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# **The Influence of Breaks in Optimal Storage Conditions on 'Cripps Pink' Apple Physiology and Quality**

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

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## Abstract

Apples stored onshore in Australia and New Zealand, are maintained at optimal storage conditions with the aid of low temperatures; controlled atmospheres (CA) and new technologies that retard the production or effect of ethylene (AVG and 1-MCP respectively). These technologies allow distribution of the highest quality apples to local and export markets on a year round basis. However, during distribution, maintenance of optimal storage conditions may be lost due to refrigeration system breakdown, operational constraints or management decisions. This thesis quantifies the influence of commercially realistic breaks in optimal storage conditions (temperature and CA) on fruit physiology and quality, both at the time of the break and in subsequent optimal storage conditions. The 'Cripps Pink' ('Pink Lady™') apple cultivar was chosen for consideration in this thesis because it is a high value cultivar that is of considerable importance to the Australian apple industry.

The knowledge of the behaviour of 'Cripps Pink' apples in coolstorage conditions (in air and CA) was confirmed through comparison of physiological and quality change behaviour of fruit from three harvests collected in this research and those reported recently by other authors. The investigation of the influence of breaks in temperature control during storage in air at 0°C, revealed that preclimacteric apples exposed to a break in temperature control, were advanced towards the establishment of the climacteric. Postclimacteric apple, responded by doubling ethylene production a short time after return to coolstorage. Harvest maturity, timing of break during coolstorage, length of break of temperature control and multiple breaks in temperature control, had little influence on the increase ethylene production response. Quality factors (firmness, background hue angle, and titratable acidity) were all reduced as a result of exposure to warmer temperatures, but on return to coolstorage temperatures rates of loss in these quality factors were not influenced by the increased ethylene production.

Short-term (3-day) breaks in CA while fruit remained at refrigerated temperatures were shown to have no substantial effect on fruit physiology or quality, either during the period of the break in CA or in subsequent CA storage. Breaks in temperature control in combination with breaks in CA were observed to cause a doubling of ethylene production on CA stored apples regardless of being returned to 0°C in air or CA. Those apples that were exposed to a break in temperature control and returned to air storage at refrigerated temperature lost quality (firmness and background hue angle) more rapidly than apples not

exposed to breaks in temperature control and transferred to air storage. This result strengthened the knowledge of the influence of ethylene on changes in apple quality, as found for many other apple cultivars.

The influence of the decision to transport fruit in CA or air atmosphere shipping containers was initially investigated with a laboratory simulation. Physiology (respiration rate and ethylene production) of air shipped fruit was found not only to be more rapid, but more variable between fruit, than for apples shipped in CA. This more rapid and larger variation of possible fruit physiologies, suggests that in addition to losing quality at a faster rate, the variation in the quality of fruit shipped in air will also enlarge during shipment. This hypothesis was confirmed with data pooled from treatments subjected to 0°C and 3°C, simulating the likely temperature variability within a shipping container. Validation of the influence of shipping atmosphere on delivered fruit quality, was conducted in the commercial environment. This trial found that the length of time to ship fruit from Australia and New Zealand to European markets was not sufficient to induce commercially significant differences between 'Cripps Pink' apples shipped in the two atmospheres.

Finally, as ethylene production was influenced by fluctuations in temperature control and subsequently affected quality of apples previously stored in CA, an investigative attempt to model ethylene production in temperature variable scenarios was conducted. Published models of ethylene production in apples were adapted to the variable temperature storage scenario and a new model was proposed. Unfortunately, none of the models investigated were able to predict all of the consistent behaviours of ethylene production observed during the experimental work, indicating that more knowledge of the ethylene production pathway is required, before modelling of ethylene production and subsequently apple quality can be conducted successfully.

## **Acknowledgements**

This thesis was conducted as a joint partnership between Massey University, (New Zealand) and Food Science Australia, and subsequently conducted in both countries. Additionally, 6 months was also spent as a visiting scholar at the Catholic University of Leuven, Belgium. Subsequently, there are a lot of people to who deserve thanks, for aiding me to complete this piece of work.

First thanks should go to my team of supervisors (in no particular order), Dr Kate Maguire (RipeSense™), Assoc. Prof. John Mawson (Massey University), Dr Jenny Jobling (University of Sydney) and Dr David Tanner (Food Science Australia) for firstly providing the opportunity and then without exception providing useful feedback when required. Furthermore, thanks are extended to the members of the teams of Fresh Technologies (Massey University), Supply Chain Innovation (Food Science Australia), and the Sydney Postharvest Laboratory, who helped me collect the vast data sets. A special mention must go to Sarah Campbell for her year worth of painstaking GC work and Dr Victor Escalona who gave his time to aid me with my work in the UK. Thanks also to Prof. Bart Nicolai, for allowing me to continue my study at the Catholic University of Leuven and his colleague Dr Maarten Hertog for his ever critical, but never unwarranted modelling critic and advice.

As this work had a genuine focus on assessing commercial scenarios, many organisations in the industry deserve recognition for their help, including Mr Apple New Zealand Ltd; Batlow Fruit Co-op Ltd (NSW, Australia); Maersk Sealand, Donnybrook Packing Company (WA, Australia); and Empire World Trade (Pinchbeck, UK). Thanks must also go to Food Science Australia and Maersk Sealand for sponsoring this work and to The Royal Society of New Zealand and The New Zealand Fruitgrowers Federation for financial support.

Finally, I would like to thank my family and friends for all their support during my time as a PhD student. To my loving wife Ximenita, I've enjoyed our joint journey with doing PhDs together. Without your constant support, encouragement, assistance and critic, this thesis would not be half of what it is. I love you. A special thanks to my brother Grant and his partner Pauline, for putting up with me and my apples for a couple of weeks in London; and to my colleague and good friend Dr Nick Smale, for his ever reliable support and willingness to listen and help.



## Contents

<b>1. Thesis Outline.....</b>	<b>1</b>
<b>2. Literature Review .....</b>	<b>5</b>
2.1. THE INFLUENCE OF STORAGE CONDITIONS ON POSTHARVEST FRUIT QUALITY .....	5
2.1.1. Temperature.....	6
2.1.1.1. The Influence of Temperature Variation on Produce Quality .....	6
2.1.2. Controlled Atmosphere Gas Conditions .....	13
2.1.2.1. The Influence of Gas Atmosphere Variation on Produce Quality .	15
2.1.3. Ethylene.....	15
2.1.3.1. The Biochemistry of Ethylene in Fruit.....	16
2.1.3.2. The Influence of Ethylene on Fruit Ripening.....	20
2.1.3.3. Temperature Influence on Ethylene Production .....	20
2.1.3.4. CA Effects on Ethylene Production .....	21
2.2. THE 'CRIPPS PINK' APPLE CULTIVAR .....	22
2.2.1. Origins and Appearance .....	22
2.2.2. Current 'Cripps Pink' Knowledge .....	23
2.2.2.1. At Harvest Maturity .....	23
2.2.2.2. Cool Storage Performance .....	24
2.2.2.3. Ethylene and Storage .....	24
2.2.2.4. Storage Disorders .....	25
2.3. USING MATHEMATICAL RELATIONSHIPS TO DESCRIBE POSTHARVEST FRUIT PHYSIOLOGY AND QUALITY.....	26
2.3.1. Empirical Models .....	26
2.3.1.1. Correlations of Quality to Degree-Days .....	26
2.3.1.2. Empirical Fruit Quality Models.....	27
2.3.2. The Kinetic Assumption Approach .....	28
2.3.2.1. Kinetics Modelling Formulation.....	28
2.3.2.2. Modelling the Effect of Temperature on the Rate of Change .....	30
2.3.2.3. Quality Modelling Using the Kinetic Approach.....	31
2.4. CONCLUSIONS AND OPPORTUNITIES FOR RESEARCH.....	32
<b>3. Characterisation of the Postharvest Changes of 'Cripps     Pink' Apples Stored at Refrigerated Temperatures .....</b>	<b>35</b>
3.1. INTRODUCTION .....	35
3.2. METHODOLOGY.....	36
3.2.1. Fruit .....	36
3.2.2. Storage Conditions .....	36



3.2.2.1. Air Storage.....	36
3.2.2.2. CA Storage.....	36
3.2.3. Physiological Status .....	37
3.2.3.1. Air Storage.....	37
3.2.3.2. CA Storage.....	38
3.2.3.3. Respiration Rate Determination.....	38
3.2.3.4. Ethylene Production Determination.....	39
3.2.4. Firmness .....	39
3.2.4.1. Non-Destructive Firmness Measurements .....	39
3.2.4.2. Destructive Firmness Measurement .....	39
3.2.5. Background Colour .....	40
3.2.6. Other Quality Attributes .....	41
3.2.6.1. Weight Loss.....	41
3.2.6.2. Soluble Solids and Titratable Acidity .....	41
3.2.6.3. Disorders Incidence.....	41
3.3. RESULTS AND DISCUSSION .....	42
3.3.1. Physiological Status .....	42
3.3.1.1. Air Storage.....	42
3.3.1.2. CA Storage.....	44
3.3.2. Firmness .....	45
3.3.2.1. Air Storage.....	45
3.3.2.2. CA Storage.....	48
3.3.3. Background Colour .....	48
3.3.3.1. Air Storage.....	48
3.3.3.2. CA Storage.....	49
3.3.4. Other Quality Parameters .....	49
3.3.4.1. Weight loss .....	49
3.3.4.2. Soluble Solids and Titratable Acidity .....	50
3.3.4.3. Disorders Incidence .....	50
3.4. FURTHER DISCUSSION AND CONCLUSIONS .....	51
3.4.1. Correlations Between Quality Parameters .....	51
3.4.2. Sensitivity of quality parameters to ethylene in apple cultivars.....	53
3.4.3. Final Conclusions.....	53
<b>4. The Effect of Breaks in Temperature Control on 'Cripps</b>	
<b>Pink' Apple Physiology and Quality .....</b>	<b>55</b>
4.1. INTRODUCTION .....	55
4.2. METHODOLOGY.....	56
4.2.1. Fruit, Physiological and Quality Measurements .....	56



5.2.	METHODOLOGY .....	89
5.2.1.	Fruit .....	89
5.2.2.	Storage Conditions .....	89
5.2.2.1.	Storage Technique .....	89
5.2.2.2.	Treatments Combinations.....	90
5.2.3.	Physiology and Quality Assessment .....	91
5.2.3.1.	Respiration Rate and Ethylene Production.....	91
5.2.3.2.	Firmness and Colour.....	91
5.2.4.	Data Analysis.....	93
5.3.	RESULTS AND DISCUSSION .....	93
5.3.1.	Breaking CA at Refrigerated Temperatures .....	93
5.3.1.1.	Permanent Removal from CA.....	93
5.3.1.2.	Breaking CA During Storage to Allow other Apples to be Removed .....	96
5.3.2.	Breaks in CA in Combination with Breaks in Temperature Control at Time of Loadout. ....	96
5.3.2.1.	Respiration Rate and Ethylene Production.....	96
5.3.2.2.	Firmness .....	98
5.3.2.3.	Colour .....	99
5.4.	FURTHER DISCUSSIONS AND CONCLUSIONS .....	99
5.4.1.	The Effect of Breaking CA on Apple Physiology .....	99
5.4.2.	The Influence of Ethylene on Apple Quality .....	101
5.4.3.	The Influence of CA and Temperature on Range of Fruit Physiologies .....	103
5.4.4.	Final Conclusions.....	104
<b>6.</b>	<b>The Effect of Shipping Atmosphere on 'Pink Lady™' Apple Quality.....</b>	<b>108</b>
6.1.	INTRODUCTION .....	108
6.2.	METHODOLOGY.....	108
6.2.1.	Fruit .....	108
6.2.2.	Container Settings.....	109
6.2.3.	Environmental Conditions Monitoring .....	109
6.2.3.1.	Apple Grading and Packing .....	109
6.2.3.2.	Shipping .....	109
6.2.3.3.	Shelf Life .....	111
6.2.4.	Quality Assessment .....	111
6.2.4.1.	Firmness.....	111
6.2.4.2.	Colour .....	111

6.2.4.3. Superficial Scald .....	112
6.2.5. Data Analysis .....	112
6.3. RESULTS AND DISCUSSION .....	112
6.3.1. Environmental Conditions .....	112
6.3.1.1. Apple Grading and Packing .....	112
6.3.1.2. Shipping Conditions.....	113
6.3.1.3. Shelf Life .....	113
6.3.2. Quality Assessment .....	115
6.3.2.1. Firmness .....	115
6.3.2.2. Colour .....	118
6.3.2.3. Superficial Scald .....	120
6.4. FURTHER DISCUSSION AND CONCLUSIONS .....	121
6.4.1. Validation of Quality Variation Increase Effect .....	121
<b>7. Modelling Ethylene Production in 'Cripps Pink' Apples</b>	
<b>Exposed to Variable Temperature Scenarios.....</b>	<b>123</b>
7.1. INTRODUCTION .....	123
7.2. MODELS EVALUATED .....	126
7.2.1. Commonly Used Equations .....	127
7.2.1.1. Arrhenius' Equation .....	127
7.2.1.2. Diffusion of Ethylene to Calculate Measured Ethylene Production.	
.....	127
7.2.2. Model of Tijskens et al. (1999) .....	128
7.2.3. Model of Genard and Gouble (2005) .....	129
7.2.4. The Proposed Model.....	131
7.3. METHODS.....	134
7.3.1. Treatment Selection.....	134
7.3.1.1. Model Development.....	134
7.3.1.2. Model Testing .....	135
7.3.2. Model Parameter Optimisation.....	135
7.4. RESULTS AND DISCUSSION .....	135
7.4.1. Model of Tijskens et al. (1999) .....	136
7.4.2. Model of Genard and Gouble (2005) .....	137
7.4.3. The Proposed Model.....	139
7.5. FURTHER DISCUSSION AND CONCLUSIONS .....	143
7.6. NOTATION.....	147
<b>8. Overall Discussion and Recommendations.....</b>	<b>148</b>
8.1. Introduction.....	148
8.2. Postharvest Behaviour of the 'Cripps Pink' Apple cultivar .....	148

8.3.	The Effect of Breaks in Temperature Control .....	149
8.3.1.	Apple Physiology .....	149
8.3.2.	Apple Quality .....	150
8.4.	Breaks in Controlled Atmospheres .....	151
8.4.1.	Permanent Removal from CA .....	151
8.4.2.	Breaks in CA while Remaining at 0°C .....	151
8.4.3.	Breaks in CA in Combination with Breaks in Temperature Control. .	152
8.4.4.	Physiology and Quality Variation Suppression Effect of CA .....	152
8.5.	The Influence of Ethylene on Apple Quality .....	153
8.6.	Models of Ethylene Production.....	155
8.7.	Future Opportunities .....	157
8.7.1.	Further evaluation of the Induced Increase in Ethylene Production. 157	
8.7.1.1.	Further Opportunities with the 'Cripps Pink' Apple Cultivar .....	157
8.7.1.2.	Response of Other Apple Cultivars and Horticultural Products .	157
8.7.1.3.	Potential for Increased Volatile Production.....	157
8.7.1.4.	Use of Documented Response to Gain Understanding of Ethylene Control Systems.....	158
8.7.2.	Evaluation of Other Temperature Fluctuation Scenarios .....	158
8.7.3.	Consequences of the Induced Increase in Ethylene Production on Laboratory Technique.....	159
8.7.4.	Comparison of Apple Cultivars to Gain Understanding of Ethylene Control and Quality Influences. ....	159
8.7.5.	Optimisation of Controlled Atmosphere Operations .....	159
8.7.6.	Economical Evaluation of the Benefit of CA Containers .....	160
8.7.7.	Creation of Models that Predict Fruit Physiology and Subsequent Quality Changes. ....	161
<b>9.</b>	<b>References .....</b>	<b>163</b>
<b>10.</b>	<b>Appendix .....</b>	<b>180</b>
10.1.	ADAPTED MODEL OF TIJSKENS ET AL. (1999).....	180
10.2.	ADAPTED MODEL OF GENARD AND GOUBLE (2005).....	182
10.3.	THE PROPOSED MODEL.....	184