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# REFRIGERATED STORAGE OF THE JULIE MANGO

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## ABSTRACT

The shelf-life of the Julie mango was investigated with respect to the temperature and time in storage. Fruits were stored under ambient conditions (28°C), and at refrigerated temperatures (6°C, 10°C and 14°C). On the day of harvest and at 7 day intervals, fruits were removed from storage and chemically and physically analysed. Weight and volume loss in storage, fruit firmness, starch content, total soluble solids and acidity were measured. On removal from storage some fruits were allowed to ripen under ambiant conditions after which they were similarly analysed. Fruits kept under ambient conditions were used as the control, and these were analysed as they ripened. Fruits under ambient conditions ripened after a maximum of 8 days while fruits stored at 14°C ripened in storage after 21 days to an acceptable quality. Fruits at 6°C and 10°C did not attain any significant degree of ripeness in storage up to 42 days. At this time however, there were signs of chilling injury, particularly for fruits held at 6°C. At 10°C a storage life of 4 weeks appears promising.

## RESUME

CONSERVATION SOUS REFRIGERATION DE LA MANGUE JULIE

La conservation de la mangue Julie a été étudiée en fonction du temps et de la température. Les fruits sont conservés dans les conditions ambiantes à 28°C et aux températures de 6°C, 10°C et 14°C. Les fruits sont analysés chimiquement et physiquement le jour de la récolte et 7 jours après conservation. Les pertes de poids et de volume au cours de la conservation,

la fermeté du fruit, la teneur en amidon, les composés solubles totaux et l'acidité sont mesurées. A la sortie de la conservation certains fruits sont laissés à mûrir et analysés comme témoins et analysés dès maturation. Dans les conditions ambiantes les fruits murissent au bout de 8 jours alors que les fruits conservés à 14°C murissent après 21 jours avec une qualité acceptable. Les fruits à 6°C et à 10°C n'ont atteint aucun degré de maturation en conservation observable au bout de 42 jours. Au bout de ce moment apparaissent des signes de détérioration surtout sur les fruits à 6°C. A 10°C une conservation pendant 4 semaines parait prometteuse.

## INTRODUCTION

The mango fruit (*Mangifera indica* ) which is not oriental origin is accepted worlwide due to its appealing organoleptic characteristics. In the Caribbean region, the Julie mango is one of the more acceptable varieties with good potential for export. However due to the perishable nature of the fruit, its shelf-life is limited and transport over long distances particularly by sea is a problem. Hence methods of preservation of the fruit without a loss in quality need be investigated.

Refrigerated storage is one of the most common methods employed for increasing the self life of perishable rate and metabolic activities associated with ripening, consequently reducing the time taken for the fruit to ripen. Quality must be maintained under these conditions to ensure acceptability of the fruits when ripe. Many factors affect the quality of stored fruits and these include the harvest maturity, methods of harvesting and handling, the storage temperature, time in storage, protection from dessication and freedom from disease infection.

Mangoes should be harvested when fully matured but still green with shoulders raised above the point of stem insertion (Wardlaw and Leonard, 1936). At this stage the latex flow from the stem is minimal and the stem breaks easily. Damaged and bruised fruits detract from the quality of commodities in storage hence they should be harvested and handled with care. The critical temperature below which the fruits would experience chilling injury, must be determined experimentally. The storage time/ temperature relationship is also very important since fruits would store well at different temperatures for a specified lenght of time. Chilling injury is characterised by the formation of discoloured, pitted regions on the skin, non-uniform ripening, poor colour and flavour, high acidity with low sugar content. Hence there is a low sugar/acid ratio of ripened fruits which also show a reduced resistance to pathogens. Fruits tend to lose moisture during storage hence it is necessary to protect them from excessive dessication. Protective packaging, as well as the maintenance of a high relative humidity

storage environment can be considered. Chilling injury can be aggravated by dessication of fruits in storage.

Fungal diseases are a major problem with stored fruits. For mangoes, anthracnose is the most important. Even though a fruit may appear unblemished when harvested it often carries latent infections which become evident when the fruit ripens. The disease is accentuated by chilling, prolonged cold storage, slow repening and delayed distribution (Wardlaw and Leonard, 1936). Spalding and Reeder (1972) found that the disease may be arrested for 3 weeks when stored at 12.5°C by hot water treatment alone (55°C for 5 minutes). When Benomyl or Thiobendazole is added to the hot water, increased control to 4 weeks is possible. Bruising of fruits enhances pathological deterioration.

The critical temperature at which mangoes can be stored depends on the variety and the time in storage. Storage time and temperatures have been suggested for different varieties of mangoes (Table 1).

The objective of this study was to evaluate the behaviour of the Julie Mango when stored at various low temperature, with a view to obtaining the optimum storage condition.

## MATERIALS AND METHODS

In July 1988 fully matured, green Julie mangoes were carefully hand-picked from two trees. Fruits were transported to the laboratory where they were individually washed with tap water. After being air dried they were randomly numbered from 1-86. The fruits were then dipped in a hot fungicidal solution of Benlate (0,1%) for 5 minutes at 51-53°C. After allowing to dry in air, their weights in air and water were obtained. They were wrapped in tissue paper, randomly selected and placed in trays in a single layer. Fruits were then stored in three «walk-in» refrigerated storage chambers.

Four (4) fruits were selected for sampling on the day of harvest, eight (8) were stored under ambient conditions (28°C) and twenty-four (24) fruits were stored at each of the refrigerated temperatures of 6°C, 10°C and 14°C. To minimize dessication the relative humidity in the chambers were maintained above 85% and the trays containing the tissue wrapped fruits were covered with a perforated sheet.

At weekly intervals, four (4) fruits from each of the low temperatures were removed from the storages. Two of the fruits were analysed immediately and two were left to ripen under ambient conditions, after which they were analysed. The fruits held under ambient conditions were analysed as they

ripened.

Analysis consisted of the measurement of the following parameters : - weight loss, volume loss, specific gravity, total soluble solids, acidity, sugar/ acid ratio, starch content, colour changes, pathological deterioration, texture and taste.

The weight loss was obtained as a percentage of the loss in weight over the initial weight. The volume was determined by the upthrust in water and the volume loss was calculated as a percentage of the loss in volume over the initial volume. Specific gravity was calculated from the weight and volume determinations. A penetrometer (Koehler Digital Penetrometer, Model - K19566) and cone (weight - 32.5 g ; base diameter - 18 mm ; height 35 mm) were used for measuring fruit flesh firmness. The depth of cone penetration was measured after 5 seconds, using and added weight of 50 grams. An Abbe Refractometer (Atago, Type IT) was used to measure the total soluble solids in Brix percentage using a 1:1 dilution of the mango pulp. The acid content was determined using a method adopted from the Association of Analytical Chemists (A.O.A.C.). The sugar/acid ratio was calculated from the total soluble solids and acid content. Starch was determined by the method of Ward and Johnston (1960) given in Chemical Methods of Plant Analysis and which compared the intensity of a starch iodide complex with starch concentrations using a spectrophotometer (Spectronic 20D). Evaluation of colour, decay and taste were done by observation.

Fruits under ambient conditions ripened after 3,7 and 8 days. Those held under refrigerated conditions were stored for up to 42 days at 10°C and 6°C for up to 21 days at 14°C.

## RESULTS AND DISCUSSION

The data was evaluated by the analysis of variance technique to determine the effects of time, temperature and ripening and the interactions between these factors on the physical and chemical changes of the stored fruits.

Weight loss

The weight loss of fruits in storage was significantly affected by storage temperature ($p < 0.001$), time in storage ($p < 0.001$), ripening ($p < 0.001$), temperature/time interaction ($p < 0.001$) and temperature/time/ripening interaction ($p < 0.05$).

The loss in weight increased with time and on ripening for all treatments. However at the higher temperatures, weight loss was more rapid as seen in

**Table 1 : Published information on time/temperature studies of various mango varieties**

| Author | Year | Variety | Country | Storage temperature | Storage time |
|---|---|---|---|---|---|
| Wardlaw and Leonard | 1936 | Julie | Trinidad | 7,2-10°C | 15-20 days |
| Sadasivam et al | 1970 | Bangalora | India | 9 ±1°C | 15 days |
| Sadasivam et al | 1970 | Neelam | India | 9 ±1°C | 15 days |
| Rolz et al | 1977 | Mammey | Brazil | 13°C | 14-21 days |
| Mathur et al | 1953 | Alphonzo | India | 8,3-10°C | 42 days |
| Mathur et al | 1953 | Seedling | India | 5,5-7,2°C | 42 days |
| Mathur et al | 1953 | Peter | India | 5,5-7,2°C | 42 days |

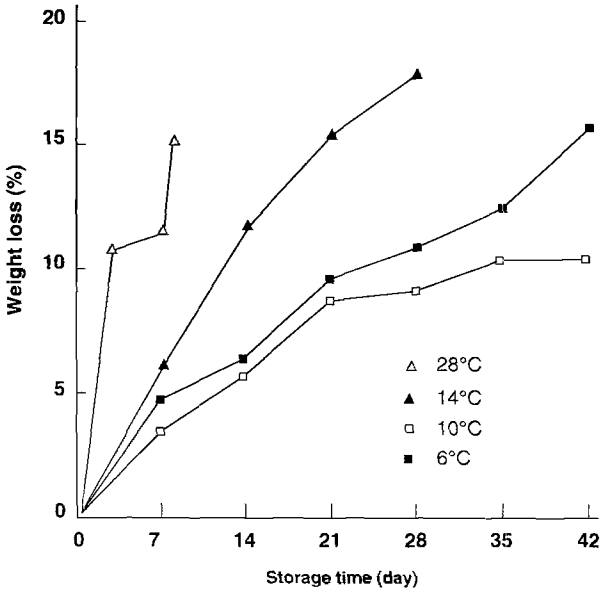


**Figure 1 : The weight loss of Julie mangoes in storage, at four temperatures**

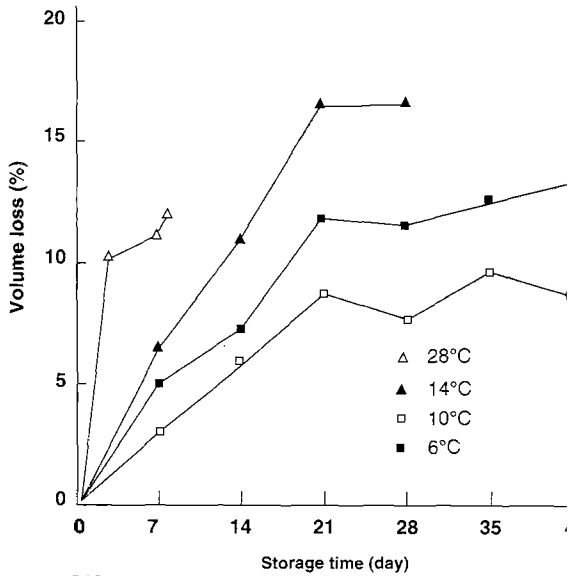


**Figure 2 : Shrinkage or loss in volume of Julie mangoes in storage, at four temperatures**

Figure 1. Under ambient conditions (28°C) a rapid increase to 15.2% was observed after eight (8) days in storage. A less steep increase was observed for fruits held at 14°C, while the weight losses were more gradual at 10°C and 6°C. After 10 days in storage the estimated values for weight loss of fruits held at 14°C, 10°C and 6°C were 8.8%, 5.0% and 5.5% respectively and after 4 additional days under ambient conditions (28°C), the fruits ripened with corresponding increases to 17.3%, 13,8% and 13.9%.

Fruits held at 14°C ripened after 21 days with a weight loss of 15.5%. At 10°C and 6°C however, the fruits were not ripe even after 30 days in storage and were found to have weight losses of 9.1% and 11.7% respectively ; when these fruits were removed from storage and left under ambient conditions (28°C), they ripened after three (3) days with corresponding weight losses of 17.4% and 21.6%.

Volume loss (shrinkage)

The loss in volume may be due to the loss in turgidity of the cells due to water lost through transpiration. Volume changes may also be affected by the movement of gases in and out of the fruit. Figure 2 shows that the loss in volume follows the same trend as the loss in weight. Loss in volume was significantly affected by storage temperature ($p < 0.001$), time in storage ($p < 0.001$) and temperature/time/ripening interaction ($p < 0.001$).

Fruits kept under ambient conditions showed a rapid decline in volume, to a value of 11.8% after 8 days. Fruits were ripe after this storage period.

After 10 days fruits stored at 6°C, 10°C and 14°C showed estimated volume losses of 6.6%, 4,8% and 8.9% respectively and on ripening these values increased to 13.2%, 13.5% and 16.5%. Further volume changes occured with time in storage.
After 30 days in storage at 6°C and 10°C, the volume losses of the fruits were estimated at 11.6% and 7.8% respectively which on ripening increased correspondingly to 18.2% and 14.3%.

It was observed that the volume loss at 6°C was higher that at 10°C, as shown in Figure 1, and may be attributed to differences in the environmental conditions of relative humidity and air movement under which fruits were stored.

Firmness of fruit flesh

Firmness of the fruit flesh is inversely proportional to the depth of fruit penetration as measured by the penetrometer. The firmness of the flesh of

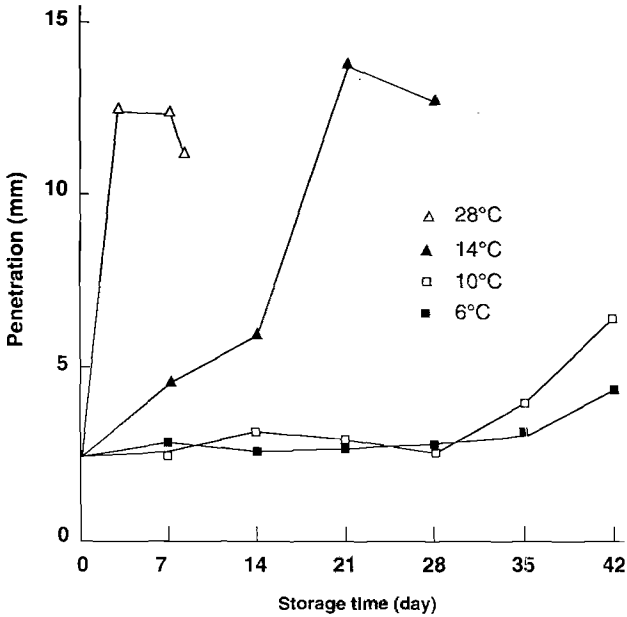


**Figure 3 : Firmness of stored Julie mangoes, as measured by a penetrometer**

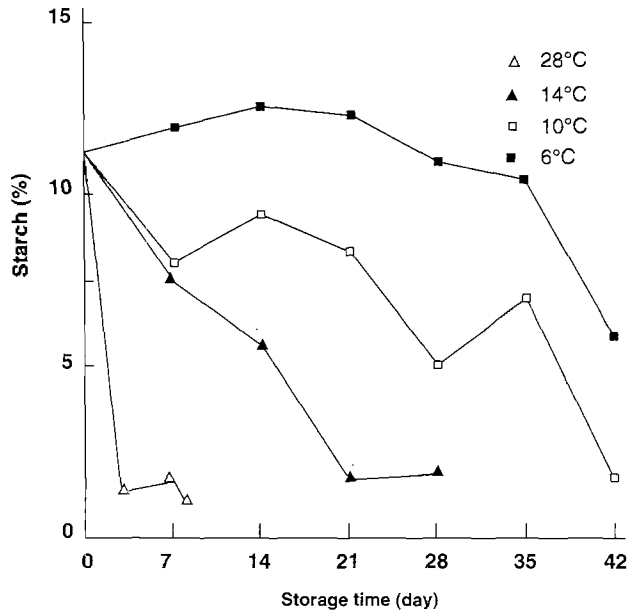


**Figure 4 : Changes in starch content with time of Julie mangoes in storage, at four temperatures**

freshly harvested mangoes averaged 2.4 mm. As the fruit ripens it softens due to the hydrolysis of protopectins. Firmness was significantly affected by storage temperature ($p < 0001$), ripening ($p < 0.001$, temperature/time interaction ($p < 0.001$) and time/ripening interaction ($p < 0.001$). Fruits softened with time in storage at 28 and 14°C however at 6 and 10°C little softening occured with storage time up to day 35 (Figure 3) and such fruits were relatively firm even after 42 days in storage. Softening is an *indicator* of ripening and at the lower temperatures of 6 and 10°C ripening is retarded.

Fruits held under ambient conditions (28°C) showed a sharp increase in the rate of softening as the fruits ripened, giving a penetration depth of 12.4 mm.

After 10 days in storage at 14°C, 10°C and 6°C, the penetration depths of the fruits were estimated at 6.3 mm, 2.0 mm and 2.5 mm respectively. When such fruits were ripened under ambient conditions the corresponding values obtained were 11 mm, 12 mm and 14 mm respectively, values which are consistent with fruits stored and ripened under ambient conditions.

After 21 days in storage, the fruits held at 14°C showed a penetration depth of 13.8 mm indicating that fruits had ripened in storage.

At 10°C and 6°C however, the estimated penetration depths of the fruits in storage after 30 days were 5.4 mm and 3.0 mm, values which indicated that some softening had occurred. When fruits were left to ripen under ambient conditions, the corresponding penetration depths were estimated to be 10.0 mm and 14.0 mm respectively.

Starch content

The starch content for freshly harvested Julie mangoes averaged 11.3% prior to storage. In storage this value declined, however, the rate of hydrolysis decreased significantly as the temperature was lowered as seen in Figure 4. As the fruits ripened the starch content declined rapidly. Mattoo and Modi (1969) found with the Alphonso mango a reduction from 14% in the unripe fruit to 0.03% in the fully ripe fruit. An increase in the enzyme amylase which is responsible for the hydrolysis of starch was also noted.

For fruits stored under ambient conditions the starch content declined rapidly to 1.2% in 8 days, as the fruits
ripened. Fruits stored at 14°C, 10°C and 6°C for 10 days showed estimated starch contents of 6.2%, 8.9% and 12.9% respectively and on ripening these values decreased correspondingly to 1.5%, 1.7% and 2.2%.

After 21 days in storage at 14°C, the starch content of the fruits dropped to 1.7% which indicated that fruits had ripened in storage.

The starch content of fruits held in storage at 10°C and 6°C after 30 days were estimated at 5.7% and 9.8% respectively, which only declined to corresponding values of 1.5% and 2.7% on ripening under ambient conditions.

At the lower temperatures and for extended storage there was a definite retardation of starch hydrolysis and ripening, the effect being most marked at 6°C. It was also observed that at these temperatures fruits ripened with slightly higher starch content when compared to ambient stored fruits. This may be attributed to slight chilling injury.

Sugar/acid ratio

Prior to storage the sugar/acid ratio for freshly harvested fruits was 2.3 and druing storage this value was significantly affected by storage temperature ($p < 0.001$), ripening ($p < 0.001$), temperature/time interaction ($p < 0.001$), time/ripening interaction ($p < 0.001$) and temperature/time/ripening interaction ($p < 0.05$).

Sugar/acid (S/A) ratios declined as the temperatures under which the fruits were stored were lowered. It is noted that as temperatures were lowered, total soluble solids declined, while the acid content appeared higher. These factors clearly explain the reduction in the S/A ratio with lowered storage temperatures.

Fruits stored under ambient conditions ripened after 3, 7 and 8 days to give an average S/A ratio of 32.0. Fruits held for 10 days at 14°C, 10°C and 6°C showed estimated S/A ratios of 11.1, 1.3 and 1.2 respectively, which increased correspondingly to 35.7, 24.1 and 31.3 on ripening.

Fruits held for 21 days at 14°C showed an estimated S/A ratio of 29.0 indicating that the fruits ripened in storage.

Fruits held at 10°C and 6°C for 30 days showed S/A ratios of 11.9 and 4.9 respectively which increased correspondingly to 16.9 and 19.1 when fruits were ripened. These results show that with extended time in storage, when fruits were allowed to ripen, the S/A ratio declined. This may have resulted from slight chilling and the resulting higher acid content of the fruits.

## CONCLUSIONS

Julie mangoes harvested at the mature green stage, and stored under ambient (28°C) conditions showed a maximum shelf life of 8 days, ripening with the typical orange coloured flesh. Under these conditions, the maximum weight and volume losses were 15.2% and 11.9% respectively, fruit firmness

in
storage declined steadily and rapidly, the starch content dropped from 11.3% to 1.2% while the sugar/.acid ratio increased from 2.3 to 32.0.

Storing Julie mangoes under refrigerated conditions of 14, 10 and 6°C reduced the changes associated with storage and ripening under ambient conditions. Weight and volume losses were reduced, particularly at 6 and 10°C, while fruit firmness was maintained for up to 35 days, again at 6 and 10°C. Starch hydrolysis was also affected by storage temperature, with negligible changes occuring in fruits held at 6°C for up to 35 days. Again at 6°C, little changes were observed in the sugar/acid ratio, while at 10°C, only small changes were noticeable, up to 35 days in storage.

Fruits held at 14°C ripened in the refrigerated storage after 21 days, developing the typical orange flesh colour. At this time, fruit firmness, total soluble solids, acid, and starch contents were as expected for fruits stored and ripened under ambient conditions, indicating an acceptable quality. This appears to be a very suitable temperature for the storage of Julie mangoes for 2-3 weeks.

While fruits at 6 and 10°C showed only small changes associated with ripening, after 42 days in storage, on ripening such fruits, quality was unacceptable. There were considerable weight and volume losses, decay was severe, colour development was impaired, while a low sugar/acid ratio affected fruit flavour and taste. As the storage temperature was decreased, and storage time increased, the fruits were subjected to chilling injury. Storage at 6°C is therefore not recommended for any protracted period.

At 10°C, storage of Julie mangoes for 4 weeks appears quite promising.

## ACKNOWLEDGEMENTS

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## REFERENCES

Association of Official Analytical Chemists (1984). Official Methods of analysis of the AOAC. 14th Edition, AOAC, Virginia, U.S.A.

MATHUR, P.B., SINGH, K. K. and KAPUR, N. S. (1953). 'Cold storage of mangoes'. Indian J. Agric. Sci. 23, 65-77.

MATTOO, A. K. and MODI, V. V. (1969). 'Ethylene and ripening of mangoes'. Plant Physiol. 44, 308-310.

ROLZ, C., DESHPANDE, S., PAIZ, L., ORTIZ, J., FLORES, M.C., SANCHEZ, M. and DeORTEGA, M. (1972). 'Chemical changes and fruit quality during the ripening of tropical fruits'. Turialba 22, 65.

SADAVISAM, K., MUTHUSWAMY, S., SUNDARARAJ, J. S. and VASUDEVAN, V. (1970). 'Note on chilling injury in mango (M. *indica* L.) fruits in refrigerated storage'. Indian J. Agric. Sci. 41(8), 715-716.

SPALDING, D. H. and REEDER, W. F. (1972). 'Postharvest disorders of mangoes as affected by fungicides and heat treatment'. Plant Disease. Reporter 56(9), 751-753.

WARD, G. M. and JOHNSTON, F. B. (1960). Chemical methods of plant analysis. Canada Dept. of Agric. Research Branch, Ottawa, p57-58.

WARDLAW, C. W. and LEONARD, E. R. (1936). 'Storage of West Indian mangoes'. I.C.T.A. - Memoir Publications No. 3.