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Accelerated Fruit Libraries to Predict Storage Potential of ‘Hayward’ Kiwifruit Grower Lines

A thesis presented in partial fulfilment of the requirements for the degree of Doctor of Philosophy in Food Technology at Massey University, New Zealand.

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Abstract

Reducing postharvest losses is a major challenge of the kiwifruit industry. Inherent variability between kiwifruit grower lines makes the prediction of postharvest storage quality a difficult task. This research aims to establish an Accelerated Fruit Library (AFL) rapid test methodology to collect data that would enable *a priori* segregation of 'Hayward' kiwifruit grower lines for storage potential. In the AFL, fruit losses were accelerated by storing at 20 °C and measured regularly at 3 day (d) intervals. The resulting pattern of losses in the AFL was assumed to reflect the losses in optimal storage (0 °C). Results from a preliminary study found that late harvested lines in the AFL displayed a more rapid decline in firmness than those harvested earlier, corresponding with the highest recorded ethylene contamination in the room. Therefore, later AFL attempts were refined by storing each grower line in a flow through system to maintain ethylene independence. The refined AFL methodology ensured expression of inherent loss patterns of each grower line. From the AFL data, parameters describing the distribution, variability and defect count were extracted. Number of fruit < 0.6 kg_f, 1st quartile, 3rd quartile firmness, mean and median firmness, SSC:firmness ratio and number of rots during AFL monitoring were slightly correlated ($r \geq |0.5|$) with fruit firmness at 126 d of optimal storage. None of the AFL parameters had consistent correlation ($r \geq |0.5|$ continuously at more than two measurement occasions) with storage firmness. Later, AFL softening curves were described with the Complementary Gompertz equation using the non-linear mixed effects procedure for fitting. Grower lines with higher fitted rate of firmness change parameter (κ) during AFL monitoring had a tendency to have low firmness at 100 and 126 d of optimal storage ($r = -0.53$ and -0.45 respectively). Using the fitted κ as a segregation guide, 60% of grower lines were successfully categorised into 1 of 3 storage potential categories (i.e. low, medium and high). Notably, κ successfully identified 90% of the low storage grower lines. Removing grower lines identified as low storing (65% of whole population) changed the proportion of observed low storing lines in the remaining population from 35% to 10%. However, in the next season where validation of the AFL methodology was conducted, using the fitted κ as a segregation tool resulted in only 53% of grower lines being correctly categorised. Meanwhile, 78% of grower lines with low storage potential were accurately predicted. However, removal of lines categorised as low storing (64.7%

of whole population) changed the proportion of observed low storing lines in the remaining population from 53% to 33.3%. Overall, the AFL methodology could have potential to segregate grower lines with different storage potentials but unfortunately higher proportion of low storing lines in the remaining population categorised as medium and high storage restrict its industrial application. Further development of the AFL methodology to predict storability of kiwifruit grower lines may be achieved with incorporation of pre-harvest information (change in fruit quality e.g. SSC and firmness on vine), compositional attributes (amount of minerals e.g. calcium), physiological indicators (e.g. respiration rate and ethylene production) and processes (e.g. cell wall changes and enzymatic activity) of fruit ripening during storage.

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Table of contents

Abstract	i
Acknowledgments.....	iii
List of Figures	xiii
List of Tables.....	xix
List of Abbreviations	xxiii
1 Introduction and Thesis Overview	1
1.1 Introduction	1
1.2 Thesis overview	3
2 Literature Review	5
2.1 Overview of kiwifruit industry in New Zealand	5
2.2 Kiwifruit supply chain	7
2.2.1 Storage of kiwifruit	10
2.3 Factors influencing storage quality	11
2.3.1 Pre and at-harvest factors.....	11
2.3.2 Postharvest factors	15
2.3.2.1 Postharvest handling	15
2.3.2.2 Temperature	15
2.3.2.3 Ethylene.....	16
2.4 Management of kiwifruit quality	18
2.4.1 Firmness variability	19
2.4.1.1 Kiwifruit softening.....	20
2.4.1.2 Modelling kiwifruit softening	22
2.4.2 Postharvest diseases	24
2.5 Accelerated shelf life testing	25
2.5.1 Accelerated fruit library.....	26

2.5.2	Options to accelerate kiwifruit softening	27
2.6	Quality standards and sampling plan	29
2.7	Summary	32
3	Accelerated Fruit Library of Kiwifruit – A Preliminary Understanding	33
3.1	Introduction	33
3.1.1	Objectives	35
3.2	Materials and methods	35
3.2.1	Firmness	37
3.2.2	Soluble solids content (SSC)	37
3.2.3	Dry matter (DM)	38
3.2.4	Ethylene detection	38
3.3	Data manipulation and analysis	38
3.3.1	At-harvest	38
3.3.2	Optimal storage	39
3.3.3	Accelerated fruit library (AFL)	39
3.3.4	Relating at-harvest and AFL to optimal storage	41
3.4	Results and discussion	43
3.4.1	At-harvest	43
3.4.2	Optimal storage	45
3.4.3	Accelerated fruit library (AFL)	47
3.4.3.1	Ethylene effect in AFL	49
3.4.4	Relationship of at-harvest and AFL parameters with seasonal life	50
3.5	Implications for future AFL experiments	57
3.5.1	Number of grower lines	57
3.5.2	Softening potential evaluation	57
3.5.3	AFL sample manipulation	58

3.6	Conclusion.....	60
4	Refined Accelerated Fruit Library.....	63
4.1	Introduction	63
4.1.1	Objectives	64
4.2	Materials and methods.....	64
4.2.1	Data manipulation.....	66
4.3	Results and discussion.....	67
4.3.1	Description of the data.....	67
4.3.1.1	At-harvest.....	67
4.3.1.2	Optimal storage	69
4.3.1.3	Accelerated fruit library (AFL).....	71
4.3.2	Prediction of storage potential	73
4.3.2.1	Relationship of arrival day and storage potential.....	73
4.3.2.2	Relationship of at-harvest and AFL parameters with storage potential	74
4.4	Conclusion.....	80
5	AFL Softening Curve Parameters to Predict Storage Potential (*).....	81
5.1	Introduction	81
5.2	Materials and methods.....	82
5.2.1	Modelling of AFL firmness data	83
5.2.1.1	Choice of modelling approach	84
5.2.1.2	Model application.....	85
5.2.1.3	Grower line dependent model parameter estimation	86
5.2.2	Testing CG model parameters as predictors of storage potential	87
5.2.2.1	Threshold selection for best possible predictive categorisation.....	87
5.3	Results and discussion.....	89
5.3.1	Modelling AFL firmness data.....	89

5.3.2	Testing CG model parameters as predictor of storage potential	95
5.3.3	Threshold selection for best possible categorisation.....	96
5.3.4	Application of κ thresholds in future	97
5.4	Conclusion	98
6	Validation of Accelerated Fruit Library (*)	101
6.1	Introduction.....	101
6.2	Materials and methods	102
6.3	Data analysis	104
6.4	Results and discussion	105
6.4.1	Description of the data	105
6.4.1.1	At-harvest	105
6.4.1.2	AFL softening.....	106
6.4.2	AFL based prediction of storage potential category	109
6.4.2.1	Use of same κ thresholds.....	109
6.4.2.2	Re-defined thresholds of κ for validation data set.....	111
6.4.2.3	60% of GLs with highest κ	112
6.5	Conclusion	113
7	Discussion and Recommendations (*)	115
7.1	Introduction.....	115
7.2	Establishment of AFL	116
7.2.1	Ethylene effect.....	116
7.2.2	Rotten fruit effect	117
7.2.3	Fruit packaging.....	117
7.2.4	Reduction in AFL data collection	119
7.3	AFL softening losses.....	122
7.3.1	High temperature.....	123

7.3.2	Ethylene application	123
7.3.3	Data manipulation.....	124
7.4	Modelling of softening	125
7.4.1	Empirical modelling	125
7.4.2	Modelling biological age of kiwifruit.....	126
7.5	Interpretation of AFL to predict storage potential.....	129
7.5.1	Storage potential prediction.....	129
7.5.2	Grower lines predicted as longer storage than observed	130
7.5.3	Seasonal differences between GLs	131
7.5.4	Comparison of required sale with industry.....	134
7.6	Research opportunities	135
7.6.1	Collection of pre-harvest data.....	135
7.6.2	Use of at-harvest data to predict model parameters.....	136
7.6.3	Assessment of fruit quality	137
7.6.3.1	Physiological status of fruit.....	137
7.6.3.2	Compositional attributes	138
7.6.4	Physiological process of kiwifruit softening	138
7.6.5	Use of novel non-destructive techniques	139
7.7	Recommendations	140
7.8	Conclusion.....	141
	References.....	143
	Appendix.....	169

List of Figures

Figure 2.1: Generalised scheme of processes involved in kiwifruit supply chain.....	9
Figure 2.2: Kiwifruit softening phases in relation to different physiological processes (Schröder and Atkinson, 2006).	21
Figure 2.3: Operating characteristics curves for sample size of 300 with different acceptance numbers.	30
Figure 3.1: Fruit distribution and scheme of data collection for at-harvest, optimal storage and accelerated fruit library for each GL in 2010.	36
Figure 3.2: An hypothetical cumulative frequency graph to show different parameters of AFL firmness data. NoF: number of fruit.	41
Figure 3.3: Scheme of data manipulation and calculation of correlation coefficients (r) for at-harvest and AFL parameters with storage performance of kiwifruit GLs.	42
Figure 3.4: SSC (A), DM (B) and firmness (C) of GLs at harvest day in 2010. Each data point represents a GL. For SSC and DM each data point is an average of 30 fruit (10 fruit per MB pack), and for firmness an average of 297 fruit. Soft fractile represents firmness value of 9 th softest fruit in population of 300 fruit for each GL.	44
Figure 3.5: Change in soft fractile values of 20 GLs during optimal storage in 2010. Each firmness line represents a single GL and comprises data of 10 measurement occasions at 21 day intervals. Soft fractile is firmness of 9 th softest fruit in a population of 300. Red line represents export threshold limit of 1 kg _f	46
Figure 3.6: Change in SSC development during optimal storage for 20 GLs in 2010. Each line represents a single GL and comprises data of 10 measurement occasions at 21 day intervals. SSC at each measurement occasion comprise an average of 15 fruit.	46
Figure 3.7: Pearson correlation of seasonal life of GLs with ISO day of arrival. Each data point represents a GL.	47

- Figure 3.8: Change in soft fractile of 20 GLs during AFL monitoring in 2010. Each line represents a GL and comprises data of 10 measurement occasions at 3 day intervals. Soft fractile is firmness of 9th softest fruit in a population of 300. Red line represents export threshold limit of 1 kg_f..... 48
- Figure 3.9: Change in SSC development during AFL monitoring for 20 GLs in 2010. Each line represents a single GL and comprises data of 10 measurement occasions at 3 day intervals. SSC at each measurement occasion comprises an average of 15 fruit..... 49
- Figure 3.10: Correlation between at-harvest SSC with rank of GLs for seasonal life (d). SSC is mean of 30 fruit per GL. Highest rank means highest and lowest rank represents lower seasonal life of any GL. Each data point represents a GL..... 57
- Figure 3.11: Correlation of seasonal life with soft fractile at 126 day of optimal storage. Each data point represents one GL..... 58
- Figure 3.12: Mean firmness values at 15 day of AFL monitoring with rank of GL for soft fractile at 126 day of optimal storage. Each data point represents mean firmness of approximately 300 fruit for each GL. Extended horizontal bars represent the range of mean values for 10 samples of 30 fruit..... 60
- Figure 4.1: Fruit distribution and data collection for at-harvest, AFL and optimal storage measurements for each GL in 2011..... 65
- Figure 4.2: Diagram shows flow through system to keep each GL independent during AFL..... 66
- Figure 4.3: At-harvest SSC (A), DM (B) and firmness (C) of GLs in 2011. Each data point represents one GL. For SSC and firmness, each data point shows an average of 36 fruit and for DM average of 15 fruit..... 68
- Figure 4.4: Soft fractile of 57 GLs after 100 (A) and 126 (B) day of optimal storage in 2011. Each data point is a GL. Red line represents an export threshold of firmness at 1 kg_f..... 70
- Figure 4.5: SSC of 57 GLs after 100 (A) and 126 (B) day of optimal storage in 2011. Each data point is an average of 15 fruit from a GL..... 71

- Figure 4.6: Firmness curves of 57 GLs during AFL monitoring in 2011. Each line represents a GL and comprises of 8 data points at 3 day intervals. Each data point is an average of 36 fruit..... 72
- Figure 4.7: Change in SSC of 57 GLs during AFL monitoring in 2011. Each line represents a GL and comprises of 8 data points at 3 day intervals. Data point at-harvest represents average of 36 fruit. For AFL each data point is an average of 15 fruit. 73
- Figure 5.1: Scheme of methods performed to use AFL monitoring system to predict storage quality. 83
- Figure 5.2: Sensitivity analysis of each CG parameter on the resulting model shape, when each parameter was changed by 25% (red) from values of an ordinary softening curve (black). 90
- Figure 5.3: Sensitivity analysis for GL dependent CG parameters observed in population of GLs. The black line represents the model with average parameter values while red line shows model with different extremes of B and κ . For these curves, global parameters A_0 of 0.31 kg_f and β of 73.39 were used..... 91
- Figure 5.4: Raw (A) and fitted (B) softening curves of 57 GLs during AFL monitoring in 2011. CG₂ with global A_0 (0.31 kg_f) and β (73.39), and GL dependent B (range of 2.65 to 6.94 kg_f) and κ (range of 0.23 to 0.93 d⁻¹) parameters was used to fit the firmness data. 92
- Figure 5.5: Histogram of mean absolute error (MAE) of fits by CG₂ for the firmness date of 57 GLs during AFL monitoring in 2011. 93
- Figure 5.6: Comparison of raw (dots) and fits (red) of firmness data by CG₂ during AFL monitoring in 2011. GLs were selected to demonstrate the range of softening patterns including lines with minimum and maximum mean absolute error (MAE) of fits. Each dot point represents an average of 36 fruit. B represents upper asymptote (kg_f) and κ is rate of firmness change (d⁻¹). GL number shows the ascending order in which lines were collected over a harvest period of 5 weeks..... 94

- Figure 5.7: Histogram of GL dependent CG_2 parameters, B (A) and κ (B), estimated from 2011 AFL softening data and correlation between them (C). 95
- Figure 5.8: Correlation of rate of firmness change parameter (κ) during AFL monitoring with soft fractile at 100 day of optimal storage in 2011. Each data point is a GL. Red line represents an export threshold of 1 kg_f 96
- Figure 6.1: Fruit distribution and data collection for at-harvest, AFL and optimal storage measurements for each GL in 2012..... 103
- Figure 6.2: At-harvest SSC (A), DM (B) and firmness (C) of 51 GLs in 2012. Each data point represents a GL. For SSC and firmness, each data point shows an average of 36 fruit and for DM average of 15 fruit per GL. 105
- Figure 6.3: Raw (A) and fitted (B) softening curves of 51 GLs during AFL monitoring in 2012. CG_2 with global A_0 (0.31 kg_f) and β (125), and GL dependent B (range of 2.86 to 7.03 kg_f) and κ (range of 0.19 to 1.07 d^{-1}) parameters was used to fit the firmness data..... 107
- Figure 6.4: Histogram of mean absolute error (MAE) of fits by CG_2 for the firmness data of 51 GLs during AFL monitoring in 2012. 108
- Figure 6.5: Histogram of GL dependent CG_2 parameters, B (A) and κ (B), estimated from 2012 AFL softening data and correlation between them (C). 108
- Figure 7.1: Histogram of fruit firmness in 3 modular bulk (MB) packs. Packs represent same GL at one measurement occasion during AFL monitoring in 2010. Each pack contains 99 fruit. 118
- Figure 7.2: Kiwifruit in a modular bulk (MB) pack (A) demonstrating the spread of rot in comparison with fruit in single layer tray (B). 119
- Figure 7.3: CG fitted mean curves of AFL softening data collected in 21 (A), 18 (B), 15 (C) day with 3 day intervals and 18 day with 6 day intervals (D)..... 121
- Figure 7.4: Raw data (A), CG fitted (B) and time shift CG fitted (C) softening curves of 54 kiwifruit GLs randomly selected from harvest season of 2011 (blue) and 2012 (red). Raw data comprises of 8 data points (mean of 36 fruits) at 3 day interval. 128

- Figure 7.5: Inconsistent (blue) and incomplete (red) softening of GLs during AFL monitoring predicted by rate of firmness change (κ) thresholds ($\kappa_\alpha = 0.63$ and $\kappa_\beta = 0.53$) to have longer storage potential than observed in 2011 and 2012..... 130
- Figure 7.6: At-harvest SSC (A), DM (B) and firmness (C) of three seasons. Each data point represents an average for a GL. SSC shows an average of 36 fruit in 2010 and 30 fruit per GL in each of 2011 and 2012. Firmness represents an average of 297 fruit in 2010 and 36 fruit per GL in each of 2011 and 2012. DM shows an average of 30 in 2010 and 15 fruit per GL in each of 2011 and 2012..... 132
- Figure 7.7: Minimum temperature of Te Puke region in 2010 (red), 2011 (black) and 2012 (blue) during late autumn (21st April to 31st May) starting from ISO day of 111 to 152. Data were collected by National Institute of Water and Atmosphere, New Zealand..... 133
- Figure 7.8: Comparison of cumulative dispatch rate (%) of ‘Hayward’ main crop by industry and predicted by AFL method in 2011 and 2012. Sale pattern was predicted until 126 day of optimal storage for both seasons..... 134

List of Tables

Table 3.1: Parameters derived from AFL data at each measurement occasion. Each population was obtained from 3 MB packs of count 36 ‘Hayward’ kiwifruit resulting in approximately 300 individuals.....	40
Table 3.2: Pearson correlation coefficients (r) of at-harvest and AFL parameters with seasonal life (d) of ‘Hayward’ kiwifruit GLs. Yellow highlights represent negative correlation ($r \leq -0.5$) and green highlights show positive correlation ($r \geq 0.5$). Grey highlights represent unrounded coefficient values with $r \leq 0.5 $. NoF: number of fruit.	52
Table 3.3: Spearman correlation coefficients (r) of ranked at-harvest and AFL parameters with ranked seasonal life (d) of ‘Hayward’ kiwifruit GLs. Yellow highlights represent negative correlation ($r \leq -0.5$) and green highlights show positive correlation ($r \geq 0.5$). Grey highlights represent unrounded coefficient values with $r \leq 0.5 $. NoF: number of fruit.	54
Table 3.4: Correlation coefficients (r) of actual at-harvest and AFL parameters with ranked seasonal life (d) of ‘Hayward’ kiwifruit GLs. Yellow highlights represent negative correlation ($r \leq -0.5$) and green highlights show positive correlation ($r \geq 0.5$). Grey highlights represent unrounded coefficient values with $r \leq 0.5 $. NoF: number of fruit.	55
Table 3.5: Correlation coefficients (r) of seasonal life with soft fractile of GLs at each measurement occasion during optimal storage.	58
Table 4.1: Pearson correlation coefficients (r) of at-harvest and AFL parameters with soft fractile at 126 day of optimal storage. Yellow highlights represent negative correlation ($r \leq -0.5$) and green highlights show positive correlation ($r \geq 0.5$). Grey highlights represent unrounded coefficient values with $r \leq 0.5 $. NoF: number of fruit	75
Table 4.2: Spearman correlation coefficients (r) of ranked at-harvest and AFL parameters with ranked soft fractile at 126 day of optimal storage. Yellow highlights represent negative correlation ($r \leq -0.5$) and green highlights show positive correlation ($r \geq 0.5$). Grey highlights represent unrounded coefficient values with $r \leq 0.5 $. NoF: number of fruit	77

- Table 4.3: Correlation coefficients (r) of at-harvest and AFL parameters with ranked soft fractile at 126 day of optimal storage. Yellow highlights represent negative correlation ($r \leq -0.5$) and green highlights show positive correlation ($r \geq 0.5$). Grey highlights represent unrounded coefficient values with $r \leq |0.5|$. NoF: number of fruit..... 78
- Table 5.1: Example of contingency table to compare number of GLs measured and categorised by κ thresholds in three storage categories (low, medium and high). Green cells show correct categorisation. Yellow cells represent missed and red cells are for false categorisation. Row and column total shows number of GLs measured and categorised (respectively) in each storage category..... 88
- Table 5.2: AIC of CG versions with different combinations of global and GL dependent parameters. Full details of outputs are provided in appendix 1..... 89
- Table 5.3: Correlation coefficients (r) of fruit quality (firmness and rots) in optimal storage with AFL softening model parameters B (kg_f) and κ (d^{-1}) in 2011. 96
- Table 5.4: Contingency table compares the number of GLs measured and categorised by κ thresholds ($\kappa_\alpha = 0.63$ and $\kappa_\beta = 0.53$) in three storage categories (low, medium and high) in 2011. Green cells show correct categorisation. Yellow cells represent missed and red cells are for false categorisation. Row and column total shows number of GLs measured and categorised respectively in storage categories..... 97
- Table 6.1: Contingency table compares the number of GLs measured and categorised by κ thresholds ($\kappa_\alpha = 0.63$ and $\kappa_\beta = 0.53$) in three storage categories (low, medium and high) in 2012. Green cells show correct categorisation. Yellow cell represents missed and red cells are for false categorisation. Row and column total shows number of GLs measured and categorised (respectively) in each storage category 110
- Table 6.2: Contingency table compares the number of GLs measured and categorised by κ thresholds ($\kappa_\alpha = 0.67$ and $\kappa_\beta = 0.59$) in three storage categories (low, medium and high) in 2012. Green cells show correct categorisation.

Yellow cells represent missed and red cells are for false categorisation. Row and column total shows number of GLs measured and categorised (respectively) in each storage category.	111
Table 6.3: Contingency table compares the number of GLs measured and categorised by higher 60% of κ in two storage categories (low and high) in 2012. Green cells show correct categorisation. Yellow cells represent missed and red cells are for false categorisation. Row and column total shows number of GLs measured and categorised (respectively) in each storage category..	112
Table 7.1: Comparison of GL dependent parameters of CG fitted to softening data representing different data collection patterns.	121
Table 7.2: Correlation coefficients (r) of firmness change parameter (κ) of curves representing different data collection patterns in AFL monitoring with firmness in optimal storage.	122
Table 7.3: Correlation coefficients (r) of at-harvest fruit quality with GL dependent parameters of CG fitted for AFL data in 2011.	137

List of Abbreviations

AFL	accelerated fruit library (s)
A_o	lower asymptote of softening curve
B	upper asymptote of softening curve
β	horizontal shift factor of softening curve
CG	complementary Gompertz
$^{\circ}\text{C}$	degree Celsius
cm	centimetre (s)
CMM	complementary Michaelis–Menton
CO_2	carbon dioxide
d	day (s)
DM	dry matter (%)
EXP	exponential
FF	flesh firmness
g	gram (s)
GL	grower line (s)
h	hour (s)
IEP	inverse exponential polynomial
ISO	international organisation for standardisation
JMM	jointed Michaelis - Menten
κ	rate of softening
κ_{α}	threshold limit for higher κ value (s)
κ_{β}	threshold limit for lower κ value (s)
kg	kilogram (s)
kg_f	kilogram force
L	litre (s)
MAE	mean absolute error
MB	modular bulk (s)
Mg	magnesium
min	minute (s)
mm	millimetre (s)
μL	microlitre (s)

mL	millilitre (s)
n	number
N	newton
NZ	New Zealand
nL	nanolitre (s)
nlme	non-linear mixed effects
<i>O</i>	observed
<i>P</i>	predicted
ppb	part per billion (s)
ppm	part per million (s)
pptv	part per trillion volume (s)
%	percent
<i>r</i>	correlation coefficient
RH	relative humidity (%)
s	second (s)
SF	soft fractile
SSC	soluble solids content
t	time
τ	time shift