QUALITY CHANGES IN PINEAPPLE (*Ananas comosus* Merr. cv. Josapine) STORED AT LOW TEMPERATURE

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Quality changes in pineapple (Ananas comosus Merr.cv.Josapine) stored at low temperature / Nur Atiqah Anuar.

Lihat sebelah

QUALITY CHANGES IN PINEAPPLE (*Ananas comosus* Merr. cv. Josapine) STORED AT LOW TEMPERATURE

By
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the requirements for the degree of
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ENDORSEMENT

The project report entitled **Quality Changes in Pineapple (*Ananas comosus* Merr. cv. Josapine) Stored at Low Temperature** by **Nur Atiqah binti Anuar**, Matric No. **UK 16038** has been reviewed and corrections have been made according to the recommendations by examiners. The report is submitted to the department of Agrotechnology in partial fulfillment of the requirement of the degree of Agrotechnology (Post Harvest Technology), Faculty of Agrotechnology and Food Science, Universiti Malaysia Terengganu.

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DECLARATION

I hereby declare that the work in this thesis is my own except for quotations and summaries which have been duly acknowledged.

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ABSTRACT

Studies on the storage of pineapple cv. Josapine were conducted. The fruits used in this experiment were selected based on maturity index of 0 and stored at 10°C and at ambient temperatures for up to 4 weeks. It was assumed that when storage temperature is high, rate of fruit metabolism after harvest increases therefore causing them to deteriorate in quality. The objective of this study was to observe the quality changes of pineapple cv. Josapine stored at low temperature. Four batches of pineapples were stored one at ambient temperature storage and at low temperature of 10°C. Changes in fruit quality on the physical and chemical changes were evaluated weekly. Observations and analysis were made on weight loss, skin colour, crown condition, flesh colour, ascorbic acid, total soluble solids and pH. Fruit quality was maintained throughout storage at low temperature and deteriorated faster for fruit stored at ambient. From all the parameters that were studied, the first treatment, which was the storage at 10°C gave the best result for the all parameters. This was because low temperature slowed down the rate of metabolism of the fruit. Therefore, quality changes in pineapple stored at low temperature was minimal as compared to ambient temperature storage.

ABSTRAK

Kajian terhadap buah nanas kv. Josapine telah dijalankan. Buah telah dituai kira-kira pada indeks kematangan 0 dan disimpan pada suhu 10°C dan pada suhu sekitar sehingga 4 minggu. Adalah dianggap bahawa apabila suhu penyimpanan adalah tinggi, kadar metabolisma buah selepas tuaian adalah tinggi seterusnya menyebabkan kualiti buah rendah. Objektif kajian ini adalah untuk mengkaji perubahan kualiti buah nanas kv. Josapine yang disimpan pada suhu rendah. Empat kumpulan nanas telah disimpan pada suhu sekitar dan suhu rendah 10°C. Perubahan kualiti buah pada keadaan fizikal dan sifat kimia telah diselidik pada setiap minggu. Pemerhatian dan analisis dilakukan terhadap kehilangan berat, warna kulit, keadaan jambul, warna isi, asid askorbik, pepejal larut keseluruhan dan pH. Kualiti buah terpelihara sepanjang dalam penyimpanan pada suhu rendah dan berubah dengan cepat dalam penyimpanan pada suhu sekitar. Dari kesemua parameter yang dikaji, rawatan pertama iaitu penyimpanan pada suhu 10°C memberikan keputusan yang terbaik keada semua parameter yang dikaji. Ini disebabkan oleh suhu rendah melambatkan kadar metabolisma buah. Oleh itu, perubahan kualiti buah nanas yang disimpan pada suhu rendah adalah minima jika dibandingkan dengan penyimpanan pada suhu sekitar.

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°C	-	Degree Celcius
Kg	-	kilogram
%	-	Percent
TSS	-	Total Soluble Solids

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CHAPTER 1

INTRODUCTION

1.1 Background of study

Pineapple (*Ananas comosus* Merr.) is a tropical fruit and it belongs to the family Bromeliaceae and is herbaceous monocot. It forms rosette, has spiny leaves which are arranged spirally on its stem with the base having axillary buds which later appear as lateral shoots known as "suckers" or "ratoons" which are later used to yield a "ratoon crop" or a second crop from the same field (Rieger, 2006). There are many known varieties of pineapple in Malaysia namely Sarawak, Moris, Johor and Masmerah. In Malaysia, the most consumed pineapples were from the varieties Moris and Sarawak. Josapine was the first ever hybrid pineapple introduced by the Malaysian Agricultural Research and Development Institute (MARDI) in 1996 that was commercialized. Malaysia is famous for its exports of canned pineapples where they account for 95% for export market while the remaining is for the domestic market (MPIB, 2010). Fresh pineapple on the other hand accounts for only 5% for the export market and the 70% for the domestic market. The major pineapple producing countries are Thailand, followed by the Philippines, China, Brazil and India. All in all, the Asian region is the world's major pineapple producer.

The nutrients composition in pineapple include Vitamin A, Thiamin (B1), Riboflavin (B2), Niacin, Vitamin B6, Vitamin C (ascorbic acid), Riboflavin, Pantothenic acid, Aminobenzoic acid and Folic acid (Salvi and Rajput, 1995).

Pineapple is a non-climacteric fruit, where they are not capable of continuing their ripening process once removed from the plant (Kader, 2000), has low respiration rate and ethylene production and possesses a high commercial value to the local market and also export market. Josapine pineapple is harvested 120 days from flower induction and is stored at a low temperature of 8°C - 10°C and can be kept for 4 to 5 weeks (MARDI). For a half ripe fruit of Smooth Cayenne variety, a storage at a temperature range of 8.5°C – 12.5°C can hold its shelf life for 2 weeks and further held for another 1 week. For mature green fruit of the same variety, when stored below 10°C, it is susceptible to chilling injury. So for shipping of pineapples abroad, the most ideal storage temperature would be between 8.5°C and 10°C depending on the variety being exported and the stage of maturity the fruit is being harvested to ensure its organoleptic quality as well as its storage life.

1.2 Problem statement

Low temperature storage is applied to almost all fruit commodities after harvest to provide a condition that is suitable to keep its quality and that would lengthen the shelf life of the fruits before transportation or selling. Low temperature assists in the slowing down of biochemical activities in fruits and inhibits or slows down enzymatic reactions that would cause post harvest losses in fruits. Keeping fruits within their optimal temperature range and relative humidity is important factor in maintaining their quality and minimizing post harvest losses (Lurie, 2005). The recommended temperature for storage of pineapple is 7 to 12 °C, to be kept for 14 to 20 days, provided the fruit is at the colour break stage (Paull, 1993) with a relative humidity of 85 to 90%, which would significantly reduce water loss.

However, not all fruits have the same storage temperature. While a certain temperature is suitable for the storage of one type of fruit, it might not be suitable for other types of fruits and might as well cause chilling injury. Above the freezing point for non chilling sensitive commodities and the minimum safe temperature for chilling sensitive commodities, every 10°C increase in temperature accelerates deterioration and the rate of nutritional quality loss by two to three folds (Kader, 1992). Therefore it is crucial to investigate the optimal temperature in the extension of the post harvest life of fruit commodities.

1.3 Significance of study

Pineapple is one of the important tropical fruit that is being traded in the local market and being exported to foreign markets. Since the last 15 years the pineapples have been filling demands from around the world, shipping them to Singapore, Saudi Arabia and Jeddah. Pineapples for cultivars Mauritius and Sarawak kept at 8- 10°C can be stored for 3 to 4 weeks but are susceptible to black heart disorder. The similar condition was observed by Smith (1987) who reported that at a temperature range of 5- 21°C, black heart disorder was present in Australian pineapple. This study is conducted to observe the changes in quality attributes in pineapple cultivar Josapine stored at low temperature.

1.4 Objective

The aim of this project is to study the quality changes of pineapple cv. Josapine, stored under low temperature.

CHAPTER 2

LITERATURE REVIEW

2.1 Pineapple (*Ananas comosus* Merr.)

Pineapple (*Ananas comosus* Merr.) is one of the most popular tropical fruits. Pineapple is produced in many countries and is native to South America especially in Brazil and Paraguay. The world production of pineapple is dominated by Southeast Asia where in 2001, Thailand has produced 1.979 million tons followed by the Philippines with a total of 1.618 million tons while in the Americas, Brazil has produced 1.43 million tons. The total world production in 2001 was 14.220 million tons. The role that pineapple plays in our daily diet is providing 60 calories energy per 100 grams of the fruit and the chemical compositions of pineapple per 100 grams are 86 grams of water, 16 grams of carbohydrate and 2 grams of dietary fibers all for per 100 grams of ripe fruit. The ripening process of pineapple involves a series of biochemical processes and enzymatic activities. Ripening of fruits includes the changes in the flesh firmness, carbohydrate metabolism, respiration rate and ethylene production (Fergus and Boyd, 2005). These processes contributes to the deterioration of the fruit's quality after harvest such as enzymatic browning and chilling injuries which include wilting that is drying an discolouration of the crown, failure of green-shelled fruit to yellow, browning and dulling of yellow fruit and internal flesh browning (Lim *et al.* 1985).

2.2 Quality Changes of Fruit

Quality of fruits is seen through their appearance such as size, shape, colour, gloss and freedom from defects and decays (Kader, 2005). Quality changes occur in every produce that is harvested because produces continue to respire even after detached from the original plant. The factors that influence the quality changes of fruits includes pre harvest and post harvest factors. These include genetic factors namely selection of cultivars and rootstocks, pre harvest climatic conditions and cultural practices, maturity at harvest and harvesting method, post harvest handling procedures and processing methods (Goldman *et. al.*, 1999; Lee and Kader, 2000). Proper storage is probably the best method to slow the quality changes of commodities if not prevent them from too rapid deterioration. However, injury such as chilling injury during storage can occur in produce if not given extra attention of their physiological properties. According to Paull and Rohrbach (1987), symptoms of chilling injury include dull shell colour when ripe, wilting of the crown, water-soaked appearance of the pulp, increased susceptibility to decay and internal browning. Chilling injury develops when whole fruits are stored at temperatures below 10°C for an extended period of time. Symptoms appear after the chilled fruits have been removed to non chilling temperatures and their incidence can be alleviated using controlled or modified atmospheres (Paull and Rohrbach, 1985; Chitara and da Silva, 1999). In non climacteric fruits, with the right amount of ethylene concentration, the fruit will continue to ripen, along with factors such as temperature.

2.3 Low Temperature Storage

Storage of fruits at a low temperature is one of the ways of extending the post harvest storage life of the fruits. Low temperature storage together with a controlled or modified atmosphere can extend the post harvest lie of fruits. Low temperature inhibits the biochemical reactions and enzymatic activities in the fruits that would lead the fruits to deteriorate easily. When pineapples are exposed to low temperature, it results in severe internal discolouration (Paull and Rohrbach, 1985. Smith, 1983). Susceptible fruits are generally lower in ascorbate and sugar content and are opaque (Abdullah and Rohaya, 1983; Abdullah *et al.*, 1985; Paull and Rohrbach, 1985; Swete Kelly and Bragshaw, 1993). In a previous study, Josapine is said to be resistant to black heart disorder. In a preliminary study by Marrero and Kadir (2001), it was found that post-cutting life of pineapple pieces ranged from 4 days at 10°C to over 2 weeks at 0°C. Temperature management for fresh produce is a key to quality maintenance. Lowering the temperature as quickly as possible after harvest will slow the rate of metabolism and therefore extend the product's shelf life.

CHAPTER 3

MATERIALS AND METHODS

3.1 Materials

3.1.1 Collection of sample

In this study, pineapple samples were harvested and collected at a commercial pineapple plantation in Kampung Be'oh, Gunung Bachok, Kelantan at index 0. The harvested fruits were placed in perforated cardboard boxes and were stored in a cold storage room at 10°C and at ambient temperature for 4 weeks. A total of 24 pineapples were used in this project.

3.1.2 Reagents

Reagents that were used in this project were meta-phosphoric acid (HPO_3) and 2,6- dichloroindophenol, DCIP.

3.2 Methodology

3.2.1 Storage of fruit

The pineapples were stored at two different conditions, at 10°C and at ambient temperature at 28°C. The fruits were placed in cardboard boxes, with holes made at each side of the boxes. Each box contained 3 pineapples. At each condition, there were 4 boxes respectively, with the fruits at each condition totaling 12 altogether.

3.2.2 Sampling of fruit for analysis

Two types of analysis had been performed on the fruits, namely physical analysis and chemical analysis. Each week, one batch of fruit (one box) was taken out from the both storage conditions and evaluated. Each fruit in each of the boxes were evaluated for their weight loss, skin colour, crown conditions, flesh colour, presence of black heart, ascorbic acid, pH and total soluble solids (TSS).

3.2.2.1 Weight loss evaluation

The weight loss of the pineapple was taken by measuring the differences in the weight before and after storage. Each week, the weights of all the pineapple were taken. The weight loss is expressed in percentage.

The percentage of weight loss is calculated as follow:

$$\frac{\text{Initial weight of fruit (kg)} - \text{final weight of fruit (kg)} \times 100\%}{\text{Initial weight of fruit (kg)}}$$

3.2.2.2 Physical changes evaluation

3.2.2.2.1 Skin colour

The determination of skin colour that was observed was determined by the maturity index chart provided by MARDI.

Index	Description
1	Green
2	Breaker
3	25% yellow
4	50% yellow
5	75% yellow
6	100% yellow

3.2.2.2.2 Crown condition

The crown condition was determined by the following scores:

Index	Description
1	Very good, fresh and green
2	Good with slight yellowing of the tips
3	Moderate, dry tips ad yellowing
4	Bad, dry tips and more yellowing
5	Very bad and very dry

3.2.2.2.3 Flesh colour determination

The flesh colour of the fruit was determined by the following score indications:

Score	Description
1	White
2	White with trace of yellow
3	More white than yellow
4	More yellow than white
5	Yellow

3.2.2.3 Chemical analysis

3.2.2.3.1 Analysis for ascorbic acid content

Ascorbic acid content in the fruit was determined by titration with 2,6- dichloroindophenol (DCIP). The fruit sample was mashed to bring out the juice extract. 20 ml of sodium hypochlorite (HPO_3) was then mixed with 5 g of the extracted juice and filtered through Whatmann filter paper into a beaker. Then, 5 ml of the mixture was pipette into a conical flask and 5 ml of sodium hydrochloride (HCl) solution was added to the solution. The solution was with 2,6-dichloroindophenol until a light, distinct pink persist.

3.2.2.3.2 pH determination

The pH for the fruit was determined by using a digital pH meter. 5 g of the fruit flesh was mashed and 10 ml of distilled water was added. The pH reading was taken using the pH meter.

3.2.2.3.3 Analysis of total soluble solids (TSS)

The total soluble solids (TSS) were measured using the handheld refractometer. Results were expressed in degrees of Brix (°Brix). Sample for the TSS analysis was prepared by blending the flesh of the pineapple with a kitchen blender. A few drops of the pineapple juice was placed onto the prism of the refractometer and the reading was taken.

3.2.3 Statistical Analysis

Analysis of variance (one- way ANOVA) is performed on the data obtained using the SPSS procedures.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Results

The results and observation obtained from the four weeks of experiment based on the parameters chosen to be studied are as follows:

4.1.1 Weight Loss

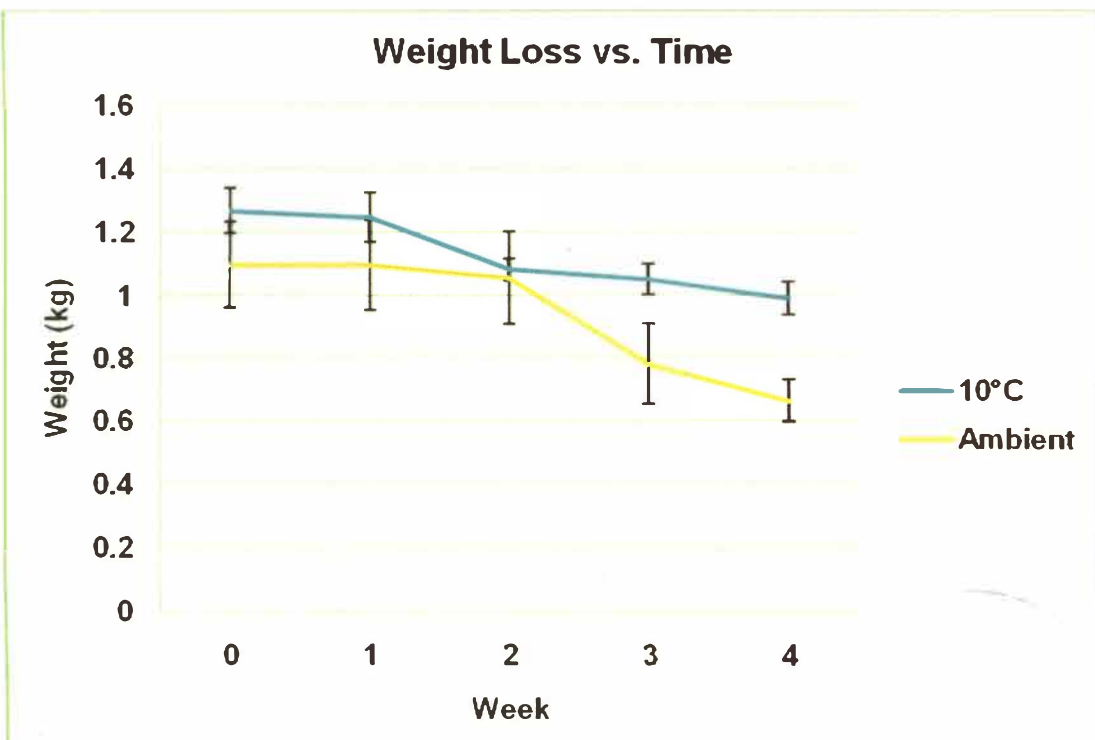

Figure 4.1: Comparison of average weight loss of pineapple cv. Josapine at two different treatment conditions

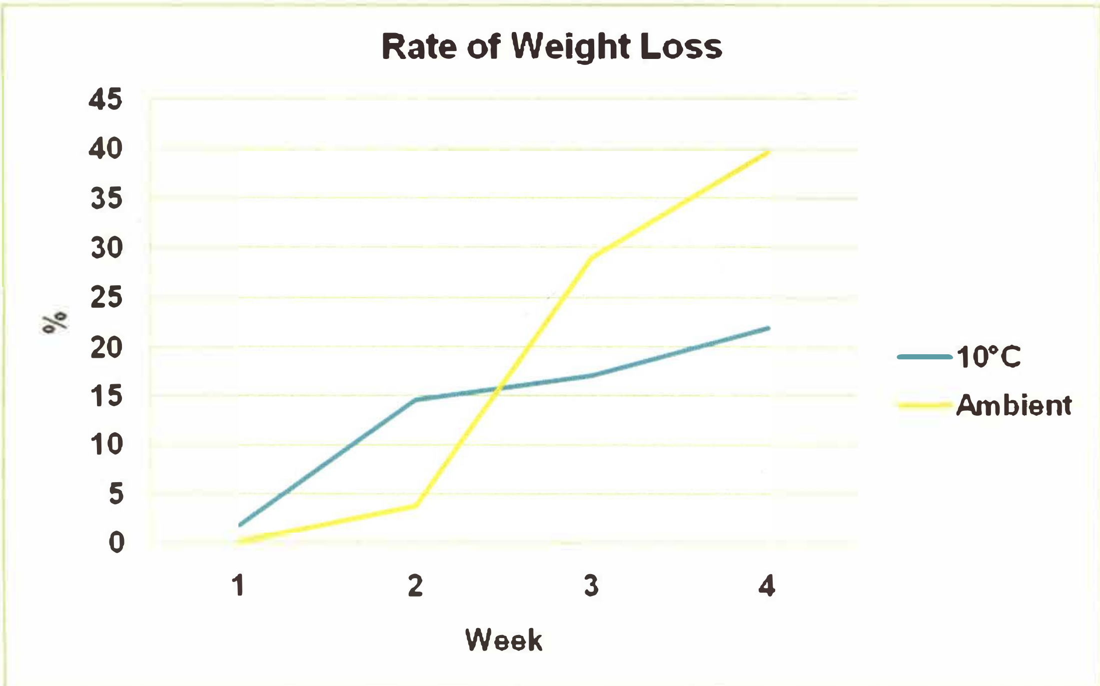

Figure 4.2: Comparison of average rate of weight loss of pineapple cv. Josapine at two different treatment conditions

The weight loss of the Josapine pineapple is presented in Figures 4.1 and 4.2. With time, the weight of the Josapine pineapple decreases for both treatments (Figure 4.1).

From week 1 to week 2, there was a gradual weight loss in the pineapple at treatment 1 (10°C). As for treatment 2 (ambient), there was a slow rate of weight loss.

By week 3, there had been a rapid weight loss in the pineapple at treatment 2 (ambient) indicating a significant change ($P<0.05$), whereas for treatment 1 (10°C), the weight loss is slower than in treatment 2. Prolonged storage of the pineapples resulted in an excessive weight loss which recorded a maximum of 39.7% (Figure 4.2) after 4 weeks of storage for treatment 2.

From figures 4.1 and 4.2, it can be said that high temperature (ambient) hastened the ripening of the pineapple, which causes a rapid water loss from the fruit. Once fruits are harvested they constantly lose water to the environment. Since the lost of water cannot be replaced by the tree, weight loss occurs (Lurie, 2005). Temperature has a great effect on the rate of respiration of a produce, where as temperature rises, so will the rate of respiration resulting in a shorter shelf life (Jobling, 2000).

According to Abdullah *et al*., 1996, the same observations were made in the storage of N36 pineappple at 10°C and after being held further for one week at ambient. Therefore, storage of Josapine pineapple at 10°C extends the quality of the pineapple by slowing the respiration rate of the pineapple. The weight loss can be reduced by lowering the transpiration rate by applying a moisture barrier on the surface of the fruit (Abdullah *et al*., 1996). Fruits packed and sealed in propylene bags and stored at 8°C and 10°C had significantly less weight loss (Selvarjah, 2002).

4.1.2 Total Soluble Solids (TSS)

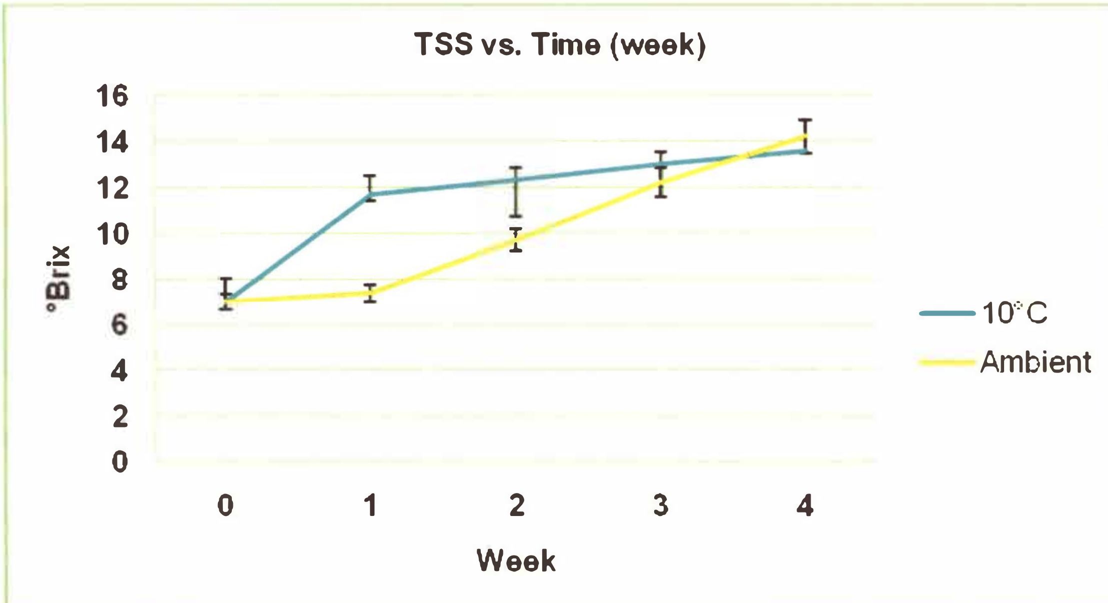

Figure 4.3: Comparison of average rate Total Soluble Solids (TSS) of pineapple cv. Josapine at two different treatment conditions

Changes in the total soluble solids (TSS) of fruits during period of storage are directly correlated with the hydrolytic changes in the starch concentration. Conversion of starch to sugar is an important index in the ripening of mangoes and many other fruits (Kays, 1991). Figure 4.3 showed that the interaction between temperature and storage time had a highly significant effect on the total soluble solids of the pineapple. It was observed that the percentage of total soluble solids had an increasing trend during the four weeks of storage at 10°C and ambient.

The maximum total soluble solids (TSS) content were observed in treatment 2 (14.20%) at the fourth week of storage followed by treatment 1 (13.63%) also by the final week of storage. After one week of storage, there was a significant difference ($P<0.05$) in the content of total soluble solids between the two treatments, but it only holds true until the second week of storage. After storage time of three weeks, the total soluble solids contents were no longer significant. This may be due to that starch was completely converted to sugar. The same effect was observed by Carillo *et al.*, 2000; Doreyappa-Goda and Huddar, 2001 and Kittur *et al.*, 2001. A study of shaded (low temperature) compared with sun exposed (high temperature) apples showed that there were differences in both maturity at harvest and ripening behavior post harvest (Klein *et al.*, 2001). Exposed apples were firmer and had higher soluble solids than shaded apples, but also produced more ethylene and had higher starch levels than shaded apples at harvest (Lurie, 2003). The increase in the total soluble solids (TSS) might be due to the alteration in the cell wall structure and breakdown of complex carbohydrates into simple sugars by enzymatic actions during ripening and further hydrolysis decreased the total soluble solids (TSS) during storage.

After one week of storage at both treatments, there was an increase of the total soluble solids (TSS) of the pineapples. From week one onwards, the total soluble solids (TSS) for the pineapple in treatment 2 showed a rapid increase compared to the treatment 1 pineapples.

Therefore, storing pineapples at low temperature (10°C) is best because low temperature slows ripening process by which carbohydrate metabolism is involved, thus extending the keeping quality of the pineapples.

4.1.3 Vitamin C (Ascorbic Acid)

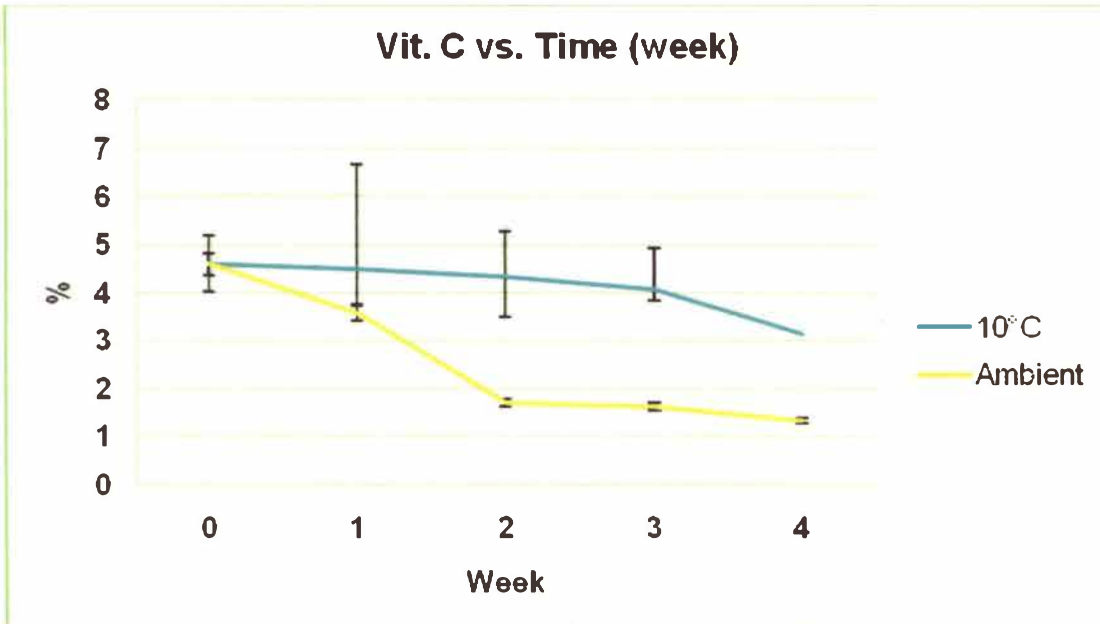

Figure 4.4: Comparison of average vitamin C (ascorbic acid) contents of pineapple cv. Josapine at two different treatment conditions

The ascorbic acid contents in the Josapine pineapples show a decreasing trend with time of storage at both temperature treatments. For every 10°C increase in temperature, deterioration and the rate of loss in nutritional quality are accelerated by two- to threefold (Kader, 1992). Figure 4.3 shows that as storage time increases, the average ascorbic acid levels in the pineapple decreased, a decreasing trend observed for both temperature treatments. The levels of ascorbic acid in the fruit at harvest are greatly determined by external factors during growth, especially the climatic condition (Abdullah *et al.*, 1996).

At storage temperature of 10°C, the level of ascorbic acid had decreased at a steady rate, while for the storage at ambient temperature the decline of ascorbic acid level in the pineapple was rapid after one week of storage, and showed a significant difference ($P<0.05$) after the second week of storage for both storage temperature.

4.1.4 pH

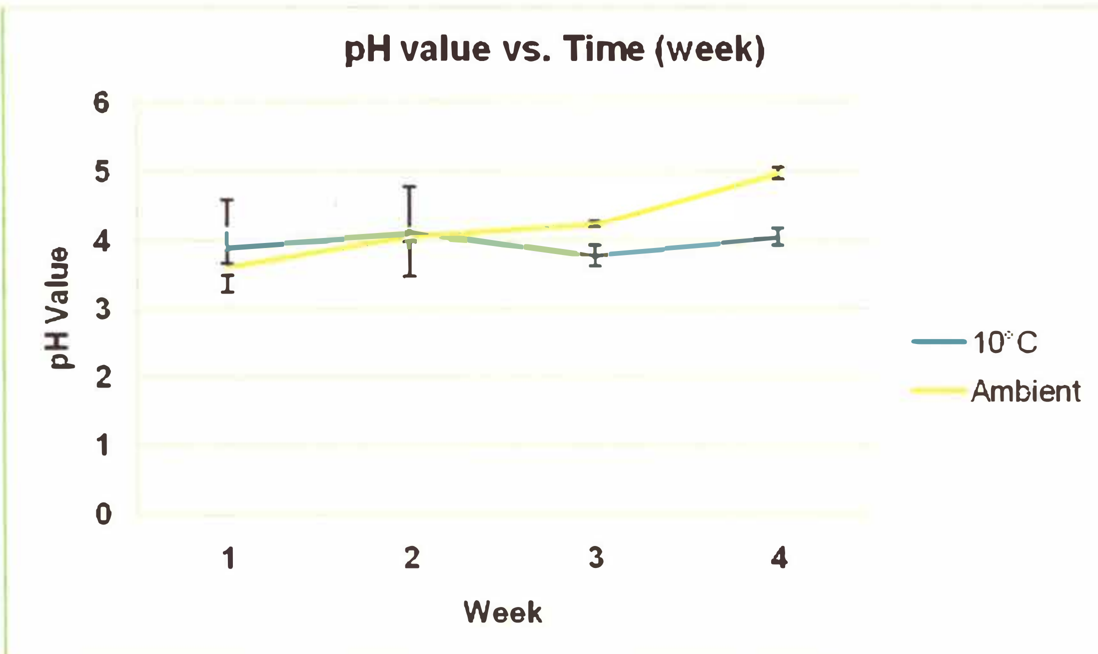

Figure 4.5: Comparison of average pH levels of pineapple cv. Josapine at two different treatment conditions

The pH value of the pineapple stored at low temperature did not show any specific trend. There was a slow increase in the pH value for the pineapple in low temperature storage until week 2 but began to decline on week 3, while the pH value for the pineapple stored at ambient showed a steady increase in the pH value. The highest pH value exhibited by the pineapple stored at ambient was at week 4 with an average of 4.97, while for low temperature, the highest pH value was at week 2 with an average of 4.13. There were no significant differences ($P<0.05$) in pH value from week 1 to 2 but were observed from week 3 to week 4.

pH value is associated with the acid content in a fruit. The pH value in the temperature treatments showed an increasing trend except for low temperature at week 3 (Figure 4.5). Acid content usually decreases during ripening due to the utilization of organic acids during respiration or their conversion to sugars (Kader, 2005), resulting in the increase of pH. The results are in agreement with

Saradhuldhat and Paull (2007), who reported that at a late stage of pineapple fruit development, the soluble solids content gradually increased whereas the titratable acidity declined.

Due to the slowed respiration at low temperature, utilization of organic acids and conversion to sugars decline, resulting in lower pH. For pineapple eating quality in terms of pH value, the best pH would be in range of 4- 4.5, so this is given by the pineapple stored at low temperature with a maximum pH of 4.13.

4.1.5 Skin Colour

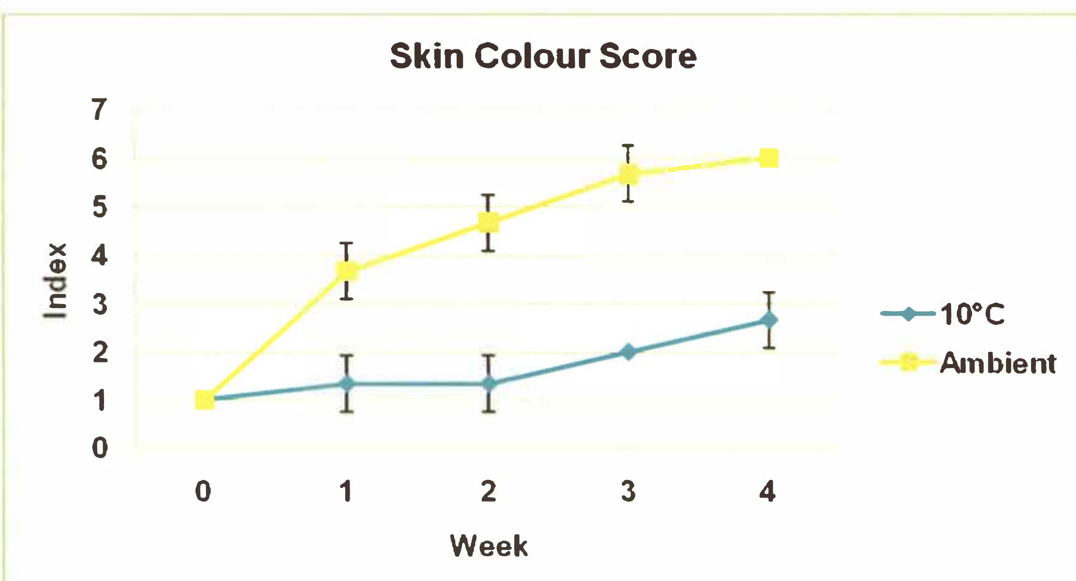

Figure 4.6: Comparison of average skin colour scores of pineapple cv. Josapine at two different treatment conditions

The skin colour score of pineapple stored at both temperature treatments showed increasing trends. Colour score increased with time. For the storage at low temperature, the score gradually increased to a higher score, while for storage at ambient, the score rapidly increased to a higher score (Figure 4.6). There were significant differences (P<0.05) in the scores exhibited by both treatments.

During maturation and ripening of fruits, pigments which are chemicals responsible for skin and flesh colour, undergo many changes. These include loss of chlorophyll (green colour), which is influenced by pH changes, oxidative conditions and chorophyllase action; synthesis and/or revelation of carotenoids (yellow and orange colours) and development of anthocyanins (red, blue and purple colours), which are fruit specific (Kader, 2005). The changes from a green skin colour to a slight yellow is in agreement with Kader (2005) where it occurred due to loss of chlorophyll, with the influence of pH.

4.1.6 Crown Condition

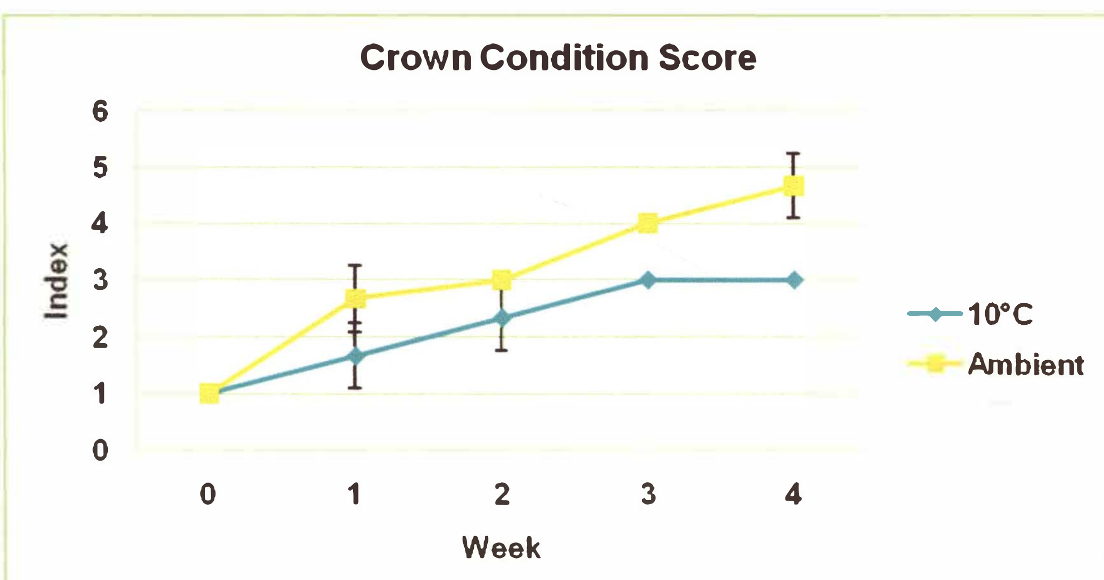

Figure 4.7: Comparison of average crown condition scores of pineapple cv. Josapine at two different treatment conditions

An increasing trend in the crown score exhibited by the pineapples at both storage conditions. Both treatments showed a gradual change in the crown score, from one week to the next. Storage at low temperature showed an increase from score 1 at the first week of storage to 3 on the third week of storage and maintained it until week 4. While the score for storage at ambient continued to increase until the final week. Significant differences ($P<0.05$) were observed at the final weeks of storage.

Storage at low temperature maintained the crown condition at least at the acceptable level that is moderate with drying tips and yellowing compared to the ambient storage condition which was bad with dry tips and more yellowing. According to Abdullah *et al.*, 1994, it has been proposed that the deterioration in crown quality was mainly due to chilling injury of the crown.

4.1.7 Flesh Colour

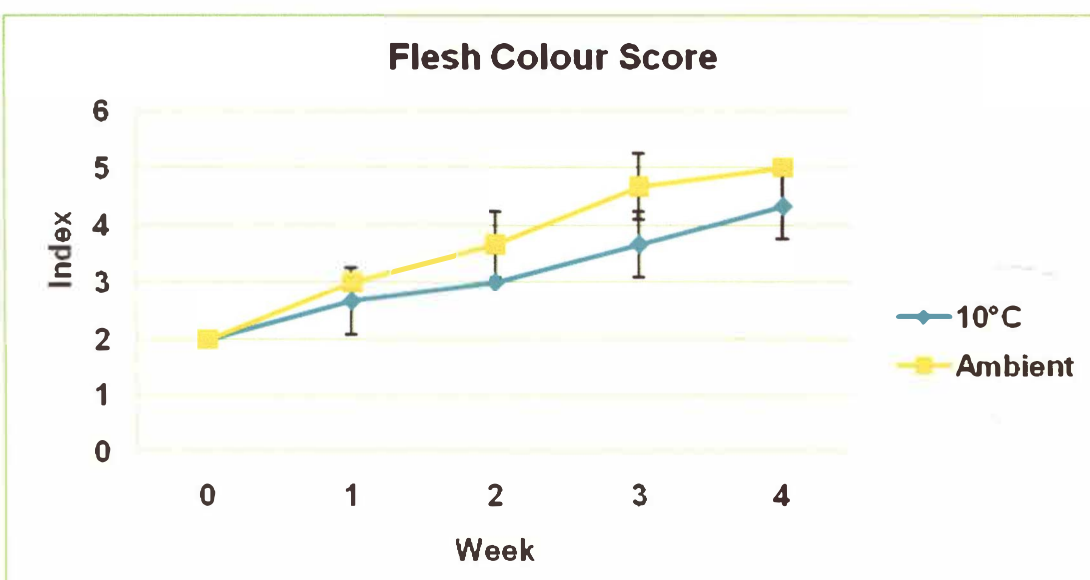

Figure 4.8: Comparison of average flesh colour scores of pineapple cv. Josapine at two different treatment condition

The flesh colour score for both temperature treatments showed an increasing trend. The increase was gradual for both treatments. The flesh colour was higher for the pineapple stored at ambient than the low temperature. The flesh colour indicated that the yellowing process was inhibited by exposure to low temperature. As reported by Kader (2005), synthesis and/or revelation of carotenoids which give yellow and orange colour to the flesh during period of ripening occur in the pineapples during storage. The flesh colour for both treatments showed the colour transition from white with traces of yellow to completely yellow. There were no significant differences ($P<0.05$) in the flesh colour score during the entire storage period. The flesh also did not indicate any symptoms of chilling injury.

Storage at low temperature is said to be better since the rate of change in the flesh colour is slower as compared to storage at ambient temperature.

Table 4.1: Quality change on the skin colour of Josapine pineapple stored at low temperature

Treatments	Weight (kg)				
	Week 0	Week 1	Week 2	Week 3	Week 4
10°C	1.00±0.00	1.33±0.33	1.33±0.33	2.00±0.00	2.67±0.33
Ambient	1.00±0.00	3.67±0.33	4.67±0.33	5.67±0.33	6.00±0.00

The data shown are the means of three replicates and standard deviation for total soluble solids (mean±standard deviation).

Table 4.2: Quality change on the crown condition of Josapine pineapple stored at low temperature

Treatments	Weight (kg)				
	Week 0	Week 1	Week 2	Week 3	Week 4
10°C	1.00±0.00	1.67±0.33	2.33±0.33	3.00±0.00	3.00±0.00
Ambient	1.00±0.00	2.67±0.33	3.00±0.00	4.00±0.00	4.67±0.33

The data shown are the means of three replicates and standard deviation for total soluble solids (mean±standard deviation).

Table 4.3: Quality change on the flesh colour of Josapine pineapple stored at low temperature

Treatments	Weight (kg)				
	Week 0	Week 1	Week 2	Week 3	Week 4
10°C	2.00±0.00	2.67±0.33	3.00±0.00	3.67±0.33	4.33±0.33
Ambient	2.00±0.00	3.00±0.00	3.67±0.33	4.67±0.33	5.00±0.00

The data shown are the means of three replicates and standard deviation for total soluble solids (mean±standard deviation).

Table 4.4: Quality change on the weight loss of Josapine pineapple stored at low temperature

Treatments	Weight (kg)				
	Week 0	Week 1	Week 2	Week 3	Week 4
10°C	1.27±0.05	1.24±0.04	1.08±0.02	1.05±0.02	0.99±0.03
Ambient	1.10±0.08	1.09±0.08	1.05±0.08	0.78±0.07	0.66±0.04

The data shown are the means of three replicates and standard deviation for total soluble solids (mean±standard deviation).

Table 4.5: Quality change on the TSS value of Josapine pineapple stored at low temperature

Treatments	TSS (%)			
	Week 1	Week 2	Week 3	Week 4
10°C	11.67±0.60	12.30±0.45	13.03±0.32	13.63±0.32
Ambient	7.40±0.21	9.67±0.18	12.17±0.93	14.20±0.83

The data shown are the means of three replicates and standard deviation for total soluble solids (mean±standard deviation).

Table 4.6: Quality change on the Vitamin C value of Josapine pineapple stored at low temperature

Treatments	Vitamin C (%)			
	Week 1	Week 2	Week 3	Week 4
10°C	4.50±0.34	4.34±1.25	4.07±0.54	3.14±0.50
Ambient	3.57±0.34	1.69±0.45	1.62±0.50	1.32±0.14

The data shown are the means of three replicates and standard deviation for total soluble solids (mean±standard deviation).

Table 4.7: Quality change on the pH value of Josapine pineapple stored at low temperature

Treatments	pH			
	Week 1	Week 2	Week 3	Week 4
10°C	3.94±0.37	4.13±0.37	3.75±0.09	3.99±0.07
Ambient	3.60±0.04	4.05±0.02	4.23±0.04	4.97±0.05

The data shown are the means of three replicates and standard deviation for total soluble solids (mean±standard deviation).

Table 4.8: Rate of weight loss (%)

Week	1	2	3	4
10°C	1.755170755	14.58081178	17.09123202	21.880401
Ambient	0.127629209	3.778115835	28.96355625	39.662614

Table 4.9: Average of Total Soluble Solids (TSS) content (%)

Week	0	1	2	3	4
10°C	7	11.7	12.3	13	13.6
Ambient	7	7.4	9.7	12.2	14.2

Table 4.10: Average of Ascorbic Acid (Vitamin C) value (%)

Week	0	1	2	3	4
10°C	4.6	4.5	4.34	4.07	3.14
Ambient	4.6	3.57	1.69	1.62	1.32

Table 4.11: Average pH value

Week	1	2	3	4
10°C	3.94	4.13	3.75	3.99
Ambient	3.6	4.05	4.23	4.97

Table 4.12: Average of Skin colour score

Week	0	1	2	3	4
10°C	1	1.333333	1.333333	2	2.666667
Ambient	1	3.666667	4.666667	5.666667	6

Table 4.13: Average of crown condition score

Week	0	1	2	3	4
10°C	1	1.666667	2.333333	3	3
Ambient	1	2.666667	3	4	4.666667

Table 4.14: Average of flesh colour score

Week	0	1	2	3	4
10°C	2	2.666667	3	3.666667	4.333333
Ambient	2	3	3.666667	4.666667	5

CHAPTER 5

CONCLUSION

5.1 Conclusion

The study on the quality changes in Josapine pineapple was done to determine the best storage temperature to slow down if not to maintain the quality of the pineapple. Storage of Josapine pineapple at a low temperature (10°C) did not show any symptoms of chilling injury or the presence of black heart disorder as observed in most pineapple cultivars such as Mauritius (Abdullah and Rohaya, 1983) and Sarawak (Abdullah *et al.*, 1986). Low temperature is said to slow down metabolism processes in a fruit thus weight loss due to increased respiration and other undesirable qualities as a result of high temperature storage are therefore also reduced or set at a low level.

From the results obtained, weight loss at low temperature storage showed a lower rate than of ambient temperature, where at ambient storage, the rate had dramatically increased after a prolonged storage period, twice the rate of that of low temperature storage. Low temperature storage also showed a slow deterioration rate on other properties of the pineapple such as skin colour, crown condition, flesh colour, total soluble solids (TSS), ascorbic acid (Vitamin C) and pH.

To sum up, based on this study, and from the parameters being studied, it is found that storing pineapple at low temperature (10°C) is the best treatment for extending the shelf life and quality of the pineapple until consumption. Proper storage temperature will determine the fruit's quality to be sold to consumers and their acceptance on their quality attributes.

5.2 Suggestion for Further Study

Besides low temperature being the factor of keeping quality of Josapine pineapple, other possibilities of extending the shelf life and keeping the quality of the fruit should be explored. Methods such as modified or controlled atmosphere storage of the fruit could be executed for fresh cuts of Josapine pineapples. More studies on the deterioration of pineapples should be made in order to understand other factors beside temperature alone that could have caused quality deterioration.

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APPENDICES

pH

Appendix A: Test of homogeneity of variances

Week	df1	df2	Sig.
1	1	4	0.450
2	1	4	0.848
3	1	4	0.020
4	1	4	0.000

Appendix B: ANOVA result

Week	Sum of squares	df	Mean square	F	Sig.
1	0.041	5	0.051	0.103	0.764
2	0.053	5	0.026	4.266	0.108
3	0.819	5	0.065	13.761	0.021
4	0.823	5	0.030	12.804	0.023

Total Soluble Solids (TSS)

Appendix C: Test of homogeneity of variances

Week	df1	df2	Sig.
1	1	4	0.012
2	1	4	0.018
3	1	4	0.455
4	1	4	0.577

Appendix D: ANOVA result

Week	Sum of squares	df	Mean square	F	Sig.
1	2.367	5	0.592	3.254	0.146
2	1.407	5	0.352	4.797	0.094
3	5.773	5	1.443	4.954	0.090
4	4.767	5	1.192	3.044	0.156

Weight loss

Appendix E: Test of homogeneity of variances

Week	df1	df2	Sig.
1	1	4	0.203
2	1	4	0.785
3	1	4	0.053
4	1	4	0.004

Appendix F: ANOVA result

Week	Sum of squares	df	Mean square	F	Sig.
1	0.052	5	0.013	0.656	0.463
2	0.046	5	0.011	3.887	0.120
3	0.037	5	0.009	2.146	0.217
4	0.015	5	0.004	0.090	0.779

Ascorbic Acid (Vitamin C)

Appendix G: Test of homogeneity of variances

Week	df1	df2	Sig.
1	1	4	0.123
2	1	4	0.158
3	1	4	0.029
4	1	4	0.058

Appendix H: ANOVA result

Week	Sum of squares	df	Mean square	F	Sig.
1	1.372	5	0.343	0.001	0.981
2	10.647	5	2.662	4.971	0.090
3	3.200	5	0.800	0.073	0.800
4	1.599	5	0.400	1.912	0.239

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QUALITY CHANGES IN PINEAPPLE (ANANAS COMOSUS MERR. CV. JOSAPINE) STORED AT LOW TEMPERATURE - NUR ATIQAH BINTI ANUAR