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EFFECT OF TEMPERATURE OF STORAGE ON QUALITY OF DORIS PLUMS

By M. D. LITTMANN, B.Sc.

SUMMARY

Doris plums may be stored for 2 weeks at 32° or 30°F and following removal to 70°F maintain an acceptable post-storage quality in excess of 1 week. The variety appears to be suitable for export from Australia to South-east Asian countries.

I. INTRODUCTION

Although trial shipments of Doris plums to South-east Asia have indicated an export potential for this variety, information on suitable storage temperatures, and on the storage behaviour of the fruit, is lacking.

Plums are a highly perishable product, and much diversity exists in estimation of maximum storage life (Kidd and West 1936; Tindale, Trout and Huelin 1935), and of response to storage temperatures among varieties. Although storage temperatures of 31–32° are usually recommended (Huelin and Tindale 1940; Padfield 1954; Srivastava and D'Souza 1962; Ginsburg 1965; Lutz and Hardenburg 1968), other recommendations which have been made for some varieties are 40°F (Jackson 1960) and 32–34°F (Smith 1937).

Most stored plums require, in addition to a suitable holding temperature, some higher temperature at which satisfactory ripening will occur. Optimum ripening temperatures have been reported at 65°F (Tindale, Trout and Huelin 1935), 60°F (Kidd and West 1936) and 45°F (Huelin and Tindale 1940). However, Couey (1960) observed damage to Eldorado plums at temperatures close to 45°F, and Furlong and Barker (1935) reported this as an unsatisfactory temperature for Kelsey plums, which were better ripened at 60°F or 70°F. Uota (1955) found that some varieties of plums ripen normally at 90°F.

The purpose of this investigation was to establish if Doris plums could be satisfactorily stored for periods adequate for their export from Australia to South-east Asia. A minimum storage period of 2 weeks, and about 7 days as a post-transport period, are required.

II. MATERIALS AND METHODS

Plums used in the experiments (Prunus 'Doris') were obtained in the Stanthorpe district and were placed in cool storage within 24 hr of harvest.

Fruit were harvested with a green ground colour showing a trace of yellow. An attempt was made to measure physiological age by determining the time to the appearance of the respiratory climacteric, but under the conditions used (68°F) no climacteric could be detected.

The experiments reported here were performed using five consignments of fruit, and these were taken over three seasons. Five growers were selected and were representative of widely separated areas of the growing district. During 1968 and 1969, fruit was stored at 55°, 35°, 32° and 30°F for periods of 0, 1, 2, 3, 4, and 5 weeks (referred to as "storage period" in the text), following which the plums were held at 70°F (referred to as "post-storage period"). After removal to 70°F, samples were drawn three times per week for taste assessment. The 1968 results were used as a basis for planning the more detailed experiment of 1969.

Results from these two seasons indicated that some storage times, and one of the storage temperatures, were clearly inferior. In the third season, therefore, additional data were obtained for the more effective storage treatments: plums from three growers were placed in storage at 55°, 32° and 30°F for 2 and 3 weeks, following which the fruit were held at 70°F, samples being taken for taste assessment as before.

A panel of 20 tasters assessed samples according to the following hedonic scale:

Like extremely	9
Like very much	8
Like moderately	7
Like slightly	6
Neither like nor dislike	5
Dislike slightly	4
Dislike moderately	3
Dislike very much	2
Dislike extremely	1

Although the taste preferences of South-east Asians may not equate exactly with those of the taste panel used in these experiments, this method should provide a firm basis for commercial export trials.

III. RESULTS

(a) Pattern of Temperature Effects, 1969

The changes in fruit acceptability and post-storage shelf life, in response to storage duration and temperature, are illustrated in Figures 1 and 2. The data are taken from the 1969 results. Although these, in terms of storage life, were appreciably better than in other seasons, the temperature relationships were similar from year to year.

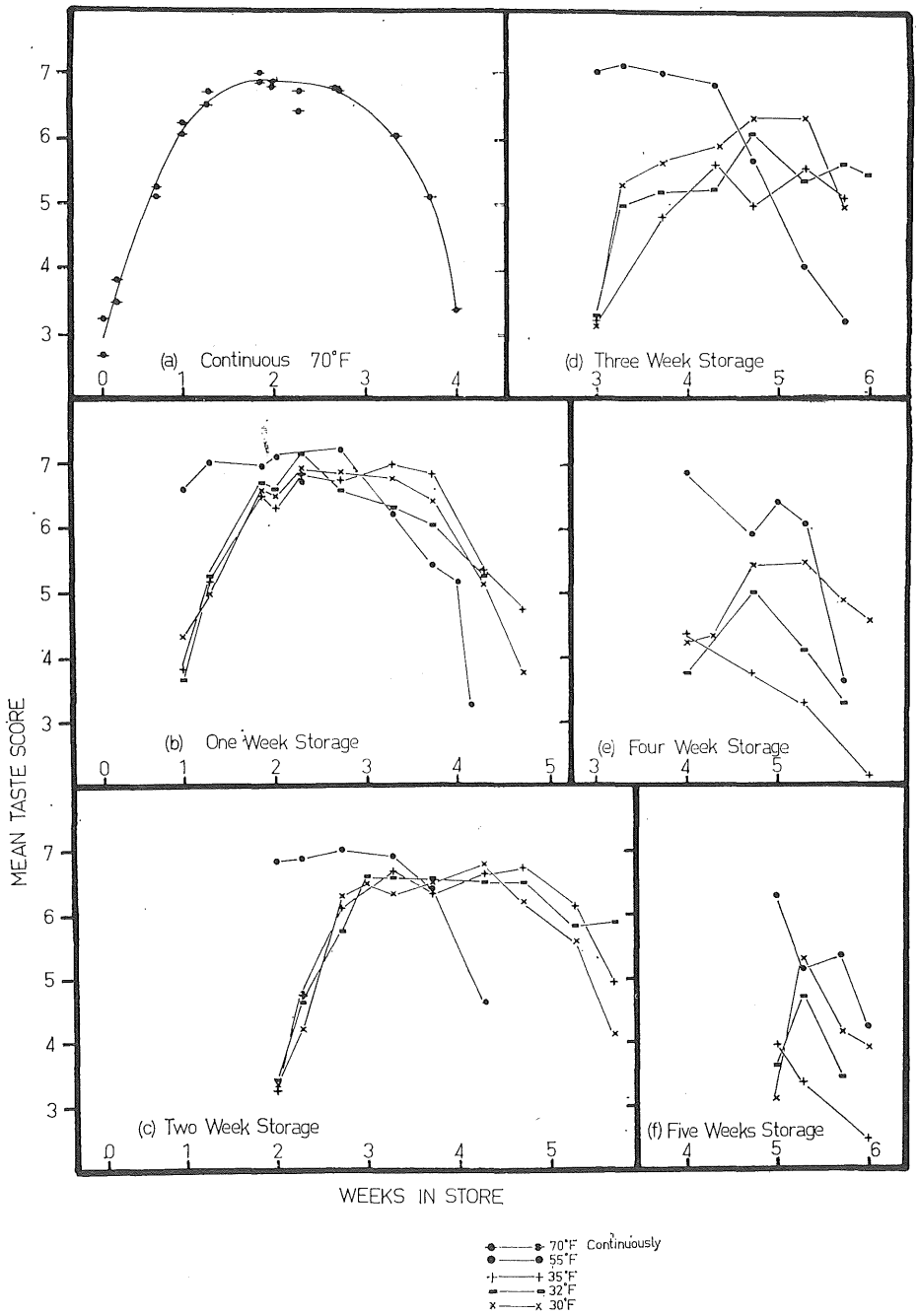

Fig. 1.—Taste scores at 70°F after storage at lower temperatures.

All points in Figure 1 are means of 20 taste assessments. A taste index of 6 (like slightly) was taken as minimum acceptable quality and the periods during which the fruit remained above this level are shown in Figure 2.

Figure 1a shows the course of quality changes for fruit held continuously at 70°F. Within 6 or 7 days from harvest, the fruit had reached a taste value of 6 and it remained above this level for approximately 16 days.

Fruit held at 55°F behaved quite differently on removal to 70°F from fruit held at the lower temperatures (Figure 1). Initial and maximum quality were higher, and maximum quality occurred sooner and fell less rapidly with each removal. On removal to 70°F, initial quality of fruit stored at 55°F was close to the maximum obtained; and for removals at 1, 2 and 3 weeks closely followed the quality pattern obtained with fruit stored continuously at 70°F. Apparently at 55°F, fruit became eating ripe at a rate similar to those at 70°F. After storage at lower temperatures initial quality changed little throughout the period of the experiment, fruit apparently ripening only on removal to 70°F.

Fruit stored at 55°F had a maximum quality rating higher than that stored at any other temperature. This was above 7 for removals 1, 2 and 3. In contrast, the maximum quality reached after storage at 30°, 32° and 35°F became successively lower with each removal, being about 7 after 1 week, 6·5 after 2 weeks, and from 5·5 to 6 after 3 weeks.

After 5 weeks' storage at 30° and 32°F (Figure 1) some slight improvement in quality occurred after removal, but this was not commercially significant and fruit never reached an acceptable quality. Fruit held at 35°F deteriorated rapidly after removal from both 4 and 5 weeks' storage.

It is notable that there was little difference in the pattern of quality development of fruit removed after 1 or 2 weeks' storage at 30°, 32° or 35°F (Figure 1, b and c). With longer low-temperature storage (Figure 1d, e and f), differences in pattern of development of palatability after removal became more apparent; with decreasing temperature of storage quality maxima occurred later and at any one storage time were greater with decreasing temperature.

Duration of acceptable quality (Figure 2) was not markedly affected by storage of up to 2 weeks at any of the temperatures. Where fruit were held longer than 2 weeks at 32° or 35°F, a rapid reduction in duration of acceptable quality occurred after removal to 70°F. This reduction was less rapid at 30°F, 1 week of acceptable quality occurring at 70°F after 3 weeks' storage. Rate of decline was least, however, in fruit stored at 55°F.

Although fruit stored at 30°F for 3 weeks were still acceptable 5·5 weeks after harvest (the longest period obtained), their acceptable life was not significantly different from some of the other times and temperatures of storage (Figure 2), nor was the maximum quality very high (approximately 6·4) (Figure 1).

After 55°F storage for 4 weeks, 1 week of acceptable quality remained. Although in Figure 2, one day is shown above a quality rating of 6 after 5 weeks at 55°F, the fruit were deteriorating very rapidly and were not commercially acceptable.

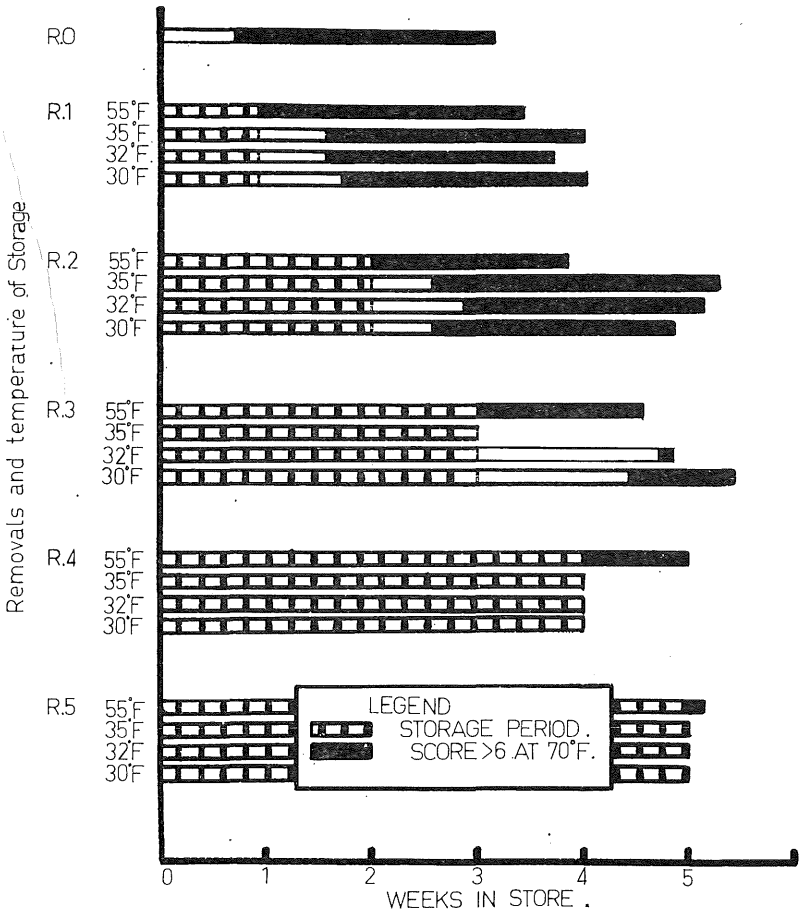

Fig. 2.—Duration of acceptable quality in 1969 experiments.

Although the duration of acceptable quality after 2 weeks' storage at 35°F was slightly greater than found at other temperatures (Figure 1c) its significance is doubtful, and the more rapid deterioration of fruit after longer storage at this temperature (Figure 1 d, e, f) led to its exclusion from later experiments. The data obtained in 1968 (Table 1) supported this decision.

TABLE 1

DURATION (DAYS) OF ACCEPTABLE EATING QUALITY
(MEAN TASTE SCORE > 6)—1968

Storage Temperature (°F)	After 2 Weeks	After 3 Weeks
30	15·0	10·0
32	11·0	9·0
35	3·5	1·5
55	9·0	7·1

(b) Duration of Acceptable Quality, All Seasons

In Figure 3 are shown the times during which eating quality exceeded the taste value of 6 (like slightly) for all experiments at temperatures of 30°, 32° and 55°F after storage periods of 2 and 3 weeks. All values were obtained in the same manner as for 1969 results described above.

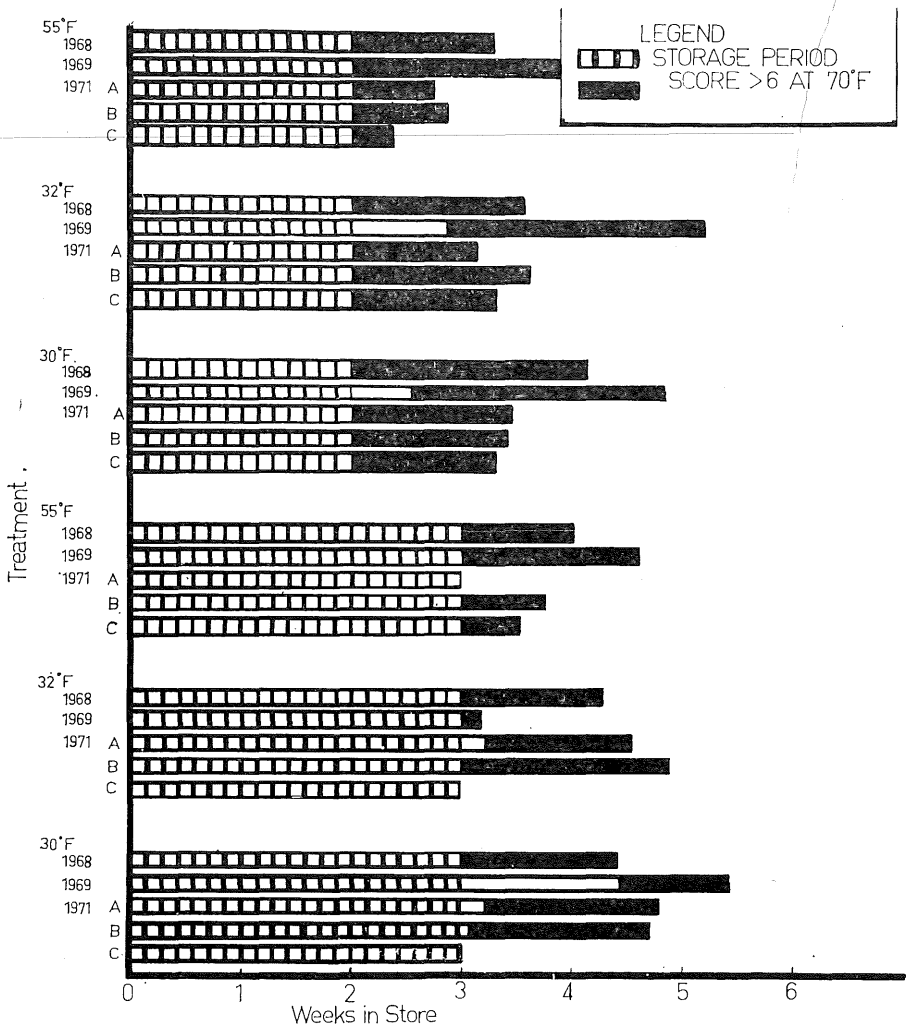

Fig. 3.—Duration of acceptable quality, all seasons.

The mean duration of acceptable quality is calculated for each storage period and temperature and is illustrated in Table 2. Differences between mean durations of consignments held at the various temperatures, and for the two storage periods, were tested for statistical significance. Storage temperatures of 30° and 32°F were shown to be significantly better than 55°F ($P < 0{\cdot}01$) after 2 weeks' storage. When all temperatures were combined, duration of acceptable quality was significantly longer ($P < 0{\cdot}05$) for 2 weeks' storage than for 3 weeks.

TABLE 2

DURATION OF ACCEPTABLE EATING QUALITY (MEAN TASTE SCORE > 6)
Means of 5 growers

Treatment	Days (± S.E.)	D95%*	D99%*
2 weeks' storage—			
30°F	12·14 ± 1·412	8·2	5·6
32°F	11·22 ± 1·456	7·2	4·5
55°F	7·20 ± 1·816	2·2	..
3 weeks' storage—			
30°F	7·98 ± 2·092	2·2	..
32°F	6·52 ± 2·593	..	..
55°F	5·74 ± 1·840	0·6	..

* No. of days (duration > 6) probably exceeded by 95% and 99% of similar consignments.

To establish estimates of confidence in performance of consignments, statistical analysis was employed to determine the number of days that the fruit of 95% and 99% of consignments similar to those in these experiments would have exceeded a mean taste value of 6. From Table 2 it may be seen that after 2 weeks' storage, the fruit of 95% of consignments stored at 30°, 32° and 55°F would have been of acceptable quality for at least 8·2, 7·2 and 2·2 days respectively; at 30° and 32°F the fruit of 99% of similar consignments would have been acceptable for at least 5·6 and 4·5 days respectively, while less than 99% of consignments of fruit stored at 55°F would even reach an acceptable stage; after 3 weeks' storage at 30° and 55°F, duration of acceptable quality would be as low as 2·2 and 0·6 days respectively before 95% of consignments would be included. Less than 95% of consignments stored at 32°F would reach acceptable quality.

IV. DISCUSSION

The results indicate that the ripening and storage characteristics of this variety make it suitable for export to South-east Asian countries, 2 weeks at 30° and 32°F giving a satisfactory post-storage shelf life. Longer storage periods should not be recommended.

Although no statistical differences were shown between fruit stored at 30° and at 32°F, repeated trends (Figure 1, Tables 1 and 2) strongly suggest that of the two, 30°F is the superior storage temperature for this variety.

From the 1969 results it appeared that temperatures of 32° and 35° were less suitable than 30° or 55°; after 2 weeks, rapid loss of eating quality occurred at 35°F, and to a lesser extent at 32°F. Although the combined results show that 32°F is more suitable than 55°F, the inferior performance of intermediate temperatures for storage should not be overlooked. Davis, Boyes and Beyers (1936) found that plums stored at 37°F were less acceptable than those stored at either 32° or 40°F. This effect of poor quality development at intermediate temperatures is also known in other fruits (Brooks and McCulloch 1936; Davis and Boyes 1938).

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REFERENCES

BROOKS, C., and MCCULLOCH, L. P. (1936).—Some storage diseases of grapefruit. *J. agric. Res.* 52:319-51.

COUEY, H. M. (1960).—Effects of temperature and modified atmosphere on the storage life, ripening behaviour, and dessert quality of Eldorado plums. *Proc. Am. Soc. hort. Sci.* 75:207-15.

DAVIS, R., and BOYES, W. W. (1938).—In *Rep. low Temp. Res. Lab., Cape Tn* 1936-37:53-67.

DAVIS, R., BOYES, W. W., and BEYERS, E. (1936).—In *Rep. low Temp. Res. Lab., Cape Tn* 1934-35:78-114.

FURLONG, C. R., and BARKER, J. (1935).—Report on ripening tests with South African pears and plums in 1934. *Deciduous Exchange Notes*, Bull. No. 23.

GINSBURG, L. (1965).—In *Decid. Fruit Grow.* 15 (3):0-6.

HUELIN, F. E., and TINDALE, G. B. (1940).—The cool storage of plums. Progress report. *J. Dep. Agric. Vict.* 40:247-53.

JACKSON, D. I. (1960).—Cool storage of Hawkes Bay plums. *Orchard. N.Z.* 33:335-7.

KIDD, F., and WEST, C. (1936).—The cold storage of English plums. *Fd Invest. Leafl.* No. 1.

LUTZ, J. M., and HARDENBURG, R. E. (1968).—The commercial storage of fruits, vegetables, and florist and nursery stocks. *Agric. Handb. U.S. Dep. Agric.* No. 66.

PADFIELD, C. A. S. (1954).—Omega plums—can they be exported? *Orchard. N.Z.* 27 (7):17-9.

SMITH, W. H. (1937).—Cold storage of Victorian plums. *Fruit Grow.* Feb. 4.

SRIVASTAVA, H. C., and D'SOUZA, S. (1962).—Refrigerated storage of plums. *Fd Sci.* 11:219-26.

TINDALE, G. B., TROUT, S. A., and HUELIN, F. E. (1935).—Cool storage of plums. First progress report. *J. Dep. Agric. Vict.* 33:552-4.

UOTA, M. (1955).—Effect of temperature and ethylene on evolution of carbon dioxide, ethylene and other oxidizable volatiles from three varieties of plum. *Proc. Am. Soc. hort. Sci.* 65:231-43.

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The author is an officer of Horticulture Branch, Queensland Department of Primary Industries, stationed at the Sandy Trout Food Preservation Research Laboratory, Brisbane.