IMPACT OF LATE HARVEST ON CITRUS CROP LOSSES AND JUICE QUALITY

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Abstract. Following the freezes of the 1980s and the 2004 hurricanes, the number of processing plants and packinghouses decreased as a result of reduced availability of fruit, and structural damage to some packinghouses. During the same period, the shift from FCOJ (Frozen Concentrated Orange Juice) to NFC (Not from Concentrate) required increased cold storage capacity as more juice was being stored as single strength. Processors preferred for growers to delay harvest and hold fruit on the tree rather than having to increase processed product storage capacity. Growers have been concerned about their fruit losses from preharvest drop and return crop, reduced juice content and higher sugar to acid ratios above the preferred range for best consumer acceptance of NFC. Previous studies and data from the Florida Agricultural Statistical Service (FASS) confirmed that preharvest drop increased about 3% loss per month of delay in harvest, and yield in the following year decreased in response to late harvest. These combined losses can be as much as 20% but more typically are in the 10 to 15% range. Juice content and soluble solids per box did not decrease through February for early-midseason oranges, or through June for late harvest cultivars. The average brix/acid ratio did increase to the upper acceptable level (19) by February in early-mids and by June in late season cultivars. Many citrus blocks are out of the acceptable ratio range by these dates. Selecting blocks with smaller crops for late harvest to minimize reduced return crop effects and choosing high acid fruit for late harvest in order to provide acceptable ratio fruit for NFC late in each harvest period may be desirable. In some years, preharvest drop rates were much higher than in other years. The reasons for this should be examined.

Following the freezes of the 1980s, the number of processing plants and packinghouses decreased as a result of reduced availability of fruit. During that same period, the shift from FCOJ to NFC required increased cold storage capacity as more juice was being held as single strength. Processors preferred for growers to delay harvest and hold fruit on the tree rather than increase processed product storage capacity. In addition, the 2004 hurricanes reduced the number of packing houses in Florida and the overall production capacity of fresh fruit because of tree losses and the spread of citrus canker. Harvesting labor shortages added to the harvesting problems and resulted in delayed harvests even though production was lower than in previous years. The combination of these circumstances has created new adverse conditions for the grower.

Late harvest has resulted in more fruit loss from preharvest drop, but that effect is not well documented for Florida (Ali Dinar et al., 1976). Late harvest can reduce the following year’s bloom and yield particularly for ‘Valencia’ orange trees in Arizona and California (Hilgeman et al., 1967a, b; Jones and Cree, 1954; Jones et al., 1964). Limited data suggest that similar effects occur in Florida (Ramirez et al., 1977).

Fruit juice content and acidity may decline to unacceptable levels in late harvested fruit particularly in tropical climates (Reuther and Rios-Castano, 1969). The impact of late harvest on these variables in Florida oranges is not clear. The objective of this work was to use available literature and data from the Florida Agricultural Statistical Services (FASS) to determine the impact of late harvest of early-mid season and late season orange types on fruit drop, fruit quality and return yield in the following year. The outcome of this analysis was the basis of an assessment of negative impacts that late harvest has on production and fruit quality of citrus delivered to processors.

Materials and Methods

Literature on impact of date of harvest on yields, return yields, and fruit quality was evaluated for various growing areas in the USA. Additional data were obtained from the FASS for citrus fruit drop rates and juice quality for the 1998 through 2004 harvest (totaling 6) seasons. Data for early-mid-season (mostly ‘Hamlin’ cultivar) and late season (mostly ‘Valencia’) were collected monthly by FASS from their record groves in the five citrus districts.

Average data for each Florida Citrus District (FASS designation) for each harvest month in each of the 6 harvest seasons were entered into a spreadsheet for calculation of numerical averages and graphic analyses. Relationships among these data were determined using correlation and regression analyses.

Results and Discussion

Yield decreased in both the first and subsequent years when harvest of ‘Valencia’ orange trees in California was delayed (Jones and Cree, 1954). In the first year, yields declined by 10% by the mid-season harvest (July 24) and as much as 15% for the late harvest (September 21) compared to the yields at the beginning of the harvest season (June 4). This was apparently the result of fruit drop as the season progressed though not specifically stated by the authors. By midseason in the second year, the decrease in yield was 20% and with late harvest, yields declined as much as 35%. Assuming the drop rate was similar in both years, this represented an additional 10% yield loss due to reduced cropping at midseason and an additional 20% reduction in yield from reduced fruit set from harvesting late in the season.

Similar results were reported for relatively late harvests under Arizona conditions (Hilgeman et al., 1967a, b). In a heavy crop year, early harvests yielded 900 to 950 fruit/tree. The next year, 610 to 750 fruit were harvested early. Only 317 to 401 fruit were harvested per tree the second year when the harvests were late in both years. This was a 27% yield reduction compared to the early harvest date due to alternate bearing and a 47% reduction (20% additional loss) in the second
year if fruit were harvested late rather than early. Thus, there was a 20% reduction in the second year due to late-late harvest during the 2 years. These results were almost identical to the California results.

Florida’s harvest seasons are earlier than for California or Arizona as ‘Hamlin’ harvest starts in October for fresh fruit and continues from December into March for processing. The later maturing ‘Valencia’ crop is harvested from March for fresh use through July for processing. The total preharvest drop of grapefruit resulting from late harvest was about 10% in Florida (Table 1; Ali Dinar et al., 1976). However, Ramirez et al. (1977) did not find any decrease in yield of grapefruit with later harvest because an increase in fruit size apparently compensated for the fruit drop in that year. In studies of yields of late harvested ‘Hamlin’ and ‘Valencia’ oranges over a 2-year period, Ramirez et al. (1977) reported that in the second year yields decreased 1.2 and 0.9 boxes per tree for the two orange cultivars, respectively (Tables 2 and 3). This represented a reduced yield in year two of 10 and 19%, respectively, compared to harvesting early in the second year. From FASS data for 6 years, the preharvest drop rate of early-mid and late maturing oranges was 2.6 and 3.3% per month, respectively, with late maturing cultivars (‘Valencia’) having the greater loss in the second monthly period (Fig. 1). Early-mid-season oranges (‘Hamlin’) apparently had a uniform drop rate over the time period for which data were available.

The amount of drop that had previously occurred when harvest began for each cultivar was very different from year to year. Early-midseason cultivars lost only 4.5% of their fruit in 2000-01 by December, whereas 10% were lost in 1998-99 and in 2002-03 (data not shown). Harvest for late season fruit started in April with a 5% yield loss to dropped fruit in most years. Again in 1998-99 and 2002-03, the losses were already 15% by this time (data not shown). It might be useful to evaluate the differences in climatic, bloom, and yield conditions between the low and high drop years to see which factors influence variations in preharvest drop.

Based on the above studies and FASS data, it appears that fruit drop losses might increase by 6 to 10% if harvest is delayed 2 months past February 1 for early-mids and past June 1 for late season cultivars. The effect of late harvest on the next year’s crop may approach another 10% reduction in yield under Florida conditions. Some data suggest that low yield crops can be harvested late with less effect of reducing next year’s crop than if a heavy crop is held until late in the harvest season (Hilgeman et al., 1967b). It might benefit growers to have the

| Table 1. Percentage drop of grapefruit at different harvest dates (Ali Dinar et al., 1976). |
|-------------------------------------------------|-----------------|-----------------|-----------------|-----------------|
| Harvest date                                   | 17 Jan          | 18 Feb          | 20 Mar          | 18 Apr          | 18 May          |
| Total drop %                                   | 1.8             | 3.4             | 5.2             | 8.2             | 18.4            |
| Drop % change from 17 Jan                      | 1.6             | 1.8             | 3.0             | 10.2            |

| Table 2. Effect of harvest dates on yields of ‘Hamlin’ oranges in year 1 and year 2 of harvest timing trials (Ramirez et al., 1977). |
|-------------------------------------------------|-----------------|-----------------|-----------------|-----------------|
| Harvest date                                   | 24 Nov          | 28 Dec          | 30 Jan          | 25 Feb          |
| Year 1, boxes/ tr                              | 12.1            | 11.7            | 11.4            | 10.6            |
| Year 2, boxes/ tr                              | 11.8            | 11.6            | 10.6            | 9.4             |
| Monthly change Yr 2                            | -0.2            | -1.0            | -1.2            |

| Table 3. Effect of harvest dates on yield of ‘Valencia’ orange trees in year 1 and year 2 of harvest timing trials (Ramirez et al., 1977). |
|-------------------------------------------------|-----------------|-----------------|-----------------|-----------------|
| Harvest date                                   | 17 Apr          | 15 May          | 12 Jun          | 18 Jul          |
| Year 1, boxes/ tr                              | 2.9             | 2.9             | 3.1             | 3.2             |
| Year 2, boxes/ tr                              | 4.8 a           | 4.4 ab          | 4.3 ab          | 3.9 b           |
| Monthly change Yr 2                            | -0.4            | -0.5            | -0.9            |

*Means within a row followed by different letters differ significantly as determined by DMRT at P <0.05.

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Fig. 1. Average percentage of fruit dropped for early-mid (‘Hamlin’; A) and late (‘Valencia’; B) season orange cultivars during the harvest seasons for 1998 through 2004.
option of selecting citrus blocks with smaller anticipated yields for late harvest within both harvest seasons. This option does not consider, however, how juice quality might be affected.

The effect of late harvest on fruit grade and juice quality is a second major issue. According to the FASS data, percentage juice content or pounds solids per box were not reduced by late harvest (Figs. 2 and 3). Pounds solids per box actually increased significantly until the last month of recorded harvest data for both early-mid and late season cultivars. Thus, growers and processors do not suffer any loss from either decreased juice content or solids per box from harvests as late as February or June for early-mids or late cultivars, respectively. Unfortunately, the FASS data do not allow evaluation of possible losses if harvest is delayed into March for early-mids or July for late cultivars because many of the sampled groves were harvested by these dates. There can be an additional juice loss during the late harvest and handling before processing (Davies et al., 1999). This may be as much as 3% of juice volume with associated losses in soluble solids (personal communication) but these are not included in the FASS data.

Acidity (%) declined and soluble solids (%) increased in the juice from both early-midseason (Fig. 4a, b) and late season (Fig. 5a, b) oranges for these six seasons of FASS data. The rate of such changes is a climate related issue (Albrigo, 2004; Reuther and Rios-Castano, 1969). In the years examined, the average brix/acid ratio changed from 12.5 to 18 for early-midseason (Fig. 4c) and from 11 to 17 for late season oranges (Fig. 5c). These averages were not out of an acceptable range for processed oranges and even in individual years, the average ratios were only 19 in February in 1999 and 2002 for early-mids, and 19 for late cultivars in 2004 (individual data not shown).

From grower reports in several years, 'Hamlin' oranges in many blocks had ratios of 18 in December. These were years when bloom was early and fall temperatures were warmer than normal (Albrigo, 2004). Processors were reluctant to start processing early in December as they hoped that soluble solids values would increase. However, these blocks had ratios above 20 by February. Based on the average data from FASS, it is possible to have acceptable ratios at later harvest, but only if fruit with an initially low ratio (high acidity, low solids) is saved for the later harvests. Whether low ratio fruit early in the season can also be a low yield crop and therefore, desirable for late harvest, needs to be determined.
It appears that the fruit drop from later harvests is about 3% per month and reduced return crop the following can be up to 10%. These are the primary losses that growers face when they harvest late in each season. Losses can be as much as 20% from late harvest of the current crop plus the fruit set losses in the second year. Losses are probably only 10 to 15%, however, if harvest is only moderately late. Growers do not appear to lose juice or soluble solids from late harvests under Florida conditions. Juice soluble solids to acid ratio may become unfavorable with late harvest and juice taste quality may be compromised.

**Literature Cited**


