PROJECT TITLE:

EFFECT OF LENGTH OF PEDUNCLE ON THE QUALITY OF SOLO PAPAYA FRUIT DURING RIPENING

PRESENTED BY:

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DECLARATION

I thereby declarethat this work presented to the Department of Horticulture is the outcome of my own research work and that no such work has ever been presented anywhereelse. Works by other authors, which served as sources of information have duly acknowledged by references to the authors.

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I dedicate this work to my mother Badoo Pogba-n-nyu, wife, Naah Clare, son Tingbani Bertin Balannoe and to all brothers.

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ABSTRACT

Papaya (*Carica papaya L*) is an important fruit crop for both its fresh and processed products.However it faces myriads of problems during harvesting,transportation and storage due to its high perishability. A study was carried out to compare the fruit ripening behaviours and quality of three (3) different lengths of peduncle of solo papaya fruit. Mature green fruits were harvested at random from a commercial orchard in the Atwima Akropong in the Ashanti region of Ghana. During ripening, data on various physico- chemical characteristics including fruit firmness, total soluble solids, total titratable acidity, visual peel and pulp colour, pH, sugar: acid ratio and shelf lifewere monitored in two days interval up to nine (9) days. Under ambient conditions all the fruits took seven days to ripen, however, the 2cm peduncle length fruit was more acceptable, colour change and pH, which indicates its potential for extended shelf life. Lower total soluble sugar, were also observed in the 2cm peduncle fruit for the study period which can be advantaged for extended storage which included the 1 cmlength and for sugar conscious consumers.The study also provided an understanding of the potential of the different peduncle lengths for the domestic and export markets for papaya fruits as it was discovered that both the 2cm and 1cm peduncle lengths offered better shelf life than the 0.5cm peduncle length. The study showedthat fruit meant for distant markets should be harvested with 2cm or 1cm peduncle length because they will give longer shelf life than the 0.5 cm peduncle fruit.

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INTRODUCTION

BACKGROUND

Papaya (*Carica papaya L.*),a delicious fruit, belong to the family Caricaceae. Papaya is sometimes referred to as pawpaw or papaw. It is native to tropical America, but it is grown in almost all tropical and subtropical regions of the world.

Papaya fruit is valued for its high nutritive and medicinal value. It is grown primarily for the fresh market and processed food industry, but is also used for industrial applications. The plants and fruits contain latex with the enzyme 'papain' which is used asa 'tenderizer' in the meat industry and as an ingredient in the cosmetic and medicinal industry.

The most common use of papaya is fresh inwhole pieces, in slices or in chunks and in fruit compotes. Papaya is also increasingly used to prepare juices, sauces and other products.

The world production of papaya for 2002, 2003, 2004, 2005, 2006 and 2007 were 6614, 6892, 6699, 6362, 6923, and 6937 respectively (Ghana Statistical Service, 2004). In 2008, the world production of papaya (*Carica papaya* L.) was estimated to be approximately9.1 million tonnes (FAOSTAT, 2008). The total world trade in papaya was estimated to be €162 million, representing 263 thousand tonnes in 2006. Papaya production is forecasted to show the strongest growth in output of the four major fruits which are plantain, pineapple and mango. Output is expected to reach 12.4 million tonnes.

In many countries papaya is grown for both local and foreign markets. The local markets prefer medium- and large-fruited varieties that haveyellow and red flesh. Exported papaya fruit are usually small or of medium size (Codex, 2005), with yellow or red flesh (Picha, 2006; Pesante, 2003), such as solo.

The business of growing vegetables and fruits has been shown to be an important part of agriculture and have important place in supplying needed food to the human beings. This being so, many people continue to grow vegetable and fruits to sell to other people while many more will be engaged in auxiliary businesses that serve vegetable and fruit growers (Foyer, 1972).

Horticultural production is profitable. Farmers involved in horticultural production usually earn much higheras compared to cereal producers with per capita farm income. It has been reported to be five times higher (Lumpkin *et al.*, 2005).

Fruits and vegetable represent an important part of the world's agriculture production and forms an indispensable part of human diet in Ghana. The nutritional value which provides essential vitamins, minerals, protein, dietary fibre and calories are well documented (Anon., 1985).

Of the fruits and vegetables produced in developing countries, 30-50% never reaches the final consumer due to spoilage during harvesting, transportation, storage and processing (Nakasone and Paull, 1998). The acceptability of fruits and vegetables depends largely on how they are packaged and presented; but quality is more than packaging or anything else,Success in marketing is equally important. It is made up of a great many characteristics; some external, internal, physical or mechanical.

The first impression of quality judgment is appearance i.e. shape, size, colour, freedom of blemish and dirt. This then calls for sorting and presentation. It also makes the difference in the price people are willing to pay for the good (Samson, 1986). Of the fruits produce in Ghana papaya is one of the tastiest and healthiest (Nakasone and Paul, 1998).

Papaya is one of thefruits that can be consumed locally or exported. It also contributed significantly to the economic development of Ghana through the local and the international markets. We also get papain which is used as meat tenderizers in industries and for other medical purposes (Foyer, 1972).

Papaya is a delicate and fragile fruit that easily yield to pressures. It contains about 88.8% of water. All the parts of the plant contain latex (Samson, 1986).

Maturity at harvest, some harvesting conditions and practices coupled with time of harvest are some important factors that determine the acceptability of the papaya fruit (Samson, 1986).

Immature fruits, overripe fruits and methods of harvesting all determine the post harvesting behavoiur of the fruit. Many fruits are harvested with some length of the peduncle still attached to the fruit (Maxwell and Betty, 1984). Some of these fruits include the eggplant, squash, pumpkin, and okra. The above fruits mentionedmay not be more susceptible to bruises as compared to the papaya fruit. The peduncle is the first point of detachment of the fruit from the mother plant. Depending on how and where it is cut may both have effect on the shelf life and the ripening quality of the fruit.Again the peduncle is part of the papaya fruit in the package that occupy space. The peduncle could cause bruises on other fruits in the package on transit. This may cause quick ripening of the fruits and may shorten its shelf life and subsequently market value thereby increasing cost on export. The peduncle of the papaya can be cut at any length during harvest and could affect the postharvest characteristics quality ripening.

Horticultural production is profitable. Farmers involved in horticultural production usually earn much higher farm income as compared to cereal producers and per capita farm income has been reported to be five times higher (Lumpkin *et al*., 2005).

Ghana has great potentials to reap foreign exchange from the export of papaya and need to step up investment in this area. It has all the natural conditions that can make her become a major producer and exporter of papaya; Ghana's geographical location offers favourable climate for papaya production; abundance of sunlight and water, fertile soil and absolutely frost-free conditions (Masahudu, 2009).

Currently, Ghana is the world's fourth largest exporter of the produce to the European Union market but second to Cote d'lvoire in West Africa. Since Ghana has 3% of the 53 million euro of the EU papaya market the country can step up production for more market shares (Ghana Export Promotion Council, 2000).

The Ministry of Food and Agriculture (MoFA) is promoting selected commodities to improve their access to markets and this includes non-traditional export crops. Papaya is one of the few fruit crops that has been selected for food security and promoted over medium to long-term (MoFA, 2002).

Despite the above potentials of Ghana in papaya export, coupled with the many studies that has been conducted in order to understand the postharvest factors that influence papaya quality, information is scarce on the effect that the length of peduncle could have on the quality of the fruit during ripening. The research is therefore aimed at the effect of the length of the peduncle on the ripening quality of papaya fruit.

1.1 Main Objective

The main objective of the research is to assess the effect of the length of peduncle on the quality of the'Solo' papaya fruit during ripening.

1.2Specific Objectives

1. To determine the effect of peduncle length on some selected physical properties of 'Solo' papaya fruits

2. To determine the effect of peduncle length on some selected chemical properties of 'Solo' papaya fruit

3. To determine the shelflife of Solo papaya fruits cut to different peduncle lengths.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 ORIGIN, DISTRIBUTION AND PRODUCTION

2.1.1 Origin

Papaya(*Carica papaya L*) is native to Central America and Southern Mexico through the Andes of South America (Samson, 1986). It falls under the family *Caricaceae* with related species as *Carica stipulate, Carica pentagona* and *Carica pubescens* (Samson, 1986).

2.1.2 Distribution

The papaya spread from the point of origin to the south by the Indians, and throughout the Caribbean with Spanish exploration. The Spanish also carried it to Europe and the pacific islands. By the mid 17th century, papaya was distributed pantropically. Papaya was introduced into Hawaiian in the 1800s and Hawaii remains the only state in the USA to produce papaya commercially (Pope, 1930). A small industry developed in Florida in the first part of the 20th century but declined rapidly with the introduction of viral diseases (Maxwell *et al*., 1984).

Historically, in the 15th century, the seeds of papaya were transported to West Indies, Philippines, Africa and the Indo-Pak subcontinent before the 17th century (Reid, 1990).

2.1.3 Production

Papaya has exacting climate for vigorous growth and production. It must have warmth throughout the year and will be damaged by frost (Maxwell and Betty, 1984). Brief exposure to 0^0C is damaging and prolonged cold without overhead sprinkling will kill the plant. Papaya can tolerate moderate wind if well rooted. Cool temperatures will also alter fruit flavour(Jones *et al.*, 1939). The plant will continue to bear fruits for many years, but yield usually declines as the tree ages, and picking becomes difficult.

In commercial production, fields are usually replanted or abandoned after four to five years. Papaya makes excellent container and specimen where soil moisture and temperature can be moderate (Samson, 1986). It is cultivated in India, Peru, china, Indonesia, Venezuela, Jamaica, Brazil and many African countries (FAO, 1984).In the united state, Hawaii is the major producer and supplier of the fruit, with 2500 acres in 1989. It is also estimated that there were 350 acres of papaya grown in Dade County, Florida in 1987-1988 (Statistics of Hawaiian Agriculture, 1991).

The United States also importspapaya from foreign countries. In 1989, the United States imported 6 million pounds of fresh papaya at a CIF (cost, insurance, and freight) value of 1.1million dollars. Mexico was by far the largest supplier, with 76%of the total. Other major suppliers were the Bahamas with 9.7% and the Dominican Republic, 7.5% (Statistics of Hawaiian Agriculture, 1991).

Jamaica exports the sunrise variety, which has a deep red flesh. Export from Jamaica began in the80s, 4062 tonnes were shipped in 1995, 4704 tonnes in 1996, and 4001 tonnes were also shipped in 1998. The breakdown on export at that time was 53% of the fruit and was destined for the USA, 25% for the United Kingdom, 17% for Canada and 5% for Holland (FAO, 1999.,Chia *et al.*, 1989).

2.2.0 DESCRIPTION

2.2.1 Growth Habit

Papaya is a short-lived perennial fruit crop growing to about 9.14meters high. It is generally unbranched but will branch only when injured (Chia *et al.*, 1989). The deep purple trunk is straight and cylindrical with prominent leaf scars. Its diameter may be from 5.1-7.5 cm to cover a foot at the base (Samson, 1986).

2.2.2 Foliage

The leaves emerge directly from the upper part of the stem in a spiral on nearly horizontal petioles 30-65 cm long. The blade, deeply divided into 5-9 main segments varies from 30-60 cm in width and has prominent yellowishribs and veins. The life of a leaf is 4-6weeks. They also contain papain (Norman, 1976). Chia *et al*. (1978) reported the deeply lobed, palmate leaves are borne on long hollow petioles emerging from the stem apex. Older leaves die and fall as the tree grows.

2.2.3 Flowers

Papaya plants are dioecious or hermaphroditic with cultivars producing only female or bisexual flowers preferred in cultivation. Papayas are sometimes said to be trioecious (Norman, 1976). Female and bisexual flowers are waxy, ivory white and borne on short peduncles in leaf axils along the main stem. Each flower contains many ovaries which explain why a single flower can produce multiple fruits (Samson, 1986).

A male papaya is distinguished by the small flowers borne on long stalks while female flowers are pear-shaped when opened, and are also distinguished from bisexual flowers which are cylindrical. Bisexual flowers plants are self-pollinating, but female plants must be cross pollinated by either bisexual or male plant (Nakosone, 1986).

2.2.4 Fruits

There are two types of papayas, Hawaiian and Mexican (Chia *et al.*, 1989). The Hawaiian varieties are the papayas commonly found in supermarkets. These are pear-shaped fruits generally weighing about 0.5-2.0 kg and have yellow skin when ripe. The flesh is bright orange or pinkish, depending on the variety, with small black seeds clustered in the center. They are easier to harvest because they seldom grow taller than 3 m (Chia *et al.*, 1989).

The Mexican papayas are much larger than the Hawaiian type and may weigh up to 5 kg and more than 34 cm. The flesh may be yellow, orange or pink. The flavour is less intense than that of the Hawaiian but still is delicious and extremely enjoyable. They are easier to grow than the Hawaiian papayas (Chia *et al.*,1989).

2.2.5 Cultivars

Improvement of cultivars is directed toward high yielding, fitness for export, good texture of flesh, high sugar content, intermediate fruit size, same cavity, and uniformity and resistant to pest and diseases (Yee, 1979; Yee and Warren, 1997).

The solo variety is valued for its productivity, uniform fruit shape and size, and excellent fruit quality (Muthusamy, 2008). Solo strains are predominantly self pollinated and thus are highly inbred and uniform (Muthusamy, 2008). The solo variety was introduced into Hawaii from

Barbados in 1911 and was named solo in 1919 (Muthusamy, 2008). Thosevarieties are grown commercially in Hawaii.

The most important is the kapoho which has yellow-orange flesh and fruits that weighs 340.2 g-623.7 g, considered the ideal size for export. Kapoho is adapted to the Puna district of the island of Hawaii, where approximately 90% of the state's papaya isgrown.

The sunrise variety is pear-shaped with a slight neck. It has an average weight of 623.7 g- 737.1 g depending on the location. It has smooth skin, flesh firm, reddish-orange, and sweet with high sugar content (Muthusamy, 2008). The fruit cavity is not as deeply indented as other solo strains, making seed removal easier. The plant is precocious, maturing fruit about 9months after transplanting.

The sunset variety is small to medium-sized, pear- shaped fruit. It has orange- red skin and flesh. It is the dwarf type, very sweet and high yielding. It originated at the University of Hawaii (Morton, 1987).

The vista is also a solo variety which is medium to large fruit depending on the climate, 12.5 cm wide, up to 45 cm long. It has a yellow skin with orange to yellow flesh. It is hardy and compact producing high quality fruits (Popenoe, 1974). It needs fairly hot weather to develop sweetness (Morton and Julia, 1987). It originated from vista hence the name vista solo.

Waimanalo is another solo variety with round fruit, short neck and an average weight of 454 g-1.11 kg. It also has a smooth skin,glossy with star shaped cavity (Maxwell*et al.*, 1984). It is firm, thick flesh, orange-yellow in colour, flavour and high quality fruits that can keep well(Samson, 1984). It is recommended for fresh market and processing. Average height is 1m 10 cm to first flower and fruit of female plants are slightly rough in appearance (Popenoe, 1974).

2.2.6 Uses

Carica papaya is an important fruit throughout the tropical and sub-tropical countries (Salunkhe and Desai, 1984). At the unripe stage, the fruit is consumed as a cooked vegetable in countries where papaya is widely grown (Mendoza,2007,Mano *et al*., 2009). In Thailand, unripe fruits are used as ingredients in papaya salads and cooked dishes (Sone *et al*., 1998,). In Puerto Rico, unripe fruits are canned in sugar syrup and sold either in local markets or exported (Morton, 1987). Unripe fruits must be cooked prior to consumption to denature the papain in the latex (Odu *et al*., 2006; Morton, 1987).

The ripe fruit is consumed fresh for desert and in fruit salad or processed. It is highly accepted worldwide and the demand for fresh papaya fruit is increasing for its high content of vitamin C and provitamin A, which has protective effect against cancer, and its low-calorie status that is recommended for low hypo caloric diets (Lobo and Cano, 1998).

In addition, papaya fruit is a good source of papain and chymopapain. Both are digestive proteolytic enzymes that digest protein and used as meat tenderizers, as digestive medicine in pharmaceutical, brewing, and tanning industries, and in manufacture of chewing gum(Nakasone and Paul, 1998).

Papaya seeds are sometimes used to adulterate whole black pepper (Morton, 1987). The leaves of papaya contain papain, a strong proteolytic enzyme. Crushed leaves may be used to tenderize meat, however, stomach troubles, purgatives effects and abortion may result from consumption of the dried papaya leaves.

Papaya puree is also prepared from fully ripe peeled fruits with the seeds removed. Papaya flesh is pulped, passed through a sieve and thermally treated. The puree is an important immediate product in the manufactureof several products such as beverages, ice cream, jam and jelly (Brekke *et al*., 1972, Ahmed *et al*., 2002).Powdered or dried papaya can be used as a meat tenderizer or as an ingredient in soup mixes (Singfield, 1998).

Papaya pomace, skins, leaves and other by-products of papaya processing may find use in animal feed application (Babu *et al*., 2003; Alobo, 2003, Ulloa, 2004).

2.2.7 Nutritional Qualities

Papaya is considered to be a rich source of provitamin and ascorbic acid (Wenkam and Miller, 1995). While the vitamin is generally associated with carotene, the yellow pigment in the papaya is not carotene but caricaxanthin (Muthukrishman and Irulappan, 1992). The composition and food value of ripe papaya fruit per 100g of edible flesh is given as 88% moisture, carbohydrates 10%, protein 0.5%, fat 0.1%, acid 0.1%, fibre 0.7%, and ash 0.6%. It also has a calorific value of 40 (Purseglove 1969).

2.3.0 CULTURAL PRACTICES

2.3.1 Location

Papayas like to be warm with both sunshine and reflected heat (Popenoe, 1974). The young plant is sensitive to full sunlight and requires filtered sun for the first year or two (Purseglove, 1969). Once established, they prefer full sun (Samson, 1986) and also like to be free from strong winds as possible. They can be planted on mounds or against the foundation of building where water can be controlled (Purseglove, 1969). Papaya grows best in warm areas below 152meterselevation. Fruit production and quality declines at high elevation. It also requires 1000-1500 mm of rainfall evenly distributed throughout the year.

2.3.2 Soil

Papaya does well in well-drained, well aerated, fertile, and preferably rich in organic matter soils with pH of 6-7. Flat land is preferred (Storey, 1972). Trees in water-logged soils die by drowning in 3-4 days (Samson, 1986). The soils need to be moist in dry weathers and dry in cold weather. Papaya does not tolerate salty water or soils (Purseglove, 1969).

2.3.3 Spacing

A spacing of 1.8 m x 1.8 m is normally followed in most of the places. Field trials conducted indicates that a spacing of 1.8 m x 1.8 m for varieties like CO. 1, CO.2 and Solo, and 2.1 m x 1.2 m (3.968 plants/ha) for Coorg Honey Dew variety was optimum for Bangalore conditions. The spacing of 1.4 m x 1.4 m or 1.6 m x 1.4 m is ideal for CV Pusa Delicious under sub-tropical conditions of Bihar. For the dwarf variety Pusa Nanha a closer spacing of 1.25 m x 1.25 m has been found satisfactory. For papain production a spacing of 1.6 m x 1.6 m was recommended based on field trials conducted in Tamil Nadu. In West Bengal under a spacing of 1.5 m x 1.5 m (4, 444 plants/ha) fruit yield of 98.7 tonnes/ha could be recorded with papaya variety Ranchi.

2.3.4 IRRIGATION

Watering is the most crucial aspect in raising papayas. Once established, the plant must be kept on to the dry side to avoid root rot. Though resistant to drought, irrigation may be required in dry months. Purseglove(1969) advises 50-70mm every 3-4 weeks.

2.3.5 FERTILIZER APPLICATION

The papaya responds to the application of an organic or granular fertilizer high in potassium twice ayear. It also requires regular application of nitrogen fertilizers but the exact rate have not been established (Purseglove, 1969). Feed monthly and adjust according to the response of the plant. Phosphate deficiency causes dark green foliage with a reddish-purple decoloration of leaf veins and stocks (Samson, 1986).

2.3.6 PRUNING

Papaya does not need to be pruned, but some growers pinch the seedlings or cut back established plants to encourage multiple trunks (Samson, 1986). Little pruning may be done to remove dead or damaged branches. Trunks of older and very tall papayas may also be cut back for rejuvenation (Samson, 1986).

2.3.7 Frost

Papaya need warmth and frost free environment. Prolong cold even if it does not freeze, may adversely affect the papaya plant and the fruit (Samson, 1986).

2.3.8 Propagation

Papaya is usually propagated by seed. Seed should be planted in sterile soil as young seedlings have a high mortality rate of damping off (Purseglove, 1969). Under ideal conditions, seeds may germinate in about two weeks but may take three to five weeks (Purseglove, 1969). Seedling usually begins flowering 9-12 months after germination (Purseglove, 1969).

2.3.9 Harvest Maturity

Papaya fruit should be harvested when the colour of the skin changes from dark green to light green and when one yellow streak begin development from the base upward. Fruits in this condition will continue to ripen normally after harvest (Akamine and Goo, 1971).

2.4.0 Harvesting

Maturity at harvest is the most important determinant of storage life and fruit quality.Papaya is harvested both manually and mechanically depending on the size and height of the tree using specialized tools, knives and by hand. When harvesting by knives, the peduncle is snapped or cut from the next to the tree –then immediately trimmed flush against the top of the fruit. The specialized implement for harvesting of fruits inaccessible by hand due to tree height, comprises of a long pole, a small circular hoop at the top, a small mesh bag attached to the hoop, and a horizontal blade above the hoop and the bag. The blade is positioned below the peduncle of the fruit and the pole moved upward, the fruit is detached from the tree and then drops gently into the mesh bag below the hoop at the top of the pole.

Papaya fruits should be harvested after colour break when some yellow shows on the fruit but before fully yellow about 9-12 months after transplanting(Reid, 2002;Alkamine and Goo, 1971).

Fruit for home consumption are harvested when half yellow. If left to ripen on the tree, the fruit is often damaged by fruit flies and birds (Cook, 1975). When the fruits are required for distant market, they are selected and wrapped in newspapers and packed in single layers in bamboo baskets putting lining materials with paddy straws or saw dust.

For local market, the fruits are stored in single layer covered with a thin layer of paddy straw. When the fruit is meant for export, they must be carefully picked and should have reached an appropriate degree of development and ripeness in accordance with criteria proper to the variety and/or commercial type and to the area in which they are grown. They must be packed in such a way to protect the produce properly. The material used inside the package must be new, clean, and of a quality such as to avoid causing any external or internal damage to the produce. They shall be packed in each container in compliance with the code of practice for packaging and transport of fresh fruits and vegetables (Wardlaw and Leonard, 1935).

Efforts have been made to objectively measure the fruit maturity and with a non destructive, physical method. Three methods have been tried and tested and have proved to be more efficient. They are, delay in light emission intensity (Forbus *et al.*, 1987, Forbus and Chan, 1989), body transmission spectroscopy at three wavelengths (Birth *et al.*, 1984) and reflectance measurement-hunter 6 value (Coney and Hayes, 1986).

2.4.1 Ripening

During their growth, papaya steadilyaccumulates starch. First, they elongate then increase in width. The increase in width continues as long as the fruit are not harvested so that they become rounded or oval(Tucker and Grierson, 1987).

Papaya is picked green and ripens under controlled, temperature, relative humidity and ventilation to prevent accumulation of carbon dioxide(which blackens the peel). Normal ripening will occur at 5^0C or higher concentration of oxygen. (McGrath and Karahadian, 1994).

Ripening of papaya is represented by a sequence of changes in the colour of the peels from green to yellow, as defined by a colorimetric scale from 1 to 7(Anon., 1980) and the texture and flavour of the pulp. These developments are linked to changes in metabolism and biochemical composition. Of the latter, the transformation of starch into sugar, and the evolution of aroma are the most noticeable. Numerous enzymesystems, which has not been all elucidated, controlled the co-ordination of the reactions involved.

In another development, Biales (1960), reported that, fruits detached from the branch with the peduncle attached ripened later than when it was removed, the peduncle and stem supply a ripening inhibitor to the fruit or the stem may act as a sink for ripening hormone produced in the fruit.

The presence of 6 cm long peduncle on avocado delayed onset of the climacteric by 2 days and also caused reduced ethylene production from all parts of the fruit (Tingwa and Young, 1975).

2.5 Pest and Diseases

The disease of papaya includesthose that are caused by virus, fungi and nematodes.

2.5.1The Papaya Ringspot Virus

This is one of the most severe papaya diseases and is often the limiting factor in papaya production throughout the world (Nakasone and Paull, 1998). It induces veins- banding mottling and yellowing spots or discoloration of leaf, water soaking streaks on the petioles, and ring spots appear on fruit or even on leaves (Nakasone and Paull, 1998). It stunts the plant and drastically reduces the size of fruits, sugar content, and taste. Some infected plants will bear fruits or production will decline. It spreads very fast and has become the limiting factor in papaya production throughout the world (Nakasone and Paull, 1998). It is mostly transmitted by aphids (Chay-Prove *et al*., 2000).

It can be controlled by selection and growing tolerant varieties, transplanting at a time when there are relatively few winged aphids are around, immediately eradicate and bury the whole infected plant once found, also practice cross protection with specific mild strains, but it often breaks down after a few months, losing its effectiveness and control aphids on the farm (Nakasone and Paull, 1998).

2.5.2 Damping-off *(Pythiumultimum).*

It is caused by fungi which live in the soil. The disease is favoured by high temperature and wet weather, wet soil, poor drainage, deep sowing, poor soil aeration, high nitrogen in the soil and sunshine shortage (Hines *et al*., 1965). Infected seedlings will wilt, fall and then die (Paull, 1998).

Damping off can be controlled by the use of virgin land or sterilize soil with steam at 32.3^{0}C for 30minutes and also protect the plastic films from rain water (Hines *et al.,* 1965). The above mentioned environmental conditions can be improved to favour seedlings and also drench the solution with 35% Etridiazole. (Hines *et al.,* 1965)

2.5.3 Phytophthora fruit rot (*Phytophthora palmivaro*)

This occurs in hot and humid seasons especially after typhoon attack. It causes root rot on young and adult plants and finally wilts or dies (Ko, 1982). Also itmay cause lesions and white mould appears on the fruit and then fruit drops.

Phytophthora fruit rot can be controlled by crop rotation, selection of well drain soils, avoid harming root or rogue and deeply bury the diseased fruits (Paull, 1998).

2.5.4 Anthracnose(*Glomerella cingulata*).

Thisdisease attacks the petioles and the fruit. Symptoms mainly appear on the mature fruit and thus shorten its shelf life (Alvarez and Nishijima, 1987). The symptoms are usually round, water soaked lesions which if enlarged, will be slightly sunken. The fungus frequently produces light orange masses of spores in central lesions (Alvarez and Nishijima, 1987).

The disease can be controlled by the treatment of harvested fruits with hot water at 49^0Cfor 20minutes, and thendips in cool water for 20minutes and then dry it. It can also be sprayed with 80% Mancozeb (Dithane M- 45) W.P. 1:400 with spreader/ sticker (Alvarez and Nishijima, 1987).

2.5.5 Rhizopus Fruit Rot(*Rhizopus stolonifer)*

The fungus invades injured fruits only. It causes soft rot and produces masses of visible black sporangia; leakage of cell fluid from the rotting will also occur (Nashijima *et al*., 1990). It can be treated by heat treatment to kill pathogens and also remove and destroy the rotting fruits in packing sheds (Nishijima, 1990).This means that care must be taken during harvesting, transporting and packing to avoid bruising or injuring the fruits

2.5.6 Root Knot Nematode *(Meloidogyne spp)*

It causes swelling or retardation of the root and stunting of the plant. It can be controlled with nematocides and also by rotation after rice crop.

2.5.7 Aphids (*Aphids spp)*

They suck young leaves which become curled and crinkled and even defoliate, especially at seedling stage. Some aphids also transmit the virus diseases (Nakasone and Paull, 1998).

2.5.8 Other Insects

Other insects include scales, thrips, beetles, leafhoppers, moths, mealy bugs, white fly, and stink bug (Hunter and Buddenhagen, 1972). These are minor insects, but may occasionally cause certain damage to papaya. These can be controlled by keeping the plantation relatively free of weeds, select the proper insecticides to control the outbreak and harvest all fruits at mature green stage, and then pick and disposed off all soft, ripen and infested fruits promptly to prevent fruit fly infestation and reproduction within the plantation (Hunter and Buddenhagen, 1972).

.2.6.0 SOME CHEMICAL AND PHYSICAL CHANGES THAT TAKES PLACE DURING QUALITY RIPENING

2.6.1 Conversion of starch into sugar

There are two main types of carbohydrates in papaya fruit, cell wall polysaccharides and soluble sugars. Best quality fruit is determined largely by sugar content (Storey, 1972). During early stage of fruit development, glucose is the main sugar. The sucrose content increases during the ripening process (Hulme, A. C., 1971).

The most striking post-harvest chemical change which occur during the post-harvest ripening of papaya is the hydrolysis of starch and the accumulation of sugar (i.e. sucrose, glucose and fructose; Loesecke (1950), Palmer (1971) which are responsible for the sweetening of the fruit as it ripens. In papaya the breakdown of starch and the synthesis of sugar are usually completed at full ripeness and continue in over-ripe and senescentfruit (Marriott *et al*., 1981).

During ripening, the sucrose content was shown to increase from 13.9+_5.0mg/g fresh weight in green fruits to 29.8+_4.0mg/g fresh weight in ripe fruits (Gomez *et al*., 2002).Chan *et al*., 1970 also confirms that sucrose is the main sugar of *Carica papaya* (80% of total soluble solids in full ripened fruit)

2.6.2 Firmness

Assessment of firmness is important in the evaluation of fruit susceptibility to physical and mechanical damage which can adversely affect the ripening quality of the fruit (Kramer, 1964). Under normal storage conditions, papaya undergoes significant textural transformation as they pass through the ripening process. The crisp, hard and green fruit turns into yellow fruit with tender and soft internal pulp at optimum ripening stage, and becomes mushy as it advances toward senescence.

Loss of pulp firmness during ripening varies with cultivars. Pulp firmness is often inversely related to ripening; implying that, as ripening progresses, pulp firmness declines (Smith *et al.*, 1989). Loss of pulp firmness or softening during ripening has been associated with two or three processes.

The first is the breakdown of starch to form sugar. The second is the breakdown of the cell wall or reduction in the middle lamella cohesion due to solubilization of pectin substances (Palmer, 1971; Smith *et al*., 1989). The third is the movement of water from the peel to the pulp during ripening due to osmosis

2.6.3 Change in total soluble solids (TSS) content

During ripening in papaya, the total soluble solids increase (Chan *et al*., 1979). In ripe papaya, sugar forms the main component of the total soluble solids (Gomez*et al*., 1979) since the amount of sugar in fruits usually increases as the fruit matures and ripens, the soluble solid content of the fruit can be a useful index of stage and quality of ripeness. To attain maximum total soluble solids in solo type papaya the yellow colour must cover 6% of the fruit surface skin (Akamine and Goo, 1971).

2.6.4Change in Total Titratable Acidity (TTA)

Usually organic acids decline during ripening as they are respired or converted to sugar (Wills *et al*., 1989). Organic acid are important in giving a desired sugar-to- acid balance which result in pleasing fruit taste during ripening. Acidity measured as titratable acidity, in the pulp tissues of papaya shows large increases during ripening or as ripening progresses (Akamine and Goo, 1971). Therefore titratable acidity could be used as an index of quality ripening during fruit ripening, titratable acidity was reported to increase up to the climacteric peak and declined afterward in papaya (Selvarag *et al*., 1982).

2.6.5 Change in pH

Pulp pH is an important post-harvest quality attribute in the assessment of fruit ripening quality. Pulp pH rapidly declines in response to increasing ripeness (Chan *et al*., 1979). Generally when fruits are harvested at matured green stage, the pulp pH is high but as ripening progresses pH drops (Chan *et al*., 1979). Thus the pulp pH could be used as an index of quality ripening.

2.6.6 Change in Peel and Pulp Colour

The colour of papaya contributes more to the assessment of quality by the consumer than any other single factor. Therefore peel and pulp colour of papaya is important post-harvest selection criteria. The colour of the fruit could give an indication of the state of deterioration, disease incidence and/or contamination. The peel colour is often the major post-harvest criterion used by researchers, growers and consumers to determine whether the fruit is ripe or unripe (Medlicott *et al*., 1992).

Colour is critical as the first assessment of the quality of papaya fruit. Consumers associate the colour of the peel with specific taste or uses and they will usually buy if the colour is suited to the required purpose or desire.

In some countries like Ghana, if the pulp colour of papaya is white, consumers feel that, the fruit is immature and if the pulp colour is orange or light yellow it indicates that the fruit is matured. Therefore, assessment of peel and pulp colour is important in the post-harvest ripening quality determination. Colour charts or colour measuring instruments are used for this purpose (Knee, 1980).

2.6.7 Shelf Life

Shelf life is simply the time period that a fruit can be expected to maintain a predetermined level of quality under specified storage conditions. Shelf life begins immediately the green-life of the fruit ends (Aked, J. 2000). Shelf life of fruit is dependent on textural firmness which is due to cell wall modification resulting in structural changes in starch and non-starch polysaccharides (Yashoda *et al*., 2006). Shelf life is directly proportional to firmness. This means that as firmness reduces shelf life also reduces. Again, fruit softening rate is a character that determines fruit shelf life and thought to be the result of cell wall degradation (Brummell and Harpster, 2001).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Location of experiment

The research was carried out at the Department of Horticulture laboratory ofthe Kwame Nkrumah University of Science and Technology, Kumasi in the Ashanti region of Ghana.

Fruits were harvested from an orchard at Atwima Akropong in the Ashanti region of Ghana and were transported to the laboratory overnight.

Kumasi features a tropical wet and dry climate with relatively constant temperature throughout the year. Kumasi has an average rainfall of around 1400 mm per year. The city features two different rainy seasons (bimodal), a long rainy season from March-July and a shorter season from September- November. In actuality, the month of March through to November is one long wet season, with a relative precipitation in August. Similarly to the rest of West Africa, Kumasi experiences the harrmattan during the low sun months. Lasting from December to February, the harrmattan is the primary source of the city is dry season.

It is located on longitude 0.15W and 2.25W, latitude 5.50N and 7.46N.

3.2 Experimental Design

The complete randomized design was used for the experiment. The research was to compare the quality of ripening of papaya fruits using different peduncle lengths. It involved the use of peduncle lengths of 0.5cm, 1cm and 2cm. the different peduncle lengths constituted the treatments. The treatments were replicated 3 times in a completely randomized design.

3.3Experimental Materials

Solo papaya fruits were harvested from an orchard located at Atwima Akropong on the outskirts of Kumasi. Fruits were harvested at the mature green stage; 120DAA.

Fifty'solo' papaya fruits were harvested randomly from the 10hectare farmland. They weretransported to the laboratory of the Department of Horticulture, KNUST in Kumasi for the study.

Fruits were sorted for size and to remove damaged fruits. The fruits were then randomly divided into three lots:

The first lot of ten fruits had the peduncle length of 2 cm long,

The second lotof ten fruits had the peduncle length of 1 cm long and

The third lot of ten fruits had the peduncle length of 0.5 cm.

3.4.Parameters Studied

The following fruit quality parameters were studied:

1. Firmness of fruit
2. Total soluble solids content
3. Total titratable acidity
4. pH
5. Sugar: acid ratio
6. Colour of fruit
7. Shelf life

3.4.1 Measurement of Firmness

Pulp firmness of papaya fruit was measured using the method recommended by AOAC, 1990.

Papaya fruit were cut longitudinally at the mid portion with a sharp knife (i.e. with both peel and pulp). The cut fruit was placed face up on a platform. The force required to penetrate the pulp tissue with the 6 mm diameter cylindrical probe penetrometer (Instron 4442 penetrometer) was measured. The value recorded for the triplicate for the various treatments represented the forces required for each pulp to yield to the tip of the probe. The values were recorded in kilograms.

3.4.2 Total soluble solids

Total soluble solids in the papaya juice were determined as follows; according to the method of Dadzie and Orchards (1992). Thirty (30) grams of the pulp tissue was blended in a kitchen blender with 90 ml distilled water and filtered using a filter paper. A single drop of the filtered juice was placed in the prism of the refractometer (Atago N-McCormick fruit Tech., brix ranges from 0-20% at 25^0C). The refractometer was pointed towards a light source and the percentage total soluble solids read. The result was expressed in percentages. The recorded value was multiplied by three; because the initial pulp sample was diluted three times with the distilled water.

3.4.3 Total titratable acidity

Total titratable acidity of the papaya fruit was measured as follows:

Thirty (30) grams of fresh pulp tissue was weighed into a kitchen blender and 90ml distilled water added. This was blended for 2 minutes and filtered using a sieving net. Twenty-five (25) ml of the filtrate was transferred into a conical flask. Twenty-five (25) ml of distilled water and

4-5 drops of phenolphthalein indicator were added. A 25 ml burette was filled with 0.1M sodium hydroxide (NaOH) and adjusts to the zero mark after eliminating the bubbles. The 0.1M NaOH was titrated with the filtrate and the indicator until the indicator just changes pink/red. The titre volume of the NaOH added was recorded.

The acidity of the juicewas expressed as percentage citric acid (g anhydrous citric acid/100ml juice, (Codex Alimentarius, 1992).

. **3.4.4 pH determination**

Thirty grams of the pulp tissue was weighed into a kitchen blender and 90ml of distilled water was added and then blended and the content was filtered using a filter paper (AOAC, 1990). The pH (Model 420A, Orion Research, and Beverly, MA) electrode was washed in distilled water and the electrode placed in the filtrate. It was allowed for 5 minutes for reading to bestabilized. The pH value of the filtrate was then recorded.

3.4.5 Sugar: Acid Ratio

Thirty grams(30g) of fresh pulp tissue was weighed into a kitchen blender. This was blended for 5 minutes and filtered using muslin cloth. Ten (10) ml of the filtered juice was pipetted into a 250 ml beaker. 50 ml of distilled water was added to the ten (10) ml juice in the 250 ml beaker and 3-4 drops of phenolphthalein indicator added. Twenty-five (25) ml burette was filled with 0.1M sodium hydroxide (NaOH) and adjusted to the zero mark after eliminating the bubbles. The 0.1 M NaOH was then titrated with the filtered juice/water and the phenolphthalein indicator until the colour changes pink. The titre volume of the NaOH added was recorded. The sugar: acid ratio was then calculated by using the formula:

Sugar: Acid = *Brix value/ percentage acid

Where percentage acid = Titre volume x acid factor x 100/ 10 ml(juice)

And citric acid factor = 0.0064 (AOAC, 1990).

3.4.6 Measurement of Colour

Fruits were classified according to peel colour by visually matching the peel colour of the fruits against a standard colour chart (AOAC, 1990).

The key to the colour determination was as follows:

G: green skin without yellow stripe

1: green skin with light yellow stripe

2: green skin with well defined yellow stripe

3: one or more orange-coloured stripe in skin

4: clearly orange-coloured skin with some light green areas

5: characteristic orange-coloured skin

6: fruit colour similar to 5 but more intense

3.4.7 Measurement of Shelf Life

Shelf life begins immediately the green-life of the fruit ends. Shelf life was assessed by regular visual inspections of the fruit. Shelf life was calculated as the period in days between the commencement of ripening and the end of saleable life or edible life on the shelf.

3.4.8 Statistical Analysis

All data were subjected to analysis of variance (Anova) using statisticastudents' edition. Differences between means were separated at 5% least significant level.

4.0 RESULTS AND DISCUSSIONS

4.1 RESULTS

4.1.1 FIRMNESS

The results of the effect of peduncle length on the firmness of solo papaya fruit during ripening(holding) has been reported in Figure 1.1

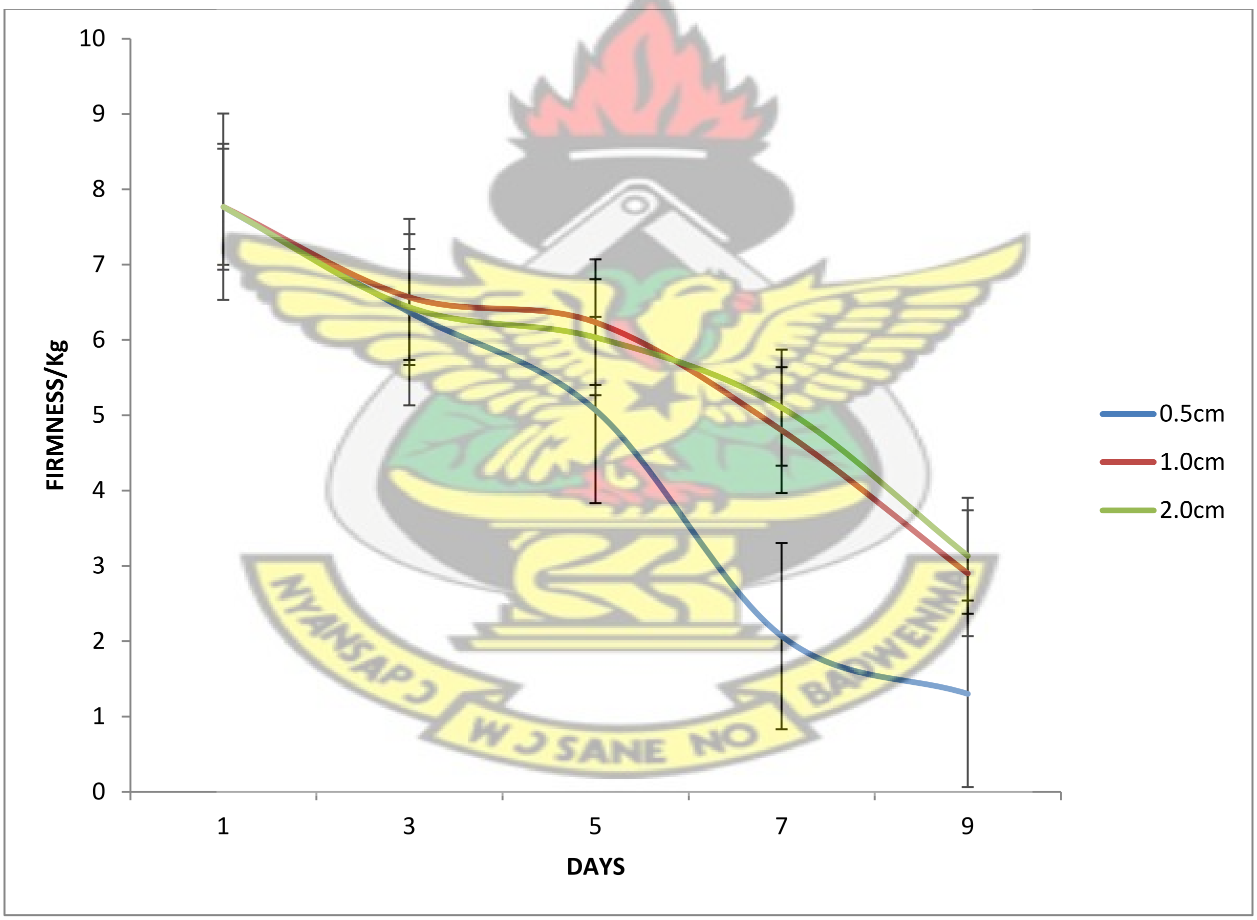

Figure 1.1: Firmness of Solo papaya fruits observed for the study period

There was generally a decrease in firmness for all the treatments during holding as shown by the days spent in holding. Up to day three after harvest no significant differences (P>0.05) were observed irrespective of the treatments. However differences were observed at day five where fruits with peduncle cut of 2 cm and 1 cm had firmer pulp than 0.5 cm cut length. Whereas cut length 2 cm and 1cm were similar in firmness (6.03 and 6.23 kg respectively) for the 0.5 cm cut length, 5.07 kg was sufficient to penetrate the fruit.

4.1.2Total Soluble Solids.

The result of the effect of length of peduncle on the total soluble solids of Solo papaya fruit during holding has been reported in Figure 1.2

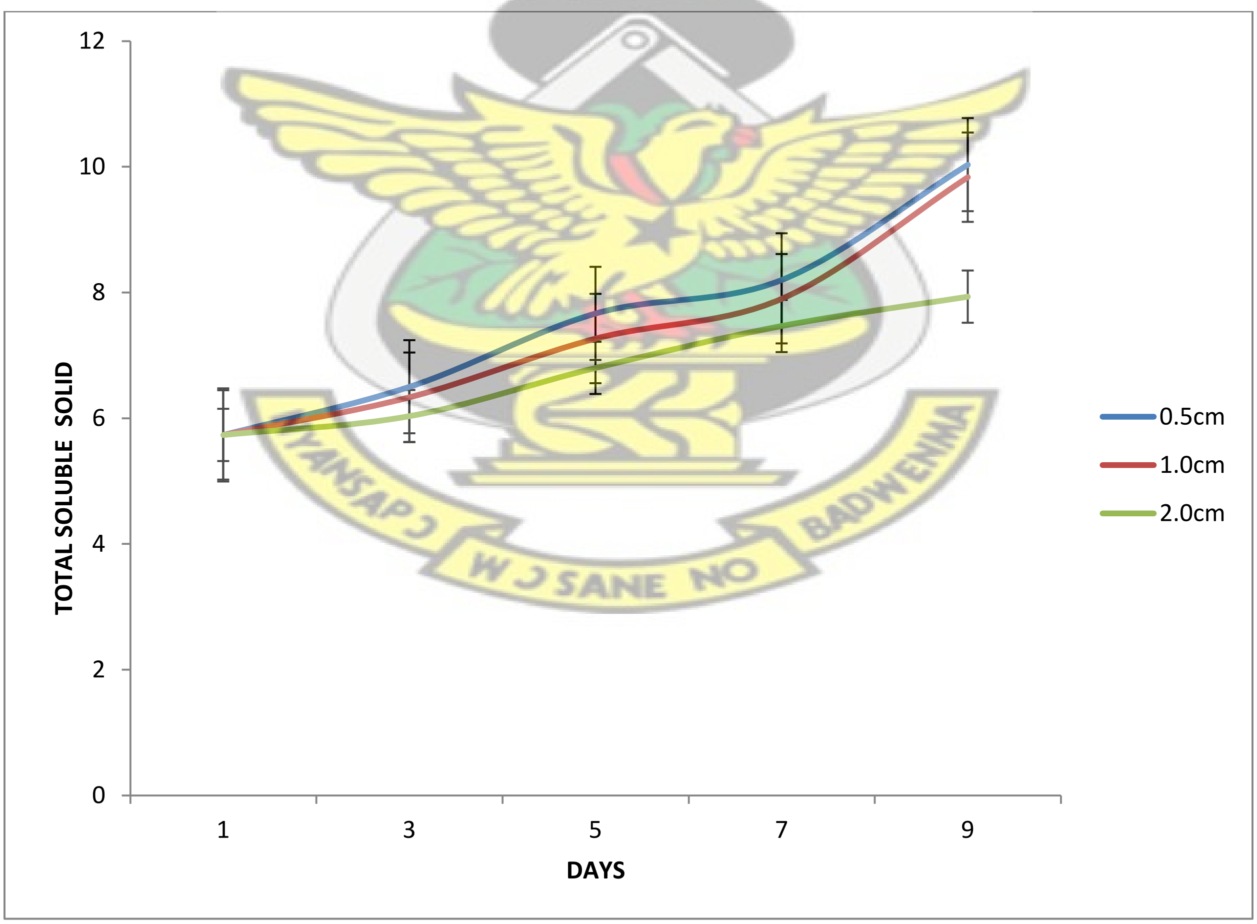

Figure 1.2: Total Soluble Solids of Solo papaya fruit observed for the study period

From Figure1.2, there was generally an increase in the total soluble solids content for all the treatments throughout the study period. However the 0.5 cm and the 1.0 cm cut peduncle lengths showed no significant differences between themselves and likewise the 1.0 cm and 2 cm cut lengths but differences existed between the 0.5 cm and the 2 cm cut peduncle lengths. All the treatments showed significant differences among themselves at day five after harvest. From then up to day nine, there was no significant difference between the 0.5 cm and the 1 cm cut peduncle lengths but both showed significant differences with the 2 cm cut length

4.1.3 Total Titratable Acidity

The result of the effect of peduncle length on the total titratable acidity of Solo papaya fruit during holding has been reported in Figure 1.3

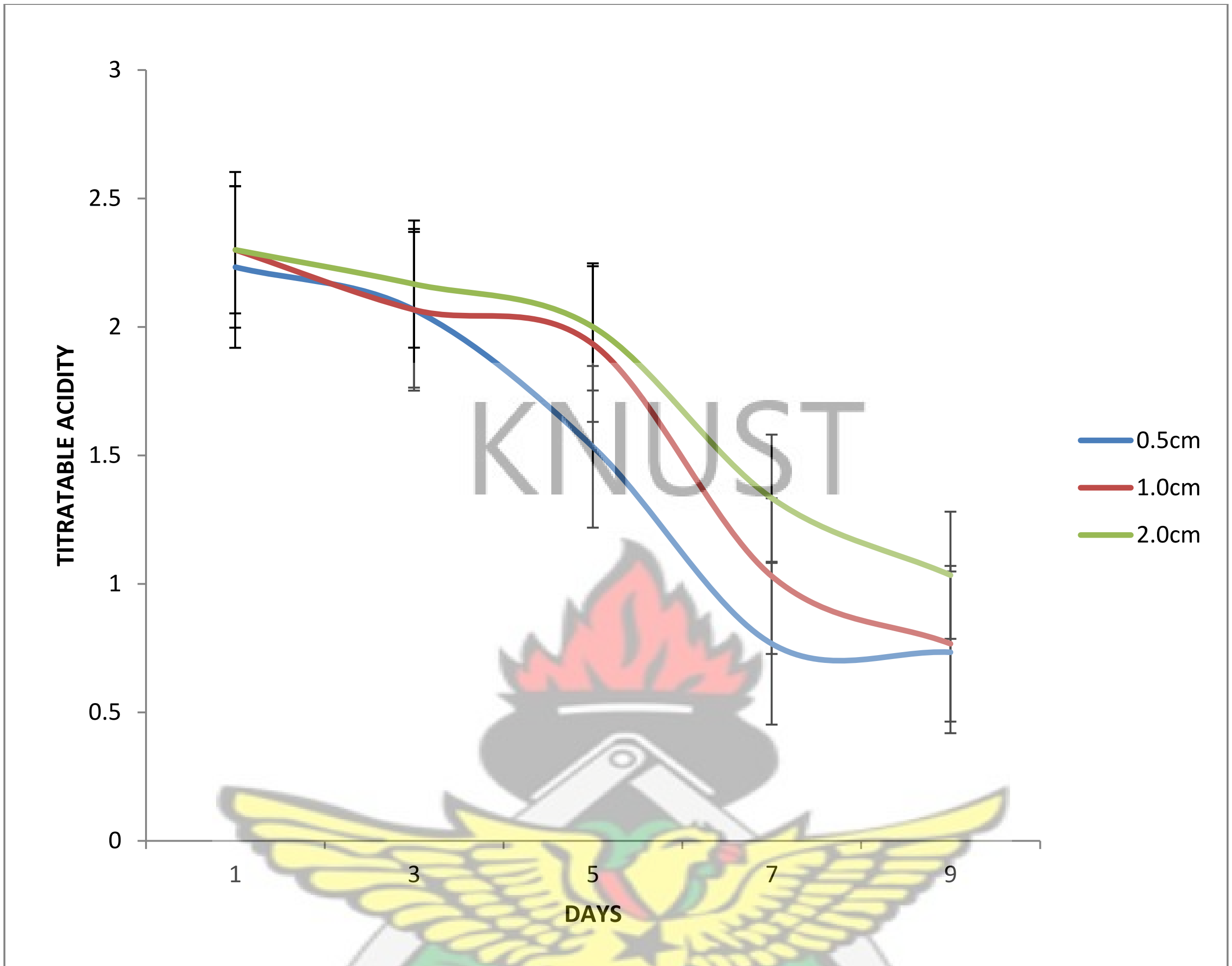

Figure 1.3: Total Titratable Acidity of Solo papaya fruit observed for the study period

From Figure 1.3, there was a decrease in the total titratable acidity as observed, no significant differences between the treatments up to day three. However, at day five after harvest, the 1cm and the 2 cm cut peduncle lengths did not show any significant differences amongst themselves but they were significantly different from the 0.5 cm cut peduncle length. On day seven after the treatments, all showed significant differences among themselves. On the ninth day there were no significant differences between the 0.5 cm cut peduncle length and the 1cm cut peduncle length but were both significantly different from the 2 cm cut length.

4.1.4 pH.

The result of the effect of peduncle length on the pH of Solo papaya fruit during holding is shown in Figure 1. 4

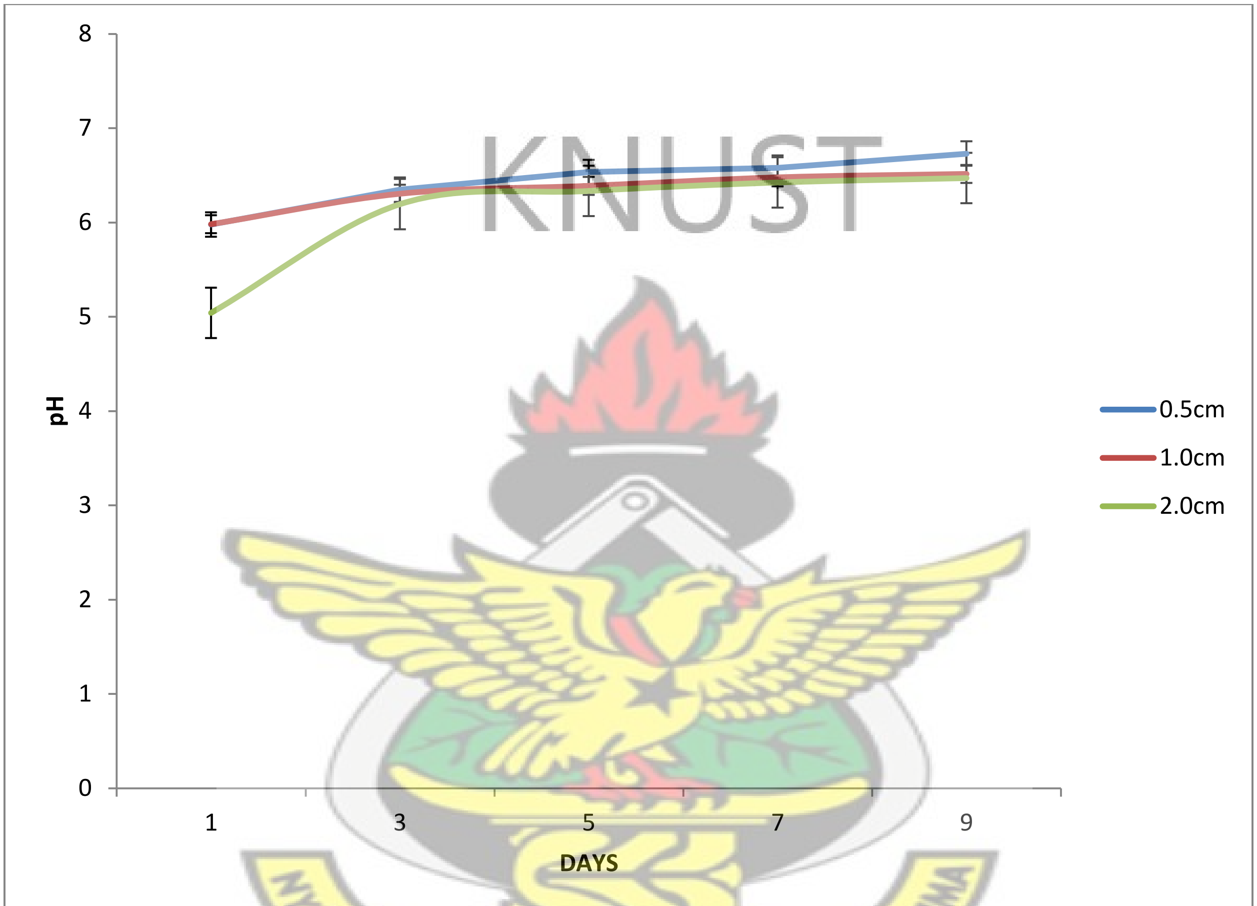

Figure 1.4: The pH of Solo papaya fruit observed for the different cut peduncle lengths of nine days

From Figure 1.4, there was generally an increase in the pH values for all the treatments. Significant differences were observed for all the days except day one.

4.1.5 Sugar: Acid Ratio.

The result of the effect of peduncle length on the sugar: acid ratio of Solo papaya fruit during holding is reported in Figure 1.5

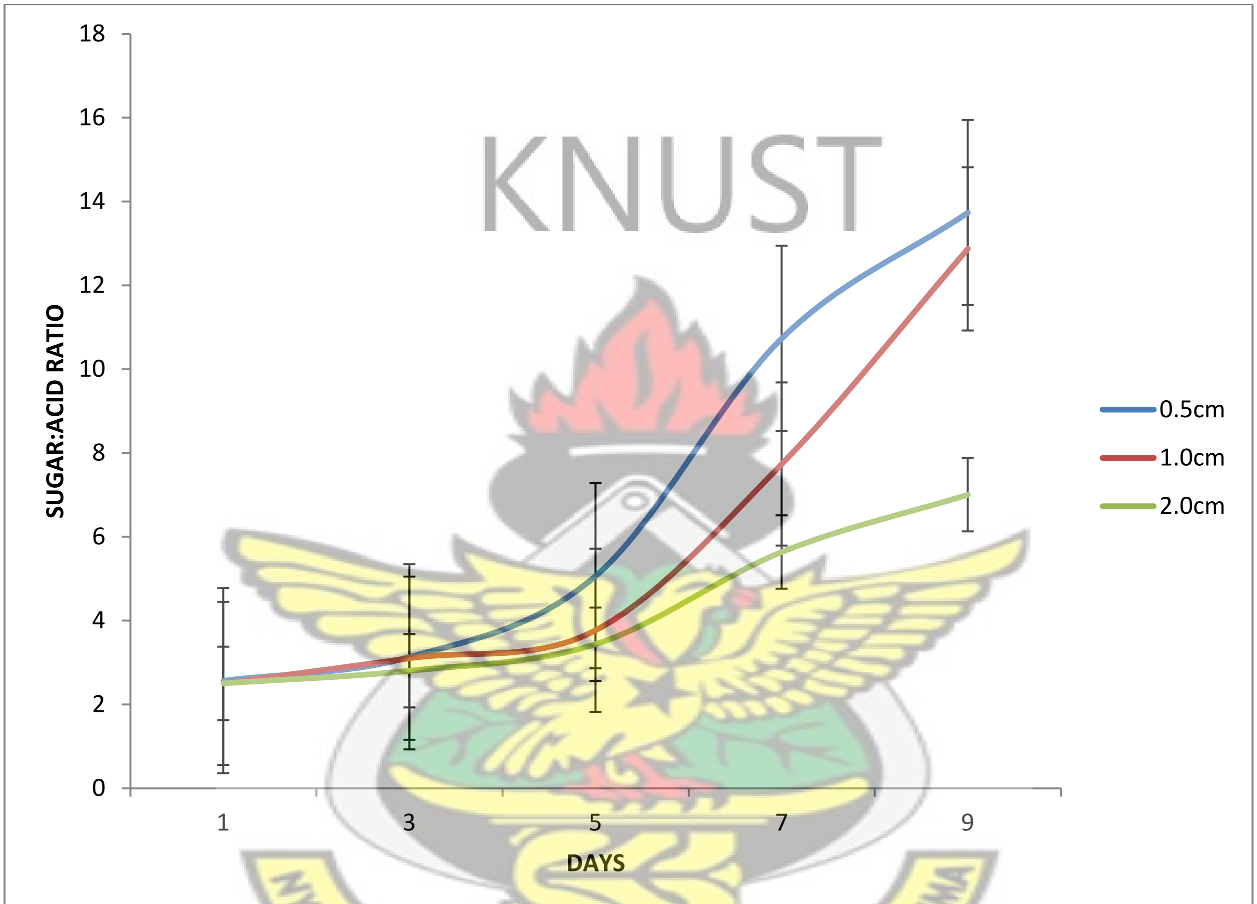

Figure1.5: Sugar: acid ratio of Solo papaya fruit observed for the nine days

From Figure 1.5, there was generally an increase in the sugar- acid ratio for the treatment during the ripening process. On the third day after the harvest, the 1.0 cm cut length did not show any difference but between the 0.5 cm and the 2 cm cut lengths, there was significant difference. It was also observed that, at day five after harvest difference between the 1 cm and the 2 cm with the 0.5 cm cut lengths was noticed. On day seven, all the cut lengths were significantly different from one another with the 2 cm cut peduncle length having the least value. On the ninth day after harvest, there was no significant difference between the 0.5 cm and the 1 cm cut lengths but there was a difference between the 0.5 cm cut length and the 2 cm cut peduncle length.

4.1.6Colour

The results of the effect of peduncle length on thecolour of Solo papaya fruit during holding is shown in Figure 1.6.

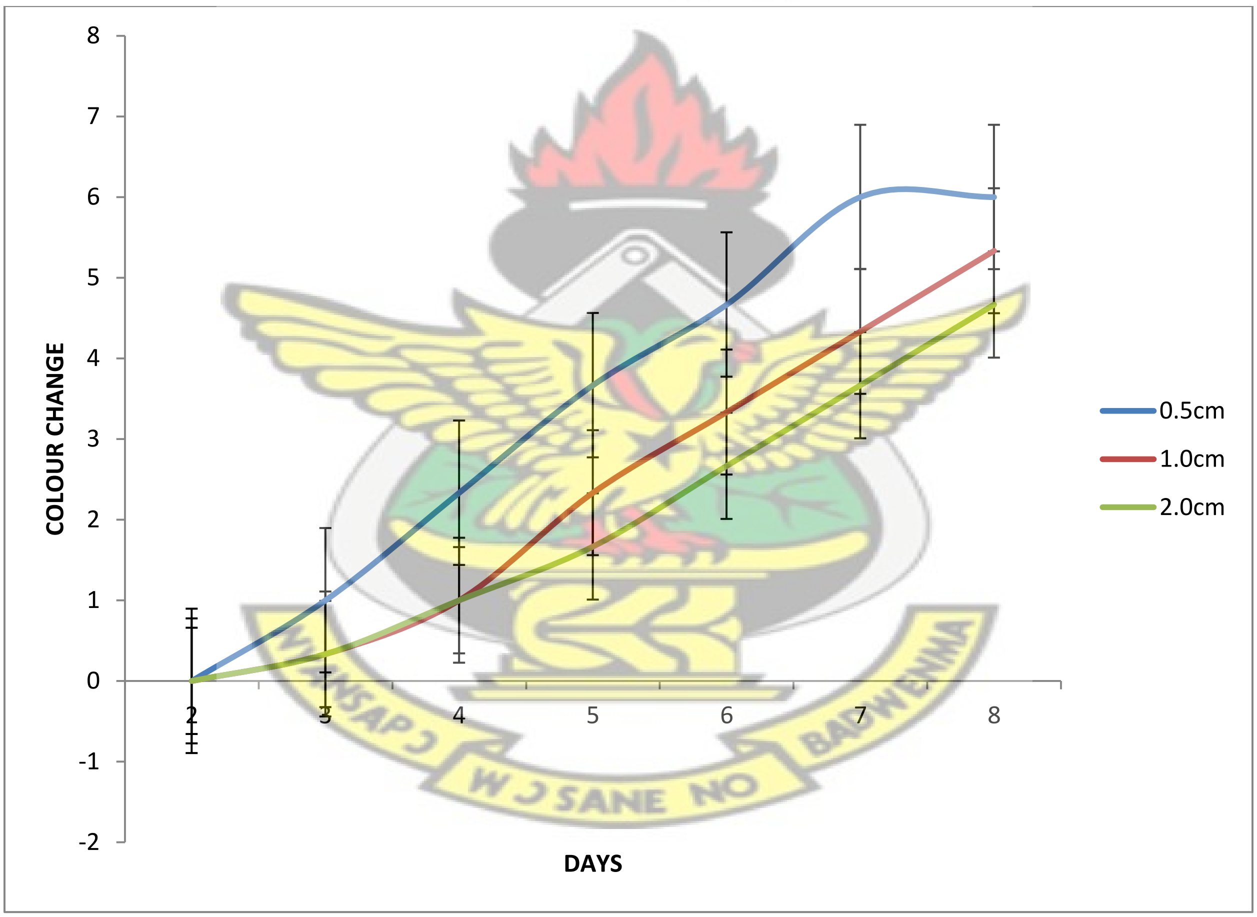

Figure1.6: Colour changes of Solo papaya fruit observed for the eight days

There was generally an increase in the ripeness from green to yellow shown by the colour change from the 2nd day to the 8th day. There was no significant difference between the 1cm and the 2cm cut lengths for the entire period of holding as far as colour development is concerned (Appendix 1). However, both the 1cm and the 2cm cut lengths showed significant differences with the 0.5cm cut length. The 0.5 cm cut length showed much more yellowing with time while the 2cm cut length showed the least colour change.

4.1.7 Shelf Life

The result of the effect of peduncle length on the Shelf life of Solo papaya fruit during holdingis shown in Table 1.7

Peduncle length	DAYS
0.5cm	7
1.0cm	9
2.0cm	12
Lsd cv(%)	1.1535 6.04

Table 1.7: Shelf life of Solo papaya fruit observed for the different peduncle lengths for nine days

Form Table1.7, it was noticed that the saleable or edible life ended for the 0.5cm peduncle fruit at day seven. On the ninth day, it was also observed that the 1cm peduncle fruit reached the end of its edible life. From further observations the 2cm cut peduncle fruit had its edible or saleable life ending on the twelve day.

4.2.0 DICUSSIONS

4.2.1 Firmness of fruits

Firmness is important in the evaluation of fruit susceptibility to physical and mechanical damage. It describes how easy fruit yield to pressures (Kramer, 1984) once a fruit is harvested it undergoes significant textural transformation as it passes through the ripening process (Kramer 1964).

From the first day of the treatments to the last day, there was a decline in the firmness of the fruits. As the fruit ripened, the firmness declined. This is supported by Smith *et al.*, (1989), who reported that pulp firmness is inversely related to ripening, that is as ripening progresses, firmness declines.

The study showed that cutting the peduncle at 0.5 cm resulted in fast softening of the Solo papaya fruit pulp during holding. On the other hand, cutting the peduncle at either 2 cm or 1 cm was found to be equally better in delaying softening during holding. This suggests that the length of the peduncle was having an effect on the ripening quality of the fruit. On day nine, the one with 0.5 cm cut peduncle length showed much ripeness and the one with 2 cm cut peduncle length showed much firmness.

4.2.2 Total Soluble Solids

During the ripening of papaya fruit, it was reported and documented by Chan *et al* (1979) that total soluble solids increases as the fruit ripens. In ripe papaya, it is also reported that sugar forms the main component of the soluble solids, Chan *et al.*(1979).

Baile, J. B., (1960), reported that fruits detached from the branch or stem with the peduncle attached ripens later than when it was removed; this may be explained by the fact that the peduncle and stem may supply a ripening inhibitor to the fruit or may act as a sink for ripening hormones produced in the fruit.

Although all the fruits continued with the hydrolysis of starch and the accumulation of sugars (sucrose, glucose and fructose), which is responsible for the sweetening of the fruit; they did so at different rates (Loesecke, 1950; Palmer 1971).

The result from the study showed that, cutting the peduncle length at 0.5 cm will hastened the accumulation of the sugars. On the other hand, cutting the peduncle lengths at 1 cm and 2 cm will delay the sugar accumulation on holding. With high temperatures and inadequate packing houses, it will be better to harvest with peduncle attached to delay the accumulation of the sugars which will eventually extend the shelf life of the papaya fruit.

Marriott, *et al,* (1981), also explained that the breakdown of starch and synthesis of sugar is usually completed at full ripeness in papaya while in plantain this breakdown is slower and less complete and continues in over- ripe and senescent fruits.

4.2.3 Total Titratable Acidity

Normally total titratable acidity declines during ripening as fruits respire and convert acidity to sugar according to Wills *et al* (1989). This assertion was proven as the fruits titratable acidity continued to decline with ripening. There was no significant difference between the treatments for the first and third days. This is also supported by Akamine and Goo (1971) who observed that acidity measured as total titratable acidity in pulp tissue of papaya fruit showed slight decline in the early days than as the ripening progresses.

On the fifth day after the treatment, there were no significant differences between those with peduncle 1 cm and 2 cm, but the 2 cm peduncle showed significant difference from the 0.5 cm peduncle. This could also be supported by the assertion made by Tingwa and Young (1975), who reported that the peduncle may supply a ripening inhibitor to the fruit that made it to show that differences.

On the seventh day after the treatment, all the treatments showed significant differences amongst themselves. The 2 cm peduncle recorded the highest mean value followed by the 1cm peduncle fruit and finally the 0.5 cm peduncle fruit. This means that the 0.5 cm peduncle fruit will ripen faster than the 1cm and then the 2 cm peduncle fruit. This is also supported by the report made by Tingwa and Young (1975) that the presence of a 6 cm long peduncle on avocado fruit delayed the onset of climacteric and caused a delay in the production of ethylene from all parts of the fruit.

This means that the length of the peduncle has an effect on the ripening quality of the solo papaya fruit on holding.

It has also been reported by Selvarag*et al* (1982) that during ripening, total titratable acidity increase to the climacteric peak and then decline afterward in papaya. This showed that the 2 cm peduncle fruit was yet to reach its climacteric peak.

4.2.4pH

The pulp pH is an important post harvest quality attribute in the assessment of ripening quality. It rapidly increased in response to increasing ripeness (Chan *et al*., 1979). From day one, the pH was high and continued to increase throughout the ripening days.

The significant differences on the fifth day can also be attributed to the differences in the length of the peduncle which inhibit the supply of the ripening hormone. This means that, on the fifth day, the 2 cm peduncle fruit was more acidic than the 1 cm peduncle fruit which was also more acidic than the 0.5 cm peduncle fruit. Hence the one with the highest pH exhibited much ripening quality and will ripen before those with the lowest pH value. In this case, the 0.5 cm peduncle fruit could ripen first (as it did), then the 1 cm peduncle fruit will follow and lastly the 2 cm peduncle fruit.

On the 7th and 9th days, there were not much significant differences between the 0.5 cm peduncle and the 1 cm peduncle but showed significance differences with the 2 cm cut peduncle fruit. Hence on the ninth day, the 0.5 cm peduncle was less acidic than the 1cm and the 2 cm peduncle fruits. Generally, it has been reported by Chan *et al* (1979), that, when fruits are harvested at matured green, the pulp pH is high but as ripening progresses it drops.

4.2.5 Sugar-Acid Ratio

The sugar-acid ratio contributes to the unique flavour of citrus. At the beginning of the ripening process the sugar-acid ratio is low, because of the low sugar content and high fruit acid content. This makes the fruit taste sour. On the first day, there was no significant difference between treatments. The mean values obtained for the treatment indicates that they were more acidic. But as ripening progressed, the fruit acids are degraded because of the hydrolysis of the starch in the fruit and the accumulation of the sugars (sucrose, glucose and fructose), Palmer, (1971) which are responsible for the sweetening.

This observation supports the claim made by Morgan and Hall in 1964, and Pratt and Goeschl in 1969, that the peduncle is supplying an auxin to the fruit and ripening is initiated only when the source of the auxin is depleted and the level in the fruit is reduced to some critical value. And as the source gets depleted, more ripening hormones are produced and the fruits tend to accumulate sugars as fruit goes on. This is what was observed in the Day 9.

On the whole, there were not much significant differences between the 1 cm cut peduncle length and the 2 cm cut peduncle length fruits on holding. Hence the 2 cm cut peduncle length could be reduced to 1 cm cut peduncle length to provide for more space and probably avoid bruises on transport.

4.2.6 COLOUR

Colour is critical as the first assessment of the quality of papaya fruits. Consumers associate the colour of the peel with specific taste or uses and will usually buy if the colour is suited to the required purpose or desire. From the time of the beginning of ripening in the fruit until full ripeness is attained, the process is continuous. The first noticeable change that was observed was the development of yellow colour in the funiculars. The colour then spread outward, full ripeness is attained when the outer surface is completely yellow(Akamine and Goo, 1971).

Visual assessment of the colour revealed higher values (yellowing) for the fruit with 0.5cm cut peduncle and was significantly different from the 1cm and 2cm cut peduncle fruits. This was followed by the 1cm peduncle fruit and finally by the 2cm peduncle fruit which is an important feature from consumers perspective. This means that the 2cm peduncle fruit had delayed ripening. This is corroborated by Biale(1960) who reported that fruit detached with peduncle attached ripens later than when it was removed.This will delay the ripening of the fruit and increase its shelf life.This also means that the 2cm cut peduncle fruit will inhibit ethylene production better than the 1 cm, and this will also show much inhibition than the 0.5cm peduncle fruit.

As the fruit ripens, the colour changes from green to yellow as was observed from the values obtained. The change in colour is as a result of chlorophyll degradation leading to the unveiling of previously present pigment. Papaya is a climacteric fruit, it will exhibit a rise in ethylene production and respiration as it ripens.Ethylene plays a very important role during ripening of fruits, such as stimulating the development of ripening attributes as colour.

.4.2.7 SHELF LIFE

In a globalized economy, the control of ripening is of strategic importance because excessive softening limits shelf life. Shelf life of fruits is dependent on textural firmness which is due to cell wall modification resulting in structural changes in starch. This cell wall modification is as a result of ethylene production and the respiration rate. Increased ethylene production and respiration rate is also the result of water deficit in the tissues (Yang and Pratt, 1978). Once the fruit is detached from the mother plant, there is bound to be water deficit as the fruit still respires.

Shelf life is directly proportional to firmness. This means that as firmness reduces shelf life also reduces. Again, fruit softening rate is a character that determines fruit shelf life and also thought to be as a result of cell wall degradation (Brummell and Harpster, 2001).

From the results obtained, lower softening in the 2cm peduncle fruit under ambient ripening conditions expresses better shelf life potential as compared to 1cm peduncle and 0.5cm peduncle fruits: and the rate of softening may be due to the breakdown of cell wall or reduction in the middle lamella cohesion due to the solubilization of pectin substances Palmer(1971). This is also be due to the rate at which ethylene is produced in the fruit and its respiration rate. Since the peduncle is a ripening inhibitor, it inhibits the production of ethylene which subsequently will reduce the respiration rate.

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusion

The research was aimed at assessing the effect of the length of peduncle on the quality of the Solo papaya fruit during ripening. The following parameters were used to assess the quality of the solo papaya fruit during ripening: firmness, total soluble sugars, total titratable acidity, pH,sugar: acid ratio, colour change and shelf life of the fruit on holding. The study revealed that cutting Solo papaya peduncle at 2 cm length peduncle fruit will offer better keeping ability than 1 cm length which will also offer a better keeping ability than the 0.5 cm length peduncle fruit. As regards colour loss, the 2 cm cut length showed more delay in colour loss.

For total soluble sugars,the 0.5 cm fruit showed a much higher value showing much sugar accumulation than the 1 cm and the 2 cm length fruits. Hence it was better to harvest with a peduncle attached than without a peduncle.

Again, pH development was much slowly in the 2 cm and the 1 cm than 0.5 cut length.

There was shelf life extension with longer lengths of peduncle. The 2 cm peduncle length offered better shelf life than the 1 cm and the 0.5 cm peduncle lengths.

From the result obtained, it can be concluded that cutting the peduncle to 2 cm length delayed ripening compared with the 0.5 cm length. Although, longer peduncle length could result in bruises and piercing, proper fruit arrangement in appropriate packing materials could reduce it. The study has shown that the cut length of the peduncle could be extended from 1 cm to 2 cm length. This would delay ripening and allow for longer transportation period as well as longer display period on shelves during sale.

5.2 Recommendations

From the study, I recommend that:

The fruit weight,length, width, volume and other simple physical parameters be looked at whether there will be changes in them.

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APPENDIX 1

TABLE 1: Firmness observed for Solo papaya fruits for nine days

Peduncle Length	DAY 1	DAY 3	DAY 5	DAY 7	DAY 9
0.5cm	7.7667a	6.3667a	5.0667a	2.0667a	1.3000a
1.0cm	7.7667a	6.4333a	6.0333b	4.8000b	2.9000b
2.0cm	7.7667a	6.5667a	6.2333b	5.1000b	3.1333b
Lsds	0.1153	0.2825	0.2307	0.4051	0.2903
cv (%)	0.74	2.19	2.00	5.08	5.94

TABLE 2: Total soluble solids of Solo papaya fruits observed for a nine-day period

Peduncle Length	DAY 1	DAY 3	DAY 5	DAY 7	DAY 9
0.5cm	5.7333a	6.5000a	7.6667a	8.2000a	10.0330a
1.0cm	5.7333a	6.3333ab	7.2667a	7.9000a	9.8333a
2.0cm	5.7333a	6.0333b	6.8000b	7.4667b	7.9333b
Lsds	0.5028	0.3940	0.2209	0.3124	0.2825
cv (%)	4.39	3.14	1.53	1.99	1.53

TABLE 3: Total titratable acid of Solo papaya fruits observed for a nine-day period

Peduncle Length	DAY 1	DAY 3	DAY 5	DAY 7	DAY 9
0.5cm	2.2333a	2.0667a	1.5333a	0.7667a	0.7333a
1.0cm	2.3000a	2.0667a	1.9333ab	1.0300b	0.7667a
2.0cm	2.3000a	2.1667a	2.0000b	1.3333c	1.0333b
Lsds	0.1332	0.1998	0.2978	0.1977	0.1153
cv (%)	2.93	4.76	8.18	9.48	6.84

TABLE 4: Changes in pH of Solo papaya fruits observed for a nine-day period on holding

Peduncle Length	DAY 1	DAY 3	DAY 5	DAY 7	DAY 9
0.5cm	5.9767a	6.3467a	6.5333a	6.5800a	6.7300a
1.0cm	5.9800a	6.3033a	6.3867b	6.4767b	6.5133b
2.0cm	5.0400a	6.1933b	6.3333c	6.4233b	6.4700b
Lsds	0.1519	0.0739	0.0516	0.0639	0.0569
cv (%)	1.27	0.59	0.40	0.49	0.43

TABLE 5: Sugar: acid ratio of Solo papaya fruits for a nine (9)-day period in storage

Peduncle Length	DAY 1	DAY 3	DAY 5	DAY 7	DAY 9
0.5cm	2.5000a	3.1333a	5.0667a	10.7330a	13.0332a
1.0cm	2.5000a	3.1000ab	3.7667b	7.7333b	12.8670a
2.0cm	2.5000a	2.8000b	3.4333b	5.6333c	7.0000b
Lsds	0.2401	0.3124	0.9371	1.3599	1.7857
cv (%)	4.77	5.19	11.47	8.47	7.62

TABLE 6: Colour changes of Solo papaya fruits observed over eight days under ambient conditions

Peduncle length	DAY 2	DAY 3	DAY 4	DAY 5	DAY 6	DAY 7	DAY 8
0.5cm	0.5667a	1.0000a	2.3333a	3.6667a	4.6667a	6.0000a	6.0000a
1.0cm	0.0000a	0.3333a	1.0000b	2.3333b	3.3333b	4.3333b	5.3333b
2.0cm	0.0000a	0.3333a	1.0000b	1.6667b	2.6667b	3.6667b	4.6667b
Lsds	0.6660	0.9418	0.6660	1.1535	1.1535	0.9418	0.9481
cv (%)	150	84.85	23.08	22.59	16.24	10.18	8.84

TABLE 7: Shelf life observed for Solo papaya fruits under ambient conditions

Peduncle length	DAYS
0.5cm	7
1.0cm	9
2.0cm	12
Lsd Cv (%)	1.1535 6.04

APPENDIX 2

Anova for Colour Day 1

Source	DF	SS	MS	F	P
Peduncle	2	0.0000	0.0000	M	M
Error	6	0.0000	0.0000		
Total	8	0.0000			

Grand Mean 0.0000 CV M

WARNING: The total sum of squares is too small to continue.

The dependent variable may be nearly constant.

Anova for Colour Day 2

Source	DF	SS	MS	F	P
Peduncle	2	0.88889	0.44444	4.00	0.0787
Error	6	0.66667	0.11111		
Total	8	1.55556			

Grand Mean 0.2222 CV 150.00

Anova for Colour Day 3

Source	DF	SS	MS	F	P
Peduncle	2	0.88889	0.44444	2.00	0.2160
Error	6	1.33333	0.22222		
Total	8	2.22222			

Grand Mean 0.5556 CV 84.85

Anova for DAY4

Source	DF	SS	MS	F	P
Peduncle	2	3.55556	1.77778	16.00	0.0039
Error	6	0.66667	0.11111		
Total	8	4.22222			

Grand Mean 1.4444 CV 23.08

Anovafor DAY5

Source	DF	SS	MS	F	P
Peduncle	2	6.22222	3.11111	9.33	0.0144
Error	6	2.00000	0.33333		
Total	8	8.22222			

Grand Mean 2.5556 CV 22.59

Anova for DAY6

Source	DF	SS	MS	F	P
Peduncle	2	6.22222	3.11111	9.33	0.0144
Error	6	2.00000	0.33333		
Total	8	8.22222			

Grand Mean 3.5556 CV 16.24

Anova for DAY7

Source	DF	SS	MS	F	P
Peduncle	2	8.6667	4.33333	19.50	0.0024
Error	6	1.3333	0.22222		
Total	8	10.0000			

Grand Mean 4.6667 CV 10.10

Anova for DAY8

Source	DF	SS	MS	F	P
Peduncle	2	2.66667	1.33333	6.00	0.0370
Error	6	1.33333	0.22222		
Total	8	4.00000			

Grand Mean 5.3333 CV 8.84

FIRMNESS ANOVA

Anovafor DAY1

Source	DF	SS	MS	F	P
Peduncle	2	7.100E-30	3.550E-30	0.00	1.0000
Error	6	0.02000	0.00333		
Total	8	0.02000			

Grand Mean 7.7667 CV 0.74

Anova for DAY3

Source	**DF**	**SS**	**MS**	**F**	**P**
Peduncle	2	0.06222	0.03111	1.56	0.2856
Error	6	0.12000	0.02000		
Total	8	0.18222			

Grand Mean 6.4556 CV 2.19

Anova for DAY5

Source	**DF**	**SS**	**MS**	**F**	**P**
Peduncle	2	2.33556	1.16778	87.58	0.0000
Error	6	0.08000	0.01333		
Total	8	2.41556			

Grand Mean 5.7778 CV 2.00

Anova for DAY7

Source	**DF**	**SS**	**MS**	**F**	**P**
Peduncle	2	16.7622	8.3811	203.86	0.0000
Error	6	0.2467	0.04111		
Total	8	17.0089			

Grand Mean 3.9889 CV 5.08

Anova for DAY9

Source	DF	SS	MS	F	P
Peduncle	2	5.97556	2.9877	1.4153	0.0000
Error	6	0.12667	0.02111		
Total	8	6.10222			

Grand Mean 2.4444 CV 5.94

<u>TOTAL SOLUBLE SUGAR</u>

Anovafor DAY1

Source	DF	SS	MS	F	P
Peduncle	2	7.100E-30	3.550E-30	0.00	1.0000
Error	6	0.38000	0.06333		
Total	8	0.38000			

Grand Mean 5.7333 CV 4.39

Anova for DAY3

Source	DF	SS	MS	F	P
Peduncle	2	0.33556	0.16778	4.31	0.0690
Error	6	0.23333	0.03889		
Total	8	0.56889			

Grand Mean 6.2889 CV 3.14

Anova for DAY5

Source	DF	SS	MS	F	P
Peduncle	2	1.12889	0.56444	46.18	0.0002
Error	6	0.07333	0.01222		
Total	8	1.20222			

Grand Mean 7.2444 CV 1.53

Anova for DAY7

Source	DF	SS	MS	F	P
Peduncle	2	0.81556	0.40778	16.68	0.0035
Error	6	0.14667	0.02444		
Total	8	0.96222			

Grand Mean 7.8556 CV 1.99

Anova for DAY9

Source	DF	SS	MS	F	P
Peduncle	2	8.06000	4.0300	2.0150	0.0000
Error	6	0.12000	0.02000		
Total	8	8.18000			

Grand Mean 9.2667 CV 1.53

TOTAL TITRATABLE ACIDITY

Anova for DAY1

Source	DF	SS	MS	F	P
Peduncle	2	0.00889	0.00444	1.00	0.4219
Error	6	0.02667	0.00444		
Total	8	0.03556			

Grand Mean 2.2778 CV 2.93

Anova for DAY3

Source	DF	SS	MS	F	P
Peduncle	2	0.02000	0.01000	1.00	0.4219
Error	6	0.06000	0.01000		
Total	8	0.08000			

Grand Mean 2.1000 CV 4.76

Anova for DAY5

Source	DF	SS	MS	F	P
Peduncle	2	0.38222	0.19111	8.60	0.0173
Error	6	0.13333	0.02222		
Total	8	0.51556			

Grand Mean 1.8222 CV 8.18

Anova for DAY7

Source	DF	SS	MS	F	P
Peduncle	2	0.48247	0.24123	24.64	0.0013
Error	6	0.05873	0.00979		
Total	8	0.54120			

Grand Mean 1.0433 CV 9.48

Anova for DAY9

Source	DF	SS	MS	F	P
Peduncle	2	0.16222	0.08111	24.33	0.0013
Error	6	0.02000	0.00333		
Total	8	0.18222			

Grand Mean 0.8444 CV 6.84

SUGAR: ACID RATIO

Anova for DAY1

Source	DF	SS	MS	F	P
Peduncle	2	0.00889	0.00444	0.31	0.7461
Error	6	0.08667	0.01444		
Total	8	0.09556			

Grand Mean 2.5222 CV 4.77

Anova for DAY3

Source	DF	SS	MS	F	P
Peduncle	2	0.20222	0.10111	4.14	0.0743
Error	6	0.14667	0.02444		
Total	8	0.34889			

Grand Mean 3.0111 CV 5.19

Anova for DAY5

Source	DF	SS	MS	F	P
Peduncle	2	4.46889	2.23444	10.16	0.0119
Error	6	1.32000	0.22000		
Total	8	5.78889			

Grand Mean 4.0889 CV 11.47

Anova for DAY7

Source	DF	SS	MS	F	P
Peduncle	2	39.4200	19.7100	42.54	0.0003
Error	6	2.7800	0.4633		
Total	8	42.2000			

Grand Mean 8.0333 CV 8.47

Anova for DAY9

Source	DF	SS	MS	F	P
Peduncle	2	63.8467	31.9233	39.96	0.0003
Error	6	4.7933	0.7989		
Total	8	68.6400			

Grand Mean 11.433 CV 7.82

pH

Anova for DAY1

Source	DF	SS	MS	F	P
Peduncle	2	0.00762	0.00381	0.66	0.5509
Error	6	0.03467	0.00578		
Total	8	0.04229			

Grand Mean 5.9989 CV 1.27

Anova for DAY3

Source	DF	SS	MS	F	P
Peduncle	2	0.03749	0.01874	13.72	0.0058
Error	6	0.00820	0.00137		
Total	8	0.04569			

Grand Mean 6.2811 CV 0.59

Anova for DAY5

Source	DF	SS	MS	F	P
Peduncle	2	0.06436	0.03218	48.27	0.0002
Error	6	0.00400	0.00067		
Total	8	0.06836			

Grand Mean 6.4178 CV 0.40

Anova for DAY7

Source	DF	SS	MS	F	P
Peduncle	2	0.03807	0.01903	18.62	0.0027
Error	6	0.00613	0.00102		
Total	8	0.04420			

Grand Mean 6.4933 CV 0.49

Anova for DAY9

Source	DF	SS	MS	F	P
Peduncle	2	0.11642	0.05821	71.77	0.0001
Error	6	0.00487	0.00081		
Total	8	0.12129			

Grand Mean 6.5711 CV 0.43

SHELF LIFE

Anova for SHELFLIFE

Source	DF	SS	MS	F	P
Peduncle	2	70.2222	35.1111	105.33	0.0000
Error	6	2.0000	0.3333		
Total	8	72.2222			

Grand Mean 9.5556 CV 6.04