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EXTERNAL COLOR AS MATURITY INDEX OF MANGO

ABSTRACT

Haden mangoes at the green maturity stage were classified according to their maximum yellow and red external color intensity using a Hunterlab Color Difference Meter, and were allowed to ripen at 23 ± 2°C. The mangoes were checked daily and when completely ripe, the internal color intensity and the content of T.S.S. were determined. Intensification of surface coloration was related to the initial color intensity of the mangoes. Fruits with a more intensive initial red or yellow coloration had ripened more rapidly than mangoes with less intensive coloration. All fruits with initial coloration of $b_L > 22$ or $a_L > 0$ had ripened within 12 days whereas 33% of the mangoes with values of $b_L < 16$ and 22% of the mangoes with $a_L < 0$ did not ripen within that time period. Fully ripened mangoes which had initially a more intensive coloration had developed a more desirable internal coloration and a higher content of T.S.S. It was concluded that both, the maximum red and maximum yellow color intensities at harvest, could serve as a good index of mango maturity. The maximum red coloration was found to be a more sensitive maturity index than the maximum yellow coloration.

INTRODUCTION

MANGO CULTIVATION in tropical countries is important for economical and nutritional reasons. In 1974, more than 30 varieties of mango were grown in Venezuela on an area of about 6000 ha and a yield of about 9000 tons. The variety "Haden" which is also grown in Florida is of excellent quality and has a good potential for exportation, provided it could be preserved for extended periods without losses of quality.

Effective preservation of the fruits is governed by several factors such as the stage of maturity at harvest and the handling of the fruits before and after harvest. The determination of harvest time in such a way that will enable maximum shelf life but at the same time will not risk an abnormal ripening is essential if exportation of those fruits is desired.

The subject of maturity indices for mangoes has been treated extensively in the literature. Cheema and Dani (1934) were first to suggest four different stages of maturity based on color changes and the outgrowth of shoulders. Since then, additional maturity indices have been suggested. Rao et al. (1970) suggested the use of the morphological characteristics while Rao and Srinath (1967) suggested the use of heat units as a maturity index. The use of starch content and specific gravity were described by Popenhoe and Long (1957) as well as Mukerjee (1959). Other maturity indices that were also suggested are the diameter of fruits (Date and Mathur, 1958), the sugar content (Harkness and Cobin, 1951), the flesh color (Krishnamurthy and Subramanyan, 1970) and the ratio of the total solids and sugar to acidity (Hussein and Youssef, 1973). Most of these parameters have little pratical significance and as stated by Hulme (1971), as yet no single parameter can be used as a maturity index of mango.

The objective of our study was to develop a simple and reliable index for mango maturity that would be convenient for practical application. In this report we present results on ripening and its relationship to the intensity of the red and the yellow colorations at harvest.

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EXPERIMENTAL

MANGOES of the Haden variety at different degrees of maturity were obtained from a local experimental station. The fruits were transported from the field to the laboratory packed in wooden cases cushioned with cloth shreds. To reduce anthracnose infection, immediately upon arrival at the laboratory the fruits were washed in water containing a commercial detergent, then rinsed and allowed to dry.

Color was measured by a Hunterlab Color Difference Meter model D25 D2 calibrated with a standard yellow tile (L_L = 78.1, a_L = −2.2, b_L = 22.6). External color was evaluated with a restricted cell aperture as described by Peleg and Gomez Brito (1975). Maximum external yellow and red colorations were evaluated on the day of harvest while maximum internal color was measured on ripening day or on day 12 post-harvest for fruits which did not ripen completely. For measurement of the internal coloration no cell aperture restriction was necessary.

Following color determination, the fruits were stored for 12 days at ambient temperature (22–24°C) and allowed to ripen. An experimental period of 12 days was chosen because of our previous findings in which all fruits that had ripened satisfactorily did so within 12 days. The fruits were checked daily and when fully ripened, as evidenced by their softening, odor and color development, the internal color and T.S.S. were determined. T.S.S. were determined by a refractometer and the results expressed in °Brix. The remaining fruits, classified as "almost ripe" or "not ripe" were analyzed on day 12 in the same way as described above.

RESULTS & DISCUSSION

MEASURING external color intensity of mangoes with the standard Hunter Color Difference Meter was somewhat difficult because of the narrow diameter of the fruits, their curvature, and at times because of anthracnose infection. Therefore, effective measurements of the color intensity had to be done on a limited area of the peel. Restricting the aperture of the Hunter with a plastic sheet having a known diameter proved to be a satisfactory solution. This approach was also suggested by Peleg and Gómez Brito (1975).

Color intensification was evaluated both in randomly selected sites of the peel and sites having the most intensive yellow or red coloration. The rate of color intensification was found to be different in each of the various sites chosen at random. For example, sites with Hunter a_L values of −1.6 and −1.2 at harvest had yielded upon ripening values of 1.4 and 5.3, respectively. Likewise, sites with initial b_L values of 3.4 and 3.3 had turned at ripening with values of 8.5 and 3.9, respectively. This variation in color intensification rates, thus, ruled out the possibility of using random sites color intensification as a maturity index.

The relationship between ripening time and the initial maximum yellow coloration as expressed by Hunter b_L units is given in Figure 1. It is evident that in the group of fruits having values of $b_L < 16$, most of the fruits needed more than 8 days to ripen and about one-third of the fruits did not ripen completely within 12 days. In the group of fruits with values of $16 < b_L < 22$, about 17% of the fruits ripened within 4 days and the majority needed less than 8 days to ripen. In the latter group only 11% of the fruits did not ripen within 12 days. In the group of mangoes with the most intensive yellow coloration, ripening was very fast and almost all the mangoes ripened within 8 days.

The relationship between ripening time and the maximum

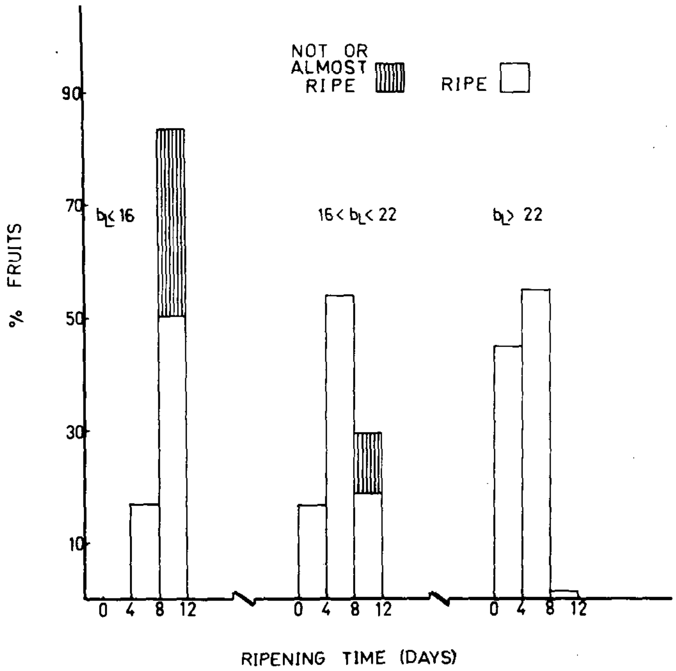

Fig. 1—Ripening of mango fruits as a function of their initial yellow color intensity (Hunter b_L).

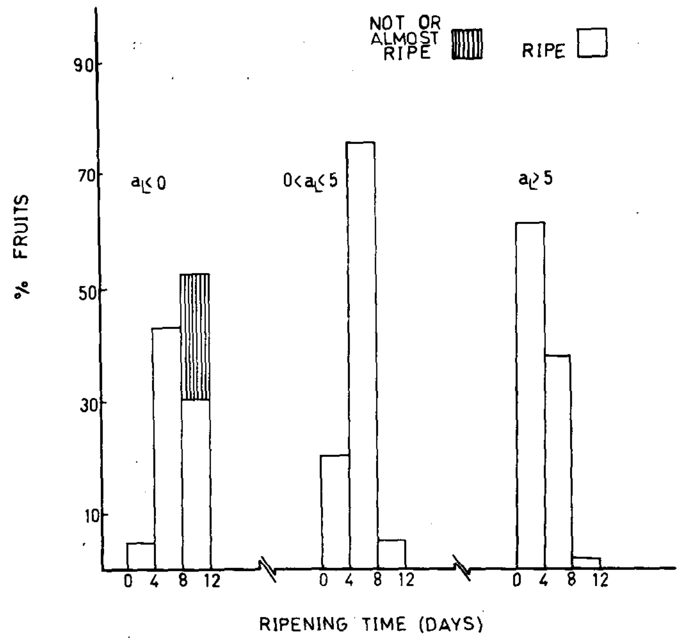

Fig. 2—Ripening of mango fruits as a function of their initial red color intensity (Hunter a_L).

red coloration at harvest, expressed by Hunter a_L units, is presented in Figure 2. It is evident that in the group of fruits with the initial lowest red color intensity or the highest green color intensity ($a_L < 0$), only 5% of the mangoes ripened within 4 days and more than half of the fruits needed more than 8 days to ripen. More than 20% of the fruits did not complete their ripening within 12 days. In the groups with more intensive initial red coloration or the less intensive green coloration, ripening was faster: in the group having initial values of $5 > a_L > 0$, about 20% of the fruits ripened within 4 days while in the group with the maximum initial coloration ($a_L > 5$) about 60% of the fruits ripened within that time period. It should be noted that in those two groups all the mangoes had ripened within 12 days.

As shown above, all the "almost ripe" or "not ripe" mangoes had negative a_L values at harvest but their b_L values varied considerably. This would suggest that the initial a_L values could be better correlated with the maturity stage of the mangoes and therefore could be a more sensitive maturity index than the initial b_L values. Negative a_L values represent greeness while the positive a_L values represent redness. Since the most unripe fruits at harvest have the most negative a_L values, it is expected that their ripening would be slower and even unsatisfactory as shown in this study. It is interesting to note that the red coloration was also a more sensitive maturity index for papaya (Peleg and Gómez Brito, 1975).

The internal quality of the fruits ripening at the different time intervals was evaluated in terms of the internal color intensity and the T.S.S. content. Figure 3 demonstrates that the most intensive internal coloration—in terms of Hunter a_L/ Hunter b_L (orange color)—was in those fruits ripening sooner after harvest. In the group ripening within 4 days after harvest, the percentage of mangoes with a_L/b_L ratios > 0.6 was about 87% and declined to about 62% in the group ripening 5–8 days after harvest. It declined still further to about 6% in the group ripening 9–12 days postharvest. On the contrary, the percentage of mangoes with a_L/b_L ratios < 0.4 was highest in the group ripening 9–12 days after harvest. This percentage declined to about 4% in the group ripening 5–8 postharvest. All fruits ripening 1–4 days postharvest had a_L/b_L ratios greater than 0.4.

The correlation between the maximum red color intensity at harvest and the development of the internal coloration is seen in Figure 4. The correlation coefficient was 0.720 with 104 mangoes studied. Thus, the value of maximum a_L at harvest could be used also for prediction of the internal color development. It should be noted, however, that in fruits having a_L values of 7 or higher at harvest, the internal orange color intensity upon ripening is about the same. The internal coloration was also correlated with the T.S.S. content of the ripe fruits. As evident from Table 1, fruits with a more intensive orange coloration (higher ratios of Hunter a_L/Hunter b_L) had the tendency to have higher T.S.S. content than fruits with lower a_L/b_L ratios.

Using the external color as an index of maturation has several drawbacks. It is time consuming and allows for error in

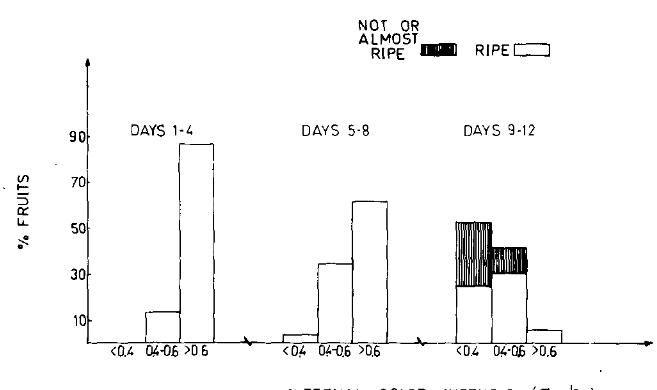

Fig. 3—Maximum internal color intensity at ripeness (Hunter a_L/Hunter b_L) as a function of the postharvest ripening time.

the color evaluation, because of an inaccurate maximum color determination or anthracnose infection. Nonetheless it has several clear advantages. It is an objective determination, and correlates well with the velocity of ripening and the internal quality of the fruits. In addition, during the color evaluation the fruits are not damaged. When applied, after more studies, it will enable classifying fruits into groups according to their predicted ripening time; to channel fruits to different uses according to their predicted internal quality development; and will help in determining the type of postharvest treatments that should be applied according to the designated use of the fruits.

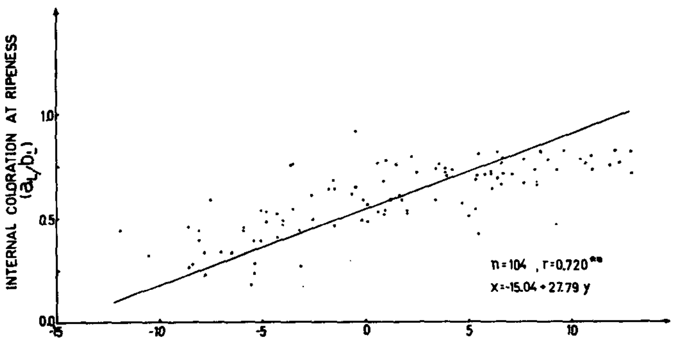

Fig. 4—Relationship between the maximum initial red color intensity at harvest (Hunter a_L) and the maximum internal yellow color intensity at ripeness (Hunter a_L/Hunter b_L).

Table 1—T.S.S. of ripe mangoes (Haden) in relation to their internal color intensity

Max internal coloration (a_L/b_L)	°Brix (mean ± S.E.)
<0.4	14.7 ± 1.5
0.4–0.6	15.4 ± 2.1
>0.6	16.5 ± 2.0

REFERENCES

Cheema, G.S. and Dani, P.G. 1934. Report on export of mango to Europe in 1932-33. Bombay Dept. Agric. Bull. 170.

Date, W.B. and Mathur, P.B. 1958. Preliminary studies on the refrigerated gas storage of mangoes. Food Sci. (India) 7: 283.

Harkness, R.W. and Cobin, M. 1951. Haden mango maturity observations during 1950. Florida Mango Forum 141-146.

Hulme, A.C. 1971. The mango. In "The Biochemistry of Fruits and their Products," Vol. 2, p. 233. Academic Press, London.

Hussein, M.A. and Youssef, K.E. 1972. Physicochemical parameters as index of optimum maturity in Egyptian mango fruits. Mangifera indica L. Beitr. Trop. Landwirt and Veterinarnmed. 4: 395.

Krishnamurthy, S. and Subramanyan, H. 1970. Respiratory climateric and chemical changes in the mango fruits (Mangifera indica L.) J. Am. Soc. Hort. Sci. 95(3): 333.

Mukerjee, P.K. 1959. Biochemical and physiological studies during development of mango fruit. Hort. Adv. 3: 95.

Peleg, M. and Gómez Brito, L. 1975. The red component of the external color as a maturity index of papaya fruits. J. Food Sci. 40: 1105.

Popenhoe, J. and Long, W.C. 1957. Evaluation of starch content and specific gravity as measures of maturity of Florida grown mangoes. Proc. Fla. State Hortic. Soc. 70: 272.

Rao, S.V.P. and Srinath, M.K. 1967. Heat unit requirements for the maturation of mango variety Baneshan. Indian J. Hor. 24: 156.

Rao, P.V.S. Giridhar, N., Prasad, P.S.P.K. and Rao, G.N. 1970. Optimum maturity and harvesting time of mangoes, var. Banesham. I. Physicomorphological features of fruits vs. maturity. Indian J. Hort. 27: 117.

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ACIDIFIED CANNED MUSKMELON . . . From page 1310

Rothschild, G., van Vliet, C. and Karsenty, A. 1975. Pasteurization conditions for fruit juices and comminuted products of Israeli citrus fruits. J. Food Technol. 10(1): 29.

Rouse, A.H. and Atkins, C.D. 1952. Heat inactivation of pectinesterase in citrus juices. Food Technol. 6: 291.

Siddappa, G.S. 1969. "Processing and Preservation of Some Lesser Known Fruits of India," p. 149. Proceedings of Tropical Products Institute Conference.

Siddappa, G.S. and Bhatia, B.S. 1958. Canning of muskmelon with other fruits. Food Sci. 7: 114.

Stumbo, C.R. 1973. "Thermobacteriology in Food Processing," 2nd ed, Academic Press, New York, NY.

Suryaprakash Rao, P.V., Prasad, P.S.R.K. and Nageswara Rao, G. 1968. Evaluation of some muskmelon varieties of Andhra Pradesh for canning and for preparation of nectors. Indian Food Packer 22(3): 18.

Zoueil, M.E. and Esselen, W.B. 1959. Thermal destruction rates and regeneration of peroxidase in green beans and turnips. Food Res. 24: 119.

Ms received 11/18/76; revised 2/19/77; accepted 2/22/77.

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