fertilizer is required at higher light levels.

Nitrogen increased tissue levels of N, slightly decreased K and had no effect on Ca and Mg in both experiments (Tables 3 and 4). In Expt. 1, increasing N slightly decreased P, but N had no effect on P in Expt. 2. Levels of N, K and Mg were similar in both experiments but tissue Ca was higher in Expt. 1 than Expt. 2. An increase in P levels increased tissue P and decreased tissue Ca (Table 3). Increasing levels of K did not influence tissue N or P, decreased Ca and Mg and increased tissue K. Tissue P was the only element affected by placement of water and fertilizer. More P was absorbed when the water-fertilizer solution was applied to the vase of the plant than to the medium. Treatments had no effect on Cu, Fe, Mn or Zn in *A. fasciata* tissue which averaged 20, 160, 140 and 170 ppm, respectively.

Table 3. Influence of N, P, K on foliar content of *Aechmea fasciata*, Expt. 1.

Element	mg/10 cm pot/4 wk	% dry wt N	P	K	Ca	Mg
N	50	1.3a[z]	0.33b	3.2b	.79a	.51a
	100	1.5b	0.27a	2.8a	.79a	.53a
	150	1.8c	0.26a	2.9a	.81a	.54a
P	25	1.5a	0.20a	3.0a	.97b	.53a
	50	1.6a	0.29b	3.0a	.73a	.53a
	75	1.4a	0.36c	2.9a	.68a	.51a
K	50	1.5a	0.30a	2.2a	.92c	.61c
	100	1.5a	0.27a	3.2b	.82b	.51b
	150	1.4a	0.28a	3.4b	.65a	.45a

[z]Mean separation, within elements in a column, by Duncan's multiple range test, 5% level. Numbers are average of 54 units.

Table 4. Influence of N, K and method of water-fertilizer application on foliar content of *Aechmea fasciata*. Expt. 2.

Element	mg/12.5 cm pot/4 wk	% dry wt N	P	K	Ca	Mg
N	60	1.2a[z]	.29a	3.4c	.32a	.39a
	120	2.0b	.31a	2.4a	.37a	.37a
	180	2.4c	.30a	2.7b	.34a	.35a
K	60	2.1a	.31a	1.7a	.39b	.45c
	120	1.8a	.31a	3.1b	.34ab	.36b
	180	1.9a	.28a	3.8c	.30a	.30a
Water-fertilizer placement						
Medium		1.8a	.26a	2.8a	.34a	.36a
Plant vase		2.0a	.34b	2.9a	.35a	.37a

[z]Mean separation, within a series in a column, by Duncan's multiple range test, 5% level. Numbers are averages of 36 units (N & K) and 54 units (water-fertilizer).

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HortScience 11(6):586–588. 1976.

Postharvest Control of Endogenous Brown Spot in Fresh Australian Pineapples with Heat[1]

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Additional index words. Ananas comosus, black heart

Abstract. **Heating fruits at 37.2°C for 24 hours controlled endogenous brown spot (EBS) in refrigerated fresh pineapples [*Ananas comosus* (L.) Merr. cv. Smooth Cayenne]. Heat treatment after refrigeration was more effective than before refrigeration and reduced molding of the fruit butt. Heat treatments did not affect surface coloring, fruit weight loss, crown browning, senescence, decay incidence, translucence, flavor, or pulp aroma, but did improve pulp appearance by making it more golden yellow than of untreated fruits.**

Endogenous brown spot (EBS) or black heart as it is called when the spots are coalesced is an important physiological disease of pineapples, and its formation (1, 2, 4), symptoms (1, 4), and incidence (1, 5, 9) have been described. In Queensland, Australia, up to 50% of the winter fruits may be discarded after slicing at the cannery because they are afflicted with this disease. Summer fruits, on the other hand, do not seem to be afflicted with the malady when immediately processed. In Hawaii, this disease is rarely seen in fruit being processed in the cannery in any season, but it is the most important problem in fresh fruit shipped overseas under refrigeration. Development of this malady during and after refrigeration causes fruit losses that range from little to total loss. Heat treatment to control this disease proved effective for Hawaiian pineapples (1). The present paper reports the results of experiments conducted to determine the effect of heat on the incidence of EBS in refrigerated summer Queensland pineapples.

Fresh pineapples for this investigation were obtained from Queensland in the summer months of Jan. and Feb., 1975. They were harvested in the morning at commercial harvest stages (2–30% yellowed fruit surface) and shipped via railway in the afternoon of the same day to Division of Food Re-

[1]Received for publication July 23, 1976. Journal Series No. 1919 of the Hawaii Agricultural Experiment Station.

[2]This work was carried out in the laboratories of the Division of Food Research, Commonwealth Scientific and Industrial Research Organization, North Ryde, New South Wales, Australia, while the author, on leave from the University of Hawaii, was a visiting scientist. The technical assistance of W. M. Bailey is acknowledged with appreciation. R. Wassman of Golden Circle Cannery, Queensland, supplied the fruits for this investigation and information on the status of endogenous brown spot in Australia.

search, Commonwealth Scientific and Industrial Research Organization, North Ryde, New South Wales. Upon arrival the following morning, they were immediately installed in experiments, 8 to 19 fruits per treatment. The fruits were selected and matched for surface color development (% of surface area yellowed) so that the degree of initial surface color was the same in all treatments in any experiment. Fruits were first weighed and then placed on their sides in open fiberboard cartons for treatment. In order to ascertain the status of EBS incidence in freshly harvested fruit, an additional lot of 8 or more fruits was cut and examined at the start of each experiment.

Heat treatments (24 hr) were applied either before or after refrigeration in a walk-in incubator maintained at 37.2°C and 33% relative humidity, and refrigerated storage (6 days) occurred in walk-in cold rooms maintained at 3° and 90% relative humidity or 7° and 74% relative humidity. After treatments, the fruits were placed in a holding room maintained at 23° and 65–70% relative humidity for 6 days before final observations were made. Fruit temperature determined immediately after all heat treatments using thermometers inserted in the core of 2 fruits in each lot, averaged about 34°. Control fruits were stored in cold rooms for 7 days and then placed in the holding room for 6 days before final observations were made together with the treated lots.

Final observations were made on the intact fruit as follows: % surface color, fruit wt, degree of crown browning (0 = none; 1 = slight; 2 = moderate; 3 = severe), % moldy butt (% of exposed peduncle area covered by mold), no. of senescent fruitlets (darkened and watery), and no. of decayed fruits. Fruits with the crown and butt ends removed were then cut longitudinally into quarters, and the core segments were cut away to expose the spots fully. The no. and degree of darkening (0 = none; 1 = slight; 2 = moderate; 3 = severe; 4 = coalesced) of the spots were recorded along with the degree of pulp translucence (1 = opaque; 2 = opaque-translucent; 3 = translucent). Taste, aroma, texture, and appearance of the pulp were judged by a panel of 3 tasters.

In all cases, freshly harvested pineapples did not show any EBS. Therefore it is concluded that the cold treatment used in the experiments induced the malady.

In 5 different experiments, the heat treatment controlled EBS, but in 3 of these the no. of spots per fruit in the controls (no heat) was less than 6, and these control fruits were probably still salable (1). Therefore the results of these 3 experiments are not presented here. In the other 2 experiments (Table 1), the incidence of EBS in the controls was high (30 or more spots per fruit) which shows that the effects of the treatments are similar in fruits refrigerated at either 3° or 7°C.

Heat treatments either before or after refrigeration, were effective in controlling EBS as judged by the no. of spots, their degree of darkening, and the % of fruits with the malady. However, the post-refrigeration heat treatment was superior to the pre-refrigeration heat treatment (Table 1). The post-refrigeration heat treatment also reduced the degree of butt molding. The treatments did not significantly affect the other parameters (final surface color, weight loss, crown browning, senescence, decay, and pulp translucence). Taste, aroma, and texture of the pulp were not affected by the treatments, but the appearance of the pulp seemed more golden yellow in the treated lots than in the controls. These results are similar to those of the previous investigation on Hawaiian fruit (1), with one exception: in the previous study, weight loss was greater in the heated fruits. They are also similar to results obtained with refrigerated grapefruit in which intermittent warming prevented rind injury (3) and with apples in which warming reduced breakdown in cold storage (8).

Extremely high humidities have been used to restrict the development of chilling injury in bananas (6) and other tropical and subtropical fruits (7), while on the other hand, low humidities have reduced low temperature breakdown in apples (8). In the previous work with Hawaiian pineapples (1), a high relative humidity of 96% was used with refrigeration; but in the present investigation, lower relative humidities of 74% and 90% were used. In both cases, however, EBS developed. Therefore, the role of humidity on the development of the malady in fresh pineapples is not clear.

At present, some fresh Queensland pineapples are shipped overseas by air. Should shipments occur by sea under refrigeration, the results of this investigation suggest heat treatments could effectively control EBS in export fruit. Furthermore, these results and those obtained in Hawaii (1) indicate the possibility of controlling this physiological disease of fresh pineapples in postharvest handling in other areas of the world.

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Table 1. Effects of pre- and post-refrigeration heat treatments on EBS incidence, surface coloring, weight, crown browning, butt molding, senescence, decay incidence, and pulp translucence of fresh pineapples refrigerated at 3° and 7°C.

Heat treatment before 6-day storage in holding room[z]	No. spots/ fruit[v]	Spot darkening/ fruit[v]	% EBS fruit[u]	% final surfact color/ fruit[v,t]	% wt loss/ fruit[v]	Degree crown browning/ fruit[v]	% moldy butt/ fruit[v]	No. senescent fruitlets/fruit[v]	% decayed fruits	Degree pulp translucence/ fruit[v]
Refrigeration (3°C, 90% relative humidity)										
Pre-refrigeration[y]	14.6b	1.0b	62.5	96.8a	6.2a	0.6a	46.2b	0a	0	2.2a
Post-refrigeration[x]	0.5a	0.5a	25.0	97.4a	6.4a	0.4a	15.9a	0a	0	2.4a
Control[w]	32.8c	3.0c	100.0	98.9a	6.4a	0.9a	43.8b	0a	0	2.2a
Refrigeration (7°C, 74% relative humidity)										
Pre-refrigeration[y]	8.2b	0.9b	66.7	95.1a	6.3a	0.7a	71.1b	0a	0	2.2a
Post-refrigeration[x]	0.4a	0.2a	11.1	91.2a	6.2a	0.6a	28.3a	0a	0	2.1a
Control[w]	30.1c	1.9c	100.0	97.3a	6.9a	0.7a	66.7b	0a	0	2.3a

[z]23°C, 65–70% relative humidity.

[y]Heat (37.2°C, 33% relative humidity) 24 hr followed by refrigeration 6 days.

[x]Refrigeration 6 days followed by heat 24 hr.

[w]Refrigeration only 7 days.

[v]Mean separation within columns by Duncan's multiple range test at 5%.

[u]% of all fruits with EBS, regardless of no. of spots.

[t]Avg initial surface color for each treatment: 20% and 16% for fruit refrigerated at 3° and 7°C, respectively.

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HortScience 11(6):588–590. 1976.

Ethylene Degreening of 'Bearss' Lemons[1]

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Additional index words. Citrus limon, decay control, thiabendazole, benomyl, ethephon

Abstract. **The time required to degreen Florida 'Bearss' lemons can be greatly reduced by the use of 1 to 10 ppm ethylene at 25 or 30°C. Degreening was accomplished in 2 to 3 days instead of the 2 to 3 weeks required with the current commercial practice of cool coloring at 15° without ethylene. Applications of a benzimidazole fungicide (thiabendazole, benomyl) prior to degreening adequately controlled decay. Rapid degreening with ethylene at higher temperatures (25° or 30°) eliminates the need for cool coloring storage and brings lemon availability more nearly in phase with consumer demand.**

'Bearss' lemons grown in Florida to be marketed as fresh fruit are commercially degreened by cool coloring at 15°C under high humidity and without ethylene until an acceptable color develops (8). This procedure can require as long as 3 weeks. The 3-week delay limits marketing potential since harvest begins in midsummer when market demand is at its peak.

The use of ethylene for degreening of Florida-produced lemons has been avoided because it reportedly increased stem-end rot (1, 2, 5). Recently, postharvest applications of ethephon and storage at 15° has been suggested as a means of reducing the degreening time (9). The time is only reduced 30 to 50% with this method, and refrigerated storage is still required.

Florida lemons generally start maturing when the summer demand for lemons is maximal. Therefore, when juice content is adequate i.e. over 30% v/v, harvest and rapid degreening using ethylene at temp of 25 or 30°C would improve marketing by bringing lemon availability more nearly in phase with consumer demand. The effectiveness of thiabendazole (TBZ) and benomyl (Benlate) against the stem-end rot fungi, *Diplodia natalensis* P. Evans and *Phomopsis citri* Fawc., made the use of ethylene for degreening appear feasible. The purpose of this study was to determine the optimum temp and ethylene concn for degreening and to evaluate thiabendazole and benomyl for decay control on lemons degreened with ethylene.

'Bearss' lemons used in degreening studies were hand washed and graded for color and size. The laboratory procedure described by Wheaton and Stewart (11) for preparing fruit for color measurements was used. Ten fruit were placed at 15, 20, 25, and 30°C and exposed to ethylene concn of 0, 0.1, 1, and 10 ppm (± 5%) in a continuously flowing system. An additional 10 fruit were treated with 1,000 ppm ethephon and stored at 15° without additional ethylene. Ethylene concn was verified daily with a gas chromatograph equipped with a flame ionization detector. Color change was measured at intervals of 1 to 2 days with a Hunterlab D25 Color Difference Meter. An a/b value of −0.20 was considered as optimum greenish-yellow color acceptible for lemons to be used commercially.

Decay, primarily stem-end rot, as influenced by ethylene and fungicides, was evaluated in separate lots of 100 to 300 lemons. These fruit were cool

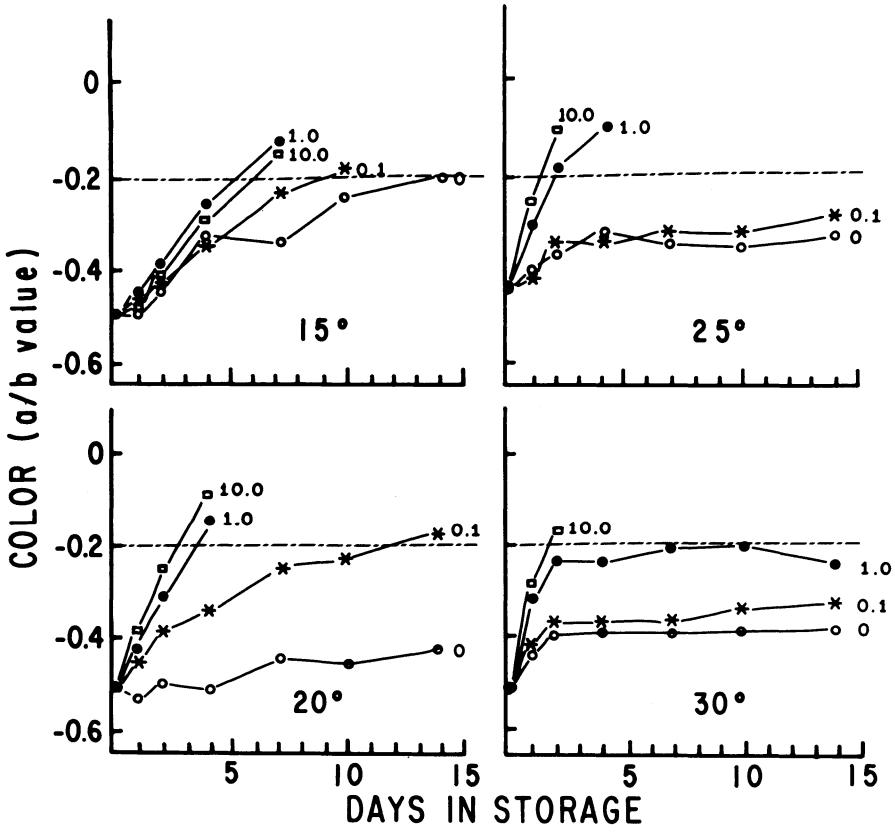

Fig. 1. Postharvest color change of 'Bearss' lemons harvested Oct. 7, 1973 and held at 4 concn (ppm) of ethylene each at 4 temp. An a/b value of −0.2 is optimum marketable color.

[1]Received for publication June 21, 1976. Florida Agricultural Experiment Stations Journal Series No. 6155.
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