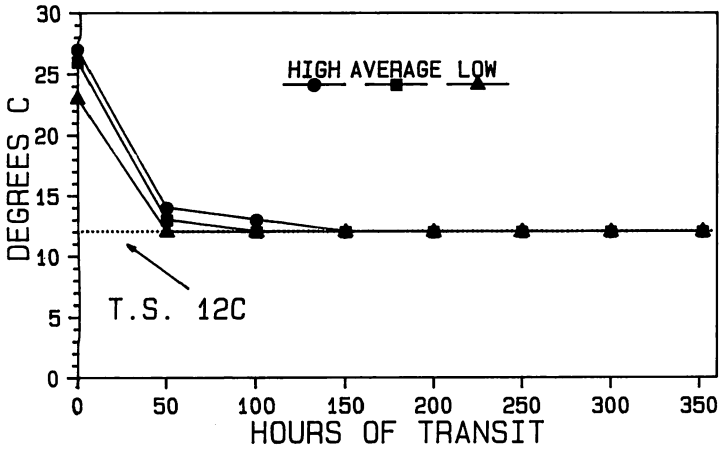

Fig. 2. Temperature profile of potted Areca palms in a 13.7 m van container shipment with bottom-air delivery from Florida to Europe, Aug. 1989 (summer).

inside the van container ranged from 79 to 90% during the first 24 hours of transit while the refrigeration system was cooling the load mass. After initial cooling, the relative humidity ranged from 90 to 100% during the remainder of transit. Upon arrival, the paper sleeves were wet and the Areca palms had free moisture on the foliage. This free moisture can cause damage to some types of ornamental plants with lush leaves which may turn black and start to decay during or after transit. In the last shipment with the humidity reduction system set at 80%, the relative humidity ranged from 75 to 92% during the first 24 hours of transit while the refrigeration system was cooling the load mass. After initial cooling, the relative humidity ranged from 75 to 95% during transit. The relative humidity inside the van container was higher than the setting of the humidity reduction system because the air was picking up moisture from the plants. Upon arrival, the paper sleeves were only damp and the Areca palms did not have free moisture on the foliage. The humidity reduction system performed satisfactorily in reducing the relative humidity within the van container and preventing moisture buildup on the plants. This system would be desirable for other commodities requiring lower levels of humidity during transit such as onions, garlic, flower bulbs, etc.

Plant condition. The plants arrived in excellent condition in all 3 shipments without any foliage discoloration even though there was free moisture on the foliage in the first 2 shipments. The receiver preferred the plants from the shipment with the humidity reduction system set at 80% because the plants were drier. This system would be more beneficial for other types of foliage plants with lush leaves such as Schefflera. The potted plants which were stacked on an incline 9 to 11 layers high in the 13.7 m high cube van containers arrived in excellent condition without any damage to palms.

In general, we can conclude that this 13.7 m van container, which is the largest on the market, is acceptable for shipping potted foliage plants. The van container with the bottom-air delivery and air exchange system performed satisfactorily. The added feature of humidity reduction will also improve the arrival condition of plants by reducing or preventing free moisture buildup on plants during transit. Further tests are needed to determine the level of relative humidity which is required by plants during transit.

Literature Cited

1. Conover, C. A. and R. T. Poole. 1982. Results of the Florida test shipment. Fla. Nurseryman 29(4):28-29.
2. Homrich, S. 1985. U.S. ornamental plants making a name in foreign markets. Foreign Agr. 23(3):18-19.
3. Ilker, Y., C. A. Conover, and B. J. Pratt. 1983. Overseas transportation of potted ornamental foliage plants in integral refrigerated containers. Proc. 16th Intern. Congr. of Refrigeration, Commissions D2 and D3, Paris, France 9-14.
4. Poole, R. T. and C. A. Conover. 1983. Influence of simulated shipping environments on foliage plant quality. HortScience 18:191-193.
5. Risse, L. A., W. G. Kindya, T. Moffitt, W. R. Miller, and R. E. McDonald. 1980. In-transit temperatures of leatherleaf fern and celery shipped in commercial and experimental van containers to Europe. U.S. Dept. Agr. AAT-S-11.
6. Risse, L. A., W. R. Miller, and T. Moffitt. 1982. Shipping fresh fruits and vegetables in mixed loads to the Caribbean. U.S. Dept. Agr. AAT-S-28.
7. Risse, L. A., R. T. Hinsch, and A. Bongers. 1986. Export of potted ornamental foliage plants to Europe in refrigerated van containers with an under-the-load air delivery system. Proc. Fla. State Hort. Soc. 99:232-234.

Proc. Fla. State Hort. Soc. 102:166-169. 1989.

REFRIGERATED VACUUM PACKAGING OF CARAMBOLA SLICES

R. F. MATTHEWS, J. A. LINDSAY, P. F. WEST AND A. LEINART
Food Science and Human Nutrition Deoartment
Universitv of Florida, IFAS
Gainesville, FL 32611

Abstract. **The carambola, *Averrhoa carambola* L., is of commercial importance in South Florida with an estimated 75 hectares planted. Approximately 20 to 25% of the fruit may not meet fresh fruit standards. Utilization of this fruit for refrigerated slices was investigated. Treatment of slices included: 1) hot water dip 2) antimicrobial dip 3) citric acid dip. Three packaging films with oxygen permeabilities ranging from 15 to 8000 cc/m²/24 hr were evaluated. Film with very high (8000) oxygen permeabilities resulted in excessive browning of slices. Slices which were citric acid dipped and vacuum packaged retained satisfactory color, texture and flavor for six weeks. Hot water dipping resulted in darkening of the slices. Sodium benzoate-potassium sorbate dipped slices had reduced yeast and mold counts but lower flavor acceptance.**

Florida Agricultural Experiment Station Journal Series No. N-00146.

The carambola (*Averrhoa carambola* L.) is a tropical fruit which has achieved commercial importance in South

Florida in recent years. In 1987 there were an estimated 75 hectares of carambola orchards in Florida (3) compared to only 25 hectares in 1985 (5). Although most carambola is marketed as fresh fruit, approximately 25% of the fruit, due to size, shape or appearance, do not meet fresh market standards. These non-standard fruit could be utilized for processed products, which would reduce waste and improve returns to the growers.

The cultivar "Arkin" is the principal one in commercial production because of its excellent flavor and resistance to handling damage (5). A list of carambola cultivars grown in Florida, including fruit characteristics, was published by Campbell et al. (5).

The sugar and acid levels of carambola vary widely between cultivars. The sugars are predominately glucose and fructose and oxalic acid and malic acid the predominant organic acids (2, 3, 4). Wagner et al. (8) screened eighteen carambola selections and reported Brix ranging from 5.0 to 9.9 and pH ranging from 2.8 to 4.8. They reported oxalic levels from 39 mg/100g to 679 mg/100g. Campbell et al. (3) reported oxalic acid levels for the Arkin cultivar of 150 mg/100g at harvest; after storage at 10°C for 44 days the level of oxalic acid was reduced to 80 mg/100g. They reported a malic acid concentration of 100 mg/100g fresh weight.

The carambola fruit is a good source of vitamin C, with reported values ranging from 17 to 50 mg/100g for different selections (8, 10). Wenkam and Miller (9) reported an ascorbic acid value of 35 mg/100g fresh fruit.

There is very little published information on the processing of carambola. Research reports on pasteurized-refrigerated mango slices (6) and peach products (7) indicated satisfactory products were developed.

Objectives of this research were to evaluate the processing of carambola as packaged slices maintained as a refrigerated product. Various treatments including heat pasteurization, antimicrobial dip and citric acid dip were investigated.

Materials and Methods

Mature carambola fruit were obtained from a commercial packer in Homestead, Florida and transported to Gainesville, FL for processing. Fruit were ripened at 18°C to a light yellow color.

Ripe fruit were washed in a 200 ppm chlorine water for ten minutes. The fruit were rinsed in potable water. Fruit were sliced into three sixteenths inch thick with a "Tomato King" hand operated slicer (Redco Inc., Wilmington, DE).

Hot Water Dip Treatment. Slices were packaged in P640 film pouches, vacuum sealed and dipped in 100°C water for 45 seconds. Internal slice temperature reached 77°C. The pouches were immediately immersed in 5°C water to cool to room temperature.

Citric Acid Dip. Slices were immersed in a 1 percent citric acid solution for ten minutes at room temperature. Slices were removed and allowed to drain for one minute prior to packaging.

Antimicrobial Dip. Slices were immersed in a potassium sorbate (0.5%) and sodium benzoate (0.5%) solution for ten minutes at room temperature. Slices were allowed to drain for one minute prior to packaging.

Vacuum Packaging. Following treatment approximately 24 slices were arranged in three rows with slices overlapping on a sheet of LLDPE film. The slices were manually placed into the desired film pouch and air *removed, nitro*gen flushed and vacuum sealed using a "Multivac vacuum sealer" (Koch Co., Kansas City, MO.).

Packaging film. Films were obtained from Cryovac Division, W. R. Grace & Co., Duncan, S.C. Oxygen transmissions in $cc/m^2/24$ hr of the films specified by the manufacturer were as follows: LLDPE, 8000; P-640, 200-300; and P-840B, 10-15.

Microbiological Evaluation. Sealed packages of carambola were aseptically opened, and the entire contents blended for 2 min at high speed. Samples were immediately serially diluted into 0.1% peptone water pH 7.0, and 1 ml inoculums from each dilution were surface plated onto brain heart infusion (BHI, Difco) and malt extract agar (MEA, Pitt and Hocking, 1985). Inoculated plates were allowed to dry by incubation at 55°C for 5 min.

For the total aerobic plate count (TA), duplicate sets of BHI plates were incubated at 37°C for 24 h, and then further incubated at 25°C for 24 h. For the total anaerobic plate count (TAN), duplicate plates of BHI were incubated anaerobically, using an anaerobic gas pack (BBL, Cockeysville, MD), again at 37°C for 24 h, then at 25°C for 24 h. Enumeration of yeasts and molds was done using duplicate MEA plates incubated aerobically as described above. Incubation of the MEA plates anaerobically was considered unsuitable, since yeasts and molds found on the surfaces of fresh fruits are usually either strict aerobes or facultative anaerobes. Total aerobes, total anaerobes and total yeasts from each sample were expressed as colony forming units (cfu)/100 g of sample.

Color Measurement. Color of slices was measured with a HunterLab Color/Difference Meter D25-2 using a C2-11155 yellow color standard. Seeds and particles were removed from 20 to 24 slices. Slices were then pureed in a Waring Blendor for one minute. The puree was poured into an Agtron sample cup (2 1/4") for color measurement.

Brix, pH and titratable acidity. Brix of the puree was measured with a Reichert ABBE digital refractometer. pH was measured with a Corning 130 pH Meter and titratable acidity was measured by titration of a 50 ml sample with 0.5 N NaOH to an endpoint of pH 8.2. Acidity was calculated as percent citric acid.

Sensory Evaluation. Slices were evaluated for flavor and color by a 30 member sensory panel using an hedonic scale from 9 (like extremely) to 1 (dislike extremely).

Experimental Design. In experiment 1 three films (LLDPE, P-840B and P-640) and hot water dip and citric acid dip were evaluated. In a second experiment citric acid dip or benzoate-sorbate were evaluated at 4°C and 13°C storage for nine weeks. All evaluations were determined from duplicate samples.

Statistical Analysis. Data was evaluated by analysis of variance and means compared using Duncan's multiple range procedure.

Results and Discussion

Packaging Film. The packaging film had a significant effect on the quality of the stored slices. Slices stored in the highly oxygen permeable LLDPE film were significantly

darker in color than slices stored in the other films after *three weeks storage* at 4°C, and continued to darken during storage (Fig. 1). The film with the lowest oxygen permeability (P840B) maintained the best color of slices during storage (Fig. 1). The intermediate oxygen permeability film (P640) maintained satisfactory color of vacuum packaged slices during the nine weeks storage period.

The P840B film packaged slices had high numbers of yeast colonies at 0, 3, 6 and 9 weeks storage, significantly greater numbers than the other treatments (at weeks 0, 3, and 6 (Table 1). Microbial counts for slices in the P640 film were very good (<100) for the first six weeks of storage. The LLDPE packaged slices had aerobic counts of 1000 initially but counts dropped to <100 for the three and six week storage periods. After nine weeks storage at 4°C all treatments had TA and yeast counts in the $1.0x10^5$ range. On the basis of these results the P640 film was selected for furthur experiments.

Heat Treatment. The pasteurization heat treatment of packaged slices resulted in good control of microorganisms (<100) for six weeks of storage (Table 1). After nine weeks storage significant numbers ($>10^5$) of yeasts and aerobes had developed. The heat treatment, however, resulted in darkening and unsatisfactrory color after three weeks storage. Sensory panelists also rated the color of the slices less desirable than the citric acid or vacuum packaged only slices.

Citric Acid Treatment. Citric acid (C.A.) treated slices maintained a desirable light yellow color throughout the nine weeks storage at 4°C. Microbial quality of C.A. treated slices was very good (<100) at 4°C storage for six weeks in one experiment (Table 1) and for nine weeks in a second trial (Table 2). The C.A. treated slices had high flavor quality for the first six weeks of storage but at nine weeks sensory panelists preferred the non-treated vacuum packaged slices.

Antimicrobial treatment. Carambola slices dipped into antimicrobial solution had no growth of aerobic bacteria, anaerobic bacteria or yeasts during 9 weeks storage at either 4 or 13°C (Table 2.) The treatment, however, had a negative effect on the color of the slices. After nine weeks storage, panelists rated the treated slices significantly lower than the untreated. The flavor of the antimicrobial treated slices was significantly less desirable at all storage periods than either the vacuum packed slices or the citric acid treated-vacuum packed slices (Table 3).

Table 1. Microbiological evaluation of carambola slices vacuum packaged in films with different levels of oxygen permeability and treated by citric acid dip or hot water dip (P-640 film). Stored at 4°C for nine weeks (c.f.u./100g).

Packaging treatment	Weeks of storage			
	0	3	6	9
	Aerobes			
LLDPE(V)	1000	100	<100	100,000
P840B(V)	1000	1000	100,000	100,000
P640(V)	<100	<100	<100	100,000
P640(C)	<100	<100	<100	100,000
P640(T)	<100	<100	<100	100,000
	Anaerobes			
LLDPE(V)	<100	<100	<100	<100
P840B(V)	1000	<100	<100	<100
P640(V)	<100	<100	<100	<100
P640(C)	<100	<100	<100	<100
P640(T)	<100	<100	<100	<100
	Yeasts			
LLDPE(V)	<500	<100	<100	100,000
P840B(V)	1000	1000	100,000	100,000
P640(V)	<100	<100	<100	100,000
P640(C)	<100	<100	<100	100,000
P640(T)	<100	<100	<100	100,000

C = Citric acid dipped
T = Hot water dipped
V = Vacuum packaged only

Fig. 1 COLOR EVALUATION OF CARAMBOLA

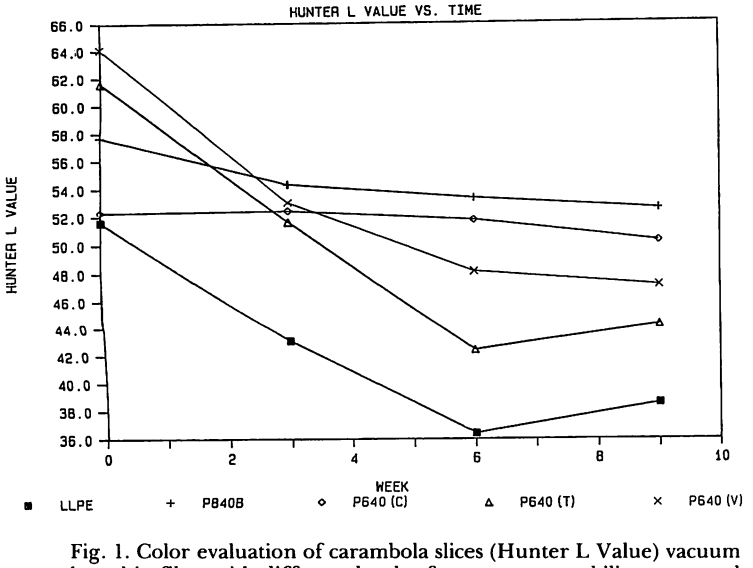

Fig. 1. Color evaluation of carambola slices (Hunter L Value) vacuum packaged in films with different levels of oxygen permeability or treated by citric acid dip (C) or hot water dip (T) and vacuum packed in P-640 film.

Table 2. Microbiological evaluation of carambola slices treated by citric acid dip or hot water dip and vacuum packaged in P-640 film. Stored at 4° and 13°C for nine weeks (c.f.u./100g).

Treatment	Storage temp.	Weeks of storage			
		0	3	6	9
		Aerobes			
Vacuum control	4°C	<10	<500	<100	<100
Citric acid	4°C	<10	<10	<10	<10
Benzoate-sorbate	4°C	<10	<10	<10	<10
Vacuum control	13°C	6×10^3	5×10^4	2×10^5	0
Citric acid	13°C	2×10^2	1×10^4	2×10^4	9×10^6
Benzoate-sorbate	13°C	<10	<10	<10	<10
		Anaerobes			
Vacuum control	4°C	<10	<10	<10	<10
Citric acid	4°C	<10	<10	<10	<10
Benzoate-sorbate	4°C	0	0	0	0
Vacuum control	13°C	6×10^3	1×10^5	0	0
Citric acid	13°C	2×10^2	0	0	0
Benzoate-sorbate	13°C	0	0	0	0
		Yeast			
Vacuum control	4°C	<10	<10	<10	<10
Citric acid	4°C	<10	<10	<10	<10
Benzoate-sorbate	4°C	0	0	0	0
Vacuum control	13°C	<10	<10	<10	<10
Citric acid	13°C	0	0	0	0
Benzoate-sorbate	13°C	0	0	0	0

Table 3. Sensory evaluation of carambola slices treated with citric acid or sorbate-benzoate and stored at 40°F.

	Color				Texture			
	Week 0	Week 3	Week 6	Week 9	Week 0	Week 3	Week 6	Week 9
Vacuum pack only	7.3a	7.4a	7.0a	7.4a	5.8a	5.6a	5.2a	5.3a
Citric acid	6.5b	7.4a	7.5a	6.4b	6.8a	6.3ab	6.5ab	5.4b
Sorbate-benzoate	6.2a	7.0a	6.9a	5.1b	6.2a	7.1a	6.6a	6.5a
	Flavor				Acceptability			
	Week 0	Week 3	Week 6	Week 9	Week 0	Week 3	Week 6	Week 9
Vacuum pack only	6.2a	6.6a	5.7a	6.5a	6.4a	6.4a	5.4b	6.5a
Citric acid	5.5ab	5.8a	6.2a	4.7b	5.6a	6.0a	6.1a	5.1a
Sorbate-benzoate	4.5a	4.4a	4.2a	4.1a	5.0a	5.2a	5.1a	4.4a

Untreated vacuum packaged slices. Slices which received no treatment and were vacuum packaged retained their color as well as citric acid treated slices in one experiment (Table 3); however in a second experiment (Fig. 1), the color was slightly better for C.A. treated slices. Flavor and overall acceptability were very good for nine weeks at 4°C. Microbial quality was good (<100) for six weeks in one experiment (Table 1) and for nine weeks in the other (Table 2).

Summary

Slices which were untreated-vacuum packaged and slices which were citric acid treated-vacuum packaged retained satisfactory color, flavor, texture and microbial quality for six weeks storage at 4°C. In some experiments satisfactory quality was maintained for nine weeks. Acceptable slice color was maintained during storage by films with oxygen permeabilities of 300 cc/m²/24 hr or less. Hot water dipping of packaged slices did not provide a satisfactory product. Sodium benzoate-potassium sorbate dipped slices had reduced yeast and mold counts but lower flavor acceptance.

Literature Cited

1. Bates, R. P. and C. A. Sims. 1987. Processing potential of Florida-grown crops. Proc. Fla. State Hort. Soc. 100:389-393.
2. Campbell, C. A. 1987. Carambola fruit development and storage in Florida. M.S. Thesis, University of Florida.
3. 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.
4. 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.
5. Campbell, C. W., R. J. Knight Jr., and R. Olszack. 1985. Carambola production in Florida. Proc. Fla. State Hort. Soc. 98:145-149.
6. Falcone, E. G., R. P. Bates, and J. A. Koburger. 1975. Process refinement and storage characteristics of pasteurized-refrigerated mango slices. Proc. Fla. State Hort. Soc. 88:482-486.
7. Harris, H. 1963. Pasteurized refrigerated peach products. Alabama Agric. Exp. Sta. Highlights of Agric. Res. 10(2):11.
8. Wagner, C. J. Jr., W. L. Bryan, R. E. Berry, and R. J. Knight, Jr. 1975. Carambol.a selection for commercial production. Proc. Fla. State Hort. Soc. 88:466-469.
9. Wenkam, N. S. and C. D. Miller. 1965. Composition of Hawaii fruits. Univ. Hawaii Exp. Sta. Bul. 135.
10. Wills, R. B. H., J. S. K. Lim, and H. Greenfield. 1986. Composition of Australian foods. 31. Tropical and sub-tropical fruit. Food Tech. Australia 38(3):118-123.

Proc. Fla. State Hort. Soc. 102:169-175. 1989.

EVALUATION OF COMMERCIAL PRECOOLING FOR SWEET CORN

MICHAEL T. TALBOT[1], STEVEN A. SARGENT[2],
JEFFREY K. BRECHT[2]
University of Florida, IFAS
Agricultural Engineering Department[1]
Vegetable Crops Department[2]
Gainesville, Florida 32611

LAWRENCE A. RISSE
USDA, ARS, European Marketing Research Center
Rotterdam, The Netherlands

Additional index words. hydrocooling, vacuum cooling, slush ice.

Abstract. **Time-temparature relationships were determined over two seasons for sweet corn precooled commercially using hydrocooling, vacuum cooling, and slush icing. The cooling efficiencies of the three precooling methods were compared immediately after cooling and after simulated shipment and storage. Quality parameters were also evaluated for the three precooling methods initially and after simulated shipment and storage. Quality factor determinations included measurements of kernel carbohydrates, moisture and pericarp content. Evaluations of husk drying, husk color, silk apparance, kernel denting and sensory panel results were made to simulate consumer preference in relationship to precooling methods. An overall evaluation and comparison of the three precooling methods is presented.**

Florida Agricultural Experiment Station Journal Series No. N-00150.

The sugar content of sweet corn, which largely determines quality, decreases rapidly at normal temperatures (1). Loss of tenderness and sweetness are not acceptable to consumers. New supersweet cultivars with twice the sugar content of previous cultivars lose their sweetness more slowly during marketing and have improved consumer satisfaction. However proper temperature management is important even with the supersweet corn varieties (2). Proper temperature management of sweet corn begins with precooling (rapid removal of field heat) from temperatures as high as 30°C.

Rapid removal of field heat is critical to retard deterioration of sweet corn. The recommendation for maximum quality retention of sweet corn is precooling to 0°C within 1 hour of harvest and maintaining at 0°C throughout the marketing channels (5). For commercial sweet corn operations in Florida, cooling to this ideal criteria is rarely achieved due to various factors, including volume of corn