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Manipulating harvest maturity and ethylene to extend storage life of feijoa

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

Srikanth Rupavatharam

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Abstract

In New Zealand feijoa (*Acca sellowiana*) are harvested by touch-picking and can be stored at 4 °C and 90% RH for up to 4 weeks with a subsequent shelf life of 5-7 d at 20 °C. Extending the storage potential of feijoa can enable export to new marketplaces through sea freight. The objective of this work was to extend the storage life of feijoa. Harvest maturity, variability within batch and ethylene all have the potential to influence postharvest storage performance.

Harvesting feijoa earlier not only makes touch-picking irrelevant but will necessitate changes to the present grading standards of feijoa. Harvesting feijoa 2 weeks prior to touch-picked maturity consistently enabled storage life extension for up to 6 weeks at 4 °C with a subsequent shelf life of 5 d at 20 °C. However, these fruit were low in SSC with high TA suggesting that their taste profiles may be altered and hence a consumer taste acceptance investigation is recommended. There is also a need to identify a ripening index for feijoa while redefining grading criteria suitable for both local and export markets.

This work demonstrates that feijoa having higher °hue (> 122) at the time of harvest possessed longer storage potential than those with lower °hue (< 122) that are ready-to-eat. Blocking ethylene responses of touch-picked or early harvested feijoa by postharvest 1-methylcyclopropene treatment had minimal effect on physiology (ethylene production and respiration rates) or quality after storage. Feijoa were also insensitive to exogenous ethylene application while CA technology stimulated surface injury. However preharvest Aminoethoxyvinyl glycine (AVG) application reduced fruit drop and delayed maturity (retaining firmness) of feijoa at the time of commercial harvest. AVG suppressed ethylene production during storage without altering quality attributes (firmness, SSC, TA
or flesh colour). A conceptual model was developed to summarise feijoa responses to ethylene manipulations. Postharvest ripening in feijoa appears to be substantially ethylene-independent.

Storage life of feijoa was extended by harvesting fruit earlier than current touch-picking maturity. Segregating feijoa by skin colour change would allow sea freight of less mature fruit. However, taste acceptance of these fruit and commercial trials of preharvest AVG are required before practical recommendations can be made to the industry.
Acknowledgements

I am grateful to the Lord God Almighty for giving me an opportunity to work in this project. I am very thankful to my chief supervisor Dr. Andrew East for his excellent advice, cherished feedback and continued support during the study. I thank my co-supervisor Professor Julian Heyes for his suggestions, guidance and encouragement during this work.

I am thankful to Peter Jeffrey, Sue Nicholson for their brilliant technical support and Jamal for analysing fruit X-rays. I thank all my colleagues at Centre for Postharvest and Refrigeration Research for their constructive appraisal on my research findings during discussion meetings.

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I would like to take this opportunity to appreciate the church, my mum, daughter, sisters and friends for their unwavering support in prayer and encouragement. This work is dedicated to my father whose word is to get wisdom though it cost all you have. It is the glory of God to conceal a matter, to search out a matter is the glory of kings (Proverbs, Holy Bible).
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<th>Full Form</th>
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<tbody>
<tr>
<td>ACC</td>
<td>aminocyclopropane-1-carboxylic acid</td>
</tr>
<tr>
<td>ACO</td>
<td>ACC oxidase</td>
</tr>
<tr>
<td>ACS</td>
<td>ACC synthase</td>
</tr>
<tr>
<td>Ag</td>
<td>silver</td>
</tr>
<tr>
<td>AgNO₃</td>
<td>silver nitrate</td>
</tr>
<tr>
<td>AIN</td>
<td>ACC insensitive</td>
</tr>
<tr>
<td>ANOVA</td>
<td>analysis of variance</td>
</tr>
<tr>
<td>AOA</td>
<td>aminooxyacetic acid</td>
</tr>
<tr>
<td>Au</td>
<td>gold</td>
</tr>
<tr>
<td>AVG</td>
<td>aminoethoxyvinylglycine</td>
</tr>
<tr>
<td>°C</td>
<td>degree Celsius</td>
</tr>
<tr>
<td>C</td>
<td>carbon</td>
</tr>
<tr>
<td>C₂H₄</td>
<td>ethylene</td>
</tr>
<tr>
<td>CA</td>
<td>controlled atmosphere</td>
</tr>
<tr>
<td>cnr</td>
<td>colourless non-ripening</td>
</tr>
<tr>
<td>CNT</td>
<td>controls</td>
</tr>
<tr>
<td>CO₂</td>
<td>carbon dioxide</td>
</tr>
<tr>
<td>CoCl₂</td>
<td>cobalt chloride</td>
</tr>
<tr>
<td>CT</td>
<td>computed tomography</td>
</tr>
<tr>
<td>Cu</td>
<td>copper</td>
</tr>
<tr>
<td>d</td>
<td>day (s)</td>
</tr>
<tr>
<td>DACP</td>
<td>diazocyclopentadiene</td>
</tr>
<tr>
<td>DMCP</td>
<td>3,3-dimethylcyclopropene</td>
</tr>
<tr>
<td>DNP</td>
<td>2,4-dinitrophenol</td>
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EIN  ethylene insensitive
ERS  ethylene response sensor
ETO  ethylene overproducing
ETR  ethylene receptor
FDP  fruit development period
g   grams
GDD  growing degree days
GLM  general linear model
H   hydrogen
h   hour
H₀   harvest at touch-picking maturity
H₁   harvest at one week before touch-picked maturity
H₂   harvest at two weeks before touch-picked maturity
H₄   harvest at four weeks before touch-picked maturity
HCN  hydrogen cyanide
HP   hewlett packard
HU   hounsfield unit
I_AD  interactance spectrum
kg   kilogram
kPa  kilo Pascal
L   litre
µL  micro-litre
L*  lightness
lb   pound force
LEACS  Lycopersicon esculentum ACS
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Definition/Description</th>
</tr>
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<tbody>
<tr>
<td>MCP</td>
<td>1-methylcyclopropene</td>
</tr>
<tr>
<td>min</td>
<td>minute</td>
</tr>
<tr>
<td>mL</td>
<td>millilitre</td>
</tr>
<tr>
<td>MRI</td>
<td>magnetic resonance imaging</td>
</tr>
<tr>
<td>MTA</td>
<td>5'-methylthioadenosine</td>
</tr>
<tr>
<td>N</td>
<td>newton</td>
</tr>
<tr>
<td>N₂</td>
<td>nitrogen</td>
</tr>
<tr>
<td>NAI</td>
<td>normalised anthocyanin index</td>
</tr>
<tr>
<td>NBD</td>
<td>2,5-norbornadiene</td>
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<tr>
<td>NDVI</td>
<td>normalised difference vegetation index</td>
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</tr>
<tr>
<td>nL</td>
<td>nano-litre</td>
</tr>
<tr>
<td>nmol</td>
<td>nano-mole</td>
</tr>
<tr>
<td>nor</td>
<td>non ripening</td>
</tr>
<tr>
<td>NS</td>
<td>not significant</td>
</tr>
<tr>
<td>NZFGA</td>
<td>New Zealand Feijoa Growers Association</td>
</tr>
<tr>
<td>O₂</td>
<td>oxygen</td>
</tr>
<tr>
<td>PAL</td>
<td>Phenylalanine ammonia-lyase</td>
</tr>
<tr>
<td>PLP</td>
<td>pyridoxal-5'-phosphate</td>
</tr>
<tr>
<td>pmol</td>
<td>pico-mole</td>
</tr>
<tr>
<td>POD</td>
<td>peroxidase</td>
</tr>
<tr>
<td>PPO</td>
<td>polyphenol oxidase</td>
</tr>
<tr>
<td>PVC</td>
<td>polyvinylchloride</td>
</tr>
</tbody>
</table>
R2E  ready to eat
$(r_{\text{co}_2})$  carbon dioxide production rate
RH  relative humidity
$rin$  ripening inhibitor
s  second
SAM  S-adenosylmethionine
SRS  space resolved spectroscopy
SSC  soluble solids content
STR  storage
STS  silverthiosulphate
TA  titratable acidity
TRS  time resolved spectroscopy
UK  United Kingdom
USA  United States of America
v/v  volume / volume
w/w  weight / weight
%  percent