

Citrus Maturity and Packinghouse Procedures

Table of Contents

	Page
Preface	ii
Introduction	xix
Fig. 1. Climacteric and non-climacteric life cycles	
Table 1. Area and disposition of Florida citrus 1976-77	xxiii
Table 2. History of citrus fruit handling	
Table 3. Outline of fruit characters, modifiers and legal consumer factors	xxix
Table 4. Glossary	xxxi
Table 5. Conversion factors	xxxvi
<u>Selected References</u>	xxxvii

Part I. FRUITS

I. <u>Fruit Structure and Composition</u>	2
A. <u>Structure</u>	2
B. <u>Composition</u>	4
Fig. 2. Structure of a citrus fruit	5
Table 6. Composition of orange juice	6
<u>Selected References</u>	
II. <u>Commercial Varieties of Citrus</u>	9
A. <u>Oranges</u>	9
1. Early	9
2. Early-midseason	9
3. Midseason	9
4. Late	10
B. <u>Grapefruit</u>	11
1. White seeded	11

Citrus Maturity and Packinghouse Procedures

Table of Contents (cont.)

	Page
2. Pink seeded	11
3. White seedless	11
4. Pink and red seedless	11
C. Specialty Fruits	11
1. 'Temple'	11
2. Tangerines	12
3. Satsumas	12
4. Tangelos	12
5. 'K-Early'	13
D. Acid Citrus Fruits	13
1. Lemons	13
2. Limes	13
Selected References	14
 III. Commercial Rootstocks	 15
Rough lemon group	16
Sour orange group	16
Fig. 3. Total soluble solids and acid of 'Duncan' and 'Marsh' grapefruit	17
Fig. 4. Soluble solids:acid ratio of 'Duncan' and 'Marsh' grapefruit	18
Selected References	19
 IV. Fruit Characters	 20
A. Seasonal Changes	20
B. Edibility	22
Fruit Characters	22
1. Internal	23
a. Organic acids	23
b. Total soluble solids	23
c. Total soluble solids:total (titratable) acid ratio	24
d. Juice content	25
e. Ascorbic acid (Vitamin C)	26

Citrus Maturity and Packinghouse Procedures

Table of Contents (cont.)

	Page
f. Active acidity (pH)	27
g. Flesh color and texture	27
h. Volatiles	27
i. Seeds, rag	27
2. External	28
a. Color	28
b. Texture	29
c. Discoloration	30
d. Blemishes	30
1) Scars	30
2) Melanose	32
3) Scab	32
4) Scales	32
5) Unhealed cuts	32
6) Bruises	33
7) Oil spotting (oleocellosis)	33
8) Oil blotch and spray burn	34
9) Hail damage	34
10) Grasshopper and katydid damage	34
11) Sunburn and sun scald	34
12) Sprouted seeds	34
13) Rough or protruding navels	34
14) Creasing	35
15) Rind breakdown	35
16) Mushiness or dryness (freeze damage)	35
17) Granulation	35
18) Miscellaneous	36
3. Miscellaneous	36
a. Weight	36
b. Size and form (shape)	36
c. Firmness	37

Citrus Maturity and Packinghouse Procedures

Table of Contents (cont.)

	Page
d. Age	37
e. Decay	37
D. <u>Consumer Factors</u>	38
1. Appearance	38
2. Palatability	39
a. The "Pritchett tongue"	39
b. Harding et al.'s nomographs	39
c. Variation of grapefruit within a packed box	40
Fig. 5. Average titratable acidity (A), total soluble solids (B), soluble solids:acid ratio (C), and juice content (D) of citrus fruit	42
Fig. 6. Maturity requirements for Brix and Brix:acid ratio in Florida 'Duncan' grapefruit	44
Fig. 7. Juice content (%, v/v) of Florida lemons during several seasons	45
Fig. 8. The "Pritchett tongue"	46
Fig. 9. Nomograph for soluble solids and acid of oranges	47
Table 6A. Grades and grade-lowering defects	47a
Table 7. Soluble solids, acid, ratio, and juice content of individual 'Duncan' grapefruit	48
Table 8. Soluble solids, acid, ratio, and juice content of individual 'Marsh' grapefruit	49
<u>Selected References</u>	50
V. <u>Preharvest Modifiers of Fruit Quality</u>	56
A. <u>Geographical (Location) Influences</u>	56
1. Climate	57
2. Soils	58
B. <u>Cultural Practices</u>	58
1. Mineral nutrition	58
2. Sprays	60
a. Scalicides	61
b. Arsenicals	61

Citrus Maturity and Packinghouse Procedures

Table of Contents (cont.)

	Page
c. Physiological sprays for fruit drop size and set	63
d. Physiological sprays for abscission	64
3. Water relations	65
4. Pruning	65
5. Tree age	65
C. Variation of Individual Fruit on a Tree	66
Fig. 10. Broad effects of geographical influences upon citrus fruit qualities	68
Fig. 11a. Seasonal variations in total soluble solids and acid of 'Marsh' grapefruit at Davenport	69
Fig. 11b. Seasonal variations in soluble solids:acid ratio of 'Marsh' grapefruit at Davenport	70
Fig. 12a. Variations of total soluble solids and acid of 'Marsh' grapefruit at several locations	71
Fig. 12b. Variations of soluble solids:acid ratio of 'Marsh' grapefruit at several locations	72
Fig. 13a. Trends in total soluble solids and acid of arsenated and non-arsenated 'Marsh' grapefruit	73
Fig. 13b. Trends in total soluble solids and acid of arsenated and non-arsenated 'Duncan' grapefruit	74
Fig. 13c. Trends in soluble solids:acid ratio of arsenated and non-arsenated 'Marsh' and 'Duncan' grapefruit	75
Fig. 14. Light classes and trends in constituents of individual 'Valencia' orange fruit on a tree	76
Fig. 15. Variation of total soluble solids with compass direction of individual 'Valencia' oranges on a tree	77
Fig. 16. Variation of total (titratable) acidity with compass direction of individual 'Valencia' oranges on a tree	78

Citrus Maturity and Packinghouse Procedures

Table of Contents (cont.)

	Page
17. Variation of soluble solids:acid ratio with compass direction of individual 'Valencia' oranges on a tree	79
Fig. 18. Variation of % juice with compass direction of individual 'Valencia' oranges on a tree	80
Fig. 19. Variation of vitamin C with compass direction of individual 'Valencia' oranges on a tree	81
Table 9. Comparison of oil-emulsion and parathion sprays with respect to total soluble solids, acid and ratio of 'Hamlin' and 'Parson Brown' oranges	82
Table 10. Average values for qualities of individual 'Valencia' oranges	83
Table 11. Relation of spot picking to total soluble solids of 'Valencia' oranges	84
<u>Selected References</u>	85
 Part II. POSTHARVEST PROCEDURES	 94
 VI. Respiration-Humidity-Degreening-Refrigeration	 99
A. <u>Respiration</u>	99
B. <u>Humidity</u>	101
1. Expressions	102
2. Some physical properties	103
3. Interactions with temperature and air movement	105
4. Desiccation, wound healing and chilling injury	105
C. <u>Degreening</u>	106
1. Operating conditions	107
2. Factors affecting degreening	109
3. Degreening rooms	110
D. <u>Refrigeration</u>	113
1. Definitions and terminology	114
2. Where should the temperature of a fruit be measured?	117

Citrus Maturity and Packinghouse Procedures

Table of Contents (cont.)

	Page
3. In-transit refrigeration	118
4. Precooling	118
5. Storage	
Fig. 20. Stylized psychrometric charts (A in U.S., B in metric units)	
Fig. 21. Psychrometric chart showing absolute (specific) humidity at 95% relative humidity and 5 temperatures	123
Fig. 22. Variation of frost hazard with humidity	124
Fig. 23. Changes in % relative humidity inside bags of oranges in master cartons during simulated transit and holding periods	
Fig. 24. Changes in % relative humidity inside loose bags of grapefruit during simulated transit and holding periods	126
Fig. 25. Hygrothermograph record of changes in relative humidity with minor fluctuations in temperature in a cold storage	
Fig. 26. Drastic increase of stem-end rind breakdown with low humidity	
Fig. 27. Slatted- and solid-floor degreening rooms (now obsolete)	
Fig. 28. False-ceiling solid-floor degreening rooms (now obsolete)	
Fig. 29. Bulk degreening bin (vertical section showing baffles)	
Fig. 30. Original design of end-flow degreening room for pallet boxes	
Fig. 31. Pallet box degreening room: a. Floor plan, b. vertical sections, c. overhead view, operated as single unit, d. overhead view, operated as 3 units	
Fig. 32. Stylized mechanical refrigeration cycle	

Citrus Maturity and Packinghouse Procedures

Table of Contents (cont.)

Fig. 33. Refrigeration capacity as related to suction and head pressures	
Fig. 34. Refrigeration power requirement as related to suction and head pressures	
Fig. 35. Diagram of experimental batch-type forced-air precooler	140
Fig. 36. Diagram of experimental 5-stage continuous flow forced-air precooler	
Fig. 37. Typical cooling curves for air and forced-air precooling and hydrocooling	
Table 13. Heat of respiration for certain fruit and temperatures	
Table 14. Relative decay following stem-end rind breakdown of fruit held under high and low humidity	144
Table 15. Some thermodynamic data for citrus fruit	145
Table 16. Transit and storage conditions for citrus fruit	
Table 17. Calculation of cooling requirements for a trailer load of oranges in cartons	147
Table 17A. Storage of Citrus fruits	148a
<u>Selected References</u>	149
VII. Postharvest Disorders and Their Controls	
A. <u>Pathological Disorders</u>	157
1. Stem-end rots	158
2. Blue and green molds	159
3. Brown rot	160
4. Alternaria rot	160
5. Anthracnose	161
6. Sour rot	161
B. <u>Physiological Disorders</u>	162
1. Rind breakdowns	162
a. Stem-end rind breakdown	162
b. Ageing	163

Citrus Maturity and Packinghouse Procedures

Table of Contents (cont.)

	Page
c. Pitting	163
d. Chilling injury	163
e. Gas burn of 'Temple', tangerines and tangelos	164
f. "Gas burn" of oranges and grapefruit	164
g. Zebra skin of tangerines	165
h. Sloughing disease of grapefruit	165
i. Stylar-end breakdown of 'Persian' ('Tahiti') limes	165
j. Oleocellosis (oil spotting)	166
k. Wood pocket of limes and lemons	166
l. Albedo browning and red blotch of lemons	166
2. Internal breakdowns	166
a. Freeze injury	166
b. Granulation	
c. Watery breakdown	
d. Membranous stain of lemons	167
3. Shriveling	167
C. Insects	
D. <u>Controls for Postharvest Disorders</u>	
1. Hot water or hot soapy water	169
2. Borax or borax-boric acid	169
3. Sodium or calcium hypochlorite	169
4. Sodium carbonate or bicarbonate	169
5. O-phenyl phenol	169
6. Dowicide A-hexamine	169
7. Diphenyl	170
8. Ammonia gas	170
9. 2,4-Dichlorophenoxyacetic acid	170
10. Thiabendazole, benomyl	170
11. 2-Aminobutane	170
E. <u>Legal Aspects and Screening Tests</u>	171
Fig. 38. More important postharvest disorders of Florida citrus fruit	

Citrus Maturity and Packinghouse Procedures

Table of Contents (cont.)

Table 18. Fungicide or fungistat treatment required for fresh citrus fruit	173
Selected References	174
VIII. Harvesting--Methods of Handling	182
Harvesting	182
B Methods of Handling	185
1. Pallet boxes	
2. Two-wheel trailers	187
a. Short-haul	187
b. Long-haul	187
3. Chapman loader	188
4. Tractor baskets	188
5. Bins	188
Table 19. Grove sampling and crop estimation	190
Selected References	192
IX. Packinghouse Procedures	
A Pre-Packinghouse Operations	198
B Basic Principles for Packinglines	198
C Packingline Operations	200
1. Dumping	200
a. Surge control	200
b. Trash elimination	200
c. Presizing	201
d. Pregrading	201
2. Washing	202
a. Wetting	202
b. Sudsing	202
c. Washing	202
d. Water elimination	202
e. Effluent treatment	203

Citrus Maturity and Packinghouse Procedures

Table of Contents (cont.)

	Page
3. Grading	204
4. Color add	
5. Drying and polishing	208
6. Waxing	209
a. Slab wax	209
b. Solvent-type "waxes"	209
c. Water-emulsion "waxes"	209
d. Fungicidal "waxes"	210
7. Fungicide application	211
a. Thiabendazole and benomyl	211
b. Sodium o-phenylphenate	211
c. Diphenyl	211
8. Stamping	211
9. Sizing	212
a. Belt-and-roll	212
b. Transverse	213
D. Post-Packingline Operations	
1. Packing	214
a. Carton filling	214
b. Bag filling	214
c. Place packing	215
d. Consumer packs	216
e. Gift fruit	216
2. Precooling	216
3. Order assembly and palletizing	217
4. Loading	217
5. Transportation	218
6. Market handling	219
E. Miscellaneous Procedures	219
1. Freeze damage separation	219
2. Packinghouse operations as sources of fruit damage	220
3. Handling of Florida lemons	221
Fig. 39. Packinghouse flow sheet.	223

Citrus Maturity and Packinghouse Procedures

Table of Contents (cont.)

Fig. 40.	Gift house flow sheet	
Fig. 41.	Combined water eliminator and fungicide wax applicator	225
Fig. 42.	Effluent recycling system	226
Fig. 43.	Multiple grade tables	
Table 20.	Physical characteristics of citrus fruit	228
Table 21.	Formulas involved in conveyor capacity	229
Table 22.	Standard equipment dimensions	230

Selected References

X	<u>Future Trends in Packinghouse Handling</u>	
A.	<u>Packout</u>	233
B.	<u>Inventory-to-Inventory Packing</u>	234
C.	<u>Consumer Packaging of Citrus Fruit</u>	235
Fig. 44.	Effect of packout on grower profits	238
Fig. 45.	Orange fresh fruit packinghouse fully integrated with a cannery	
Fig. 46.	The "Mad Customer Index": Spoiled packages at retail sale and "fruit bowls" with rots	
Table 23.	Grade-lowering defects in oranges and grapefruit	241

Selected References

	<u>Part III. LEGAL FACTORS</u>	244
XI	<u>Legal Factors</u>	245
A.	<u>Fresh Fruit Maturity</u>	245
1.	Legal requirements	245
2.	Laws and Official Rules	246
a.	Citrus Laws	246
b.	Official Rules	246
3.	Summary of maturity requirements	247
a.	General	247
b.	Oranges	247

Citrus Maturity and Packinghouse Procedures

Table of Contents (cont.)

	Page
c. Grapefruit	248
d. Tangerines	248
e. 'Temples'	248
f. Tangelos and 'K-Early'	248
g. 'Honey' tangerine ('Murcott')	249
4. Procedure for maturity tests	
a. Facilities and equipment	249
b. Sized fruit	249
c. Color break	249
d. Juice content	
e. Total soluble solids	250
f. Total (titratable) acid	250
g. Soluble solids:acid ratio	250
h. Comparison with legal requirements	250
B. Fresh Fruit Grade Inspection	251
1. Legal requirements	251
a. U.S. standards	251
b. Florida standards	
2. Standards for U.S. No. 1	253
a. Special terms and limitations	253
b. Standards for U.S. No. 1 oranges and tangelos	253
c. Subclasses of grades	253
d. Tolerances	253
3. Inspection for grade	254
a. Packinghouse grading	254
b. Official inspection	254
C. Processed Fruit	255
1. Summary of maturity requirements	256
a. Orange	256
b. Grapefruit	256
c. Tangerines	256
d. 'Temples'	256

Citrus Maturity and Packinghouse Procedures

Table of Contents (cont.)

	Page
e. Tangelos and 'K-Early'	257
f. 'Honey' tangerine	257
2. Maturity (quality) tests	257
3. Standards for grades	258
a. Florida standards	259
b. U.S. standards	261
4. Evaluation of frozen concentrated orange juice	261
a. Standards	262
b. Evaluation of reconstituted concentrate	262
Fig. 47. Florida Citrus Commission districts	265
Fig. 48. (Federal-State) (Citrus) Marketing Agreement districts	266
Fig. 49. Regulation areas of the (Citrus) Marketing Agreements	267
Fig. 50. Florida grapefruit juice requirements	268
Fig. 51. Nomograph for soluble solids:acid ratio	269
Fig. 52. Cannery flow-sheet	270
Fig. 53. Nomograph for pounds-solids per box and price	271
Fig. 54. Nomograph for pounds-juice per box price	272
Table 24. Laws, agencies and boards affecting the Florida citrus industry	273
Table 25. Florida Dept. of Citrus Official Rules applying to packinghouses and canneries	276
Table 26. Factors used in maturity standards for fresh fruit	278
Table 27. Factors used in maturity standards for cannery fruit	278
Table 28a. Florida grapefruit juice standards expressed in metric and as % juice	279
Table 28b. Formulas for calculating juice requirements	280
Table 29. Equipment for fresh fruit maturity tests	281
Table 30. Equipment for cannery fruit maturity tests	281
Table 31. Conversion of cc juice to gallons per box for oranges	282
Table 32. Temperature correction table for Brix hydrometer	283

Citrus Maturity and Packinghouse Procedures

Table of Contents (cont.)

	Page
Table 33. Conversion of ml standard alkali to % citric acid	284
Table 34. Standards for U.S. No. 1 Florida oranges, grapefruit and tangerines	286
Table 35. Subclasses of U.S. grades	
Table 36. Preliminary note sheets for grade inspection: a. Oranges, b. Grapefruit, c. Tangerines	
Table 37. Score sheet for color of processed citrus juices	
Table 38. Score sheet for flavor rating of processed citrus juices	

Selected References

APPENDIX

A. <u>Graphs from Seasonal Changes Bulletins</u>	299
B. <u>Maturity Standards for Florida Citrus Fruit</u>	