# EFFECT OF FARMER PRACTICES OF POSTHARVEST HANDLING ON QUALITY OF MAURITIUS PINEAPPLE (*Ananas comosus*).

By

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## DECLARATION

The work described in this thesis was carried out at the Food Research Unit, Department of Agriculture, Gannoruwa, Peradeniya and Faculty of Applied Sciences under the supervision of Dr. K.H. Sarananda and Mrs. Indira Wickramasinghe. A report on this has not been submitted to any other University for another degree.

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**AFFECTIONATELY DEDICATED TO MY EVERLOVING PARENTS AND SISTER**

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## ABSTRACT

Pineapple is a highly demanding fruit in Sri Lanka. The quality of pineapple at the market is lower than the inherent quality of the variety. This may be due to poor postharvest handling practices adapted by growers and traders. Pineapple quality depends on the interaction of several factors in the production line. In this study there are results of a survey of twenty five pineapple growers in Gampaha district and describes their postharvest handling practices and also recommended practices including stage of maturity at harvest, method of harvesting, method of ripening, method of transport and special handling practices. This report also consists of the results of quality comparison between market sample and the recommended practice sample. Considered quality parameters were Total soluble solids, Titratable acidity, pH, Sensory evaluation, Visual quality rating and Disease incidence. It was found that recommendations are not always applied. Pineapples are harvested at different periods in relationship to the ultimate market. A significantly higher quality was observed in pineapple harvested following recommended practice while farmer practices which lead inferior quality at market.

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# CHAPTER 1

## 1.1 Introduction

Pineapple is a non-climacteric fruit. As a non-climacteric fruit, obvious compositional changes after harvest are mostly limited to degreening and a decrease in acidity (Kader,1992). No quality improvement can therefore be expected after harvesting. Therefore, harvesting at correct stage of maturity is essential. Inability to develop quality after harvesting the fruit must be allowed to remain on the plant until they have attained satisfactory eating quality. Therefore, stage of maturity at harvesting is crucial. A non-climacteric fruit harvested when fully mature is immediately edible, and does not under go a comparable ripening process, either on or off the plant (Snowdon,1990). Harvest time is often when the base of the fruit has changed from green to yellow or light brown. Fruits may be harvested for fresh market before striking colour changes have occurred. Acceptable quality may develop before colour changes occur in the shell. Since the pineapple fruit has no accumulation of starch, there is no reserve for major post harvest quality improvements (Kader,1992).

Two varieties of pineapple are commercially grown in Sri Lanka. The 'Kew' variety produces large fruits mainly utilized for caning, while 'Mauritius' variety produces comparatively smaller fruits, suitable for consumption as fresh fruits. 'Mauritius' is the widely grown variety in Sri Lanka (Rupasinghe,1996).

The quality of pineapple at the market is lower than the inherent quality of the variety. This may be due to poor post harvest handling practices adopted by growers and traders. The possible reasons for poor quality are early harvesting, artificial ripening, poor handling during transport and post harvest diseases.

In general, an important factor behind these post harvest losses in the marketing chain of pineapple, is the basic lack of knowledge and practices in all its stages. Good produce management throughout the marketing chain is essential to maintain quality. In general terms quality infers some degree of excellence and giving the customer satisfaction. It is not possible to improve the quality of pineapple, but it is possible to slow down the rate of undesirable changes. The post harvest handling system must be aim to ensure that the fruit reaches the market in the exact condition. Careful management of the post harvest handling system must be required to obtain the best possible results.

Studies were therefore conducted with the following objectives.

(1) Study of the farmer practices of pineapple harvesting and handling.
(2) Quality comparison of pineapple harvested using farmer practices and recommended practices.

# CHAPTER 2
# Literature Review

## 2.1 Origin and Distribution

The scientific name for cultivated pineapple is *Ananas comosus*. It is a member of the plant family *Bromeliaceae*, which includes a number of ornamental bromeliads (Broadley *et al.*,1993). Bromeliads are adapted to areas with low rainfall and well drained soils. The pineapple originated in South America, where the native people selected and grew a seedless mutation of one of the many similar species that occur there.

Distribution of pineapple from the America is attributed to Spanish and Portuguese explorers and was aided by the resistance of crowns and slips to desiccation (Nakasone and Paull,1998). Today, the pineapple is found in almost all the tropical and subtropical areas of the world and has become one of the leading tropical fruits in international commerce.

## 2.2 Botany

### 2.2.1 Roots

Roots buds occur in the axils of the leaves, and can be found to within 1 or 2 cm of the stem apex (Broadley *et al.*,1993). These buds develop in to roots, usually only on the lower part of the stem. Where these developing roots grow in to the soil they are known as soil roots. These are quite shallow, and are rarely found at more than 90cm depth. Most absorption of water and minerals occur through microscopic root hairs which grow just behind the root tips. The roots which develop in the leaf axils above the soil are known as axillary roots. They grow about 50cm, and have to squeeze around the leaf bases. Axillary roots absorb water and nutrients in the same way that soil roots do.

### 2.2.2 Stem

The stem is the central support of the whole pineapple plant. If the stem is cut across, it can be seen to have two zones. (Broadly *et al.*,1993). The lager zone is the central stele, which is surrounded by the relatively thin zone called the cortex. Both regions have vascular tissue which carries water and nutrients throughout the plant. The stele, and to a lesser extent the cortex, has large storage cells for starch which pineapple plants

accumulate as they mature. The starch is used during the development of suckers and slips and during fruit formation.

### 2.2.3 Leaves

Leaves spiral up the stem to the left or right. If leaves are removed sequentially from the bottom, five arranged spirals can be observed (Broadley *et al.*,1993). The number of leaves increases regularly, with an average of five or six leaves per month. Old leaves do not abscise and mature plant may have about 70-80 active leaves (Nakasone and Paull,1998). Pineapple has stomata only on the underside of the leaf, and relatively few compared with other plants. The underside of the leaf appears soft and silvery due to the presence of leaf hairs. Pineapple plant also have specialized water storage tissue, which occurs as a large of colourless cells just under the upper surface of the leaf. These cells fill with water during periods of water surplus, and can be drawn upon in times of water shortage (Broadely *et al.,* 1993).

### 2.2.4 Inflorescence and Flower

The first sing of floral initiation, whether natural or induced, is a rapid increase in diameter of the apical meristem and, 5-6 days after this change has taken place, the peduncle begins to elongate (Nakasone and Paull,1998). It continues to elongate as the inflorescence develops. There are 100-200 flowers per inflorescence, and at anthesis one to several flowers open each day, beginning at the base of the inflorescence, over a period of 3-4 weeks . Pineapple flowers are usually self-sterile and seeds rarely form in the fruit.

### 2.2.5 Fruit

The pineapple fruit is a sorosis. It is a fusion of many individual fleshy fruit lets. Each individual fruit let develops from a flower with male and female parts. The blossoms appear in a spiral from the bottom to the top over a period of about 15 days (Broadely *et al.*, 1993). It takes approximately 4 months from end of last often flower to fruit maturity and the total time from floral initiation to harvest take between 6 and 7 moths. Temperature significantly accelerates or delays development (Nakasone and Paull, 1998).

### 2.2.6 Crown

The crown on top of the fruit is an extension of the apical meristem. It has a short starch-filled stem with meristem and leaves, and if planted is capable of forming a complete plant.

### 2.2.7 Varieties

Some of the common varieties belong to the 'Queen' group 'charlotte' 'Rothschild', 'Red and Yellow Mauritius' represent the Spanish type. 'Kew' and 'Giant Kew' represent the 'Cayenne' type (Sing, 1990).

#### 2.2.7.1 Kew

Smooth leaves and large fruits having broad and shallow eyes. (Rupasinghe,1996). Ripe fruit is yellow. Fruit shape is cylindrical and the flesh is firm, juice and pale yellow in colour. Mostly used in the processing industry.

#### 2.2.7.2 Mauritius

Spines can be seen along the margins of leaves (Rupasinghe,1996). The crown is large in size. It is mid season variety ripening in July-August. The fruits are medium in size (2-3Kg) and may be Yellow and Red skinned with flesh of the same colour. This variety has sweet taste, less juice, crisp texture, distinct flavour and excellent aroma. These fruits are well suited for fresh table variety.

## 2.3 Geography and Climate

Major areas of commercial cultivation are found between 30° N and S latitudes (Nakasone and Paull, 1998). Minor plantings extend pineapple production to sub tropical areas with mild climates beyond 30° N and S latitudes and even under protective shelters. Pineapple cultivars show considerable variation in their plant grow and fruit size when grow in different environments (Nakasone and Paull,1998).

Pineapple can be grown in a wide variety of soil types, with drainage and aeration being crucial. Favourable rainfall and altitude are 200-2500mm annually, and below 1000m respectively. Temperature range between 20-32°C is suitable for growing pineapple

(Department of Agriculture,1995). Fruit weight is significantly correlated with mean irradiance from planting to harvest (Nakasone and Paull,1998). The lower fruit mass with lower irradiance is due to a lower plant mass at forcing. Fruit acidity in the month before harvest declines with solar radiation levels, with no significant effect on total soluble solids (TSS). Cloudy days reduce pineapple growth and result in smaller plants and smaller fruit, with higher acidity and lower sugar content.

Sri Lanka has a rainfall of 2000-3000mm and temperature varying between 24-32°C, therefore is suitable for pineapple cultivation throughout the country (Rupasinghe,1996). In Sri Lanka pineapple is well distributed in colombo, Gampaha, Kaluthara and Galle in low country wet zone, and Kurunegala, Moneragala and Chillaw in low country intermediate zone.

**2.4 Maturation and Maturity Indices**

Horticultural maturity is the stage of development when a plant or plant part possesses the prerequisities for utilization by consumers for a particular purpose (Kader,1992).

Maturity of pineapple is evaluated on the extent of fruit 'eye' flatness and skin yellowing (Mitra,1997). Consumers similarly judge fruit quality by skin colour and aroma. The fruit gradually changes from dark Green to light Green Yellow sometimes to a deep Orange with the onset of maturity. As it matures the pineapple fruit also becomes less angular about the eyes, and the ends of the bracts protecting the 'eyes' dry up. When at least two-three rows of eyes at the base turn Yellow pineapple may be ready for harvest. The eyes flatten as the fruit matures (Singh,1990).

The mature fruit is between 80-86% water, 10-18% sugars and 0.5-2% acids with the remainder being minerals, pigments and proteins (Broadley *et al.,* 1993). Sugars and acids are not distributed evenly throughout the fruit. For example, the bottom portion has more sugars than the top because it is composed of older, more mature fruit lets. Pineapple can be harvested between 115-130 days after flowering depending on varieties.

## 2.5 Harvesting and Postharvest Handling

Special problems with harvesting are that pineapple should not be harvested unripe since it undetermines the quality of the fruit (Singh,1990). Pickers select fruit by size, colour or both, and twist it from the stalk. Harvesting is done by cutting the fruit stalk about 3cm below its base. The cut end is dipped in 10% solution of benzoic acid in alcohol to check the attack of fungus so that the storage life is prolonged (Singh,1990).

Successful marketing depends on the proper maturity of fruits at harvest, development of uniform colour and shape of the variety (Singh,1990).fault free fruits without injury with proper wrapping of individual fruits in transport, careful handling with no drenching in rains, helps in getting more profits.

Pineapples harvested by hand are snapped from the stalk using a downward motion. The fruit should placed in field crates and while in the field, left in shaded conditions. Collection in the field and field to pack house transport using sacks or bags will cause mechanical damage and increase the level of rejection. Care should be taken to prevent fruit damage.

Storage and transportation take an important place in post harvest handling. Losses in pineapples during transport are minimal if careful handling is employed (Mitra, 1997). In long term storage the fruits are more susceptible to postharvest losses as a result of increased a handling, control of temperature and disease incidence. Fully ripe fruits were unsuitable for transporting to distant markets, and less mature fruits are selected. Immature fruits are not shipped since they do not develop good flavour, have low brix and are more prone to chilling injury. Care is taken to avoid damage to the crown leaves. The crown is the site of most of fruits initial weight loss, having stomata that appear to be open with no diurnal cycling (Mitra,1997). The rate of the water loss declines postharvest, paralleling dehydration of crown.

## 2.6 Compositional changes and Ripening process

The most marked changes in flesh composition occur in between the 3-7 weeks prior to harvest and at the half-Yellow shell colour stage (Nakasone and Paull,1998). Just prior to this stage, translucence can start to develop, and translucent development continues after harvest.

During maturation pineapples increase in weight, flesh soluble solids, and acidity. During ripening, carotinoid pigments and soluble solids of the flesh increase dramatically and the fruit attains its maximum aesthetic and eating quality (Kader,1992). During ripening, the shell of the pineapple losses chlorophyll rapidly, starting at the fruit base, in a process similar to that of degreenig citrus fruit.

Harvested fruit are still living organs. They continue to respire and loss water as if they were still attached to the parent plant, the only difference being that losses are not replaced in the postharvest environment. They therefore suffer detrimental changes after harvest. These changes include the utilization of energy reserves through respiration, changes in biochemical composition, changes in texture associated with both water loss and biochemical change and the increased ethylene production associated with the ripening of climacteric fruit (Mitra, 1997). Fruit sugars continue to increase through to senescence unless the fruit is harvested.

**2.7 Factors affecting the fruit quality**

The most important parameter for marketing pineapples or any other commodity is consistent, high product quality. The average quality of pineapple sold in Sri Lanka is generally of much poor and more variable. The reasons for the variability are several, and optimizing quality presents a change to the fresh market pineapple industry wishing to increase sales. There are various factors affecting the variability of pineapple quality.

Pineapple quality depends on the interaction of the several factors in the production line. Proper technical management is adaptable to most of the conditions of production, but the recommendations are not always applied and fruit quality is often lesser than it should be. There are numerous reasons for the above practice. Low prices resulting in reduced input buying, exporters buying fruits from small unskilled farmers without proper technical assistance, insufficient structures and organization for the postharvest, management, etc. (Martin and Hugon, 1993). One of the main reasons is the lack of knowledge of research findings. Setting up efficient trainings with specific tools in the production line, for all categories of personnel, is necessary to disseminate this technical knowledge and consequently to sustainably increase fruit quality. In addition, research must continue to increase the technical package, particularly in physiology and postharvest technology, in order to increase the self life on ripe fruits. There is also a great need for

improving the quality control system. Today, quality is one of the main market requirements for pineapple, but the world it self has different meanings. These depend on the major constraints of the point in the production line, until it reaches the market. Producing high quality pineapples requires that, at each step, everybody aware of the constraints of the others. That means there is a need for information flow and training throughout the whole production line.

It is possible to make an initial selection for quality in the field to reduce the amount of rejects taken into the pack house (Mitra, 1997). Proper training of the pickers for judging harvest maturity and for fruit handling helps to reduce wastage from harvesting unsuitable fruit and also from damaged fruit. Hygiene in the field is important, and rejected and fallen fruits should be left in the field to act as sources of inoculum for future infection, they should be removed at regular intervals.

**2.8 Pineapple Diseases**

Pineapple diseases can be divided into those with abiotic (noninfectious) etiologies and those with biotic (infectious) etiologies; they can be divided further into those that affect the plant and those that affect the fruit (Rloetz *et al.*,1994). Abiotic and biotic pineapple plant diseases are measured by the proportion of the plant population affected (incidence) and by the effect of disease on each plant (severity). Severity may range from a reduction in growth rate, as indicated by reduced plant size and fruit weight, to plant mortality. Some of the pineapple infectious diseases are follows. Major disease of the plant are mealy bug wilt, fungal heart and root rots, bacterial heart rot, butt rot, and root damage caused by nematodes. Minor diseases are white leaf spot, anthracnose, and yellow spot (Rloetz *et al.*, 1994).

Environmental disorders are usually in reaction to changing weather conditions. Some environmental disorders are sun burn, frost injury, fruit and fruit stem splitting and blackheart (endogenous brown spot or internal brown spot) (Rloetz *et al.*, 1994).

Management induced disorders are possible to avoid or overcome if growers are aware of the potential for those problems and adjust their management accordingly (Broadley *et al.*, 1993).

## 2.9 World trade in Pineapple

Pineapples are utilized world wide as fresh fruit and processed products. Those that are grown for processing and fresh fruit export are produced on large plantations to assure a constant and predictable supply (Rupasinghe,1996). Fruit for local consumption is typically produced on small farms and marketed by the farmers.

India, Thailand, China, Vietnam, and Philippines are the major suppliers of pineapple to world market (Rupasinghe,1996). Nearly 60% of the world requirements are supplied from above Asian countries. Also 14% from Central America and 13% from South American countries. Kenya is the major African supplier to the world market.

## 2.10 Uses and Importance

(1) Fruits are relished as dessert fruit in the form of slices fresh and as canned form.
(2) Pineapple juice, squash, jam and mixed jam is very popular.
(3) From fruit core, candy is prepared.
(4) Leaves yield silky fibre which is used for making a fine fabric popularly known as pina cloth in Philippines and Taiwan. The fibre is also used for cordage.
(5) The other products like Oxalic acid, gum and pineapple flavour are also obtained.
(6) Fruits can also be used for making alcohol and vinegar.
(7) The pineapple plant and fruit initiates industries like livestock feed, enzymes, horticultural and herbals.

Table 1: Nutritional value of pineapple in 100g of flesh.

| | |
|---|---|
| Water | 87.8g |
| Energy | 46kcal |
| Protein | 0.4g |
| Fat | 0.1g |
| Carbohydrate | 10.8g |
| Calcium | 20mg |
| Phosphorus | 9mg |
| Iron | 1.2mg |
| Vitamin C | 39mg |

Source: Hand book on Pineapple, Department of Agriculture, 1995.

# CHAPTER 3
# Material and Methods

## 3.1 Experiment (1) - Survey on harvesting and handling practices of pineapples in Gampaha district.

A survey was conducted to record quality of pineapple in Gampaha district. Twenty five farmers were selected for the survey. The list of commercial pineapple growers was obtained from the District Assistant Director Agriculture's office. Twenty five farmers were randomly selected from the list and those farmers were personally interviewed to do the survey. Each farm was visited when pineapple were harvesting to observe the handling practices. Considered farmer practices were,

(1) Stage of maturity at harvest.
(2) Method of harvesting.
(3) Method of ripening.
(4) Method of transport.
(5) Special handling practices.

The questionnaire was designed to gather information on farmer practices of pineapple harvesting and handling techniques used from pre-harvest period to the point of first sale. Open-ended questions were designed to ensure the collection of detailed information on the techniques use, the skill and level of training of the personnel involved. Data were collected by using a questionnaire (Appendix-1).

## 3.2 Experiment (2)- Quality comparison between market samples and standard practiced samples.

Quality comparison was done between market sample and standard practiced sample. For the quality evaluation purpose 7 commercial farmers were selected from above survey. Standard practices were done according to the recommendations of Department of Agriculture. Fruits were harvested from the farms by following department of Agriculture recommendations. Then fruits were harvested from the farms based on their common practice.

Quality was analyzed by using following parameters.

(1) Total soluble solids (TSS).
(2) Titratable acidity (TA).
(3) pH
(4) Sensory evaluation.
(5) Disease incidence.
(6) Visual quality rating (VQR).

### 3.2.1 Total soluble solids (TSS).

The fruits were peeled and pressed juice from the middle 1/3 of the fruit was used in determining the TSS. A few drops of the juice were used to record the °Brix value using a calibrated hand held refractometer. The refractometer reading was expressed as °Brix.

### 3.2.2 Titratable Acidity (TA).

The fruits were peeled and the middle 1/3 of the fruit was cut into cubes without core. Twenty grams of cubes were weighted and pressed juice from them. 5.00ml of juice was pippeted into a conical flask and 20.00ml of distilled water was added and titrated with 0.1N NaOH in the presence of an indicator Phenolphthalein. The end point was taken slight pink colour. Percentage Titratable acidity were calculated as follows.

$$TA\% = V * N * 0.06404 * 100 / W$$

V= Volume of 0.1N NaOH solution require to neutralize whole sample.
N= Normality of NaOH.
W= Weight of the sample.

### 3.2.3 pH

The fruits were peeled and pressed juice from the middle 1/3 of the fruit was used in determining the pH using pH meter at room temperature (30°C). Firstly the pH meter reading was brought to 7.00 by using pH buffer.

### 3.2.4 Sensory Evaluation

A consumer preference test was carried out to evaluate the quality of pineapple. Sensory properties flesh colour, sweetness, sourness, mouth feel and overall acceptability were investigated using 10cm Hedonic Scale (Appendix-2). Samples were given to a trained taste panel which consisted of 10 members at Gannoruwa Food Research Unit.

The panelists were requested to make a vertical line across the horizontal line at the point that reflects his/her perception of the magnitude of the properties assessed.

After the panelists had completed their judgments the scores were tabulated by measuring the length from the left and to the vertical line made by the panelists.

### 3.2.5 Disease Incidence

Disease incidence was scored using a scale of 0-4: 0= No disease and 4= more than 30% disease.

0 = No disease.
1 = 1-10% disease.
2 = 11-20% disease.
3 = 21-30% disease.
4 = More than 30% disease.

Harvested pineapples were carefully observed and scored according to the above scale.

### 3.2.6 Visual Quality Rating

Visual quality rating was rated on a scale of 1-9. Harvested pineapples were carefully observed and scored according to the scale given below.

1 = None edible, for most discolouration and shriveling (limit of edible).
2 = Slight edible, up to 30% of surface affected.
3 = Moderately edible, up to 20% of surface affected.

4 = Severe, more than 10% of surface affected.

5 = Fair defects, moderate defects.

6 = Little, more fair, slight defects.

7 = Good, slight defects.

8 = Better, slight defects.

9 = Excellent.

Quality parameters were compared between two samples using T test and mean comparison.

# CHAPTER 4

# Results and Discussion

## 4.1 Experiment (1)- Survey on harvesting and handling practices of pineapples in Gampaha district.

### 4.1.1 Stage of maturity at harvest.

Correct stage of maturity at harvest recommended by Department of Agriculture was 25-30% yellow of shell colour. The recommendation given by the Department of Agriculture was not followed by the farmers. The harvested fruits were at the 100% green stage of maturity when harvested by 100% of the surveyed farmers. There were various reasons for adopting the method.

Some of the growers included in the survey supplied some of their produce to export market. The time taken to reach the export market was about 10-12 days by sea. The fruit should be 100% yellow in colour when presented to the ultimate market. If the fruits are harvested at 25-30% yellow stage they will be over ripe at the market. However, the Department of Agriculture recommendation is to harvest pineapple at 10% yellow stage for the export market. Another reason is if the fruits are harvested at recommended stage of maturity they need more care during transport to avoid physical damages. Ripe fruits are less firm and more susceptible to damages during transport. Not only the physical damages they will also get other pineapple diseases. In addition, if the fruits remained until the 20-30% yellow stage without harvesting, extra attention should be needed to protect them from birds. This requires an extra labour cost which increases the cost of production which results in less profit to the growers. All of above reasons can avoid by using proper crop management and postharvest handling practices. But the recommendations are not always applied and fruit quality is often lesser than it should be.

Pineapple is a non-climacteric fruit. As a non-climacteric fruit, obvious compositional changes after harvest are mostly limited to degreening and a decrease in acidity (Kader,1992). Therefore after harvesting there is no quality improvement of this fruit. Harvesting at correct stage of maturity is vitally important. However, farmers' perception of maturity is based on the external colour. But this quality index depends on the type of fruit, cultivar, fruit size and weather conditions (Amankawa,1993). One of the main reasons is the lack of knowledge on research information. Farmers always expect only their profit but not the quality of fruits. Fruits of top quality and adequate maturity at harvest have a longer shelf life than less mature ones, thus allowing more time for transportation, storage and

marketing. Such fruits satisfy importers, brokers, and consumers because of increased and repeated sales and profits and subsequent market expansion (Mc Gregor,1989). Consumers have shown a willingness to pay more for foods that are perceived as fresher, of high quality, or greater value. Meeting this demand, while maintaining adequate distribution time has necessitated new technologies designed to extend shelf life without sacrificing quality. Quality of pineapple fruits after harvest can be maintained but can not be improved (Amankawa, 1993).

### 4.1.2 Method of harvesting

Harvesting was done by 100% of the farmers using pineapple picking knife. Harvested fruits were collected in heaps at the field or they were placed directly onto transport vehicles. Recommendations given by the Department of Agriculture were cutting the fruit stalk about 4"-6" below its base with the crown and it should done in the morning session of the day. In this case recommendations given by the Department of Agriculture were followed by almost all the farmers. However, occasionally some farmers sometimes do not use sharp picking knives. This practice results in mechanical damages during harvesting. Further this leads to secondary infection of fungal attacks they each consume. Fruit bruising was a major problem during harvesting.

Pineapple harvested by hand are snapped from the stalk using a downward motion. The fruits should be placed in field crates and while in the field, left in shaded conditions. Fault- free fruits without injury helps in getting more profits (Singh, 1990).

### 4.1.3 Method of ripening

Artificial ripening is not adopted by surveyed farmers. The reason was they want to keep harvested fruits as long as possible. Ethephon was recommended by Department of Agriculture to get uniform colour to the fruit.

Controlled ripening of fruit with ethephon prior to harvest can further reduce the number of harvesting process (Nakasone and Paull, 1998). Ethephon is applied 48 hours or more before harvest to accelerate shell degreening. This accelerated shell degreening is due to destruction of chlorophyll. The application should occur when natural colouring has started to ensure good fruit quality and is sometimes less effective in hot weather.

### 4.1.4 Method of transport

Recommendations given by the Department of Agriculture are as follows. Mature fruits are suitable to transport. When transporting bottom and the sides of the vehicle should be covered with a layer of cushion lining to prevent mechanical damages. Fruits should be packed as to contact crown to crown.

Above instructions were not followed by the surveyed farmers. Harvested fruits were over loaded into uncovered vehicles and transported. Containers were not used by the farmers and due to high depth of loading compression damage can be occur. This practice results in mechanical damages during transport and further these damages serve as entry points for microorganisms. These results in high transport loss. Farmers were not concerned by the need for ventilation of produce during transport. Some farmers did not cover their fruit loads during transport to avoid exposure to sun. Although inefficiencies in the transport operation would result in substantial quality deterioration and quantitative loss of fruit.

Fully ripe fruits are unsuitable for transporting to near by markets, and less mature fruits are selected for distant markets (Mitra, 1997). Immature fruits are not shipped since they do not develop good flavour, have low °Brix and are more prone to chilling injury. Care is taken to avoid mechanical damage to the crown leaves and mechanical injury to the fruit shell (Nakasone and Paull, 1998).

### 4.1.5 Special handling practices

No farmer used special handling practices after or before harvest. The only intention of the farmers to supply the fruits to the exporters. This results in reduction in quality and the shelf life of the fruits. Although there are improved handling available to maintain the quality of pineapple growers do not adopt them mainly due to additional cost involve. Regarding postharvest handling the survey revealed that the point at which farmers considered the fruit was ready for harvest depended on its ultimate destination. The mode of freighting to external markets determines the time of harvesting. Postharvest treatment and management was not practiced on almost all farms.

It is necessary to confirm the results obtained in the Gampaha district which has large holdings of pineapple cultivation. This approach was adopted in an analysis of

postharvest handling system of pineapple in which fruit is highly perishable and susceptible to injury, resulting in substantial postharvest losses. Such an approach is viewed as having excellent potential in both domestic and export markets, but a major challenge in the reduction of loss and the retention of quality must be overcome if this potential is to be realized. This survey was therefore undertaken to assess the current handling system for pineapples in Gampaha district as a means of identifying weaknesses that may be addressed. This survey has pointed numerous deficiencies in the postharvest handling of pineapple in Gampaha district. However, the deficiencies have not translated into very large quantifiable postharvest losses.

## 4.2 Experiment (2)- Quality comparison between market samples and fruits harvested following recommendations.

The result of the quality comparison of variable Total soluble solids, Titratable acidity and pH between market sample and standard practiced sample are given in table 2.

Table 2: The mean Total soluble solids, Titratable acidity and pH of pineapple collected following farmer practice and recommended practice.

| Sample | Total soluble solids % | Titratable acidity % | pH |
|---|---|---|---|
| Farmer practiced | 14.73 | 0.27 | 3.33 |
| Recommended practiced | 17.32 | 0.27 | 3.06 |
| P | 0.0037 | 0.9456 | 0.5284 |

Each data point represents mean of 20 samples.

### 4.2.1 Total soluble solids (TSS)

A significantly higher TSS was observed in pineapple harvested at recommended stage of harvesting (Table2). Very low level of TSS of pineapple harvested at farmer practice which leads inferior quality at market ($P<0.05$).

Total soluble solids (°Brix values) gradually increases with a more rapid increase in the last 6 weeks, as the fruit reached full ripe stage (Lodh *et al* .,1972). Fruit sugars continued to increase through to senescence, unless the fruit is harvested . starch is not accumulated in the fruit and this could explain the absence of drametic changes in total soluble solids. The major sugars are available in pineapple are sucrose, glucose and fructose (Paull, 1993).

Pineapple is not capable of having significant changes after harvest, hence must be allowed to remain on the plant until they have attained satisfactory eating quality (Snowon, 1990). Therefore stage of maturity at harvest is very important. The stage of maturity at harvest dependent on the required storage or shelf-life and the method of transportation to export markets. Maturity is judged by the level of yellow colouration of the 'eyes' of the fruit. Sugar content is not always related to the colour stage as agronomic and production factors will affect sugar development. For the export market where sea shipment for seven to fourteen days is used. Therefore, fruits should be harvested at 10% yellow stage and the fruits are transported at 12°C.

### 4.2.2 Titratable acidity (TA)

Table 2 shows there was no significant difference of TA between farmer practices and recommended practices ($P > 0.05$).

The fruit has two major non volatile organic acids: Citric and Malic (paull, 1993). Citric acid increased smoothly, with fruit development peaking before malate and before full ripeness. Fruit Malic acid levels do not change after harvest or during and after storage. Unstored fruit Citric acid does not change. Titratable acidity declines with a more rapid increase in the last 6 weeks, as fruit approaches the full-ripe stage (Nakasone and Paull, 1998). After the full ripe stage of the fruit there is no change in the acidity level. Because at this stage formation of major non volatile organic acids is completed. Farmers also harvested their fruits after the full ripe stage. Therefore, no difference was seen between acidity of two samples.

### 4.2.3 pH

According to the table 2 significantly different pH was not observed in pineapple harvested recommended stage of harvesting to that of harvested using farmer practices ($P > 0.05$).

Juice pH declines as the fruit approached full ripe stage (Paull,1993). pH then increases during fruit senescence. Titratable acidity and pH showed a similar changing pattern within the fruit. Therefore, after the full ripe stage of the fruit juice pH remains reasonably constant. Then no difference was seen between pH of two samples.

### 4.2.4 Sensory evaluation

Table 3: The average percentage Flesh colour, Sweetness, Sourness, Mouth feel and Overall acceptability 0f pineapple harvested using recommended practices and farmer practices.

| Sample | Flesh colour | Sweetness | Sourness | Mouth Feel | Overall Acceptability |
|---|---|---|---|---|---|
| Farmer practiced | 71.30 | 64.8 | 46.50 | 49.30 | 69.40 |
| Recommended practiced | 86.30 | 77.80 | 36.70 | 69.30 | 79.80 |
| P | 0.0001 | 0.0004 | 0.0194 | 0.0001 | 0.0004 |

A significantly higher flesh colour was observed in pineapple harvested at recommended stage of harvesting (Table 3). Low level of flesh colour of pineapple harvested at farmer practice which leads inferior quality at market ($P < 0.05$). Flesh carotenoids increase during the final 10 days before the full ripe stage (Paull, 1993). The reason for significantly higher level of flesh colour in pineapple harvested using recommended practice therefore may due to sufficient time remain in the plant to complete carotenoid synthesis.

Significantly higher sweetness was observed in Pineapple harvested at recommended stage of harvesting and also low level of sweetness was observed in pineapple harvested at farmer practice (Table 3). Sweetness is mainly due to sugars such as Sucrose, Glucose and Fructose (Gawler,1962). The percentage soluble solid is virtually all sugar. Eating quality is highly corrected to percentage soluble solids. Sugar is synthesized in the leaves from photosynthesis, translocated and concentrated in the fruit during the last few weeks of development on the plant. Fruit sugars continued to increase up to senescence, unless the fruit is harvested. Sugars can show a difference of 4g in 100ml from the more

mature. This is the reason for significantly higher level of sweetness in pineapple harvested using recommended practices ($P < 0.05$).

Also significantly lower sourness was observed in pineapple harvested at recommended stage of harvesting and significantly higher sourness was observed in pineapple harvested at farmer practice (Table 3). There was no significant difference between titratable acidity of two samples. However there was a significant difference in sourness of two samples ($P < 0.05$). Sourness of the pineapple harvested at recommended stage of harvesting was low due to proper ripening before harvest.

Table 3 shows that significantly higher mouth feel in pineapple harvested at recommended stage of harvesting. Good mouth feel quality was due to proper harvesting and handling practices. Proper harvesting and handling practices help to reduce the physiological injuries and diseases which leads to inferior eating quality of pineapple at market. The fruit needs to be mature and firm (Nakasone and Paull, 1998). Fruits harvested using recommended practices have developed quality parameters within the plant before harvesting. Proper ripening results in softening of cells which may have attributed to the good mouth feeling properly. Lesser extent of ripening changes occurred in pineapple harvested at green mature stage would have caused firmer cell wall resulting poor mouth feel ($P < 0.05$).

Finally significantly higher overall acceptability was observed in pineapple harvested at recommended stage of harvesting (Table 3). Low level of overall acceptability of pineapple harvested using farmer practice and leads inferior quality at market. There was a significant difference between overall acceptability and two samples ($P < 0.05$). Using the parameters of eating quality in pineapple it is possible to understand how eating quality develops (Dull, 1970). Eating quality is highly correlated to Total soluble solids while factors such as acid or flavour are minor variables. Therefore, the eating quality develops in pineapple can be derived from how Total soluble solids develops. Fruit maturity, although a major factor in pineapple eating quality. An important amount of the variation in eating quality in the market place is due to differences in fruit maturity at harvest.

### 4.2.5 Disease incidence

No disease incidence was recorded in this study. 100% of the fruits had no disease incidence when at the stage of harvesting or latter. Therefore, there was no

significant difference between disease incidence and the two samples. Fruits used for these experiments were harvested from the field and packed in plastic crate before transporting to the laboratory. Due to single layer of packing compression damage, impact damage and vibration damage must have minimized. Reduction of mechanical damages would have been the major reason for the prevention of minimal spoilage. However, in the market relatively high spoilage is mainly due to poor transport conditions adopted by traders.

### 4.2.6 Visual quality rating

Visual quality of all observed pineapple was excellent. 100% of the observed fruits had no any defects. Therefore, there was no significant difference between visual quality rating of the two samples.

It is possible to make an initial selection for quality in the field to reduce the amount of rejects taken into the pack house (Mitra, 1997). Proper training of the pickers for judging harvest maturity and for fruit handling helps to reduce wastage from harvesting unsuitable fruit and also from damage fruit.

## 4.3 General Discussion

The most important parameter for marketing pineapples or any other commodity is consistent, high product quality. The average eating quality of pineapple sold in Sri Lanka is generally of much poor and more variable. The reasons for variability are several, and optimizing eating quality presents a challenge to the fresh market pineapple industry wishing to increase sales. However, the quality of pineapple at market is lesser than the inherent quality of the variety. This may be due to poor postharvest handling practices adopted by growers and traders. The possible reasons for poor quality are; early harvesting, poor handling during transport and postharvest diseases. The need is to select a variety that gives high yield, long storage life and more appealing flavour. Preharvest weather and fertilization can significantly influence the fresh fruit acidity and sugars as well as susceptibility to chilling injury (Paull, 1993).

The half yellow stage is regarded as ripe and at this stage Total soluble solids and Titratable acidity reach their maximum (Paull, 1993). This stage occurs while on the plant near the maximum in fruit weight. Considerable changes occur in flesh composition during storage. External colour would appear to be a reliable harvest index for selecting fruit of uniform eating quality but, over a several different harvests this is not the case. Overall percentage of soluble solids (TSS) is the best index of eating quality. Pineapple is a non-climacteric fruit (Kader, 1992). It can be seen that small differences in maturity at harvest result in large differences in eating quality and consequently to consumer satisfaction. Thus the effect of harvest maturity is much more important in the pineapple than with many fruits with which consumer is likely to be more familiar.

Postharvest losses of fresh fruit and vegetables have been estimated at 25-80%, but these estimates are recognized as being vague and incomplete (FAO, 1997). An intimate working knowledge of the steps between production and marketing is essential to make appropriate recommendations or interventions that reduce loss. It is also necessary to analyze the operation of the complete system rather than its component parts in order to identify the steps that offer the greatest opportunity for quality management. Pineapple quality depends on the interaction of several factors in the production line (Martin and Hugon, 1993). Recommendations are not always applied and fruit quality is often lesser than it should be. There are numerous reasons for that. One of the main reasons is the lack of the knowledge of research information. Many of the problems observed are derived from incorrect knowledge of existing techniques and research information. Moreover, existing

documentation is not well adopted to the efficient transfer of knowledge in a professional medium such as the pineapple production line. Training of the professionals involved is compulsory for all activities undertaken for pineapple quality improvement.

# CHAPTER 5
# Conclusion

The conducted survey revealed that numerous deficiencies in the postharvest handling of pineapple in Gampaha district. Considered farmer practices were stage of maturity at harvest, method of harvesting, method of ripening, method of transport and special handling practices for the survey. According to the results of the survey recommendations are not always applied and fruit quality is often lesser than it should be.

Quality comparison was done between pineapple collected following farmer practices and recommended practices. According to results of the quality comparison a significantly higher Total soluble solids was observed in pineapple collected following recommended practices when comparing to the pineapple collected following farmer practices. But no significant difference was observed between Titratable acidity and pH of two samples.

According to the results of the sensory evaluation significantly higher flesh colour, sweetness, mouth feel and overall acceptability were observed in pineapple collected following recommended practices when comparing to the pineapple collected following farmer practices. A significantly lower sourness was observed in pineapple collected following recommended practices than the farmer practice sample.

Based on above results the quality of 'Mauritius' pineapple available in the market can considerably be improved by adopting recommendation to harvest at correct stage of maturity and transported them carefully. If consumers are educated on their aspects through the consumer demand recommended practices have to be adopted by growers.

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# APPENDIX

## Appendix 1

Questionnaire used

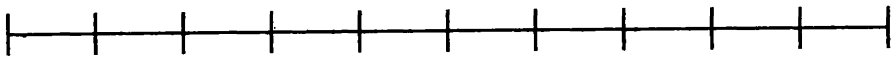
1. Name of the farmer.
2. Growing variety.
3. Harvesting stage of maturity.
4. Method of harvesting.
5. Method of ripening.
6. Method of transport.
7. Fertilizer application.
8. Special handling practices.

**Appendix 2**

Hedonic Scale used

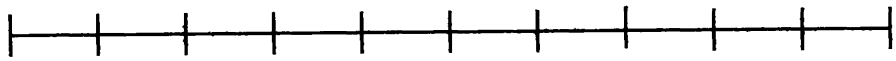
**Sensory Evaluation**

Flesh Colour



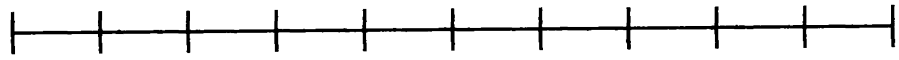
Pale Yellow

Sweetness



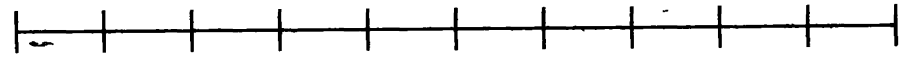
Very Low Very High

Sourness



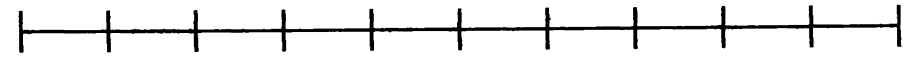
Very Low Very High

Mouth Feel



Irritating Pleasant

Overall Acceptability



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