A comparison of the morphological and physicochemical characteristics of ten carambola cultivars[1,2]

Garry Gordon[3], Tomas Ayala-Silva[4] and Stewart Reed[4]*

J. Agric. Univ. P.R. 97(3-4):171-180 (2013)

ABSTRACT

Carambola (*Averrhoa carambola* L.) is a commercial fruit crop predominantly grown in south Florida, USA, for the local market. Ten carambola cultivars from the USDA-ARS germplasm collection in Miami, Florida, were evaluated on a Krome gravely loam soil for sweetness, acidity, size and color. Physical characteristics of fruits were determined by measuring fruit length, diameter and weight. Carambola physicochemical characteristics were determined by measuring the Brix, pH, firmness and fruit color (L*, a*, b*). 'Tean Ma' had a significantly lower pH than other cultivars used in the study. 'Hew 1' was significantly longer and 'Fwang Tung' had a significantly greater diameter compared to other carambolas. The L value for 'Arkin' was significantly lower than for other carambola cultivars but the b* value of 'Wheeler' was significantly higher. There was a significantly greater amount of seeds produced by 'Arkin' in comparison to other cultivars used in the study. The results demonstrated that 'Kary', 'Key West', and 'Wheeler' produced large sweet fruit and could be planted in the hot humid South Florida environment.

Key words: *Averrhoa carambola*, Brix, color, fruit firmness, pH, fruit, tropical

RESUMEN

Comparación de las características morfológicas y físicoquímicas de diez cultivares de carambola

La carambola (*Averrhoa carambola* L.) es una fruta comercial principalmente sembrada en el sur de la Florida para el mercado local. Se evaluaron diez cultivares comerciales de carambola; a cada uno de ellos se les evaluó el dulzor, acidez, tamaño y color de la fruta. Los árboles de carambola están sembrados en un suelo Krome gravely loam, en Miami-Dade, Florida, EE.UU. Se determinaron características físicas de las frutas midiendo la longitud del fruto, diámetro y peso. Las características físicoquímicas se determinaron midiendo el dulzor (Brix, ° Bx), pH, firmeza (kg/cm), y el color

[1]Manuscript submitted to Editorial Board 2 May 2013.

[2]The authors would like to thank Dr. Ricardo Goenaga, Dr. Edward Boza, Dr. Hamide Gubbuk for their critical review of the manuscript and Dr. John M. Moore for statistical analysis.

[3]National Germplasm Repository System, Subtropical Horticulture Research Station, 13601 Old Cutler Road, Miami, FL 33158.

[4]Department of Homeland Security, APHIS, Miami, FL, USA.

de la fruta usando los valores L *, a *, b * del sistema CIE Lab. 'Tean Ma' tuvo un pH significativamente más bajo que los otros cultivares utilizados en el estudio. 'Hew 1' fue significativamente más larga, y 'Fwang Tung' demostró un diámetro significativamente mayor en comparación con el de otros cultivares. El valor L* para 'Arkin' fue significativamente menor que en otros cultivares, pero el valor b * de 'Wheeler' fue significativamente mayor. Hubo una cantidad significativamente mayor de semillas producida por 'Arkin' en comparación con las de los otros cultivares utilizados en el estudio. Los resultados demostraron que existen diversos cultivares que producen frutos grandes y dulces en el ambiente cálido y húmedo del sur de Florida.

Palabras clave: *Averrhoa carambola*, Brix, color, firmeza del fruto, pH, fruta, tropical

INTRODUCTION

Carambola (*Averrhoa carambola* L., Oxalidaceae) is a native of Asia (Janick, 2001). Some scientists place its origin in tropical Asia (Núñez-Elisea and Crane, 2000) whereas others place it in Sri Lanka and the Moluccas (Morton, 1987) or India (Mossler and Crane, 2009). Carambola cultivars have been selected or developed in numerous places around the world: 'Arkin' (Florida); 'B-10' (Malaysia); 'Demak' (Indonesia); 'Fwang Tung' (Thailand); 'Golden Star' (Florida); 'Hew 1' (Malaysia); 'Kary' (Hawaii); 'Sri Kambangan' (Malaysia); and 'Tean Ma' (Thailand) (Campbell, 1997). Brazil, Malaysia, and Taiwan are the world's largest carambola producers (Goenaga, 2007) whereas 90% of the carambolas grown in the U.S. are produced in southern Florida.

Carambola trees have alternate leaves with five to eleven leaflets per leaf (Mossler and Crane, 2009). In Florida, carambola trees grow to a height of approximately 7.6 m with a canopy in the range of 6.1 to 10.7 m (Campbell et al., 1985). The trees bear their inflorescences along their stems and branches (cauliflory), with small pink flowers that produce the carambola fruit often referred to as "star fruit" for its distinctive shape when cut in cross-section. The fruit has four to seven ribs and can range from 8.0 to 25.0 cm in length and 5.0 to 10.0 cm in width (Watson et al., 1988). The color of carambola can range from translucent light green to orange. Fruit is considered ripe when the color changes from dark to a light green and yellow between the ribs (Campbell and Koch, 1989). Carambolas are delicate and can easily be damaged when shipped (O'Hare, 1993); it is likely that fruits with thick, fleshy ribs are more resistant to handling injury than those with thinner ribs (Campbell et al., 1985). Carambola is a source of vitamin C and potassium (Crane, 1994; Wagner et al., 1975), and is typically sold as a fresh fruit. Carambola varieties are categorized as either sour or sweet (Crane, 1994).

With the technology now available to measure fruit color along with other traits, it is important to see how well the fruit of different culti-

vars of carambola develop in South Florida, where there is a long history of cultivation. Carambola trees were first offered for sale in Florida in 1887 (Royal Palm Nurseries). 'Golden Star' and 'Newcomb' were the first two cultivars named in the state of Florida (Campbell, 1965). In the 1970's, Dr. Robert Knight, Jr., brought back root stock from 'Fwang Tung' and seeds that would become 'Arkin' from a trip to Malaysia and Thailand (Campbell et al., 1985). Mossler and Crane (2009) concluded that 'Golden Star' adapted better to the limestone soils of South Florida than did 'Arkin'. Campbell and Koch (1989) found 'Golden Star' to have higher sucrose content than 'Arkin'.

Carambola trees can grow in a wide range of soil types that vary greatly in pH (Goenaga, 2007; Green, 1987). Carambola has been grown in soils ranging from acidic (pH 4.5; Green, 1987) to basic (pH 8.5; Campbell, 1989). Goenaga (2007) grew nine carambola cultivars at three different locations in Puerto Rico, and soil pH ranging from 4.77 to 8.28. In south Florida, carambola is grown on mildly alkaline soil (pH 7.4 to 7.8) and may be subject to micronutrient deficiencies (Knight, 1982).

Carambola trees grow in tropical climates but can also thrive in subtropical climates (Núñez-Elisea and Crane, 2000). In Florida, carambola trees bloom from April to May and again from September to October. This blossoming results in two harvest periods, August through September, and December through February (Mossler and Crane, 2009). Introduction of a sweet carambola cultivar, 'Arkin', in the late 1970's led to a rapid increase in consumer demand (Crane, 1993). Today, carambola cultivars from other regions of the world are introduced into south Florida to help solve various tastes, texture, color and several production-related issues. The USDA-ARS-Subtropical Horticulture Research Station in Miami, Florida, USA, maintains a collection of tropical fruit trees including 14 carambola accessions. These accessions have not been evaluated for characteristics used to select trees for breeding and improved marketability. The purpose of this study is to analyze and compare the morphological and physicochemical characteristics of ten carambola cultivars.

MATERIALS AND METHODS

The experiment was conducted at the National Germplasm Repository, Subtropical Horticulture Research Station (SHRS) in Miami, FL. The soil was a Krome (Loamy-skeletal, carbonic, hyperthermic Lithic Udorthents). Precipitation was 40.0 cm from September 2008 through February 2009, 48.0 cm from September 2009 to February 2010, and 62.0 cm September 2011 through February 2012. Soil pH ranged be-

tween 7.0 and 7.5. Trees were fertilized twice a year with N-P-K (8-4-12) at a rate of 500 g per 2.54 cm of trunk diameter. Other nutrients applied with fertilizer were: Mg (4%), S (0.56%), Mn (1.01%), Cu (0.05%), Fe (1.36%), Zn (0.14%), and B (0.06%). Weeds were controlled with glyphosate (Roundup Original Max[5]; St. Louis, MO) as needed. 'Arkin', 'Butt's Dwarf', 'Demak', 'Fwang Tung', 'Fwang Tung x Golden Star', 'Hew 1', 'Kary', 'Key West', 'Tean Ma', and 'Wheeler' cultivars were used as experimental material. Fruit was harvested from November to February in 2008-2009, 2009-2010, and 2011-2012 seasons and July to October in 2011. Fruit was harvested at maturity, when size and color were appropriate (e.g. dropping fruits; change in color if applicable) for each cultivar. Fifty fruits were harvested per tree. Fruit length, diameter, weight, Brix, firmness, pH, seed number, and color (measured with a lightness component and two chromatic components) were recorded for each fruit harvested. Length and diameter were measured with a 46-cm ruler (Pearl® L200, New York). Length was measured between the stem and distal end (Narain et al., 2001). Width was determined as the distance between the two largest ribs of the fruit. Weight was recorded by using an analytical scale (Ohaus® Model GT8000; Florham Park, NJ). Brix, was determined using 2 ml of juice with a digital refractometer (SPER Scientific 300034, Scottsdale, AZ). Fruit firmness was measured with a fruit penetrometer Model GY-1 (cropmeter.com; Strong, ME). Firmness was tested by holding fruit upright, locating the flattest side of the carambola closest to the fruit's center, and pushing the penetrometer (3.5 mm diameter) against the fruit's skin until it penetrated the fruit. Carambola pH was taken with an AR50 dual channel pH meter (Thermo Fisher Scientific; Waltham, MA) from 30 ml of fresh squeezed juice. Seed count was recorded after separating the fruit flesh from the seed. Carambola color was measured with a Minolta Chroma Meter CR-400 portable tristimulous colorimeter (Minolta Chroma Meter CR-400, Osaka, Japan) and Spectra Match software, set L* , a*, b* mode. Fruit chromaticity was recorded in accordance with Commission Internationale d' Eclairage L*, a*, b*, which describes a uniform three-dimensional color space, where the L* value corresponds to a black-white scale, and two chromatic components: -a* for green to +a* for red and –b* for blue to +b for yellow.

Tree selection was made to fit a completely randomized experimental design. Data were initially analyzed for distributional characteristics

[5]Company or trade names in this publication are used only to provide specific information. Mention of a company or trade name does not constitute a warranty of equipment or materials by the Agricultural Experiment Station of the University of Puerto Rico, nor is this mention a statement of preference over other equipment or materials.

using Proc Univariate (SAS Institute, Inc., Cary, NC 2008). Analysis of variance for fruit width, length, diameter, weight, Brix, firmness, pH, seed count, and color was performed using Proc Mixed procedure with a Tukey-Kramer test for Least Square Means separation (a = 0.05). All analyses were conducted using SAS 9.2 software (SAS Institute, Inc., Cary, NC 2008). A variation of principle component analysis, Principal Factor Analysis, was used to determine related variables. Three of the seven factors were retained and analyzed with the Rotation Method under Proc Factor of SAS.

RESULTS AND DISCUSSION

Table 1 shows results from the ANOVA test of the effect of cultivars (C), year (Y), and their interaction on selected fruit characteristics. There were significant varietal differences in all variables measured. Year and C x Y interactions were significant for all variables except firmness, pH and seed. For Brix measurements, all years differed from one another. Brix, fruit diameter, length and weight were significantly greater in 2012 than in any other year.

Table 2 gives the Least Square means for fruit size, sweetness, and other fruit characteristics. Since for most variables the effect of year was significant in 2012 only, data were combined across years. Brix readings ranged from 9.9 to 8.0, and were ranked as follows: 'Hew 1' ≥ 'Fwang Tung x Golden Star' = 'Key West' ≥ 'Fwang Tung' = 'Wheeler' = 'Demak' = 'Kary' > 'Butt's Dwarf' = 'Tean Ma' > 'Arkin'. Brix was greater than 9.0 for seven of the ten cultivars (Table 2); this Brix reading is higher than those recorded by Wagner et al. (1975). The Brix readings for 'Arkin' and 'Kary' were similar to those found by Goenaga (2007), but our values were higher than those obtained by Hallman (1989).

'Fwang Tung' fruit had a significantly larger, and 'Kary' a significantly smaller diameter when compared to other cultivars. 'Fwang Tung x Golden Star' had the second largest diameter. Goenaga (2007) had similar fruit diameter measurements for 'Arkin', but fruit diam-

TABLE 1.—*Analysis of variance for the effect of cultivar (C), year (Y) and C x Y interaction on carambola fruit Brix, diameter, length, weight, firmness, pH, and Commission Internationale d'Eclairage color values L*, a* and b*.*

Source	Brix	Diameter	Length	Weight	Firmness	pH	No. Seed	L*	a*	b*
Cultivar (C)	**[z]	**	**	**	**	**	**	**	**	**
Year (Y)	**	**	**	**	NS[y]	NS	NS	**	**	**
C x Y	**	**	**	**	NS	NS	NS	**	**	**

[z]** significant at P = 0.01 level.
[y]NS not significant at P = 0.05 level.

TABLE 2.—*Least square means for Brix (Bx⁰)[1], diameter (mm), length (mm), weight (g), firmness (kg/cm²)[2], pH[2], seed count, and color (L*, a*, and b*)[3] for carambola fruit collected at the SHRS, Miami, FL. Values are means of four years (2008-2012).*

Cultivar	(Bx⁰)	Diameter	Length	Weight	Firmness	pH	Seeds	L*	a*	b*
'Arkin'	7.96 d[4]	66.8 e	111.8 c	139.8 c	12.8 bc	3.7 de	14.4 a	46.7 g	-0.38 b	16.8 f
'Butt's Dwarf'	8.51 c	71.8 c	115.2 b	132.4 c	13.8 ab	3.9 cd	6.3 d	53.0 a	-4.26 f	24.4 b
'Demak'	9.34 b	72.7 c	114.8 b	153.6 b	14.4 a	3.5 ef	8.6 c	48.8 de	-1.81 d	19.6 d
'Fwang Tung'	9.56 b	83.6 a	114.8 b	166.2 a	11.0 d	4.3 ab	7.4 cd	48.2 f	-3.08 e	17.3 f
'Fwang Tung' x 'Golden Star'	9.64 ab	77.7 b	111.8 c	138.3 c	10.9 d	4.5 a	8.1 c	50.5 c	-3.04 e	21.0 c
'Hew 1'	9.89 a	69.6 d	120.6 a	161.2 ab	13.5 ab	3.4 f	11.3 b	49.1 d	-1.49 d	20.0 d
'Kary'	9.28 b	56.3 g	104.0 d	89.1 e	12.5 bc	3.7 de	7.3 cd	48.4 ef	-0.91 c	20.2 cd
'Key West'	9.44 b	63.3 f	107.1 d	115.3 d	10.9 d	3.9 cd	12.1 b	48.8 de	-3.44 e	19.1 e
'Tean Ma'	8.40 c	61.8 f	88.0 e	82.3 e	12.3 c	2.8 g	7.5 cd	51.9 b	0.64 a	27.8 a
'Wheeler'	9.36 b	66.5 e	91.5 e	93.4 e	13.0 bc	4.0 bc	11.9 b	52.1 b	0.55 a	28.5 a
Mean	9.04	68.2	106.1	122.4	12.6	3.9	9.5	50.0	-1.8	21.4

[1]Soluble solids.
[2]Data reported for 2011 and 2012 only.
[3]L* value corresponds to a black and white (0-100) scale, -a* for green, +a* red and –b* for blue and +b for yellow.
[4]In a column, means followed by the same letter are not significantly different at a = 0.05 by Tukey-Kramer test.

eter for 'Kary' in our study was smaller. Knight (1989) documented larger diameters for 'Demak' and 'Arkin', but his measurements for 'Fwang Tung' and 'Hew 1' were similar to ours.

Fruit length ranged from 88.0 mm to 120.6 mm. 'Hew 1' was significantly longer than the other cultivars, whereas 'Wheeler' and 'Tean Ma' were significantly shorter (Table 2). Knight (1989) recorded longer fruit length for 'Arkin' and 'Demak', but his data for 'Hew 1' and 'Fwang Tung' were similar to that found in this study. Wagner et al. (1975) recorded longer 'Tean Ma' than those in our findings. Goenaga (2007) recorded longer 'Arkin' fruit and his average 'Kary' length (126.3 mm) was much larger than our average measurement. A length of 76 to 102 mm is preferred by industry to prevent bruises during shipping (Crane et al., 1998); however, for the local market, longer fruit for slicing and display is acceptable.

Carambola average weights ranged from 82.3 to 166.2 g. The heaviest fruits were obtained for 'Fwang Tung' and 'Hew 1', fruits which were almost twice as heavy as the lightest cultivar 'Kary' (Table 2). Seven of the ten carambola cultivars averaged over 100 g per fruit. Knight (1989) recorded heavier fruit readings for 'Demak', 'Fwang Tung' and 'Arkin', but our 'Hew 1' was much heavier than in his study. Carambola fruit firmness ranged from 14.4 kg/cm to 10.9 kg/cm (Table 2). 'Key West', 'Golden Star' and 'Fwang Tung' fruit were softer than other cultivars. Firmness is an indication of the likelihood of damage during harvest and post-harvest handling. Therefore, these cultivars are probably susceptible to damage during handling. The three lowest ranking varieties, 'Key West', 'Fwang Tung', and 'Fwang Tung x Golden Star' were considered susceptible to handling damage.

Carambola pH measurements ranged from 4.5 to 2.8 (Table 2). 'Tean Ma' had a significantly lower pH than the other cultivars, and this pH was much lower than that recorded by Wagner (1975). The pH range in this study was similar to that of Weller et al. (1997), who used the cultivars 'Arkin', 'Kary', 'Fwang Tung', and 'Demak'. Fruit pH is a function of organic acids, mostly oxalic and malic acids, present at harvest (Campbell et al., 1987). Low pH is associated with sour tasting varieties (Ding et al., 2007). Higher pH values in our study are consistent with higher Brix values (reported above) than in Wagner's (1975). Also, a high pH implies less oxalic acid in the fruit improving consumer acceptability.

The number of seeds per fruit ranged from 6 to 14. 'Arkin' had significantly more seeds than other cultivars. Knight (1989) recorded fewer seeds in 'Arkin' and 'Hew' and higher seed number for 'Demak'. Seed number for 'Fwang Tung' in our study is very close to those obtained by Knight (1989). Wagner (1975) had fewer seeds for 'Tean Ma' than

those recorded in our study. Crane (1994) noted that carambola usually does not produce more than 10 to 12 seeds but our data showed 'Arkin' averaged 14 seeds.

Cultivars can be distinguished on the basis of their colors. The L* values were from 53 to 47. 'Butt's Dwarf' had a significantly higher and 'Arkin' had a significantly lower L* value than the other cultivars. Since L* measures white (100) to black (0), it could be inferred that 'Butt's Dwarf' was lighter in skin color than the other cultivars, and 'Arkin' darker. 'Tean Ma' and 'Wheeler' had significantly higher a* values than the other cultivars. In addition, the b* values for 'Wheeler' and 'Tean Ma' were significantly higher than in all the other cultivars. These varieties had more green plus yellow color giving a slight orange tint to the fruit's skin. When compared to the other carambolas, 'Arkin' and 'Fwang Tung' had significantly lower b* values thus less yellow in the skin color. A yellowish-orange fruit color is preferred by consumers (Crane et al., 1998).

There was a significant year effect in carambola Brix values (Table 1). Carambola fruits were heavier in 2012 than in any other year (Table 1); clearly, in 2012, carambola produced larger, sweeter fruit with more seeds than in any other year sampled. 'Hew 1', 'Demak' and 'Fwang Tung' produced the greatest Brix content in the winter harvests of 2008, 2009 and 2012, respectively. 'Wheeler', 'Hew 1', 'Fwang Tung x Golden Star', and 'Demak' all had a high Brix content in summer 2011. Fruits were longer, had a larger diameter and were darker with more green and less yellow skin color in 2012 (data not shown). For fruit weight there were no differences between the summer harvest in 2011 and winter harvests in 2008 and 2009 (Table 1). 'Fwang Tung x Golden Star', 'Kary', and 'Wheeler' produced a consistent fruit weight regardless of the year harvested.

In summary, three cultivars were identified with a high Brix value and large fruit size: 'Hew 1', 'Fwang Tung' and 'Demak'. Crane et al. (1998) reported that consumers preferred medium sized, sweet carambola fruit without any bitter after-taste. 'Demak' has a bitter aftertaste (Crane, 2007). 'Hew 1' and 'Fwang Tung' were acceptable as home garden trees but 'Hew 1' has whitish spots on the fruit and 'Fwang Tung' has thin ribs subject to handling damage. Several varieties, 'Kary', 'Key West' and 'Wheeler', are sweet carambolas with medium to large size and may be good selections for planting in south Florida or elsewhere in the subtropics.

LITERATURE CITED

Campbell, C. W., 1965. The Golden Star carambola. Fla. Agr. Exp. Sta. Circ. S-173.

Campbell, C. W., 1989. Propagation and production systems for carambola. *Proc. Interam. Soc. Trop. Hort.* 33:66-71.

Campbell, C. W., 1997. Carambola cultivars in Florida. *Proc. Fla. State. Hort. Soc.* 110:146-147.

Campbell, C. W., R. J. Knight Jr., and R. Olszack, 1985. Carambola production in Florida. *Proc. Fla. State. Hort. Soc.* 98:145-149.

Campbell, C. A., D. J. Huber, and K. E. Koch, 1987. Postharvest response of carambolas to storage at low temperatures. *Proc. Fla. State Hort. Soc.* 100:272–275 (1987).

Campbell, C. A., and K. E. Koch, 1989. Sugar/acid composition and development of sweet and tart carambola fruit. *J. Amer. Soc. Hort. Sci.* 114(3):455-457.

Crane, J. H., 1993. Commercialization of carambola, atemoya, and other tropical fruits in south Florida. p. 448-460. *In*: J. Janick and J.E. Simon (eds.), New crops. Wiley, New York.

Crane, J. H., 1994. The carambola (Star Fruit). Horticultural Science Document Fact Sheet HS-12. Florida Coop. Ext. Serv. Inst. Food Agri. Sci., Uni. Florida.

Crane, J. H., R. J. Knight, Jr., O. Rodriguez, and L.C. Crane, 1998. Cultivar tree growth and fruit quality evaluation of young carambola (*Averrhoa carambola* L.) trees. *Proc. Fla. State Hort. Soc.* 111:299-302.

Crane, J. H., 2007. Carambola growing in the Florida home landscape. Horticultural Sciences Document HS12. *Florida Coop. Ext. Serv. Inst. Food Agri. Sci.*, Uni. Florida.

Crane, J. H., L. Willis, S. P. Lara, and M. Ellenby, 1991. Short-term effects of topping of five year old 'Arkin' carambola trees. *Proc. Fla. State. Hort. Soc.* 104:57-60.

Ding, P., S. H. Ahmad, and H. M. Ghazali, 2007. Changes in selected quality characteristics of minimally processed carambola (*Averrhoa carambola* L.) when treated with ascorbic acid. *J. Sci. Food Agric.* 87:702–709.

Goenaga, R., 2007. Yield and fruit quality traits of carambola cultivars grown at three locations in Puerto Rico. *HortTechnology* 17(4):604-607.

Green, J. G., 1987. Carambola production in Malaysia and Taiwan. *Proc. Fla. State. Hort. Soc.* 100:275-278.

Hallman, G. J., 1989. Quality of carambolas subjected to hot water immersion quarantine treatment. *Proc. Fla. State Hort. Soc.* 102: 155-156.

Janick, J., 2001. Asian crops in North America. *HortTechnology* 11(4):510-513.

Knight, R. J. Jr., 1982. Response of carambola seedling populations to Dade County's oolitic limestone soil. *Proc. Fla. State Hort. Soc.* 95:121-122.

Knight, R. J. Jr., 1989. Carambola cultivars and improvement programs. *Proc. Interam. Soc. Hort.* 33:72-78.

Markel, G. M., J. J. Brown, and B. A. Schneider, 1998. Food and Feed Crops of the United States. Meister Publishing Company, Willoughby, OH.

Morton, J., 1987. Carambola. p. 125–128. *In*: Fruits of warm climates. Julia F. Morton, Miami, FL, USA.

Mossler, M. A., and J. Crane, 2009. Florida crop/pest management profile: carambola: Horticultural Sciences document CIR 1416. *Florida Coop. Ext. Serv., Inst. Food Agri. Sci.*, Univ. Florida.

Narain, N., P. S. Bora, H. J. Holschuh, and M. A. Da S. Vasconcelos, 2001. Physical and chemical composition of carambola fruit (*Averrhoa carambola* L.) at three stages of maturity. *Cienc. Tecnol. Aliment.* 3(3):144-148.

Núñez-Elisea, R., and J. H. Crane, 2000. Selective pruning and crop removal increase early-season fruit production of carambola (*Averrhoa carambola* L.). *Scientia Hort.* 86:115-126.

O'Hare, T. J., 1993. Postharvest physiology and storage of carambola (starfruit): a review. *Postharvest Biol. Technol.* 2:257-267.

Weller, A., C. A. Sims, R. F. Matthews, R. P. Bates, and J. K. Brecht, 1997. Browning susceptibility Changes in composition during storage of carambola slices. *J. Food Sci.* 62:2

Wagner, C. J. Jr., W. L. Bryan, R. E. Berry, and R. J. Knight Jr., 1975. Carambola selections for commercial production. *Proc. Fla. State Hort. Soc.* 88:466-469.

Watson, B. J., A. P. George, R. J. Nissen, and B. I. Brown, 1988. Carambola: a star on the horizon. *Queenl. Agric. J.* 114:45-51.