Quality changes in pineapple (*Ananas comosus* cv. N36) stored at low temperature

[Perubahan mutu nanas (*Ananas comosus* cv. N36) yang disimpan pada suhu rendah]

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Key words: pineapple, quality, low temperature storage

**Abstract**

Studies on the storage of pineapple cv. N36 were conducted. The fruit were harvested approximately 180 days after flower induction and stored at 10 °C for up to 4 weeks. Changes in fruit quality were evaluated weekly, i.e. immediately after fruit removal from low temperature storage and after being held further for another week at ambient condition. Observations were made on weight loss, skin colour, crown condition, flesh colour, black heart disorder, disease infection, ascorbic acid, total soluble solids and pH. N36 pineapple was resistant to black heart but could be infected by leathery pocket, a disease caused by *Penicillium funiculosum* Thom. Fruit quality was maintained throughout storage at low temperature but deteriorated after being exposed for 1 week at ambient following refrigeration. Although the ascorbic acid content has been associated with pineapple susceptibility to black heart, the N36 pineapple did not show any difference in the level of ascorbic acid as compared with other pineapple cultivars grown in Malaysia.

**Introduction**

The most established pineapple cultivars for fresh consumption in Malaysia are Mauritius and Sarawak. These two cultivars are commonly traded in the local market besides being exported to Singapore. Since the past...
2 years, fresh pineapples have been shipped to Saudi Arabia following a successful commercial trial shipment from Port Klang to Jeddah (Abdullah and Rohaya 1992). Initially, the Mauritius cultivar was introduced into the Saudi market followed by Gandol. Recently, these cultivars have been replaced by a new pineapple hybrid known as N36.

Storage of Mauritius and Sarawak cultivars has been comprehensively studied (Abdullah and Rohaya 1983; Abdullah et al. 1985, 1986; Abdullah et al. 1983; Suhaila and Safiah 1993). Generally, the two cultivars can be stored for 3–4 weeks at 8–10 °C. However, these cultivars are highly susceptible to black heart disorder. Black heart has been observed to develop in fruit stored at temperatures as low as 5 °C and as high as 20 °C. Similar observations were made by Smith (1987) who reported a temperature range of 5–21 °C for black heart induction in Australian pineapple. Prolonged storage at chilling temperature resulted in total inhibition of black heart (Wills et al. 1985) but the fruit are affected by the common chilling injury. Therefore, there is no real safe temperature for storage of pineapple cultivar susceptible to black heart. Besides black heart, stored pineapples are also subjected to a number of problems, especially disease infection as well as dry skin and crown leaves (Abdullah 1994a, b).

As a new pineapple cultivar, N36 was introduced into the market without sufficient information with regard to its storage and postharvest handling. This approach is risky to the Malaysian pineapple industry considering the fact that the country is still struggling to develop its export market for fresh pineapple. This study was conducted to generate information on the storage and postharvest handling of the N36 pineapple.

Materials and methods
Fruit
Pineapples cv. N36 at approximately 180 days from flower induction were harvested from Lee Pineapple Plantation, Simpang Rengam, Johor in September 1993 and March 1994. After harvesting, the fruit were transported to MARDI in Serdang. Upon arrival at the laboratory, the fruit were selected as only high quality fruit were used. The peduncle was trimmed to about 2 cm. The fruit were then placed in telescopic fibreboard boxes with each box containing six fruit.

The fruit were stored for up to 4 weeks at 10 °C (relative humidity 85–90%). After which, the fruit were removed from the storage room on a weekly basis. During each removal, six boxes were taken out of the cold room. Out of this, three boxes were examined immediately, whereas the fruit in the other three boxes were examined a week after being held at ambient condition (average temperature 28 °C).

Another lot which comprised six boxes of fruit, was placed at ambient. The fruit in three of the boxes from this lot were evaluated immediately for initial quality while the remaining three boxes were left at ambient and evaluated a week later. A total of 30 boxes of fruit were used in each experiment.

Weight loss
The weight loss of the fruit was taken by measuring the difference in the weight before and after storage (upon removal or after the 1-week holding period at ambient). Weight loss is reported in percentage.

Physical changes
- Skin colour : 1 = green, 2 = breaker, 3 = 25% yellow, 4 = 50% yellow, 5 = 75% yellow, 6 = 100% yellow.
- Crown : 1 = very good, fresh and green, 2 = good with slight yellowing of the tips, 3 = moderate, dry tips and yellowing, 4 = bad, dry tips and more yellowing, 5 = very bad and very dry.
- Flesh colour : 1 = white, 2 = white with trace of yellow, 3 = more white than yellow, 4 = more yellow than white, 5 = yellow.
• Black heart: 0 = nil, 1 = 10% flesh affected, 2 = 25% flesh affected, 3 = 50% flesh affected, 4 = 75% flesh affected, 5 = 100% flesh affected.

• Disease (leathery pocket): 0 = nil, 1 = slight, 2 = moderate, 3 = severe.

**Chemical analysis**
Each fruit was analyzed for ascorbic acid content by titration with 2,6 dichlorophenolindophenol (Ranganna 1977), pH by using an Orion digital pH meter (model SA520) and total soluble solids by a refractometer (model Atago Digital DBX-5). For this purpose, each fruit was deskinne, cut into halves and blended with a kitchen blender.

**Statistical analysis**
Analysis of variance and LSD test were performed on data. The SAS procedures were used for data analysis using a mainframe computer.

**Results**
**Weight loss**
Changes in weight loss of N36 pineapple during storage at 10 °C and after being held further for 1 week at ambient were observed (Figure 1). The weight loss increased as the storage period extended. Prolonged storage resulted in an excessive weight loss which recorded a maximum of 6% after 4 weeks of storage and 8% after being held further for 1 week at ambient in the second trial.

**Skin colour**
The skin colour of the pineapple changed slightly towards a higher score during storage at low temperature (Figure 2). The colour score advanced further when the fruit were exposed for 1 week at ambient following low temperature storage with the longer stored fruit exhibiting a higher colour score.

**Crown**
The crown remained fresh for up to 4 weeks of storage at 10 °C (Figure 3). The freshness of the crown was maintained for another week at ambient for the unstored fruit. The fresh condition of the crown was also observed in fruit which had been stored for only 1 week at 10 °C followed by 1 week at ambient. However, as the storage period at low temperature was extended, the crown quality had also declined after the fruit were exposed for another week at ambient.

**Flesh colour**
The flesh colour score changed very slightly during storage in both trials (Figure 4). There was a general trend in flesh colour

![Figure 1. Changes in weight loss of pineapple cv. N36 during storage at 10 °C and after being held further for one week at ambient](image-url)
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Figure 2. Changes in skin colour score of pineapple cv. N36 during storage at 10 °C and after being held further for one week at ambient.

Figure 3. Changes in crown score of pineapple cv. N36 during storage at 10 °C and after being held further for one week at ambient.

Figure 4. Changes in flesh colour score of pineapple cv. N36 during storage at 10 °C and after being held further for one week at ambient.
development in both trials after the stored fruit were exposed for 1 week at ambient. In trial I, the colour of the fruit during holding period at ambient advanced further with the maximum flesh colour score was observed in fruit previously stored for 2 weeks at low temperature. The flesh colour scores were lower in fruit previously stored for 3 and 4 weeks at 10 °C. In trial II, a similar trend was observed in the fruit after 1 week exposure at ambient following low temperature storage. However, the flesh colour score in fruit stored for 4 weeks did not show any development after 1 week exposure at ambient as the scores were the same during removal and after holding period at ambient.

**Black heart**
The incident of black heart was not observed in any of the fruit used in this study. The flesh remained free from black heart either upon removal from the cold room or after being held further for another week at ambient.

**Leathery pocket**
The N36 pineapples were attacked by leathery pocket disease during storage at 10 °C and after being held for 1 week at ambient (Figure 5). In trial I, leathery pocket infection was already observed in the freshly harvested samples (before storage). The intensity of the disease increased during storage at 10 °C and developed further after being held for 1 week at ambient condition. In trial II, leathery pocket was not observed in the freshly harvested fruit and during storage at low temperature. However, the disease was observed in some of the fruit exposed for 1 week at ambient following storage.

**Ascorbic acid**
The levels of ascorbic acid in the fruit at harvest are greatly determined by external factors during growth, especially the climatic conditions. Fruit in trial I were found to contain lower concentrations of ascorbic acid compared with those in trial II (Figure 6). In trial I, the concentrations of ascorbic acid during storage at low temperature were maintained for 3 weeks and declined thereafter. The concentration reduced slightly after exposure for 1 week at ambient for fruit stored for up to 3 weeks at 10 °C but declined abruptly in the fruit stored for 4 weeks. In trial II, the initial level of ascorbic acid was maintained at 10 °C for 1 week and declined gradually in the following weeks. The levels of ascorbic acid were about the same during removal of fruit from low temperature and after exposure for 1 week at ambient in fruit.
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Figure 6. Changes in ascorbic acid content of pineapple cv. N36 during storage at 10 °C and after being held further for one week at ambient

![Graph showing ascorbic acid content over storage period](image1)

Figure 7. Changes in total soluble solids of pineapple cv. N36 during storage at 10 °C and after being held further for one week at ambient

![Graph showing total soluble solids over storage period](image2)

stored for up to 2 weeks but significantly lower in fruit stored for a longer period.

**Total soluble solids**

Total soluble solids (TSS) tended to decline during storage in both trials (Figure 7). The decline in TSS was also observed in fruit of trial II after being exposed for 1 week at ambient following storage. However, the TSS content in fruit of trial I after 1 week exposure at ambient was about the same for all periods of storage.

**pH**

The pH of the flesh of pineapple in trial II showed a decreasing trend during storage (Figure 8). However, the same trend was not observed in fruit of trial I. No specific trend in pH was observed in fruit of both trials after being exposed for 1 week at ambient following low temperature storage.

**Discussion**

The weight loss in pineapple during storage can reach a very high level which can affect the fruit quality significantly. The excessive
weight loss can lead to monetary loss due to the reduced amount of salable weight. The weight loss can be reduced by lowering the transpiration rate such as by applying a moisture barrier on the fruit surface. Fruit coating or wrapping in polyethylene bags has been reported to maintain freshness and reduce weight loss during storage in fruits such as apple (Drake and Nelson 1990), citrus (Brusewitz 1985), mango (Kalra et al. 1986, 1988), pear (Drake et al. 1991) and guava (Abdullah et al. 1992).

The slight skin colour development during storage shows that the temperature of 10 °C had effectively inhibited the degreening and senescence of the fruit. Continuous skin colour development after storage indicated that the skin was still in normal condition and was not affected by chilling injury due to the storage temperature.

The flesh colour of the fruit, however, indicated that the yellowing process was inhibited by prolonged exposure to low temperature. In trial II, the flesh colour did not change at all in fruit after a 1-week holding period at ambient following 4 weeks of storage under refrigeration which may indicate the symptom of chilling injury.

The crown quality did not change during storage for up to 4 weeks at 10 °C. The crown also remained fresh in fruit which were continuously placed for 1 week at ambient without any previous exposure to low temperature. However, the deterioration in crown freshness could be observed in stored fruit after being exposed for 1 week at ambient condition; the quality deterioration was more severe in fruit stored for a longer duration at low temperature. The same observation was reported on Mauritius pineapple (Abdullah et al. 1994). It has been proposed that the tolerance level of pineapple to low temperature is probably different according to the fruit portion. The crown was less tolerance to low temperature than the fruit body and hence was more susceptible to chilling injury. It has also been proposed that the deterioration in the crown quality was mainly due to chilling injury of the crown (Abdullah et al. 1994).

The absence of black heart in N36 pineapples during and after storage at 10 °C shows that this variety is resistant to black heart. This is the first pineapple cultivar in Malaysia found to possess such characteristic. In Australia, the Hawaiian hybrid 53/116 has been known to be black heart resistant (Smith 1987). Black heart incidences in Malaysian pineapples have been reported on Mauritius, Sarawak and Gandol cultivars (Abdullah 1994a, b). The fruit susceptibility to black heart has hampered the efforts of the country in developing the
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export market for fresh pineapple. With the development of the new hybrid, shipment of fresh pineapples from Malaysia to other countries in refrigerated container can be made possible.

Although black heart is not a problem in N36 pineapples, it is very important to find ways to overcome the leathery pocket problem as it can still affect the fruit quality in the market. According to Lim (1985), leathery pocket is a disease caused by *Penicillium funiculosum* Thom. Pineapples of Hybrid I, Mauritius and Gandol cultivars are resistant to the disease. The occurrence of the disease during and after storage requires more in depth studies to be carried out before this cultivar can be recommended for large-scale plantation.

The development of black heart has been associated with the level of ascorbic acid in the fruit (Van Lelyveld and De Bruyn 1977). It has also been proposed that pineapple with a higher content of ascorbic acid will be less likely to develop black heart. However, this study very clearly proved that this hypothesis is incorrect since other cultivars known to be susceptible to black heart such as Mauritius (Abdullah and Rohaya 1983) and Sarawak (Abdullah et al. 1986) have higher concentrations of ascorbic acid than the N36 cultivar.

The TSS content of N36 pineapples tends to decline during and after storage. These results are in agreement with Abdullah and Rohaya (1983), and Abdullah et al. (1986) who reported the decrease in TSS contents of Mauritius and Sarawak cultivars during and after storage. The changes in pH which did not show a clear trend were also in agreement with the results reported by Abdullah and Rohaya (1983) on Mauritius.

**Conclusion**

N36 is the first Malaysian pineapple cultivar found to be resistant to black heart disorder. It is also one of the few cultivars in the world known to have such characteristic. With this special characteristic, it is possible to develop N36 into a major cultivar for fresh consumption and export purposes. However, the fruit susceptibility to postharvest diseases, especially leathery pocket, is a weak point and requires immediate actions to be taken before the export potential can be fully explored.

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