delay harvest for colour improvement. 4. Delayed cooling post-harvest, allowing fruit to continue ripening. 5. Pre-sizing as the additional handling tips high-risk fruit over the edge. 6. Excessive storage duration for the maturity of the fruit. 7. A high temperature difference between (cold) fruit and warm or hot water on the packing line. 8. Adjuvants in acidifiers and soap (product specific).	1. Balanced nutrition. 2. Balanced crop load management. 3. Adapting management practices based on weather during the growing season. 4. Harvesting at optimal maturity. 5. Good quality control at harvest and during storing. 6. Rapid cooling appropriate for the cultivar. 7. Not pre-sizing high-risk fruit. 8. Shortening the storage period on high-risk fruit. 9. Warming fruit before packing. 10. Using soap and acidifiers suitable for fruit at risk of developing lenticel breakdown.

Source: R.Blakey, 2018

Growers of varieties susceptible to lenticel blotch should pay particular attention to the nutrition, harvest and post-harvest management factors listed in Table 4 to the risk of lenticel spot and blotch in their fruit. Consider marketing fruit prone to lenticel spot and blotch earlier rather than later in the season.

The growers involved in the trial expressed their interested in investigating lenticel disorders in Kanzi and Jazz further, to better understand the cause and risk factors relevant to their orchards and storage situations. It is recommended this be a priority topic for future Tasmanian ACOG studies.

Managing storage rots

Storage rots were present in most of the trial blocks. It should be noted that the storage protocol for this trial did not fully reflect commercial storage practice, which may have influenced fruit quality. Most fruit destined for long-term storage would be treated with a fungicide drench prior to storage, this fruit was stored untreated. SmartFresh was not used on the trial fruit and the fruit samples were not placed in a controlled atmosphere until the samples from all nine blocks was delivered to the coolstore, therefore the earlier harvested blocks spent the first month of storage in a coolstore without controlled atmosphere.

The risk of storage rots can be reduced through pre-harvest fungicide programs as well as good harvest management techniques, including picking fruit at the right maturity and picker training to reduce bruising and mechanical damage or stem punctures to fruit. Stem clipping in varieties at risk of stem punctures, e.g. Jazz, has been shown to reduce the incidence of stem punctures and resulting storage rots. Temperature management after harvest is also very important as warm temperatures encourage pathogens to grow.

Russet in Gala

Russet is the healed scar tissue on the skin of apples which results from various forms of damage such as frost, reactions to chemical or foliar applications, pathogens or nutritional imbalances. Russeting often occurs early in the fruit development where the waxy cuticle has

not formed on the fruit and when the apples are rapidly growing. Russet was identified as a post-storage defect in three of the four Gala blocks in the trial. Russet increases fruit moisture loss in storage, reducing fruit pressure and increasing the incidence of fruit shrivel. Russeting also reduces the fruit appearance and marketability.

Different apple varieties have different levels of russet development risk; incidence of russet can be reduced in higher risk varieties. Pruning to improve air circulation and flow with the tree canopy, management of frost conditions in spring, following best-practice management guidelines for the application of sprays and foliar nutrients to ensure safe products are used, applied at correct rates and in conditions where the fruitlet surfaces are able to dry relatively quickly. In some seasons early sun damage can also cause russet damage. Fruit growing on the lateral bud of one-year-old wood is also more likely to develop russet than fruit on terminal or spurs buds.

Conclusion

The trial was a successful study to highlight quality issues impacting late-marketed fruit in Tasmania. Four key factors were found to be limiting fruit quality in the Gala, Jazz, Ambrosia and Kanzi blocks. These included: fruit firmness and poor texture, particularly in Gala; lenticel spot and blotch in Kanzi and Jazz; storage rots; and russeting in Gala.

It is recommended that the following topics be considered for further studies to better understand the cause and risk factors relevant to Tasmanian orchards and storage situations:

- Lenticel disorders in Kanzi and Jazz.
- Maintaining firmness and fruit texture in late-marketed Gala.
- Russeting in Gala.
- Storage rots.

Acknowledgements

Thank you to the following people for their assistance in this trial:

- Brett Squibb (RW Squibb and Sons), Troy Layton (Paramatta Creek Orchards), Rodney Hogan (Montague Legana) and Brent McClintock (AAAW Legana) for your willingness to participate in the Tasmanian ACOG and trial.
- Brett Squibb of RW Squibb and Sons for providing the cool storage of the trial fruit.
- The Tasmanian growers and industry representatives who participated in the sensory taste panel of the trial fruit at the Future Orchards Spring Orchard Walk in November 2022.

References

Blakey R (2018) “Managing Lenticel Breakdown – Don’t get caught by the snowball”, Stemilt Growers LLC, sourced at http://www.hort.cornell.edu/expo/proceedings/2018/Managing%20Lenticel%20Breakdown%20summary.pdf

Folder S, Hornblow C and Squibb B (2020) *Future Orchards Demonstration Trial: Final Report, Investigating Gala apple eating quality*, APAL.