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Full Length Research Paper

Optimum timing for commercializing grapefruit based on fruit internal quality and weight

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This study was conducted during the 2004 - 2005 production year on an 8 year grapefruit (*Citrus paradasi* Macf.) grove in the locality of "Las Anacuas" of the municipality of general Teran, N. L. Mexico. The objective of the study was to obtain elements based on fruit weight, internal and external quality of grapefruit and its interaction with prices, so that producers can determine the best time to sell their fruit. Results indicated that the best time for harvest, based on fruit weight was in April. It was also determined that if grapefruit is sold in November, producers lose 28% of the yield compared with April, because of the difference in fruit weight. After May, fruit begin to lose weight and internal and external quality deteriorates. With the information obtained, producers can select the optimum time to commercialize their grapefruit. Regarding internal fruit quality for fresh market, grapefruit reaches good quality by November.

Key words: *Citrus paradasi*, grapefruit, fruit, weight, yield.

INTRODUCTION

Citrus is considered the most important fruit in the world and grapefruit has a great value in human diet (Ali, 2005). Double-red flesh grapefruit varieties are popular in the USA, Israel, Europe, Mexico and are increasing in Asia (Isgro et al., 2001). According to FAO in 2002 there was a production of 5 million tons of grapefruit in 74 countries having approximately 290,000 ha. Mean yields have been reported from 18.5 tons ha^{-1} to 40 tons ha^{-1} in Florida and Turkey (Sauls, 1998), Texas reported mean yields of 44 tons ha^{-1} with a high of 60 tons ha^{-1} (USDA, 2005). In Nuevo Leon, Mexico, mean productions are 30 tons ha^{-1} even though low technology is applied. Most of the citrus production is located between 24 and 40° north-south latitude where minimum temperatures are greater than -6.6°C. Between these latitudes there are several factors that benefit growth, development, yield and fruit quality. These latitudes include humid-tropical, humid-subtropical, arid and semi-arid regions. Generally in the tropics, fruit will not mature adequately with colorless juice, low soluble solids and low soluble solid/acid ratios.

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Therefore, the fruit does not satisfy fresh market requirements. The optimum latitude for citrus production is considered subtropical and semi-arid, where countries such as Spain, Italy, Morocco, Turkey, north Mexico, USA (Florida and California) and Israel are located have been producing fresh market citrus with good external and internal quality. Grapefruit obtains the best quality in the winter and spring with hot days and cool nights, resulting in high soluble solids, low acidity and good external color. High temperatures during the day and night promote external green fruits with low sugars and high acidity that will only be good for processing. Low temperatures (< - 3°C) depending on exposure time and local conditions can cause freeze damage. High intensity of light and temperatures can affect internal and external fruit quality, which happens in Nuevo León and south Texas normally after May (Davies, 1996; Sauls, 1998). Internal maturity of grapefruit in the Nuevo Leon and south Texas area begins in October or November, but flavedo is still green. After November, the flavedo color changes slowly until the fruit is fully mature, normally by December (Sauls, 1998). Regarding internal maturity, the best index is the relationship between soluble solids and acidity. Soluble solids increase as maturity progresses with a range between 8 and 10% in grape fruits for fresh market. Aci-

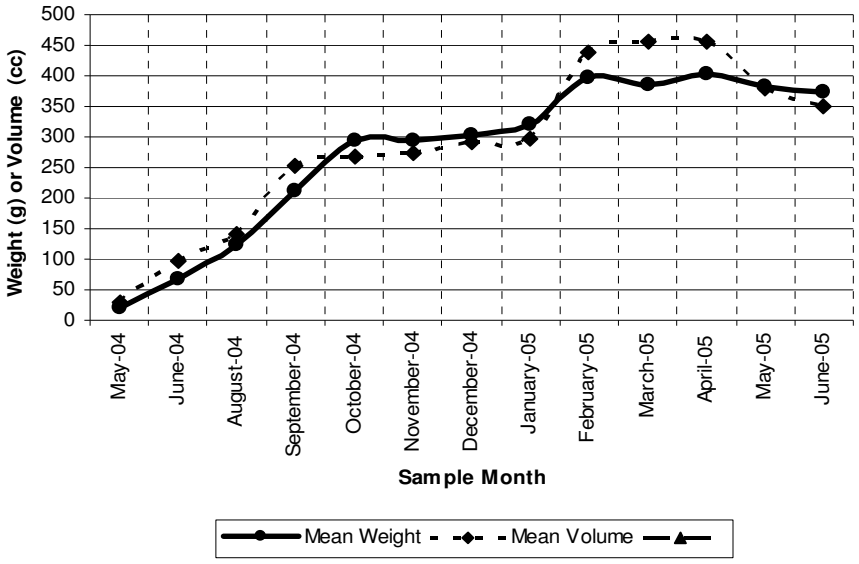

Figure 1. Behavior of fruit weight (g) and volume (cc) during the study.

dity is opposite to soluble solids, it declines as maturity progresses. The relationship between soluble solids and acidity is very important to determine if the fruit can be consumed as fresh market or processing. Soluble solids /acid ratios of 7.5 or 8.0 are good enough for fresh market grapefruit, but below 6.5 the fruit will only be good for processing. Values over 6.0 must be obtained in order for the fruit to be accepted for processing. Besides soluble solids and acidity, fruit diameter must be greater than 70 mm and contain at list 33% of juice (UNECE, 2004).

Producers in Nuevo Leon begin to sell grapefruit from mid-October through July. However, most of the grapefruit is sold between November and April based exclusively on price per ton. We set up an experiment to help producers determine the best time to harvest and sell their fruit based not only on price, but also on fruit weight in order to obtain the maximum benefits.

The present study had the objective of obtaining elements based on fruit weight and quality; analyze their interaction with the prices in different months so that producer can select the best time to commercialize their grapefruit.

MATERIALS AND METHODS

This study was conducted with the variety “Rio Red” grapefruit grafted on sour orange rootstock. Plant density was 250 trees per hectare planted at 8 m between rows and 5 m between trees within the row. The grove was 8 years old located in the “Hacienda las Anacuas” of the municipality of general Teran, Nuevo Leon Mexico with geographical coordinates of 25°-18’-38” north latitude and 99°-35’-25” west longitude. Water used for gravity irrigation came from a well with electrical conductivity equal to 1,700 µS. Irrigation frequency was once per month during hot seasons (March – September) and every 2 months for the rest of the year (October – February), if there was no significant rainfall. Data was collected from 20 trees representing an area of 11 ha. Samples were taken every month beginning in May 2004 and ending in June 2005. Fruit weight, volume and diameter data was obtained from 5 fruits per tree. Out of this sample, 20 fruits were selected to measure soluble solids, acidity and juice percentage from October 2004 to June 2005.

Variables evaluated

Fruit volume

The method used was volume displacement. The fruit was introduced in a container full of water. The water that was displaced from the container was measured in cubic centimeters with a graduated cylinder.

Fruit diameter

Measurements were made with a vernier scale when fruits were small (< 30 mm) and with a regular ruler when fruits were larger (> 30 mm). Fruit characterization was done in order to measure different parts of the fruit (Figure 1), but only total diameter was reported in this study. From the exterior to the interior, citrus fruit was classified as flavedo (exocarp), albedo (mesocarp), juice vesicles (endocarp), septum, seeds and central axis.

Fruit weight

The weight was obtained using a scale with precision in grams.

Fruit quality

Each sample consisted of 20 fruits. Fruits were weighted and squeezed. Juice volume was measured with a graduated cylinder and juice weight was determined using a scale. Based on the total weight and juice weight, the percentage of juice was obtained. From that juice, 25 ml were introduced in an Erlen Meyer bottle of 125 ml and 5 drops of Fenoftalein were added as an indicator. Sodium hydroxide (0.31125 N) was added slowly to the juice until the color changes. The amount of sodium hydroxide added was measured and converted to percent acid, which is referred as the amount of anhydrous citric acid. To obtain the amount of soluble solids, a digi-

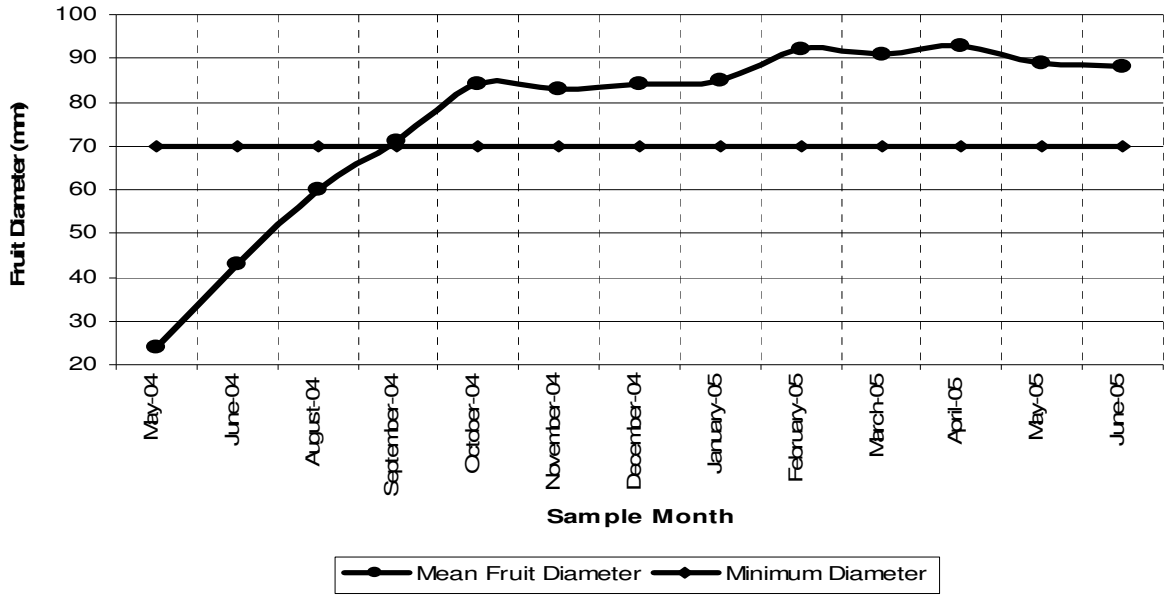

Figure 2. Behavior of grapefruit diameter during production season 2004 - 2005. The horizontal line is the minimum value (70 mm) in order to fulfill fresh market requirements.

tal refractometer was used. A couple of drops of juice were used. Corrections were made according to temperature difference and the value obtained represented brix that was the same as soluble solids (%) or amount of sugars (mainly sucrose). The values of soluble solids divided by the acidity resulted as the soluble solids: acid ratios, which were used to describe juice flavor.

RESULTS AND DISCUSSIONS

Fruit volume and diameter

Figure 1 shows mean values of fruit volume during the sampled months. Volume growth was continuous until October (269 cc) with a pronounced slope. After October and through January (3 months), volume growth was slow (51 cc). From January through February, there was a slight increase in growth (77 cc). From February through April, there was very little growth (18 cc), but the maximum fruit volume was obtained in March (456 cc). From May to June, there was a slight decrease in volume (-29 cc) besides interior and exterior aspects of the fruit quality were deteriorated. It has been reported that grapefruit variety red ruby was similar to Rio red. Fruit volume in Pakistan was reported to be 343 cc implying that results obtained in this study were above the reported values (Ghulem et al., 2004).

Fruit diameter had a similar behavior as fruit volume and the required diameter that must be obtained in order to fulfill fresh fruit standards (UNECE, 2004) was accomplished by September (Figure 2).

Volume and fruit diameter are very important in order to commercialize fresh market grapefruit. Regarding fruit diameter, classification for packing is based on size codes were 0 = > 139 mm; 1 = 109 – 139 mm; 2 = 100 – 119 mm; 3 = 93 – 110 mm; 4 = 88 – 102 mm; 5 = 84 – 97 mm; 6 = 81 – 93 mm; 7 = 77 – 89 mm; 8 = 73 – 85 mm and 9 = 70 – 80 mm. Based on this classification, size code obtained in this study were 6 to 9 from November to January and codes 4 to 9 from April to June (Figure 2). This indicates that harvested fruit fullfilled requirements for fresh fruit regarding fruit diameter (UNECE, 2004). Other studies reported larger fruit diameter in Rio red scion grafted on Swingle citrumelo and Carrizo citrange with diameters from 105 and 98 mm, respectively (Ghulem et al., 2004). Values from 99.1 to 106.9 mm from November to April without mentioning rootstocks (University California, 2006) and values of 97, 87, 97 and 100 mm on ruby red grafted on Carrizo citrange, Cleopatra mandarin, sour orange and Volkameriana, respectively were also reported (Ali, 2005). Therefore, fruit harvested in this study were below fruit diameter reported in the literature with the exception of scion ruby red grafted on Cleopatra mandarin which had lower values than fruits obtained after February in this study. Distribution of different parts of the fruit in the total diameter must also be considered. Therefore, flavedo, albedo, endocarp and central axis must be measured. If rind diameter (albedo and flavedo) accounts for a good percentage, presence of “sheepnose” fruit will affect negatively fruit commercializing.

Grapefruit mean weight

Figure 1 shows fruit mean weight from May 04 to June 05. It can be noticed that from May to October the increase was 293 g, but this fruit did not have the internal and external maturity for fresh market. Fruit weight increase

Table 1. Economic analysis of grapefruit production year 2004 - 2005.

Month	Mean Fruit Weight (g)	Production in 11 (ha)	Yield (ton ha^{-1})	Income ($1,200 pesos ton^{-1})	Increase (%)
October-04	293	344	31	$412,800	0
November-04	294	345	31	$414,209	0
December-04	302	355	32	$425,480	3
January-05	320	376	34	$450,840	9
February-05	397	466	42	$559,323	35
March-05	386	453	41	$543,825	32
April-05	403	473	43	$567,776	38
May-05	383	450	41	$539,599	31
June-05	374	439	40	$526,919	28

during October, November, December and January was very small (27 g) with a percentage of 8.4% regarding total weight in January. From January to February a very important increase was observed (77 g) representing 19.39% of the total weight in February. From February to April, fruit weight increased very little, but the maximum fruit weight was obtained in April (403 g) and begins to decrease after May. In June, the mean weight was 374 g representing a decrease of -29 g or -7.19%. Even though the decrease in weight was small, internal and external aspects of the fruit deteriorated due to sunburn, dehydration, soft fruits and fruit drop, affecting marketing (Figure 4). Therefore, we recommend that marketing based on fruit weight should be considered after February throughout May. Other studies reported mean fruit weights of 364 g for red ruby variety grafted on sour orange (Ali, 2005), Rio red with 415 and 544 g (University California, 2006), Rio red grafted on Carrizo citrange of 410 and 377 g in 1999 and 2000, respectively (Isgro, 2000). Comparison with results in the literature regarding mean weight, 2 results were below, one was similar and two above.

Marketing

Fruit was sold in late October but evaluated trees were not harvested. Yield was 344 ton in 11 ha (mean = 31.27 ton ha^{-1}) with a price of 1,200 pesos per ton. Fruit harvested in October had a mean fruit weight of 293 g with a total production of 344 ton in 11 ha obtaining an income of 412,000 pesos. In January due to the increase in fruit weight (320 g), yield would have been 376 tons, equivalent to 451,200 pesos. In April, yield would have been 473 tons with a mean fruit weight of 403 g with an income of 567,600 pesos. In this case, the difference is 129 tons between October and April, which is equal to 154,800 pesos (Table 1). The mean yield was 31 ton ha^{-1} and 43 ton ha^{-1} in October and April, respectively, which is considered a fair to good yield in the region. Other studies have obtained yields of 18.5 tons ha^{-1} and high yields of 40 ton ha^{-1} in Florida and Turkey (Sauls, 1998). In Texas, 44 tons ha^{-1} is considered a mean yield and 60 tons ha^{-1} a very good yield (USDA, 2005). 10 year old trees had a yield of 33 tons ha^{-1}(Sauls, 1998). In Brazil, Ildo et al. (2005) reported yields of 19 tons ha^{-1} from 8 year old trees. In Iran, with high density plantings, yields of 56 tons ha^{-1} were obtained. In Australia, yields of 21 tons ha^{-1} were reported (Isgro et al., 2001).

Based on the fruit weight behavior, producer can decide when to sell their fruit, but must take into account other factors when they sell after December, such as freeze and hail probability, irrigation, pesticides, bank interest, weight loss, sunburn, etc. Furthermore, by September, producers are short of money and it will be recommended to sell early a least a portion of the fruit.

In years with good prices as is considered this year, it justifies to wait until March or April to harvest, even considering the extra costs, compared with harvesting in October or November. But if the price is low or the fruit quality is not good for fresh market, it is suggested that the faster the fruit is sold the better, because their has been years that the fruit is not sold and is left in the trees which causes infestation problems and increase alternate bearing which affects the next crop. For example in production year 2002 - 2003, price per ton of good quality fruit was 900 pesos and low quality fruits was only 400 pesos per ton. That year 20% of groves production was not sold.

Internal quality of grapefruit

Results obtained in this study regarding relationship between soluble solids and acidity was 7.1 in October, which was low for fresh market fruit. By November, the value was 7.6 which is above the minimum required (7.5) for fresh market grapefruits. The relationship was good from November to May with a range from 7.6 to 9.1, but in June the value was too high (13.0) indicating that fruit will be insipid (Table 2). Soluble solids in grapefruit increases and acidity decreases as maturity progresses. The relationship between them determines juice flavor. Ratios of 7.5/1 to 9.0/1 are good for fresh fruit and ratios of 6.5/1 to 7.0/1 are good for processing fruit (Arthur and Daemmon, 2004). The minimum accepted ratio for processing is 6.0/

Table 2. Soluble solids/acid ratio and juice percentage in grapefruit.

Month	Soluble Solids/Acids	Juice (%)	Month	Soluble Solids/Acids	Juice (%)
October-04	7.1	38	March-05	9.1	48
November-04	7.6	43	April-05	8.7	47
December-04	7.7	43	May-05	9.0	46
January-05	8.5	44	June-05	13.0	44
February-05	7.8	47			

1 (Morton, 1987). We cannot have a good indicator with one of the parameters mentioned (soluble solids or acids), because there could be a large quantity of values that can give a good relationship between them and also there can be several values that can give a low or high relationship that will affect juice flavor. It has been reported that acidity has a major effect on flavor than soluble solids. For example a low value of acidity would give a high ratio, but it would be an insipid fruit. In contrary, high value of acidity (immature fruit) would give a very acid flavor.

When fruit is sold in November even if the relationship between soluble solids and acid is good, the external color of the fruit is green therefore degreening is necessary. Normally, grapefruit color by early December is good for fresh market, but elevated nitrogen fertilization may retard fruit peel coloring. Maximum juice percentage was obtained between February and April and this coincided with the maximum fruit weight and optimum relationship between soluble solids and acidity, indicating the fruit maturity was achieved during these months.

During June, internal and external fruit quality was severely deteriorated, but normally fruit prices are high, which stimulate some producers to sell their fruit in June or July.

Conclusions

i) Fruit volume has a direct relation with fruit weight.
ii) The optimum month to sell grapefruit based on mean fruit weight would be in April.
iii) If the fruit is sold in November, yield is reduced by 28% compared with April.
iv) Good relationship between soluble solids and acidity is achieved for fresh market from November through May.
v) After May, internal and external fruit is severely deteriorated and fruit weight is reduced.

REFERENCES

Ali A (2005). Effects of citrus rootstocks on fruit yield and quality of Ruby red and Marsh grapefruit. Fruits 60: 311-317.
Arthur D, Daemmon DT (2004). Grapefruit “The Forbidden Fruit”. Lakelane Florida, USA.
Davies FS (1996). An overview of climate effects on citrus flowering and fruit quality in various parts of the World. Hort. Sci. Dep. of the Univ. of Florida, Gainsville. USA.
Ghulem NJ, Tasleem G, Sharafet K, Nadi RU (2004). Performance of different grapefruit (*Citrus paradasi* Macf.) genotypes on sour orange (*Citrus aurantium* L.) rootstocks under climate conditions of Peshawer. Pakistan. J. Biol. Sci. 7(10): 1762-1766.
Ildo E, Joao E, Becerra F, Assuncao M, Da Silva Y, Cunha A (2005). Behavior of six grapefruit varieties grown under irrigation at the semi-arid region of Pernabuco-Brazil. Rev. Bras. Fruit Jabotical-SP 27(2): 245-247.
Isgro I (2000). Citrus research in the Alice Springs Region. The national red flesh grapefruit trial. Hort. Tech. Annu. Report, Australia.
Isgro N, Nesbitt A, King D, Broad I (2001). The national red fleshed grapefruit trial. Hort. Technical Annu. Report, Australia.
Morton J (1987). Grapefruit. In fruits of warm climates. Miami, Fl. USA. pp. 152-158.
Sauls JW (1998). Home fruit production grapefruit. Aggie-horticulture. tamu. edu/Citrus/grapefruit.
UNECE STANDARD FFV-14 (2004). Concerning the marketing and commercial quality control of citrus fruit. Trade/WP.7/GE/2004/25/ add.7.7.
University of California (2006). Riverside Citrus Clonal Protection Program. Variety Data VI 440 Rio Red Grapefruit. Riverside, California. http://ccpp.ucr.edu/variety/440.html
USDA (2005). Fruit and tree nuts outlook. Econ. Res. Serv. USDA.