Light mediated red colour degradation of the pomerac (Syzygium malaccense) in refrigerated storage

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Abstract

The pomerac (Syzygium malaccense) is a highly perishable tropical fruit. Harvested fruit keep for 4–6 days under ambient conditions (28°C) after which they deteriorate rapidly with increased fading of the fruit’s bright, strikingly red skin colour. Exposure to light increased greatly red skin colour loss compared to dark storage when fruit were kept at 5°C for 30 days. After 30 days, pomeracs stored under lit conditions were light red (Hunter ‘a’ value of 19.8) with an anthocyanin absorbance reading of only 0.019 and a yellow or tan discolouration within regions of red skin colour loss (Hunter ‘b’ value of 16.8). Under dark storage, degradation of red skin colour and hence yellowing was reduced. After 30 days, lit stored fruit were light red (anthocyanin absorbance reading of 0.166) with traces of yellow and with Hunter ‘a’ and ‘b’ values of 26.2 and 13.7, respectively. Total colour difference (ΔE) values also changed with both the rate and extent of ΔE changes being greater for fruit stored under lit conditions, compared with dark storage. © 2000 Elsevier Science B.V. All rights reserved.

Keywords: Pomerac; Refrigerated storage; Light storage; Dark storage; anthocyanin

1. Introduction

The pomerac (Syzygium malaccense) is much admired for the beauty of the tree, its flowers and its red, glistening fruit. (Morton, 1987). Other common names of this fruit are malay apple, malay rose-apple, mountain rose-apple, mountain apple, water apple and French cashew (Morton, 1987). Pomerac can be utilised both in the fresh or processed state in a variety of ways, thus allowing for a multi-purpose industry to be developed around the fruit. A few of the agro-industrial possibilities for processed pomerac include canned and candied fruit, jellies or pickles and wines. The pomerac is well known for its poor keeping quality. Basanta and Sankat (1994) reported a shelf-life of only 4–6 days under ambient tropical conditions (28°C) when harvested at the firm, red, ripe stage of maturity. Research on the pomerac has shown that at an optimum storage temperature of 5°C, metabolic reactions are reduced to an extent that skin colour loss is reduced but not totally prevented (Basanta and Sankat, 1994). Anthocyanins are pigments responsible for the red, pink, purple and blue colours of fruits. Foods
that owe their colour to the presence of anthocyanin pigment present particular problems with respect to colour stability (Jurd, 1972). According to Skrede (1985), anthocyanin-containing foods are susceptible to colour deterioration from a natural red or purple to a more dullish brown colour. Heat, oxygen, pH, light and enzymes are some of the factors affecting their stability (Palamidis and Markakis, 1975; Attoe and von Elbe, 1981). Browning of anthocyanin-rich foods may occur by enzymatic or nonenzymatic mechanisms (Tsai and Ou, 1996; Underhill et al., 1996). Underhill et al. (1996) stated that both peroxidase and polyphenol oxidase are involved in litchi pericarp browning. Tsai and Ou (1996) reported higher anthocyanin levels in dried roselle stored in the dark than in light storage and browning was found to be nonenzymatic. The light induced degradation of anthocyanin to furfural was the major cause of the browning.

This study was undertaken to determine the effect of light on the colour stability of pomeracs stored at 5°C so as to develop appropriate technology for its commercial storage.

2. Materials and methods

Pomeracs at the firm, red, ripe stage of maturity were manually harvested, placed in cushioned containers and transported to the Agricultural Engineering Processing Laboratory at the University of the West Indies, St. Augustine, Trinidad. Fruit were individually and gently washed using running tap water and allowed to air dry. Only fruit which were visibly free of any physical or biological defects were used in the storage trial.

The pomeracs were randomised into two experimental groups; each comprising 112 fruits. The fruits were individually, loosely wrapped using a green produce shrink-wrap of 60 gauge thickness (606-15, GP-15, Filmco, USA), placed on polystyrene trays and each group placed in identical Bally ‘walk-in’ refrigerated storage rooms set at 5°C (rh = 85%) for a maximum period of 30 days. This represented a completely randomised block design. One chamber was lit with 2-60 W cool white fluorescent light bulbs (Sylvania, USA) while the other was kept completely dark. The average light intensity in very close proximity to the surface of the fruit measured 153.7 lumens/m². Four fruit were removed from each of the two storage rooms at 5, 10, 15, 20, 25 and 30 days of storage and evaluated for colour (subjective and objective measurements) as well as anthocyanin concentration. Initial analyses were carried out on four fruit on the day of harvest.

2.1. Quality evaluation

2.1.1. Objective colour evaluation

An objective evaluation of the colour of the skin of the pomerac was determined using a Hunter Lab D25 PC 2 Colorimeter (Hunter Associates Laboratory, Inc., VA). The Hunter colour values of five circular portions of the fruit’s skin were determined. Three readings of each portion of the skin were taken when the sample was rotated horizontally. From these the mean Hunter L, a, b colour values (+a; red; −a; green, +b; yellow, −b; blue, L = 100 for perfect white) of each fruit were determined.

The total colour difference (ΔE) was calculated using the following equation (Hunter, 1987), viz:

\[ \Delta E = \left[ (\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2 \right]^{1/2} \] (1)

where ΔE is the total colour difference, ΔL is the change in Hunter ‘L’ values with time, Δa is the change in Hunter ‘a’ values with time and Δb is the change in Hunter ‘b’ values with time.

This measurement allows for an overall evaluation of the total effects of Hunter ‘L’, ‘a’, ‘b’ values.

2.2. Anthocyanin

The anthocyanin content of the skin of the pomerac was determined according to the modified method of Paull et al., (1985). Skin tissue (0.1 g) was blended for 30 s in a Waring blender, model no. 34BL97 (Waring, CN) at a moderate speed (no. 4) with 50 ml of 1% HCl–MeOH. The homogenate was filtered and the absorbance of 10 ml of filtrate was immediately read at 535 µm on a Milton Roy Spectronic 20D
series spectrophotometer (Boston, MA). The results are reported as absorbance measurements.

2.3. Sensory evaluation

The colour of the skin of the pomerac was subjectively evaluated by a panel comprised of 10 semi-trained individuals. Skin colour was rated on a scale of 1–5 as follows: 1, bright red; 2, red with traces of blue (1–10%); 3, light red with traces of yellowing (10–25%); 4, light red with yellowing/tan (25–50%); 5, light red with severe yellowing/tan (> 50%).

The experimental data were statistically analysed by the analysis of variance (ANOVA) method (Baker and Nedler, 1978).

3. Results and discussion

3.1. Hunter colour values

A fading of the bright red skin colour with increasing storage time was observed for pomeracs stored under both light and dark conditions. A decline in the Hunter ‘a’ values \( (P < 0.001) \) resulted (Fig. 1A). This fading of the red skin colour however, was more pronounced for fruit stored under light conditions \( (P < 0.001) \) with a higher Hunter ‘a’ value denoting a greater degree of redness. For pomeracs stored in the light, Hunter ‘a’ value decreased from an initial 31.8 to 19.8 after 30 days in storage while for fruit stored in the dark, which showed reduced loss of red colour, the Hunter ‘a’ value fell to only 26.2. Linear regression analysis of the data showed average rates of decline of Hunter ‘a’ value of 2.01 day \( (R^2 = 0.93) \) for light stored fruits and only 0.98 day \( (R^2 = 0.98) \) for the dark stored pomeracs. Skrede (1985) working on blackcurrant syrups, found that daylight storage at 20°C lowered half-life of Hunter ‘a’ values by 10–30% compared with dark storage.

Concomitant with the disappearance or fading of the fruit’s red skin colour, was a yellow or tan discolouration in regions where the red skin colour loss occurred. This was, therefore, more pronounced in pomeracs stored under light condi-
Fig. 2. Anthocyanin content of light and dark stored pomerac at 5°C.

tions. This yellowing of the skin was reflected by increases in Hunter ‘b’ values (Fig. 1B) and this was significantly affected by storage time \((P < 0.001)\), treatment \((P < 0.001)\) and time/treatment interaction \((P < 0.01)\). Under lit storage conditions, the Hunter ‘b’ value increased from 8.2 (day 0) for bright, red fruit (rating of 1) to 16.8 after 30 days in storage. Such fruit were light red showing a yellow or tan discolouration (rating of 4). For pomeracs stored in the dark, yellowing was reduced in storage (rating of 3) and the Hunter ‘b’ value of fruit after 30 days was lower, i.e. 13.7. Non linear regression analysis revealed that the data can be fitted to the equation \(y = a + b \ e^{-kt}\) where \(a\) is the asymptotic value, i.e. 12.9 (dark); 16.5 (light), \(b\) is a constant, \(k = 0.146\) (dark); 0.171 (light) and \(t\) is the storage time. From this model it can also be concluded that the rate of yellowing as well as the degree of yellow- ing was higher for lit stored pomeracs.

The visual changes in colour observed for light and dark stored pomeracs was also reflected in the Hunter ‘L’ value which was significantly affected by storage time and treatment \((P < 0.001)\). Fruit stored in the dark showed reduced colour loss and the Hunter ‘L’ value was only 38.8 (initial of 35.3) after 30 days. For pomeracs stored in the light however, loss of red colour was severe and as stated before, paralleled by yellowing or tanning of the skin. These changes reflected a higher ‘L’ value (48.0), indicative of a lightening in the fruit’s initial red skin colour.

The Hunter ‘L’, ‘a’, ‘b’ total colour difference \((\Delta E)\) was significantly affected by storage time \((P < 0.001)\), storage treatment \((P < 0.001)\) and by the interaction of time/treatment \((P < 0.001)\). There was an increase in \(\Delta E\) values for pomerac stored under both light and dark conditions (Fig. 1C). However, the increase was higher for fruit stored in the lit chamber at 5°C. For such fruits, the \(\Delta E\) value increased from 2.35 (day 0) to 3.17 after 30 days of storage (rate of increase averaged 0.201 \(\text{day}^{-1}\), \(R^2 = 0.47\)). This increase in \(\Delta E\) corre-
sponds to the resulting decrease in ‘a’ values and increase in ‘L’ and ‘b’ values, as the pomerac lost its red colour and a yellow or tan colour developed. Pomerac stored in the dark chamber also showed colour loss with time but at a much lower rate (rate of increase averaged 0.171 \(\text{day}^{-1}\), \(R^2 = 0.88\)) and \(\Delta E\) values increased from 1.86 to only 2.55 after 30 days in storage at 5°C (Fig. 1C).

3.2. Anthocyanins

The anthocyanin content of the fruit was sig-
ificantly affected by storage time \((P < 0.001)\) and treatment \((P < 0.01)\). At harvest fresh, red pomerac had an anthocyanin absorbance reading averaging 0.642. Under light storage, the anthocyanin absorbance decreased rapidly to 0.181 after 10 days of storage (colour rating of 2) with a visible fading of the red skin colour. This de-
crease in anthocyanin content persisted with in-
creasing storage time and by day 30, fruits were light red with a yellow or tan (25–50%) dis-
colouration within the region of red skin colour loss. Such fruits reflected an anthocyanin ab-
sorbance reading of only 0.019. Pomeracs stored in the dark also decreased in anthocyanin content, but at a much slower rate (Fig. 2). After 30 days in dark storage, pomeracs were light red with traces of yellow with an anthocyanin absorbance reading of 0.166. Non linear regression analysis revealed that the data can be fitted to the equation \(y = a + b \ e^{-kt}\) where \(a\) is the asymptotic value, i.e. 12.9 (dark); 16.5 (light), \(b\) is a constant, \(k = 0.146\) (light); 0.171 (dark) and \(t\) is the storage time. From this model it can also be concluded that the rate of yellowing as well as the degree of yellow-
ing was higher for lit stored pomeracs.

Fig. 2. Anthocyanin content of light and dark stored pomerac at 5°C.
previously and indicate a greater rate and ultimate
to light. Attoe and von Elbe (1981) also found that
pigment. Palamidis and
Markakis (1975) noted a marked increase in the
rate of anthocyanin loss when grapes were ex-
posed to fluorescent light. Light is claimed to
stimulate the activity of peroxidase (Siomos et al.,
1994) and this may account for the increased
browning observed for the light stored pomeracs.

4. Conclusions

Light had a negative effect on the skin colour
of the pomerac in refrigerated storage. Some fruit
showed extensive loss of the fruit’s natural, bril-
liant red skin colour paralleled by a yellowing or
tan discolouration. Dark storage of the pomerac is
strongly recommended as red skin colour loss
was not as severe even after 30 days at 5°C.

References

of betaine and selected anthocyanins. J. Food Sci. 46,
1934–1937.
pomerac (Syzygium malaccense) under refrigeration. Pro-
cedings of the 30th Annual Meeting, Caribbean Food
Hunter, R.S., 1987. The Measurement of Appearance. Acade-
mic Press, New York.
Jurd, L., 1972. Some advances in the chemistry of an-
thocyanin-type plant pigments. In: Chester, C.O (Ed.), The
tanea, Miami, FL.
Palamidis, N., Markakis, P., 1975. Stability of grape an-
thocyanins in a carbonated beverage. J. Food Sci. 40,
1047–1049.
changes associated with senescence of cut anthurium flow-
Siomos, A.S., Sfakiotakis, E., Dogras, C., 1994. Effect of
temperature and light on the texture of stored white as-
storage evaluated by Hunter $L, a, b$ values. J. Food Sci. 50,
514–517 and 525.
Tsai, P., Ou, A.S., 1996. Color degradation of dried roselle
Mitra, S.K. (Ed.), Postharvest Physiology and Storage of
Tropical and Subtropical Fruits. CAB International, New
York, pp. 191–208.