EFFECT OF DIFFERENT PRESERVATIVES ON QUALITY OF FRESH CUT PINEAPPLE (*Ananas comosus*) FRUIT

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EFFECT OF DIFFERENT PRESERVATIVES ON QUALITY ANALYSIS OF FRESH CUT PINEAPPLE (*Ananas comosus*) FRUIT

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CERTIFICATE

*This is to certify that thesis entitled, "**EFFECT OF DIFFERENT PRESERVATIVES ON QUALITY OF FRESH CUT PINEAPPLE (Ananas comosus) FRUIT**" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE (MS) in HORTICULTURE**, embodies the result of a piece of bona-fide research work carried out by **Nusrat Alam Riya**, **Registration no.14-06014**under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

I further certify that such help or source of information, as has been availed of during the course of this investigation has duly been acknowledged.

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Dedication

Every challenging work needs self-efforts as well as guidance of elder especially those who were very close to our heart.

My humble effort I dedicate to my sweet and loving

Father & Mother,

whose affection, love, encouragement and prays of day and night make me able to get such success and honour,

Along with all hard working

and respected

Teachers

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The Author

EFFECT OF PRESERVATIVES ON QUALITY OF FRESH CUT PINEAPPLE (*Ananas comosus*) FRUIT

ABSTRACT

An experiment was conducted in the postharvest laboratory of Sher-e-Bangla Agricultural University, Dhaka-1207, during the month of November-December 2020, to study the effect of different preservatives on quality analysis of fresh cut pineapple fruit. The experiment consisted of 7 treatments and followed Completely Randomized Design (CRD) with three replications. Treatments (7) *viz*: T_0: Not treated. T_1 : Treated with 0.5% ascorbic acid solution, T_2 : Treated with 1.0% ascorbic acid solution, T_3 : Treated with 0.5% citric acid solution, T_4 : Treated with 1.0% citric acid solution, T_5 : Treated with 1.0% calcium chloride solution, T_6 : Treated with 2.0% calcium chloride solution.Experimental result revealed that, color, texture, pH, ^{o}Brix (total soluble solids), acidity, vitamin C, and moisture content, were better preserved in the treated fruit compared to controls. Different preservatives had different results in terms ofthe preservation of the quality attributes of the fruit. Among different preservatives, 2.0% calcium chloride solution based preservative (T_6) presented a satisfactory formulation to preserve fruit quality attributes like suitable pH range (3.30, 3.34, and 3.39),the maximum total soluble solid (12.10, 12.30 and 13.00°Brix),moisture content (83.95, 78.57 and 72.97 %);the minimum titratable acidity (0.45, 0.35 and 0.32 %), β-carotene content (0.43, 0.35 and 0.30 mg), reducing sugar (1.80, 1.77 and 1.48 %) and microbial content (28.70, 31.00 and 32.00 CFU/ml) at 4^0C storage condition at 1^{st}, 2^{nd} and 3^{rd} days respectively. Therefore 2.0% calcium chloride solution used as effective preservative for the preservation of fresh cut pineapple at 4^0C storage condition.

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ABBREVIATIONS

Full word	Abbreviations
Agriculture	Agric.
Agro-Ecological Zone	AEZ
And others	*et al.*
Applied	App.
Bangladesh Bureau of Statistics	BBS
Biology	Biol.
Biotechnology	Biotechnol.
Botany	Bot.
Cultivar	Cv.
Dry weight	DW
Editors	Eds.
Emulsifiable concentrate	EC
Entomology	Entomol.
Environments	Environ.
Food and Agriculture Organization	FAO
Fresh weight	FW
International	Intl.
Journal	J.
Least Significant Difference	LSD
Liter	L
Triple super phosphate	TSP
Science	Sci.
Soil Resource Development Institute	SRDI
Technology	Technol.
Serial	Sl.

CHAPTER I

INTRODUCTION

Pineapple (*Ananas comosus* L. Merr.), belonging to the family Bromeliaceae, is one of the most promising fruits in Bangladesh. Each year a huge number of pineapples is produced extensively in this country. Bangladesh produced 2,08,401 metric tons of pineapple in 2017-18 from 14259.91 ha of land (BBS, 2019). It is mostly cultivated in the districts of Tangail, Sylhet, and Chittagong hill tracts. In respect of total production, it ranks 4th among the major fruits grown in Bangladesh. Pineapple is a good source of vitamin A and B and fairly rich in vitamin C and minerals like calcium, phosphorus and iron (Sen *et al*., 1980). Pineapple provides a range of health promoting plant chemicals. It is a source of bromelain, a protein digestive enzyme (Lodh*et. al*., 1973). In Bangladesh, the peak harvesting season of pineapple is June to September. During this period, major bulk of fruits is harvested causing a glut in the market. Hence a good quantity of this perishable fruit gets spoiled due to difficulties in timely disposal for lack of proper marketing, storage and processing facilities.

Minimal processing of fresh-cut fruits, which involves grading, washing, sorting, peeling, slicing and packaging, can affect the integrity of the fruits and cause biochemical changes and microbial spoilage that may result in degradation of the color, texture and flavor of fruits (Watada and Qi, 1999) and has a shorter shelf-life of 4–10 days compared to the original raw material which has a storage life of several weeks to months (Siroli *et al*., 2015). Pineapples are best kept in the refrigerator, but not necessary until cut. Cut fruits should be stored in an airtight container in the refrigerator for extended shelf life *viz*, 3-4 days.

The removal of the natural protective skin of fruits causes leakage of juices and sugars from the damaged tissue resulting in the fruits being highly susceptible to microbial spoilage (Oms-Oliu *et al*., 2010). An edible preservative can be used as an alternative to improve the shelf life of fresh-cut fruits (Rojas-Grau *et al.*, 2009).

Dipping in solutions of different food preservatives such as ascorbic acid, citric acid, calcium chloride etc has been suggested as successful method for maintaining quality (especially color and texture) of fresh-cut products.

Ascorbic acid (AA) is the most abundant antioxidant in nature. AA and its derivates have been used as an antioxidant and anti-browning agent in edible layer to retain postharvest quality of fresh-cut fruits and vegetables (Tapia *et al*., 2008; Xing *et al*., 2010). AA in combination with calcium salts and organic acids prevent browning and membrane breakdown by controlling the activity of polyphenol oxidase (Oms-Oliu *et al*., 2010). AA has also shown antibacterial properties for fresh-cut banana (Yurdugül, 2016), apple (Qi *et al*., 2011) and papaya (Tapia *et al*., 2008). Mostly, AA and its derivates have been used as anti-oxidative, anti-browning and antibacterial agent (Sogvar *et al*., 2016).

Citric acid is often considered safe and, as an organic acid, can be used as a food additive (Sommers *et al*., 2003). The previous study has shown that citric acid not only inhibits the growth of bacteria and fungi in fruits and vegetables but also induces the improvement of disease resistance in vegetables (Patrignani *et al*., 2015). It can also prevent browning and fruit disease by reducing the respiration of postharvest fruits (Pilizota and Sapers, 2004) and is a good additive to improve the acidity and flavor of foods, thereby improving the quality of preservation and storage and preventing food spoilage. The use of citric acid for fresh-cut water chestnut can maintain its food quality and extend its shelf life (Jiang *et al*., 2004). Citric acid treatment can slow down the decrease in the soluble sugars and titratable acidity and is beneficial to maintain the fruit quality of Chinese jujube fruits during storage (Zhao *et al*., 2009).

Calcium (Ca^{2+}) has been extensively reviewed as both an essential element and its potential role in maintaining postharvest quality of fruit and vegetable crops. The role of calcium in stabilizing cellular membranes and delaying senescence in horticultural and agronomy crops is well known (Poovaiah*et al*., 1988; Pervaiz *et al*., 2002; Hossain *et al*., 2005; Abdi *et al*., 2006; Misra and Gupta, 2006; Singh *et al*., 2006; Hosseini and Thengane, 2007; Naeem *et al*., 2009). Pre- and postharvest application of calcium may delay senescence in fruits with no detrimental effect on consumer acceptance (Lester and Grusak, 1999). Postharvest calcium dips can increase calcium content considerably compared to pre-harvest sprays, without causing fruit injury, depending on salt type and calcium concentration. Postharvest calcium application maintains cell turgor, membrane integrity, tissue firmness and delays membrane lipid catabolism, extending storage life of fresh fruits (Picchioni *et al*., 1998). Exogenously

applied calcium stabilizes the plant cell wall and protects it from cell wall degrading enzymes (White and Broadley, 2003). In Bangladesh few studies have been conducted to determine the effect of preservatives on quality analysis of fresh cut pineapple. Considering the above facts, the present study was undertaken with the following objectives:

i. To analyze the physiological, microbial and sensorial quality of fresh cut pineapple fruits due to effect of different preservatives during refrigerated storage condition
ii. To improve the nutritional quality of fresh-cut pineapple fruits by applying different preservatives during its three days of shelf life

CHAPTER II

REVIEW OF LITERATURE

An attempt was made in this section to collect and study relevant information available regarding the use of preservatives on quality analysis of fresh cut Pineapple, to gather knowledge which were helpful in conducting the experiment.

2.1 Fresh-cut Produce

The International Fresh-cut Produce Association (IFPA) defines fresh-cut products as fruit or vegetables that have been trimmed and/or peeled and/or cut into 100% usable product that is bagged or pre-packaged to offer consumers high nutrition, convenience, and flavour while still maintaining its freshness (Lamikanra, 2002). In particular, fresh-cut fruits attract consumers because they are fresh, nutritious, low priced, and ready-to-eat. As a consequence, a wide assortment of minimally processed fruits has been developed to meet consumer's needs for ''quick'' and convenient products, and to benefit from fruit's healthy image (Ahvenainen, 1996). Minimal processing gives additional value to fresh-cut fruits in terms of convenience and time saving.

2.2 Shelf life of fresh cut fruits

Several hurdles are encountered due to the difficulty in preserving fresh cut fruits freshness during prolonged periods. These products, in fact, are characterized by a shorter shelf life than their whole counterparts, because of higher susceptibility to microbial spoilage, increased respiration rate and ethylene production, which is stimulated by wounding of the tissue; in fact, the process operations (i.e. cutting, splicing, etc.) form lesions in the tissue that determine enzymatic browning, texture decay, rapid microbial growth, weight losses and undesirable volatile production, thus reducing highly the shelf life of fresh cut fruits (Chien *et al*., 2007).

2.3 Fresh-cut fruits processing

It is well known that processing of fruit promotes a faster physiological deterioration, biochemical changes and microbial degradation of the products which may result in degradation of its colour, texture and flavor, even when only slight processing operations are used (Beirne and Francis, 2003). Prior to being packaged for consumption, minimally processed fruits are subjected to one or more mild unit operations, as reported in Fig. 1, which include washing sanitizing, peeling, cutting and/or slicing, dicing, shredding, etc. Each step during the production, packaging and storage, could potentially have an effect on nutrients and quality of the prepared produce.

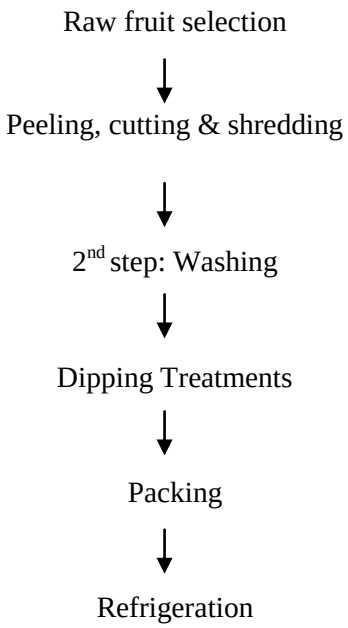


Figure 1. Flow diagram of fresh cut fruits

2.4 Quality parameters of fresh-cut fruits

The quality of fresh-cut fruits determines the value to the consumer and is a combination of parameters including appearance (size, shape, color, gloss and defects), texture (firmness, crispness and juiciness), flavor (sweetness, sourness, astringency and bitterness) and nutritional value (vitamins, minerals and dietary fiber). The relative importance of each quality depends on the product. Color is one of the most important attributes affecting the consumer's decision to purchase. However, subsequent purchases depend on the consumer's gratification in terms of texture, flavor and nutritional value of the products (Aguilar *et al.,* 2003 and Kader, 2002)

2.5 Microbial infestation of fresh cut fruits

Generally, there is a positive correlation between longer shelf-life of fresh-cut fruits and low aerobic plate count, low total plate count and especially low yeast and mold counts. Thus, it is very important to avoid sources of microbial contamination and to wash the fruits with disinfected water before cutting (Kader, 2008). Fresh-cut products are particularly susceptible to microbial growth owing to the removal of

plant protective tissues and the release of cellular fluids from cutting (Heard, 2002), which results in shelf life reduction and food-borne illnesses given that fresh-cut products are marketed as prewashed and ready to eat and not subject to further microbial killing steps, the development and proper application of sanitizing agents to remove microorganisms and control pathogen cross contamination effectively is critical to ensure the quality and safety of fresh- cut produce (Cruz *et al*., 2006).

2.6 Method to preserve fresh cut fruits

Various physical and chemical methods have been used to preserve the fresh-cut fruit quality. Physical methods include storage temperature, hurdle technology and modified atmosphere packaging (MAP). The temperature management decreases metabolic reactions, respiration rate, permeability of gases through packaging film and slow microbial growth (Watada *et al*., 1996). Effective packaging is necessary to control the gas exchange in and out of produce, minimize moisture loss and microbial growth. The chemical methods include the application of chemical preservatives such as chlorine, ascorbic acid, citrate and calcium salts for preservation. Chlorine based washing systems reduce microbial contamination of fresh-cut fruits with good efficiency but form harmful compounds (Sapers*et al.,* 2001) when reacts with organic compounds, thus, increasing the risk of cancer (Silveira *et al*., 2008). Sorbitol (a sugar alcohol) exhibits properties of disinfectant as it tends to reduce the surface tension and results in better cleaning of the surface (De Ell *et al.,* 2006). Ascorbic acid converts quinines back to phenolic compounds. Calcium treatments (like calcium chloride) extend the shelf- life of fresh produce. Calcium helps to maintain the cell wall integrity by interacting with pectin to form calcium pectate therefore, delaying senescence, reducing postharvest decay, controlling the development of physiological disorders, and making the texture firmer (Sila *et al.,* 2004; Soliva- Fortuny *et al.,* 2003) but may confer undesirable bitterness to the product (Luna- Guzman and Barrett, 2000). In fresh- cut processing, surface treatments delay physiological decay in fruit tissues as the enzymes and substrates released from injured cells during cutting operations are rinsed from the product surface.

2.7 Description of some specific preservatives

Ascorbic acid

Ascorbic acid is used primarily as an antioxidant, which can provide multiple benefits to food products. Slowing the oxidation preserves color and freshness. The low pH of ascorbic acid can help prevent microbial growth, thereby preventing spoilage and preserving freshness. For these reasons, ascorbic acid is a popular natural ingredient preservative. It can be used as a preservative in a vast array of food products, including bread, cured meats, jams and jellies, and other sauces and spreads. The Vitamin C properties of ascorbic acid make it an excellent ingredient for vitamin supplementation. Simply adding ascorbic acid to food increases the Vitamin C content. Since naturally occurring Vitamin C is easily destroyed, many foods are fortified with ascorbic acid to replenish the Vitamin C content. Ascorbic acid is often added to fruit juices, dried fruit, cereal, and other snack foods for this purpose. Mostly, AA and its derivates have been used as anti-oxidative, anti-browning and antibacterial agent (Sogvar *et al*., 2016).

Citric acid

Citric acid is often considered safe and as an organic acid it can be used as a food additive (Sommers *et al*., 2003). The previous study has shown that citric acid not only inhibits the growth of bacteria and fungi in fruits and vegetables but also induces the improvement of disease resistance in vegetables (Patrignani *et al*., 2015). It can also prevent browning and fruit disease by reducing the respiration of postharvest fruits (Pilizota and Sapers, 2004) and is a good additive to improve the acidity and flavor of foods, thereby improving the quality of preservation, storage and preventing food spoilage. The use of citric acid for fresh-cut water chestnut can maintain its food quality and extend its shelf life (Jiang *et al*., 2004). Citric acid treatment can slow down the decrease in the soluble sugars and titratable acidity and is beneficial to maintain the fruit quality of Chinese jujube fruits during storage (Zhao *et al.*, 2009). Thus, citric acid treatment is potentially an ideal fruit preservation approach.

Calcium

It is well known that calcium is involved in maintaining the textural quality of produce. Calcium ions form cross-links or bridges between free carboxyl groups of

the pectin chains, resulting in strengthening of the cell wall. A common treatment used to improve tissue firmness is to dip fruit or vegetable pieces in calcium solutions, as described for strawberries (Hernández-Muñoz, 2006), pears (Rosen & Kader, 1989), and shredded carrots (Izumi & Watada, 1994), among others.

In contrast, calcium treatment was not effective in carrot slices and sticks, a fact attributed to insufficient calcium absorption by the tissue, since the levels of calcium were two and three times higher in shredded carrots than in sticks and slices, respectively. In addition, increasing the concentration of calcium chloride in the dip solution (0.5 % or 1 %) brought an increase in the tissue calcium content of treated samples, without a subsequent correlation with product texture (Izumi & Watada, 1994).

A combined treatment associating low temperature blanching to activate the enzyme pectinesterase (PE) prior to the calcium dip is helpful in preserving fruit texture. The PE brings about the de-esterification of pectin, thus increasing the number of calcium binding sites. To such mechanism has been attributed the firming effect observed in apple slices kept at 38 ºC for 6 days immediately after harvest, and sliced and dipped in calcium solution after 6 months of cold storage (Hussain *et al*., 2012). In fresh-cut melon cylinders dipped in calcium chloride solutions at different temperatures (Lester and Grusak, 2000), texture was firmer in samples treated at 60 ºC (77 % improvement in firmness), than at 40ºC (58 % improvement) and 20 ºC (45 % improvement).

Frequently, calcium chloride has been used as a firming agent, however, it may confer undesirable bitterness to the product. Fresh-cut cantaloupe cylinders dipped in calcium lactate solutions resulted in a textural improvement similar to calcium chloride treated fruit cylinders. Sensory evaluation indicated that results were better in terms of bitterness and a more detectable melon flavour was perceived. Fresh-cut cantaloupe cylinders treated by a combination of heat treatment (60 ºC) and calcium lactate dip were not significantly different either in bitterness or firmness, in relation to fruit treated at 25 ºC (Luna-Guzman *et al.*, 1999).

2.8 Effect of chemical preservatives on fresh cut fruits

2.8.1 Total soluble solid (TSS)

Ediriweera *et al.* (2012) conducted a study to know the effect of minimally processed pineapple (*Ananas comosus* L.) cv. Mauritius stored at cold temperature for seven days were evaluated for physio-chemical, sensory and microbiological qualities. Pineapple pieces were treated with 1% sodium chloride, 1% calcium chloride, a combination of 1% sodium chloride and calcium chloride, 1% ascorbic acid, 1% citric acid, 0.1% chitosan and distilled water (control) and packed in polystyrene packages before storage. Pretreatments did not significantly affect physio-chemical properties. Many sensory attributes in minimally processed pineapple decreased after seven days of storage, but ranked neither good nor bad by taste panelists. From the experiment result revealed that the TSS ranged between 11.50-14.88^{o}Brix in all seven treatments during the 4 day storage period. The TSS of the samples from different treatments and control (distilled water) were not significantly different on 0 and 7th day ($p>0.05$).

Beaulieu and Gorny (2001) explained that the soluble solid content (SSC) and titratable acidity (TA) can change (decrease or increase) during storage of fresh-cut fruit. The SSC and TA content generally correlate with sweetness, flesh taste and flavour, which are very important characteristics for fresh-cut quality.

Pinaki *et al.* (1997) conducted an experiment on banana fruits cv. Dwarf Cavcndish with gibberellic acid (GM 250 ppm) and other chemicals viz.. 2% $CaCl_2$ and Bavistiri (100) ppm) or with their combinations and stored at ambient temperature (20-30°C) in paper boxes. They mentioned that GA_3 alone in combinations with Bavistin were slowed the rate of increase in total soluble solids. The sugars, soluble portion of starch, organic acids, soluble pectin and vitamin C are the component of total soluble solids of banana fruits pulp. The effect of chemical dip, calcium chloride plus ascorbic acid and modified atmosphere storage increased the total soluble solids of banana pulp.

2.8.2 pH

According to Schmidl and Labuza (2000) pH is dependent on the total quantity of acids as well as the strength of the acids present.

2.8.3 Titratable acidity (%)

Hussain *et al.* (2008) noticed that the increase in acidity might be attributed due to the increase in the concentration of powerless ionized acid and their salts during storage. Another reason for the rise in acidity might be due to the acid formation, reducing sugars oxidation and polysaccharide degradation or by the breakdown of uronic acid and pectin substances.

Gil *et al.* (2006) reported that the TA of whole pineapple did not change until day 6. It was 0.76 and 0.74 in days 3 and 6, and at day 9 it decreased to 0.60. The decrease in TA or increase in pH was related to deterioration of fruit characteristics such as firmness and visual quality. When pineapple pieces were exposed to light, a decrease in visual quality was observed mainly related to surface browning, whereas dark storage conditions provided a better visual quality.

Kulkarni and Aradhya (2005) suggested that a slow decrease in acidity, concomitant with increased TSS and total sugar content, is an intrinsic process during ripening of fruits to impart the flavor. During ripening, organic acids are respired or converted to sugars and acid levels decline. The TSS and acid content are the factors influencing consumption quality

Germain *et al* (2003). reported that the acidity of the fruit samples also tends to increase due to the addition of chemical preservatives.

Ball (1997) suggested that acidity decreases due to fermentation or break up of acids to sugars in fruits during respiration.

2.8.4 Vitamin-C

Vitamin C is a water-soluble vitamin and its nutritional importance to mankind is well established. It is associated with many health benefits such as promoting health cell development, healing injuries and helps in absorption of minerals such as calcium. Many food products contain vitamin C but fruits and vegetables contain significantly higher amounts. The stability of vitamin C in food products such as fresh cut fruits is influenced by a number of factors such as type of fruit, maturity state and storage condition etc.

Masamba and Mndalira (2013) studied on the evaluation of sensory quality attributes and extent of vitamin C degradation in dried fruit pieces pre –treated. Different parameters such as Vitamin C and pH values was measured before and after drying and sensory quality such as flavor, color, texture and taste was evaluated using 9 scale panel. The observation found that the use of different pre-treatments had decreased the vitamin C degradation and registering the highest reduction in the samples.

Barrett *et al.* (2010) observed that during storage of fresh-cut fruit little change occurs in the dietary fiber and mineral content, but the vitamins are lost Cutting stimulates ethylene production which in turn increases respiration and senescence leading to even more rapid loss of certain vitamins. Vitamin C content decreased in most fruit during storage. Therefore, it can be used as an index of freshness.

Gil *et al.* (2006) observed losses in vitamin C after 6 days at 5 °C were less than 5% in mango, strawberry and watermelon pieces. 10% in pineapple pieces, 12% in kiwifruit slices and watermelon cubs. Cantaloup, mango and strawberry pieces lost 10-15%; pineapples lost the most at 25% followed by 10-15% in cantaloupe, mango, and strawberry pieces after 6 days at 5 °C. The main cause of loss of vitamin C is the action of the enzyme ascorbate oxidase.

Gorny *et al.* (2002), found that the AA content of pear slices treated with exogenous AA (2%), dropped to endogenous control levels after 3 days at 0 ^{0}C. It appears that AA is most likely converted to dehydro ascorbic acid and further degraded to 2,3 diketo-gluconic acid.

2.8.5 Carotenoids

Carotenoids, which are known as vitamin A precursors, are also abundant in plant tissue. Betacarotene is the most well-known carotenoid. These vitamins scavenge free radicals derived from aerobic metabolism in chloroplasts. In addition, as described earlier, carotenoids provide yellow orange pigments to plant tissue. Damage and loss of carotenoids, which result in lowered amount of vitamin A precursors, occur by the same mechanisms described earlier for loss of carotenoids resulting in color loss. These include loss of carotenoid function due to oxidative damage, light, and lipoxygenase enzyme activity.

Viana *et al.* (2013) quantified only the total carotenoid content, and for Imperial cultivar, the content found was 266 µg / 100 g, while Smooth Cayenne, Pérola and Vitória cultivars showed lower concentrations, respectively, 2.34; 0.69 and 0.32 µg / 100g.

Ramsaroop and Saulo (2007) also investigated the total carotenoid content for Smooth Cayenne and hybrid cultivars, finding concentrations of 45.43 and 136.26 µg / 100g, respectively. This hybrid cultivar obtained greater acceptance due to its lower acidity and more yellow color, which is consistent with the total carotenoid content and also with the quantification of β-carotene, which showed 41.59 mg / 100g, against 17.22 g / 100g of Smooth Cayenne cultivar.

Gil *et al (*2006) conducted a study of several fruits such as pineapple, mango, cantaloupe, watermelon, strawberry, and kiwi fruit compared the effect of fresh cut with the whole fruit and concluded that the cut induced losses of antioxidant carotenoids (0-25%) during 9 days storage in air at 5 °C.

Gortner and Singleton (1961) suggested that the acid-catalyzed isomerization of pineapple fruit carotenoid pigments is influenced by any condition leading to loss of integrity of the cells of the fruit tissue. The swollen lower half of fully ripe, yellow, translucent fruit often will contain an appreciable fraction of isomerized pigment. Any post-harvest handling of the fruit that causes bruising of the tissue will lead to pigment isomerization in the damaged areas. After postharvest storage, for another seven days (21 day), total carotenoid levels dropped by 17% to 359 µg/100 g of FW. This decline may be attributed to the isomerization and degradation of carotenoids caused by the release of acids from bruised cells but also to enzymatic reactions.

2.8.6 Reducing sugar

Choonut *et al.* (2014) suggested that the highest level of reducing sugar (40.10±3.98 g/L) was observed from phosphoric acid treatment with water bath (100 ^{o}C, 240 min), followed by hot water treatment (34.03±1.30 g/L).

2.8.7 Moisture content

Karim *et al*. (2008) studied on the Effect of Pretreatments on Quality Attributes of Air-Dehydrated Pineapple Slices and found that the pre-treatments had given a significant effect on the moisture percentage, pH value, TTA and ascorbic acid of the

samples before drying. The percentage of moisture reduced from 82.41% of fresh pineapple to 80.53% by SO_2 solution while the 60% sucrose sample had a reduction to 81.70%.

Ruhman *et al.* (1979) found that fresh pineapple fruits contain 83.53% moisture and also mentioned that the moisture content of pineapple fruits slightly decreased with storage period.

2.8.8 Antimicrobial effect

Lianou *et al.* (2012) opined that the antimicrobial effect of weak organic acids is related to the cytoplasm acidification, osmotic stress, disruption of proton motive force, and synthesis inhibition of macromolecules. Weak organic acids are more effective for bacteria than for yeasts and molds because of the low pH (2.1–2.7) of the applied solutions. Citric, acetic, lactic, and ascorbic acids are the most common acids applied in the food industry.

Citric acid, contrary to other acids, acts as a chelating agent of metallic ions of the medium, avoiding microbial growth (Meireles *et al*., 2016; Gurtler *et al*., 2014). Citric acid treatment (0.52 mM) maintained microbial safety and visual quality of FC "Amarillo" melon during a shelf life of 10 days at 5℃ (Aguayo*et al.*, 2003). A solution of 0.1 M citric and 0.5 M ascorbic acid achieved the same effectivity as 100 ppm NaOCl to control microbial growth and maintain quality of green celery crescents (Gómez and Artés, 2004). Citric and lactic acid dipping of 0.5–1 × 10^4 ppm achieved comparable E. coli reductions of 1.9–2.3 log CFU g^{-1} to 100 ppm NaOCl in inoculated FC lettuce without significant efficacy enhancement from incrementing dipping times from 2 to 5 minute. Likewise, acetic and citric acid dipping of 0.5–1×10^4 ppm achieved similar L. monocytogenes reductions of 0.8–1.0 log CFU g^{-1} to 100 ppm NaOCl in inoculated FC lettuce (Akbas and Olmez, 2007).

Mohammed and Wickham (2005) found that the combined treatment of 300ppm AA +200ppm 4-hexylresorcinol (4-HR) on pineapple was most effective in the inhibition of browning and microbial spoilage during storage.

2.8.9 Shelf- life of fresh cut fruits

Guptaand Kumari (2015) conducted a study to investigate the effect of chemical preservatives on the shelf- life of the fresh- cut packs (150g each) were when stored at

1˚C for 6 days. Apple and pineapple fresh- cut packs were prepared. The chemical preservatives included citric acid (1% and 0.2% w/v), ascorbic acid (1% and 0.1% w/v) and calcium chloride (1% and 1.5% w/v). The physical, chemical and microbiological parameters were analyzed. The sensory aspects were also studied. The study showed that the best preservative for pineapple is calcium chloride (1.5%) increasing the shelf- life to 4 days. The most effective preservative for pineapple pack was citric acid (1%) providing a shelf- life of 5 days.

Saxena *et al.* (2009) studied on the pineapple slices using advanced hurdle technology. The shelf life of the pineapple slice was found to be 40 days at room temperature (26 ± 2 ºC). The control sample was spoiled within 6 days. The RTE pineapple slices were found to have good texture, color and sensory acceptability, during these 40 days storage.

Liu *et al.* (2007) conducted a study to know the effects of pretreatment and modified atmosphere packaging (MAP) on the quality of fresh-cut pineapples stored at 4°C were evaluated for 7 days. The pretreatment was conducted by immersing the pineapple slices in a solution containing 0.25% ascorbic acid and 10% sucrose for 2minute. MAP contained 4% oxygen, 10% carbon dioxide and 86% nitrogen. Both the pretreatment and MAP could reduce the respiration rate, ethylene production, textural and colour deteriorations, as well as the overall sensory deterioration in fresh-cut pineapples. MAP could restrain the growth of microbes but the pretreatment showed little effect. Fresh-cut pineapples exhibited wet surface and off-flavour after storage at 4°C for 3 days, while the pretreatment and MAP maintained the quality for up to 7 days.

Ragaert *et al.* (2004) reported that the effect of the chemical dip, calcium chloride + ascorbic acid L-cysteine at 5% and modified atmosphere storage on the quality and shelf life of Papaya.

2.8.11 Fresh-cut products and color preservation:

One of the limitations of fresh-cut fruit products is that they are often processed in a ripe stage, which makes them more susceptible to quality deterioration once they are cut and packaged (Toivonen and DeEll, 2002). On the other hand, This product is subjected to enzymatic browning and must betreated with a browning inhibitor to

prevent development of unsightly discoloration (Sapers *et al.,* 2002). Enzymatic browning represents a major challenge in fresh-cut fruits (Son *et al.,* 2001; Sapers *et al.,*2002). Browning occur when the products of phenyl propanoic metabolism, such as various phenolic and possibly other substrates (e.g., anthocyanin) are oxidized in reactions catalyzed by phenolates such as polyphenol oxidase (PPO) or peroxidases. Chemical dips (such as ascorbic and citric acid, calcium chloride and other compounds) have been shown to be effective in retarding browning and softening of several types of fruit such as apple (Son *et al.,* 2001; Cocci *et al.,* 2006), pineapple (Gonzalez-Aguilar *et al.,* 2004) and pear (Dong *et al*., 2000; Arias *et al.,* 2008).

Trindade *et al.* (2003) concluded that the most suitable conditions for quality preservation of fresh-cut 'Tommy Atkins' mango were dipping in a solution of 3.5% (w/w) calcium chloride at 35°C for 20 min and packaging under active modified atmosphere (5% oxygen+5% carbon dioxide). Under these conditions, fresh-cut mango maintained good quality for 5 days at 5°C.

2.8.12 Fresh-cut products and texture preservation:

Firmness retention is an important quality parameter in fresh-cut fruits and vegetable products (Agar *et al.,* 1999; Gorny*et al*., 1999). An important aspect of the fresh-cut industry is texture. Fresh-cut produce must have a reasonable shelf-life which is the time between when produce is cut and when it is consumed. If not ripe enough, it won't taste good. But if the product is cut at too ripe stage, then it will deteriorate even more rapidly.

Lamikanra and Watson (2004) study the effect of calcium dipping and temperature on the quality of Fresh-cut Cantaloupe Melon and showed that Fruit dipped in solution at 4°C had lower respiration and moisture loss rates than treated fruit at ambient temperature. Also, Calcium treatment lowered lipase activity at both temperatures but the effect was more notable in fruit treated at the lower temperature.

Botelho *et al.* (2006) investigated the quality of fresh-cut and intact strawberry during storage at 5°C. Fruits were dipped in sodium isocyanate solution and packaged in polyethylene terephthalate (PET) trays. Results showed that fresh-cut strawberry had lower SSC and firmness, lighter colorandhigherrespiratory activity than intact fruit

and showed good quality for up to 4 d after cutting compare to intact strawberry which stored for 8 days.

Arias *et al.* (2009) opined that fresh-cut treatment of 'Blanquilla' pears with 1-MCP before cutting and peeling considerably improved their textural properties and color and allows fresh cut 'Blanquilla' pears to be sold up to about 5 d after processing. Treatment with 1-MCP could be a viable alternative to common technologies for extending the shelf-life of 'Blanquilla' pears as a fresh-cut product.

Ergun *et al.* (2007) studied Physiology of fresh-cut 'Galia' (Cucumis melo var. reticulatus) from ripe fruit treated with 1-methylcyclopropene and demonstrated that 1-MCP treatment deferred loss of physical deterioration of fresh-cut 'Galia' cubes at 5°C by 2-3 d compared with controls.

2.8.13 Fresh-cut products and flavor preservation:

Flavor quality of fruits and vegetables 1st influenced by genetic, pre-harvest, harvest and postharvest factors. The longer the time between harvest and eating, the greater the losses of characteristic flavor (taste and aroma) and the development of off-flavors in most fruits and vegetables. Postharvest life based on flavor and nutritional quality is shorter than that based on appearance and textural quality. Thus, it is essential that good flavor quality be emphasized in the future by selecting the best-tasting genotypes and using an integrated crop management system including harvest at the maturity or ripeness stage and use the postharvest handling procedures that will maintain optimal flavor and nutritional quality of fruits and vegetables between harvest and consumption (Kader, 2008).

Ediriweera *et al.* (2012) said that the chemical pre-treatment’s have not significantly affected the physicochemical and microbiological properties of pineapple at first day or after on seventh day storage period. So, all final products could be considered as safe for consume. But, after seven days, the flavor of pineapple treated with 1% sodium chloride or a combination of 1% sodium chloride and 1% calcium chloride was found to be higher than that in the control and other chemical treatments. Thus, it is recommended to use either 1% sodium chloride or a combination of 1% sodium chloride and 1% calcium chloride if processed pineapple is stored for seven days.

Liu *et al* (2007) study the effects of pretreatment and modified atmosphere packaging (MAP) on the quality of fresh-cut pineapples stored at 4°C were evaluated for 7 days. The pretreatment was conducted by immersing the pineapple slices in a solution containing 0.25% ascorbic acid and 10% sucrose for 2min. MAP contained 4% oxygen, 10% carbon dioxide and 86% nitrogen. Both the pretreatment and MAP could reduce the respiration rate, ethylene production, textural and colour deteriorations, as well as the overall sensory deterioration in fresh-cut pineapples. MAP could restrain the growth of microbes, but the pretreatment showed little effect. Fresh-cut pineapples exhibited wet surface and off-flavour after storage at 4°C for 3 days, while the pretreatment and MAP maintained the quality for up to 7 days.

Marrero and Kader (2006) researches on the optimal temperature and modified atmosphere for keeping quality of fresh-cut pineapples showed that the very low respiration rates (CO_2 production of about 0.3 L kg^{-1} sec^{-1} of pulp pieces at 0, 2.2 and 5°C allowed the use of a MA film such as Mylar®, with a low 0_2 transmission rate, without development of permanent off-odors or flavors due to anaerobiosis.

CHAPTER III

MATERIALS AND METHODS

The fruits (Pineapple) samples were collected from street vendors of Dhaka City and carried to the central laboratory of Sher-e- Bangla agricultural University, Dhaka, to determine the effect of preservatives on quality analysis of fresh cut pineapple. From the collection of samples to the final analysis, all way required a number of processes which are described below.

3.1 Location

This study was implemented in the Central Laboratory of Sher-e-Bangla Agricultural University (SAU), Sher-e-Bangla Nagar, Dhaka-1207, Bangladesh.

3.1.2. Laboratory condition

The temperature and relative humidity of the laboratory room were recorded daily basis during the study period with a digital thermo hygrometer (TERMO, TFA, Germany). The average minimum and maximum temperature during the study period of the culture room was 17^0C to 27^0C respectively and the average minimum and maximum relative humidity were recorded 54% and 75%, respectively.

3.2 Test crops

Pineapple and their cut slices were was used for this experiment(Plate 1).

Plate 1. Pineapple fruits

Pineapple

Pineapple's nutrients include calcium, potassium, fiber, and vitamin. It is low in fat and cholesterol and also a good source of vitamins B1, B6, and fiber. Pineapple is a digestive and a natural anti-inflammatory fruit. Fresh pineapples are rich in bromelain. Bromelain has demonstrated significant anti-inflammatory conditions such as acute suites, sore throat, arthritis and gut and speeding recovery from injuries and surgery. Pineapple should be eaten alone between meals (USDA, 2001). Pineapple enzymes have been used with success to treat rheumatoid arthritis and to speed tissue repair as a result of injuries diabetic ulcers and general surgery and also reduces blood clotting and helps remove plague from arterial walls. It also helps to cure bronchitis and throat infections. Pineapple is an excellent cerebral toner; it combats loss of memory and sadness. It is rich in manganese and just one cup of pineapple provides 73% of the daily recommended amount of manganese. Vitamins that can be found in pineapple are vitamin C, vitamin A, calcium and potassium. It is believed that the best source for these nutrients is fresh pineapple (Plate 2). Pineapple contains bromelain, which is known to help relieve or even stop coughs altogether. The main reason is because it is anti-inflammatory and ultimately, it is known to help with the loosening of mucus.

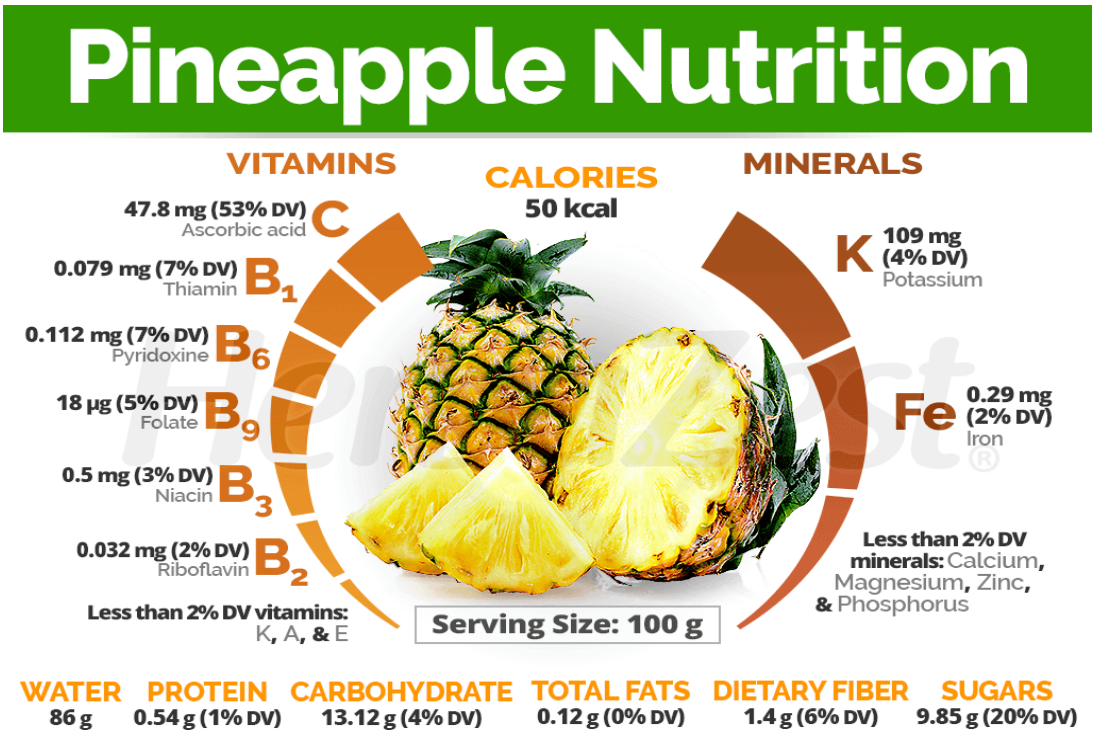


Plate 2. Pineapple nutrient composition. (Source: USDA, 2006).

3.3 Collection of samples:

The street vendor located in front of Shaheed Suhrawardy Medical College and Hospital collected from where fresh and ripe Pineappleswere purchased (Plate 3). Twenty-five Pineapple fruits were purchased from street vendor for quality analysis and preservation technique of fresh cut fruits.

Plate 3. Purchased pineapple fruits

3.4 Preparation of samples:

Fresh and fully mature but not over ripe pineapple were collected from street vendors of Dhaka city (Plate 4). Then these were properly washed, peeled and cut into desired size by street vendors for quality analysis of the fruits.

Plate 4. Slicing and cutting of pineapple samples by street vendor

3.5 Chemical preservatives

In this experiment the Ascorbic acid, citric acid & calcium chloride were

being used for this study.

3.6 Preparation of the chemical preservatives

i. Preparation of 0.5% and 1.0% Ascorbic Acid solution:

5 g and 10 g ascorbic acid powder were weighted and dissolved in separate 1 litre of distilled water respectively.

ii. Preparation of 0.5% and 1.0% Citric Acid solution:

5 g and 10 gof citric acid powders were weighted and dissolved in separate 1 litre of distilled water respectively.

iii. Preparation of 1.0% and 2.0% Calcium Chloride solution:

10 g and 20 g calcium chloride powders were weighted and dissolved in separate 1 litre of distilled water respectively.

3.7 Experimental design

The single factor experiment was laid out in a Completely Randomized Design (CRD) with three replications.

3.8 Experimental treatments

The experiment comprises of 7 treatment and replicated three times. Experimental treatments were-

T_0: Not treated.

T_1 : Treated with 0.5% ascorbic acid solution.

T_2 : Treated with 1.0% ascorbic acid solution.

T_3 : Treated with 0.5% citric acid solution.

T_4 : Treated with 1.0% citric acid solution.

T_5 : Treated with 1.0% calcium chloride solution.

T_6 : Treated with 2.0% calcium chloride solution.

3.9 Experimental set up

Treatment				
Sample	**Weight (gm)**	**Ascorbic Acid (conc %)**	**Citric Acid (conc %)**	**Calcium Chloride (conc %)**
(T_0)	150	Nil	Nil	Nil
(T_1)	150	0.5 (5 gm)	Nil	Nil
(T_2)	150	1.0 (10 gm)	Nil	Nil
(T_3)	150	Nil	0.5 (5 gm)	Nil
(T_4)	150	Nil	1.0 (10 gm)	Nil
($T_{5)}$	150	Nil	Nil	1.0 (10 gm)
(T_6)	150	Nil	Nil	2.0 (20 gm)

Sample 1(T_0) was kept in room temperature and rest of all samples were stored at 4^{o}C for 3 Days.

3.10 Dipping fresh cut fruits with different concentration of chemical preservatives

The cut sample were weighted(Plate 5) and treated with different concentration of chemical food preservatives (Plate 6), stored at 4°C temperature with polyethylene paper and later these samples were used for various chemical analysis for determination of the quality of fresh cut fruits.

For sample 1 (T_0), 450g sample were taken. Each 150g sample were packed in separate three zipper bags for three times replication. The replicated bags were tagged as T_0R_1, T_0R_2 andT_0R_3respectively.

Plate 5. Weighting of the samples

For sample 2 (T_1), 450g sample were dipped into 0.5% ascorbic acid solution for 10 minutes. From that solution, each 150g sample were packed in separate three zipper bags for three times replication. The replicated bags were tagged as T_1R_1, T_1R_2 andT_1R_3 respectively.

Plate 6. Chemical dipping of the samples

For sample 3 (T_2), 450g sample were dipped into 1.0% ascorbic acid solution for 10 minutes. From that solution, each 150g sample were packed in separate three zipper bags for three times replication. The replicated bags were tagged as T_2R_1, T_2R_2 and T_2R_3respectively.

For sample 4 (T_3), 450g sample were dipped into 0.5% citric acid solution for 10 minutes. From that solution, each 150g sample were packed in separate three air tight zipper bags for three times replication. The replicated bags were tagged as T_3R_1, T_3R_2 and T_3R_3 respectively.

For sample 5 (T_4), 450g sample were dipped into 1.0% citric acid solution for 10 minutes. From that solution, each 150g sample were packed in three separate zipper bags for three replications. The replicated bags were tagged as T_4R_1, T_4R_2 and T_4R_3 respectively.

For sample 6 (T_5), 450g sample were dipped in 1.0% calcium chloride solution for 10 minutes. After that, each 150g samples were packed in 3 separate air tight zipper bags for 3 replications. The replicated bags were tagged as T_5R_1, T_5R_2 and T_5R_3 respectively.

For sample 7 (T_6), 450g sample were dipped in 2.0% calcium chloride solution for 10 minutes. After that, each 150g of sample were packed in three separate air tight

zipper bag for three replications. The replicated bags were tagged as T_6R_1, T_6R_2 and T_6R_3 respectively.

3.11 Flow chart of operation:

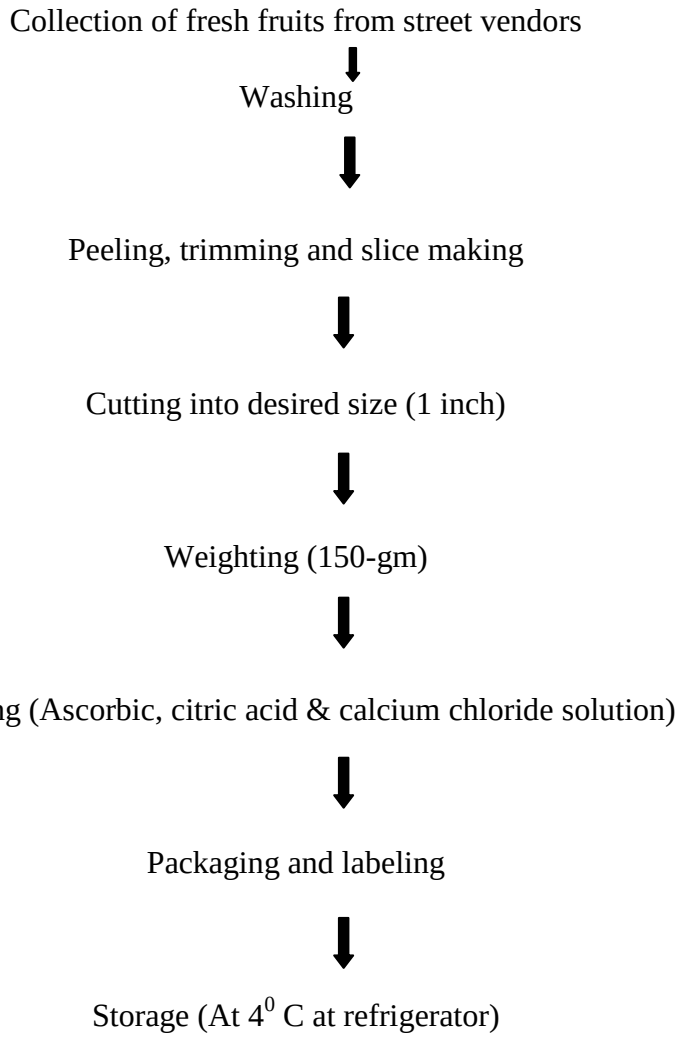


Figure 1. Typical flow chart for processing fresh-cut fruits.

3.12 Experimental equipment

Different equipment such as 4-digit electric balance, petri dish, Refrigerator, Spectrophotometer, pH meter, micro pipette, forceps, magnetic stirrer, shelf for placing petri dish, Laminar air flow, electric oven etc. were used for this study.

3.13 Data collection

Fresh cut fruits were kept in the Refrigerator (storage condition 4^0C) during 3 days and on the basis of chemical analysis various data such as total soluble solids (TSS),

pH, titrable acidity, vitamin-c, beta carotene, reducing sugar, moisture loss and sensory evaluation were recorded for the quality analysis of fresh cut fruits treated with chemical preservatives.

3.14 Procedure of recording data

i. pH determination

The pH value of fresh-cut pineapple was measured using a digital pH meter (Plate 7). The pH meter was first calibrated with different standard solutions for pH 4, 7 and 10. Then, the juice of two pieces of treated pineapples was squeezed and the pH meter immersed in the juice to record the value. The test was performed by triplicate per each treatment (coated samples and controls) at room temperature.

Plate 7. pH determination

ii. Total soluble solids (^{o}Brix)

Soluble solids concentration in the samples was measured using a refractometer and expressed in °Brix scale. A couple of drops of pineapple juice used for °Brix readings, were used for the treated and untreated samples. For this test, three readings per treatment (treated and untreated samples) and value were recorded at room temperature.

iii. Moisture content

Moisture content was determined by weight loss after drying in a vacuum oven at 60 °C for 10 hours. Each sample's weight, approximately 15g, was recorded before and

after drying (AOAC method 920.151). The samples were first chopped into small pieces and placed in aluminum canisters prior starting the drying process. The weight of canisters was also recorded for measurements that are more accurate. After removing the samples from the vacuum oven, the samples were placed in a desiccator to cool down before recording the final weight. Two pieces of pineapple for each repetition per treatment (coated samples and controls) were used for the analysis. The test was performed in triplicate and the moisture content (MC) in wet basis (w.b.)was calculated as follows:

$MC_{(wb)} = (M_{wet} - M_{dry})/ M_{wet}$

Where, M_{wet}(g) is the weight of the wet sample and M_{dry}(g) is the weight of the dry sample.

iv. Vitamin-C Estimation

a. Theory and Principle:

Fruit, vegetables and their products are important sources of ascorbic acid. The ascorbic acid is present in sufficient quantity in guava, grapefruit, lemon, pineapple, strawberry fruits etc. The products manufactured from these fruits are also considered as rich in ascorbic acid and the contents available in the commodities detected by using 2, 6 dichlorophenol indophenol visual titration method(Plate 8).

b. 2, 6 dichlorophenol - indophenol visual titration method:

The method is based on reduction of 2, 6 dichlorophenol – indophenols dye. The dye, which is blue in alkaline solution and red in acidic solution, is reduced by ascorbic acid to a colorless form. The reduction is quantitative and specific for ascorbic acid in solutions in the pH range of 1.0 - 3.5. In estimation of ascorbic acid, the prepared sample is titrated against standard 2, 6 dichlorophenol – indophenols dye to a pink end point. The titrate is then used to calculate the ascorbic acid in the sample

c. Apparatus, reagents and glassware required

i. **3% metaphosphoric acid (HPO_3)**: Dissolved 3g sticks of HPO_3 in distilled water (100 ml). Prepared 1 liter solution of 3% HPO_3 as it also required in sample preparation, 0.1% oxalic acid can also be used in place of metaphosphoric acid.

ii. **Ascorbic acid solution:** Weighted 100 mg L-ascorbic acid and dissolve in 3% HPO_3 and made volume up to 100 ml with HPO_3. Diluted 10 ml to 100 ml with 3% HPO_3 (1ml=0.1mg ascorbic acid)

iii. **Dye solution:** Dissolved 50 mg of the Sodium salt of 2, 6 dichlorophenol indophenol dye in 150 ml hot glass distilled water containing 42 mg of Sodium bicarbonate. Cooled and diluted with distilled water to 200 ml. Stored in refrigerator and standardize.

iv. Beakers - 100, 250ml

v. Volumetric flasks - 100, 250ml

vi. Measuring cylinder - 250ml

vii. Pipette - 10 ml

Plate 8. Titration for estimation of vitamin-c content

d. Procedure for estimation

d. i. Standardization of dye:

To 5 ml of Standard ascorbic acid (1ml=0.1mg) and 5 ml HPO3. Titrated this solution with the dye solution to a pink color which should persist for 15 seconds. Determined the dye factor i.e. ascorbic acid per ml of the dye.

d. ii. Sample preparation:

Fruit sample: Had taken 5g sample pissed it with hand pestle mortar, filter the juice and placed in a 100 ml conical flax and add 3% HPO_3 and make volume to 100 ml.

d. iii. Procedure for titration: Had taken 10ml (containing 3% HPO_3 / 0.1% oxalic acid) extract of the sample and titrated with the standard dye to a pink end point persisting for at least 15 seconds. Recorded the value for determination of ascorbic acid.

d. iv. Formula for determination of ascorbic acid in fresh cut fruits

$$\text{Vitamin-C content (mg/100 g)} = \frac{\text{Titre value (T)} \times \text{Dye factor (D)} \times \text{Volume made up (V1)}}{\text{Weight of the sample (W g)} \times \text{Volume extract (V2)}} \times 100$$

Where

T= Titrate value

D = Dye factor = 0.1

V_1= Volume made up =100 ml, V_2= Volume extract for titration = 10 ml and

W g= Weight of the sample = 5 g

v. Titratable acidity

5g of sample was weighted pissed with hand mortar extract filtrated the juice and transferred into a small beaker (Plate 9). After it was transferred into the conical flask and mixed toughly and made the volume up to 50 mlwith distilled water. 10 ml of the mixed solution was taken into another conical flask and 1-2 drops of phenolphthalein indicator was added. Then it was titrated against standard sodium hydroxide solution (0. IN). The end point showed colorless to pink color and was persisted about 15 seconds (AOAC, 2004). Finally, the acidity of the sample was determined by the following equation:

$$\text{Titrable acidity (\%)} = \frac{\text{T} \times \text{N} \times \text{E} \times \text{V1}}{\text{W} \times \text{V2} \times 1000} \times 100$$

Where,

T= Titrate value

N- Normality of NaOH

E= Equivalent weight of acid

V_1= Volume made tip

V_2=Volume of the sample taken for titration

W= weight of sample.

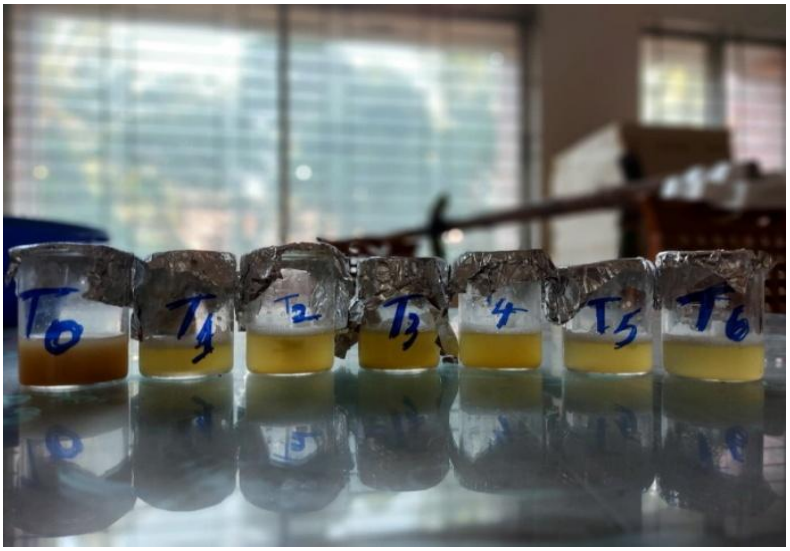


Plate 9. Five (5) g sample pissed and extract juice

vi. Reducing sugar

200 mg sample was pissed with 5 ml distill water, filtrated its and transferred into a test tube. By using pipette transferred 2 ml sample solution in another test tube, add 0.4 ml phenol and 2ml H_2SO_4 and mixed thoroughly. After sometimes put the sample solution in the spectrophotometer cube and measurement the absorbance of the sample solution at 540 nm wave length. Before doing so, taking distilled water in a cube and neutral the value. After getting the absorbance unknown concentration of the reducing sugar of the sample was measured by standard curve graph formula, y= mx + b. Where absorbance, the dependent variable, is placed on the y-axis and concentration, the independent variable is graphed on the x-axis. m is the slope of the line and b is the y-intercept. By plotting the information, we can get the reducing sugar concentration of the samples (Plate 10)

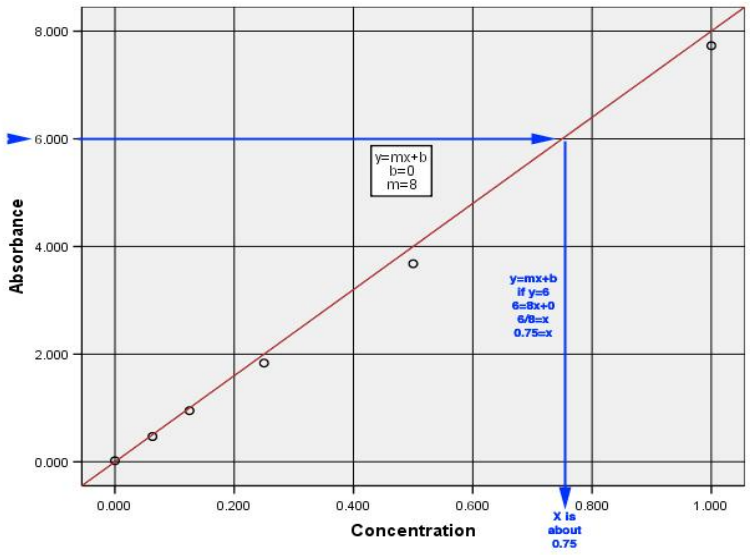


Plate 10. Reducing sugar estimation using standard curve spectrophotometer absorbance.

vii. β-Carotene content

β-carotene in fresh cut pineapple was determine according to the method of (Nagata and Yamashita, 1992). One gram of pineapple was mixed with 10 ml of acetone: hexane mixture (4:6) and vortex for 5 minutes. The mixture was filtered and absorbance was measured at 453nm,505nm and 663nm wave length. The calculation was done by following method:

β-Carotene (mg/100 g)= 0.216×A663 nm-0.304× A505nm+ 0.452× A453nm

viii. Determination of total viable bacteria

For total viable count of microorganism present in the samples (Fresh cut pineapples). Standard pour plate method was followed according to the method described in" Recommended method for the microbiological examination of food" (M.A.Ali. 2008).

Preparation of media

Ingredients Amount requirement

Peptone	2.5 gm
Agar	9 gm
Beef extract	1.5 gm
Sodium chloride (NaCl)	1 gm
Distilled water	500 ml

All necessary ingredients were measured with the help of electric balance and taken them in a conical flask and mixed thoroughly. The conical flask was heated for proper mixing. In the time of heating, the mixture was rotating with the glass rod. When the mixture was properly mixed, the mouth of the conical flask was blocked with cotton plug and covered with aluminum foil. Then the conical flask with media was placed in autoclave for sterilization (Temperature: 121^{0c}, Pressure: L 5 lb/inch^2 and time: 15 mins).

Preparation of dilution blank

In order to dilute the sample consecutively 1 ml of the original sample was diluted step wise through its series of tubes containing 9 ml of distilled water. At first 9ml of the distilled waterwas taken in a sterile test tube and then lml of the original sample was taken to the first test tube with a sterile pipette. Water with the sample was vigorously shaken for homogenous distribution of the bacterial population in the solution. This tube was denoted as "T". From the tube "T^{-1}" another 1 ml aliquot was transferred to the second tube and this tube was denoted as "T^{-2}. In this way T^{-3}, T^{-4},T^{-5}, T^{-6},$T^{-7}$and $T^{-8}$was prepared until the desired dilution is achieved. Now the tube "T^{-1}" has got the dilution 10^{-1},10^{-2},10^{-3},10^{-4},10^{-5},10^{-6},10^{-7} and 10^{-8}respectively. This procedure was repeated again for each sample.

Procedure of plating

Now from the test-tube T^{-8} 0.1 ml of the sample solution was taken in a sterile Petri dish containing 9.9 m1 of agar medium. The agar with bacterial sample was mixed by rotating theperi dish. This Petri dish was marked as "A". In this way "B", "C". "D", "E". "F" G" marked Petri dishes were prepared from T^{-8} tubes of various sample dilution respectively. Then these petri-dishes were placed on a level surface for few minutes for solidifying the agar medium.

Incubation and Bacteria colony counting

After solidification, Petri dishes were placed in the incubator at 36°C for 24 hours, the over loaded Petri dishes were avoided and the petri dishes containing countable colony were selected (Plate 11). Colonies were counted with the aid of a magnifying glass and finally the total number of bacteria per gram of sample was calculated by the following equation:

Colony count (per ml)= Number of colonies (per plate) x Reciprocal of the dilution (That is 10^{-8})

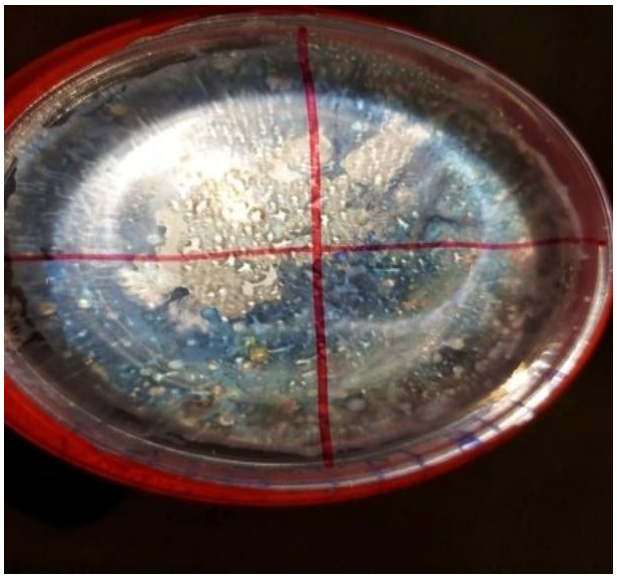


Plate 11. Bacteria colony formation

ix. Sensory evaluation

At least ten people formed the consumer test panel. Panelists were asked to evaluate the samples by visual inspection of color, odor, texture, and overall quality for days 1st, 2nd and 3rd days of storage at 4 ºC. Panelists scored the samples using a nine-point hedonic scale, where a score of 1 represents attributes most disliked and a score of 9 represents attributes most liked. The panelists evaluated one randomized sample per each treatment (7 samples in total). One sample was assigned as the control (uncoated) and the other samples were treated with chemical preservatives at various concentrations(Plate 12). Scores higher or equal to 5 were considered acceptable.

Plate 12. Sensory evaluation

3.15 Statistical Analysis

Data obtained for different parameters were statistically analyzed to observe the significant difference among the treatment. The data were analyzed using ANOVA technique with the help of computer package programme “Statistic 10 software” and mean difference among the treatments were adjudged with Least Significant Difference (LSD) as described by Gomez and Gomez (1984). Drawings were made by using Excel software.

CHAPTER IV

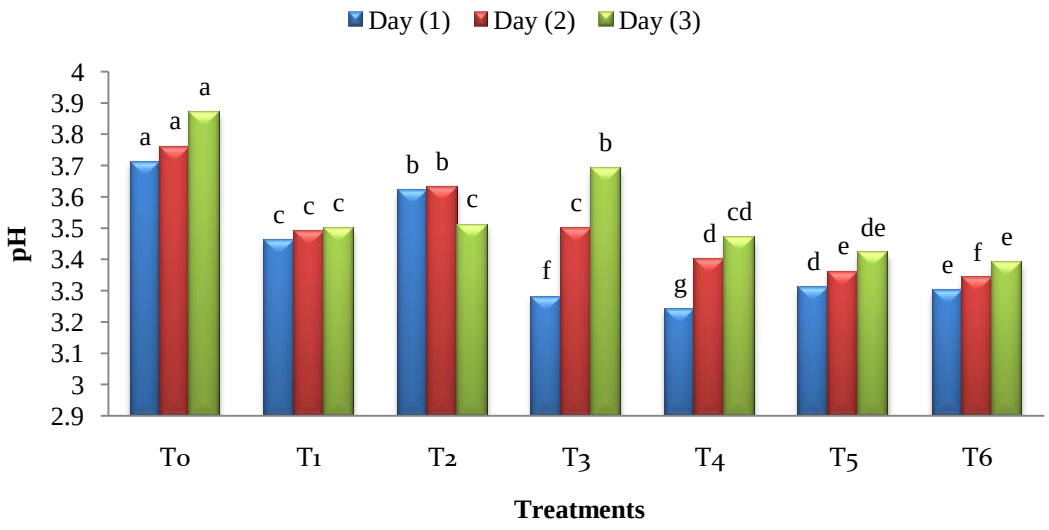
RESULTS AND DISCUSSION

Results obtained from the present study have been presented and discussed in this chapter with a view to study the quality analysis and preservation technique of fresh cut fruits which were sold by street vendors of Dhaka city. The data are given in different tables and figures. The results have been discussed, and possible interpretations are given under the following headings.

4.1 Quality analysis of fresh cut fruit (Pineapple)

4.1.1 pH

Effectiveness of preservative is dependent on pH of the product and pH is also one of the factors that determine the growth and survival of microorganisms during processing and storage. The pH of most fruit juice ranges between 6 and 7, which is a low level of acidity. The exception to this is pineapple juice, pH ranges between 3 and 4 which is due to reason that pineapples are highly acidic. Significant variation was observed in pH of fresh cut fruit due to the effect of different preservatives that applied on fresh cut fruit (Figure 1). In this experiment pH ranges between 3.7-3.90 in control and 3.30-3.70 in different treatment from 1 to 3 days storage condition. Experiment result revealed that the maximum pH (3.71, 3.76 and 3.87) at 1^{st}, $2^{nd}$and 3^{rd}days respectively was recorded in T_0 treatment. While minimum pH (3.24) was recorded in T_4treatmentat1^{st} day storage condition. At $2^{nd}$and 3^{rd} day storage condition minimum pH (3.34 and 3.39) was recorded in T_6 treatment which was statistically similar with T_5 (pH 3.42) treatment at 3^{rd} day storage condition. The decrease or increase in pH during storage would also be attributed to the effect of preservatives. During fermentation, pH usually decreases but it increases after a period. This is due to microorganisms consumed the nutrients and produced organic acids released into the medium, thus pH decreased. After the period, microorganisms face the lack of nutrients and begin to consume the organic acids as the nutrients sources, thus pH increased. According to Schmidl and Labuza (2000) pH is dependent on the total quantity of acids as well as the strength of the acids present.



Here, T_0: Control. T_1: 0.5% Ascorbic acid, T_2: 1 % Ascorbic acid, T_3: 0.5 % Citric acid, T_4: 1 % Citric acid, T_5: 1 % calcium chloride and T_6: 2 % calcium chloride.

Figure 1. Effect of food preservatives on pH measuring of fresh cut pineapple at different days on storage condition

4.1.2 Total Soluble Solid (TSS)

Total soluble solid mean, Amount of total soluble solid present in the unit volume of solution. Significant variation was recorded in total soluble solid of fresh cut fruit due to the effect of different preservatives that applied on fresh cut fruit (Table1). Total soluble solid ranges from 7 -10 °Brix in control and 9-13 °Brix in different treatment from 1 to 3 days storage condition. Experiment result revealed that the maximum total soluble solid (12.10, 12.30 and 13.00°Brix) was recorded in T_6 treatment at 1-3days storage condition. While the minimum total soluble solid (9.60, 8.13 and 7.00°Brix) was observed in T_0 treatment. This finding showed that the selected preservatives used in this study, could inhibit the fermentation activities of colonizing microorganisms in fresh cut fruit. Increase in soluble total solids may be due to break down of polysaccharides into monosaccharide and oligosaccharides while decrease may be due to fermentation of sugars into ethyl alcohol, carbon dioxide and water. Ediriweera *et al.* (2012) reported that TSS ranged between 11.50-14.88^{o}Brix in during the 7- day storage period. Beaulieu and Gorny (2001) also opened that the soluble solid content (SSC) can change (decrease orincrease) during storage of fresh-cut fruit. The SSC content generally correlates with sweetness, flesh taste and flavour, which are very important characteristics for fresh-cut quality.

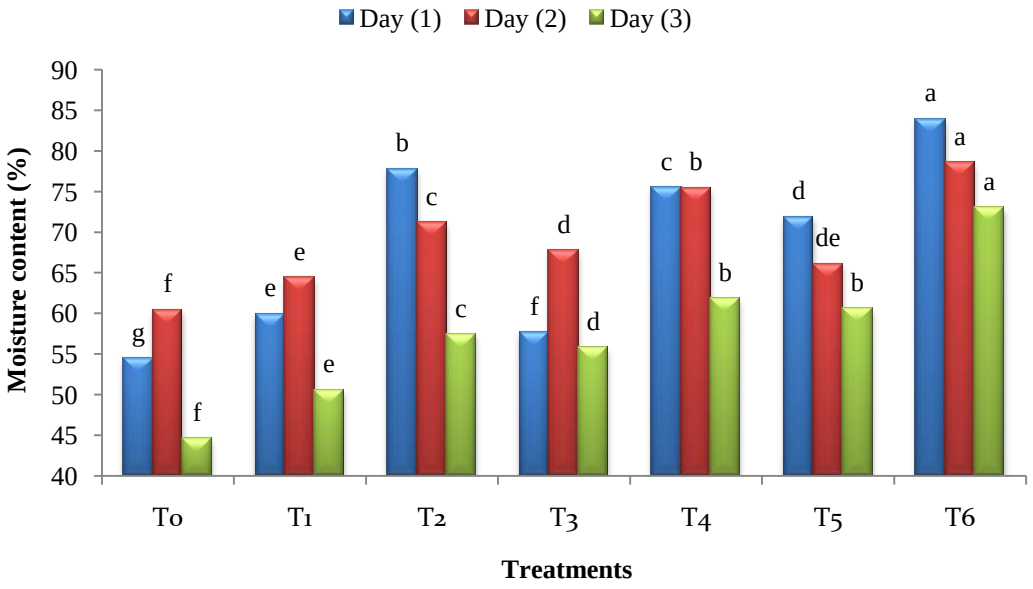
Table 1. Effect of food preservatives on total soluble solid (TSS) content of fresh cut pineapple at different days on storage condition

Treatments	TSS (Pineapple) °Brix		
	Day (1)	Day (2)	Day (3)
T_0	9.60 e	8.13 f	7.00 f
T_1	11.40 b	12.10 b	12.10 c
T_2	9.800 d	10.80 e	11.07 e
T_3	11.43 b	12.00 c	11.90 d
T_4	11.10 c	12.00 c	12.07 c
T_5	11.20 c	11.80 d	12.40 b
T_6	12.10 a	12.30 a	13.00 a
$LSD_{(0.01)}$	0.13	0.02	0.13
CV %	0.69	0.10	0.67

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.01% level of probability. T_0: Control. T_1: 0.5% Ascorbic acid, T_2: 1 % Ascorbic acid, T_3: 0.5 % Citric acid, T_4: 1 % Citric acid, T_5: 1 % calcium chloride and T_6: 2 % calcium chloride.

4.1.3 Moisture content

Moisture content is the quantity of water contained in a food material and also a fact that helps to explain the refreshing character of the food. Moisture content showed significant variation due to effect of different preservatives on fresh cut fruits (Figure 2). In this experiment moisture content ranges between (54-44%) in control treatment and (84-50%) in treated treatment from 1 to 3 days storage condition. From the experiment result revealed that the maximum moisture content (83.95%, 78.57% and 72.97 %) at 1^{st}, 2^{nd} and 3^{rd} days respectively was recorded in T_6 treatment while the minimum moisture content (54.43, 60.43 and 44.60) at 1^{st}, 2^{nd} and 3^{rd} days respectively was observed in T_0 treatment storage condition. Karim *et al*. (2008) reported that the percentage of moisture reduced from 82.41% of fresh pineapple to 80.53% by SO_2 solution while the 60% sucrose sample had a reduction to 81.70%. Ruhman *et al.* (1979) also found that fresh pineapple fruits contain 83.53% moisture and also mentioned that the moisture content of pineapple fruits slightly decreased with storage period.



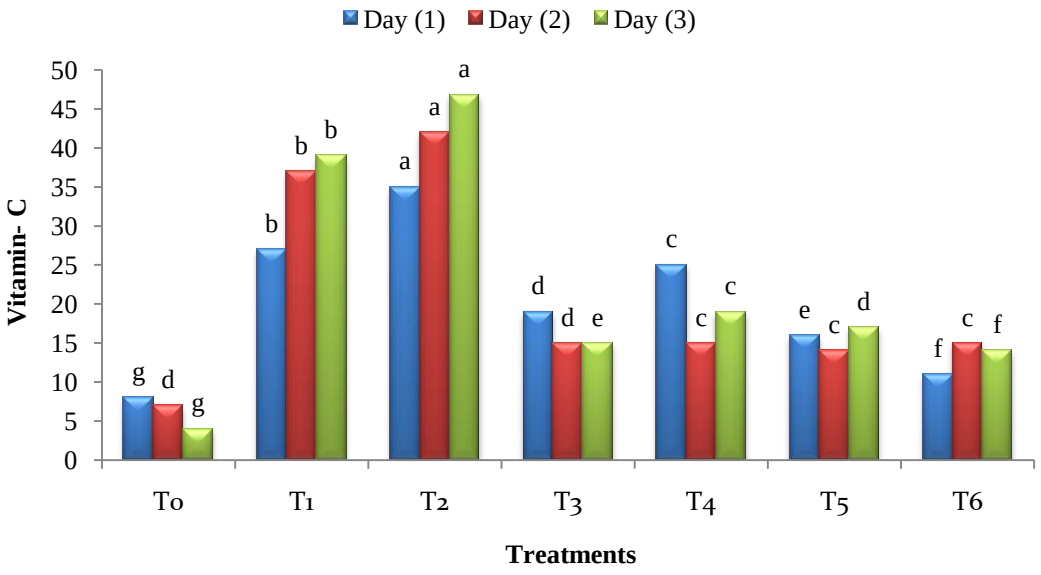
Here, T_0: Control. T_1: 0.5% Ascorbic acid, T_2: 1 % Ascorbic acid, T_3: 0.5 % Citric acid, T_4: 1 % Citric acid, T_5: 1 % calcium chloride and T_6: 2 % calcium chloride.

Figure 2. Effect of food preservatives on moisture content (%) of fresh cut pineapple at different days on storage condition

4.1.4 Vitamin-C

The stability of vitamin C in food products such as fresh cut fruits is influenced by a number of factors such as type of fruit, maturity state and storage condition etc.The three factors that lead to nutrient loss are heat, oxygen, and light. The interiors of uncut produce are protected from oxygen and light but exposed when cut. The nutrient that suffers the heaviest hit in cut fruits and vegetables is probably vitamin C. Vitamin C is carried by water, which is why it is easier for it to leak out in the fluids released after cutting or in water which may use to rinse the cut produce. Fresh cut fruits gradually loss vitamin C during storage condition (Figure 3). In this experiment vitamin C ranges between 8-4/100 mg in control treatment and 11-47/ 100 mg in treated treatments from 1 to 3 days storage condition. From the experiment result revealed that maximum vitamin C content (35.00, 42.00 and 46.80 mg at 1, 2 and 3 days respectively) was observed in T_2 treatment while the minimum (8.00, 7.00 and 4.00 mg at 1^{st}, 2^{nd} and 3^{rd} days respectively) was observed in T_o treatment. The increasing in vitamin C content in T_2 treatment is due to use of higher concentration of ascorbic acid as preservatives which effect on vitamin C content comparable to

others treated treatments. The result obtained from the present study was similar with the findings of Masamba and Mndalira (2013) who reported that the use of different pre-treatments had decreased the vitamin C degradation. Barrett *et al.* 2010 observed that during storage of fresh-cut fruit little change occurs in the dietary fiber and mineral content, but the vitamins are lost Cutting stimulates ethylene production which in turn increases respiration and senescence leading to even more rapid loss of certain vitamins. Vitamin C content decreased in most fruit during storage. Gil *et al.* (2006) observed that losses in vitamin C after 6 days at 5 °C were less 10% in pineapple pieces. Pineapples lost at 25% after 6 days at 5 °C storage condition. The main cause of loss of vitamin C is the action of the enzyme ascorbate oxidase.



Here, T_0: Control. T_1: 0.5% Ascorbic acid, T_2: 1 % Ascorbic acid, T_3: 0.5 % Citric acid, T_4: 1 % Citric acid, T_5: 1 % calcium chloride and T_6: 2 % calcium chloride.

Figure 3. Effect of food preservatives on Vitamin-C (mg/100g) content of fresh cut pineapple at different days on storage condition

4.1.5 Titratable acidity (%)

Titratable acidity deals with measurement of the total acid concentration contained within a food. In this experiment titratable acidity ranges between 1-2 % in control and 0.30-0.80 % in treated treatments from 1 to 3 days respectively (Table 2). From the experiment result revealed that the maximum titratable acidity (1.79, 1.02 and 0.89 %) at 1^{st}, 2^{nd} and 3^{rd} days respectively was observed in T_0 treatment. While the minimum titratable acidity (0.45, 0.35 and 0.32 %) at 1^{st}, 2^{nd} and 3^{rd} days respectively was recorded in T_6 treatment. An acid is a substance that donates hydrogen ions. Since acidity is the amount of hydronium ions present in a solution, pH is the logarithmic value of inverse of acidity. Higher the pH value is, lower the acidity of a system. Lower the pH value, higher the Acidity of a system. The decrease or increase in pH during storage would also be attributed to the presence of preservatives. pH also usually decreases due to fermentation process increasing. This helps microorganisms to consumed the nutrients and produced organic acids released into the medium, thus pH decreased which causes increasing the acidity of a system. After the period, microorganisms face the lack of nutrients and begin to consume the organic acids as the nutrient's sources, thus pH increased. Hussain *et al.* (2008) noticed that the increase in acidity might be attributed due to the increase in the concentration of powerless ionized acid and their salts during storage. Another reason for the rise in acidity might be due to the acid formation, reducing sugars oxidation and polysaccharide degradation or by the breakdown of uronic acid and pectin substances. Gil *et al.* (2006) reported that the TA of whole pineapple did not change until day 6. Kulkarni and Aradhya (2005) reported that the acid content are the factors influencing consumption quality. Germain *et al* (2003). reported that the acidity of the fruit samples also tends to increase due to the addition of chemical preservatives.

Table 2. Effect of food preservatives on titrable acidity (%) of fresh cut pineapple at different days on storage condition

Treatments	Titratable acidity (%)		
	Day (1)	Day (2)	Day (3)
T_0	1.79 a	1.02 a	0.89 a
T_1	0.77 b	0.54 b	0.35 f
T_2	0.58 c	0.51 c	0.45 c
T_3	0.54 d	0.45 d	0.40 d
T_4	0.51 e	0.51 c	0.47 b
T_5	0.58 c	0.38 e	0.38 e
T_6	0.45 f	0.35 f	0.32 g
$LSD_{(0.01)}$	0.02	0.03	0.02
CV %	1.52	2.81	2.43

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.01% level of probability T_0: Control. T_1: 0.5% Ascorbic acid, T_2: 1 % Ascorbic acid, T_3: 0.5 % Citric acid, T_4: 1 % Citric acid, T_5: 1 % calcium chloride and T_6: 2 % calcium chloride.

4.1.6 β-Carotene content

Beta carotene is a red-orange pigment found in plants and fruits, especially carrots and colorful fruits. Significant variation was observed in β-carotene content due to the effect of different preservatives applied on fresh cut fruits (Table 3). From the experiment result revealed that the maximum β-carotene content (0.96 mg, 0.91 mg and 0.77 mg at 1^{st}, $2^{nd}$and 3^{rd}days respectively) was observed in T_0 treatment. While the minimum β-carotene content (0.43 mg, 0.35 mg and 0.30 mg) was observed in T_6treatment at 1^{st}, 2^{nd} and 3^{rd} days storage condition. The changes of β-carotene content might be due to the effect of preservatives or storage condition that impact on β-carotene content of fresh cut fruits comparable to control treatment. Gil *et al* (2006) reported that the cut induced losses of antioxidant carotenoids (0-25%) during 9 days storage in air at 5 °C. Gortner and Singleton (1961) also reported that any post-harvest handling of the fruit that causes bruising of the tissue will lead to pigment isomerization in the damaged areas. After postharvest storage, for another seven days (21 day), total carotenoid levels dropped by 17% to 359 µg/100 g of FW. This decline

may be attributed to the isomerization and degradation of carotenoids caused by the release of acids from bruised cells but also to enzymatic reactions.

Table 3. Effect of food preservatives on β-Carotene content of fresh cut pineapple at different days on storage condition

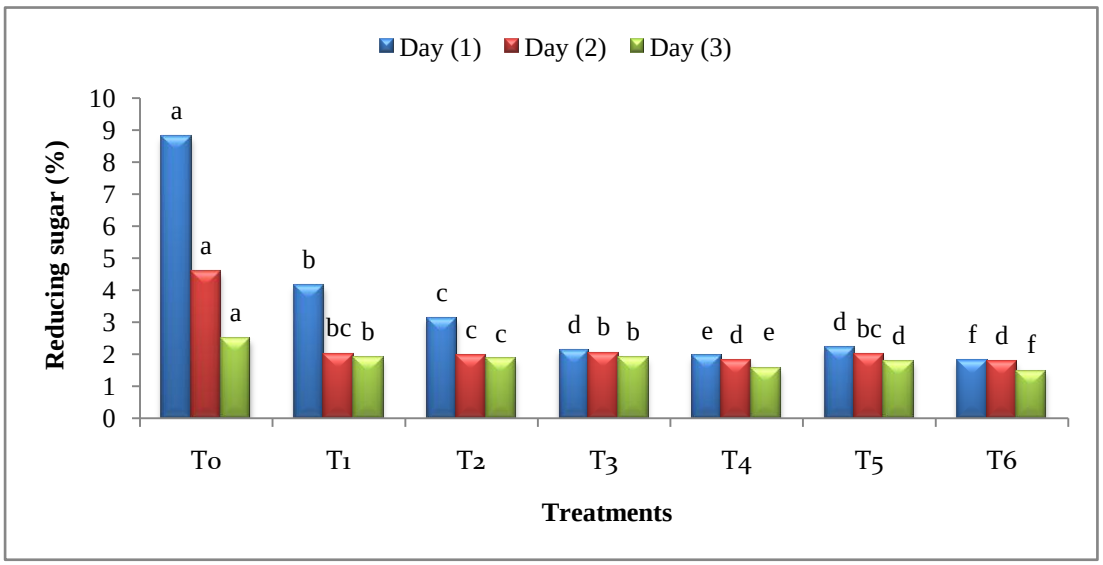
Treatments	β-Carotene content		
	Day (1)	Day (2)	Day (3)
T_0	0.96 a	0.91 a	0.77 a
T_1	0.66 b	0.47 c	0.45 b
T_2	0.46 e	0.40 e	0.37 c
T_3	0.46 e	0.39 e	0.37 c
T_4	0.50 d	0.43 d	0.34 d
T_5	0.58 c	0.56 b	0.36 c
T_6	0.43 f	0.35 f	0.30 e
$LSD_{(0.01)}$	0.01	0.02	0.01
CV %	1.96	2.25	1.76

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.01% level of probability. Here,T_0: Control. T_1: 0.5% Ascorbic acid, T_2: 1 % Ascorbic acid, T_3: 0.5 % Citric acid, T_4: 1 % Citric acid, T_5: 1 % calcium chloride and T_6: 2 % calcium chloride.

4.1.7 Reducing sugar

Significant variation was observed in reducing sugar content due to different preservatives applied on fresh cut fruits (Figure 4). From the experiment result revealed that the maximum reducing sugar (8.81%, 4.58% and 2.49% at 1st, 2nd and 3rddays respectively) was recorded in T_0 treatment while minimum reducing sugar (1.80%, 1.77% and 1.48 %) at 1st, 2nd and 3rd days respectively was observed in T_6 treatment which was statistically similar with (1.81 %) at 2nd day respectively with T_4 treatment. The slower reduction of reducing sugar during storage might be due to effect of preservatives or complex carbohydrates like hemicelluloses and other saccharides into simple soluble sugars might be responsible for this change. On the others hand decreasing reducing sugar due to increasing of fermentation process. Choonut *et al.* (2014) suggested that the highest level of reducing sugar (40.10±3.98

g/L) was observed from phosphoric acid treatment with water bath (100 ^{o}C, 240 min), followed by hot water treatment (34.03±1.30 g/L).



Here, T_0: Control. T_1: 0.5% Ascorbic acid, T_2: 1 % Ascorbic acid, T_3: 0.5 % Citric acid, T_4: 1 % Citric acid, T_5: 1 % calcium chloride and T_6: 2 % calcium chloride.

Figure 4. Effect of food preservatives on reducing sugar (%) content of fresh cut pineapple at different days on storage condition

4.1.8 Antimicrobial effect

Preservative food additives can be antimicrobial. These inhibit the growth of bacteria or fungi, including mold, or antioxidant, such as oxygen absorbers, which inhibit the oxidation of food constituents. Significant variation was observed on microbial content due to different preservatives applied on fresh cut fruits (Figure 5). From the experiment result revealed that the maximum microbial content (34.70, 37.30 and 44.70CFU/ml)at 1st, 2nd and 3rd days respectively was observed in T_0 treatment which was statistically similar with T_2 (44.30CFU/ml) treatment at 3 days storage condition. While the minimum microbial content (28.70, 31.00 and 32.00CFU/ml) at 1st, 2nd and 3rd days respectively was observed in T_6 treatment which was statistically similar with T_4 (32.30CFU/ml) treatment at 3 days storage condition. Lianou *et al.* (2012) opined that the antimicrobial effect of weak organic acids is related to the cytoplasm acidification, osmotic stress, disruption of proton motive force, and synthesis inhibition of macromolecules. Weak organic acids are more effective for bacteria than for yeasts and molds because of the low pH (2.1–2.7) of the applied solutions. Citric,

acetic, lactic, and ascorbic acids are the most common acids applied in the food industry. Mohammed and Wickham (2005) found that the combined treatment of 300ppm AA + 200 ppm 4-hexylresorcinol (4-HR) on pineapple was most effective in the inhibition of browning and microbial spoilage during storage. The results of microbiological analyses show the effectiveness of the edible preservatives as a carrier of an antimicrobial compound that helps to control microbial growth, thus extending the shelf-life.

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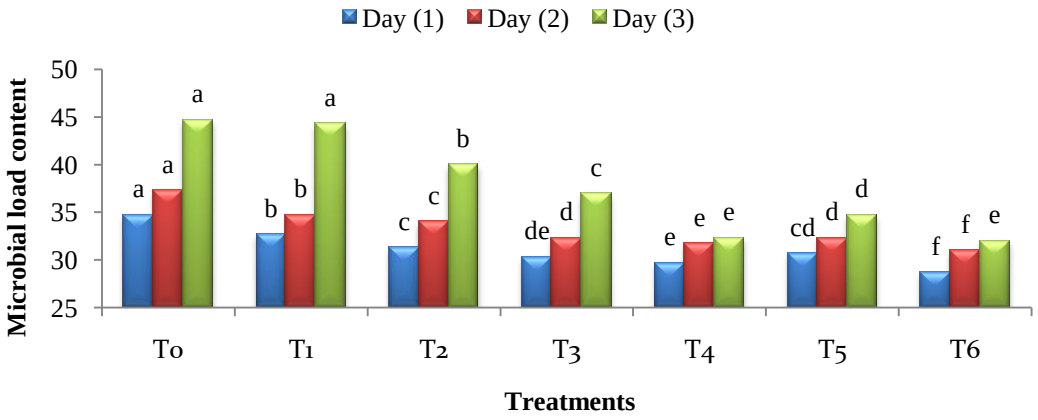


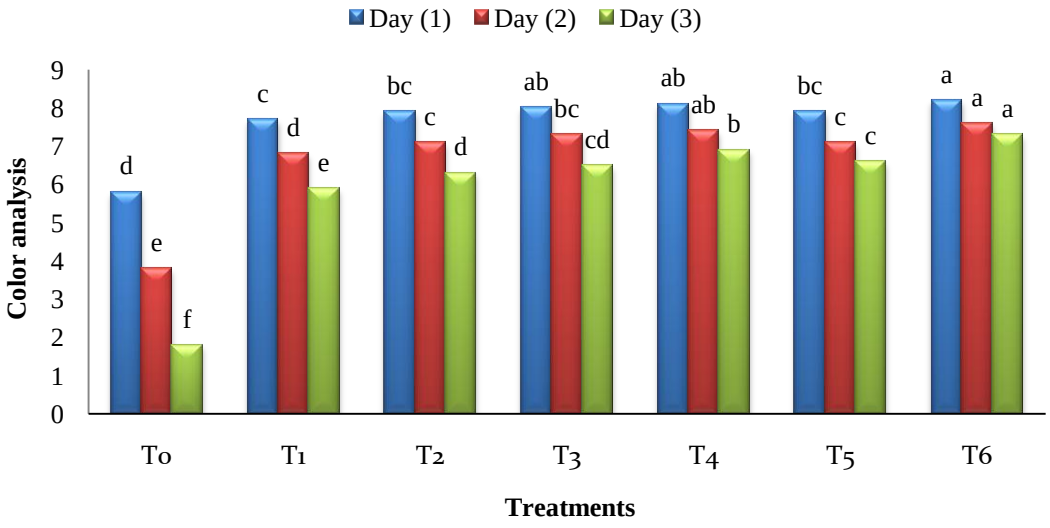
Here, T_0: Control. T_1: 0.5% Ascorbic acid, T_2: 1 % Ascorbic acid, T_3: 0.5 % Citric acid, T_4: 1 % Citric acid, T_5: 1 % calcium chloride and T_6: 2 % calcium chloride.

Figure 5. Effect of food preservatives on microbial load content of fresh cut pineapple at different days on storage condition

4.2 Sensory evaluation

4.2.1 Color analysis

Significant effect of Color analysis of fresh cut fruits was recorded due to effect of different preservatives (Figure 6). From the experiment result revealed that the maximum hedonic values for color analysis (8.20, 7.60 and 7.30 at 1, 2 and 3 days respectively) was observed in T_6 treatment at storage condition which was statistically similar with T_4 treatment (8.10 and 7.40) at 1st and 2nd days storage condition. While the minimum hedonic values for color analysis (5.80, 3.80 and 1.80) at 1st, 2nd and 3rd days respectively was observed in T_0 treatment at storage condition. Trindade *et al.* (2003) found similar results with the present study.

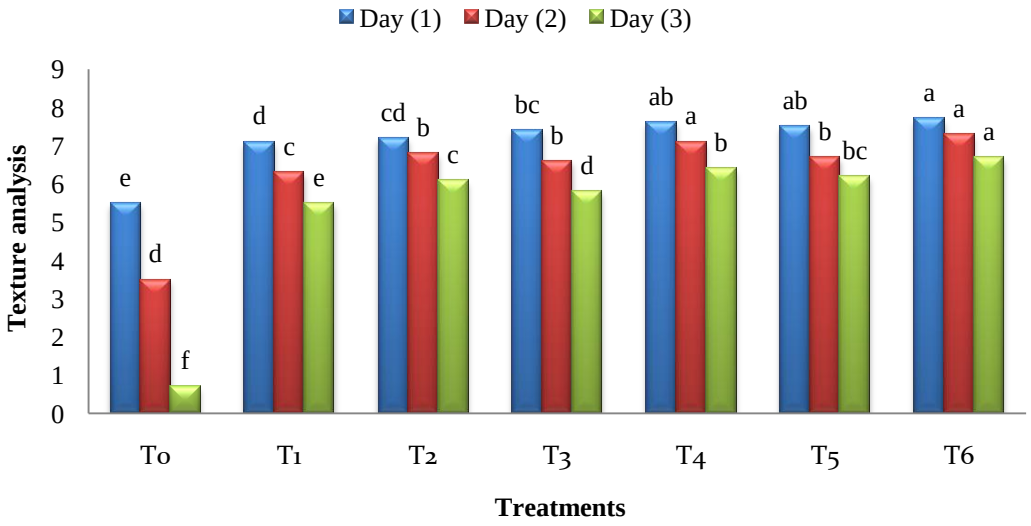


Here, T_0: Control. T_1: 0.5% Ascorbic acid, T_2: 1 % Ascorbic acid, T_3: 0.5 % Citric acid, T_4: 1 % Citric acid, T_5: 1 % calcium chloride and T_6: 2 % calcium chloride. Hedonic values: 1 = disliked extremely, 2 = disliked very much, 3 = disliked, 4 = disliked slightly, 5 = neither liked nor disliked, 6 = liked slightly, 7 = liked, 8 = liked very much, 9 = liked extremely.

Figure 6. Mean hedonic values consumers assigned for the color analysis of food preservatives treated pineapple at different days on storage condition

4.2.2 Texture analysis

Significant effect of texture analysis of fresh cut fruits was recorded due to effect of different preservatives (Figure 7). From the experiment result revealed that the maximum hedonic values for texture analysis (7.70, 7.30 and 6.70 at 1st, 2nd and 3rd days respectively was observed in T_6 treatment at storage condition which was statistically similar with T_4 treatment (7.60 and 7.10) at 2nd and 3rd days storage condition and with T_5 (7.50) treatment at 2nd day storage condition. While the minimum hedonic values for texture analysis (5.50, 3.50 and 0.70 at 1st, 2nd and 3rd days respectively) was observed in T_0 treatment at storage condition. Arias *et al.* (2009) opined that fresh-cut treatment of 'Blanquilla' pears with 1-MCP before cutting and peeling considerably improved their textural properties and color and allows fresh cut 'Blanquilla' pears to be sold up to about 5 day after processing. Ergun *et al.* (2007) reported that the physiology of fresh-cut 'Galia' (*Cucumis melo* var. reticulatus) from ripe fruit treated with 1-methylcyclopropene and demonstrated that 1-MCP treatment deferred loss of physical deterioration of fresh-cut 'Galia' cubes at 5°C by 2-3 d compared with controls

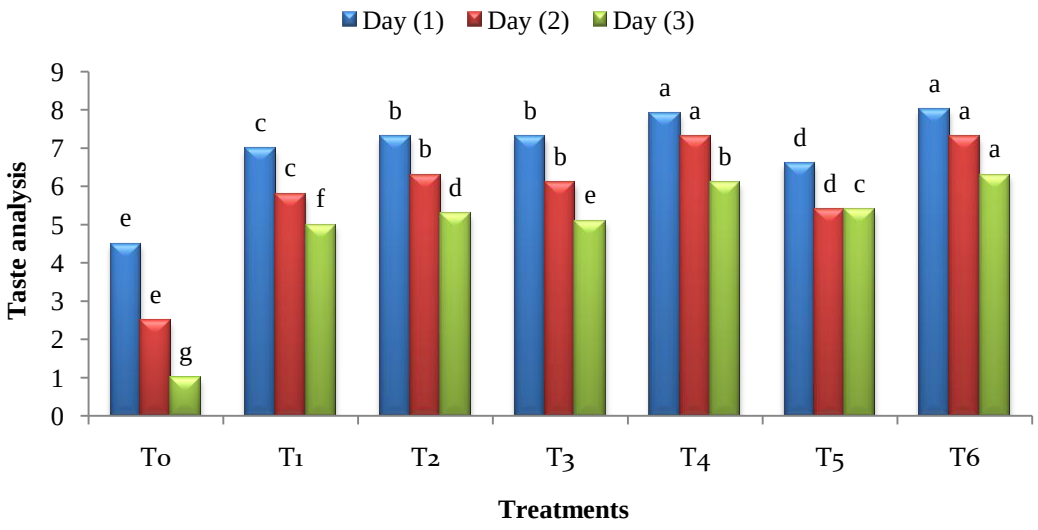


Here, T_0: Control. T_1: 0.5% Ascorbic acid, T_2: 1 % Ascorbic acid, T_3: 0.5 % Citric acid, T_4: 1 % Citric acid, T_5: 1 % calcium chloride and T_6: 2 % calcium chloride. Hedonic values: 1 = disliked extremely, 2 = disliked very much, 3 = disliked, 4 = disliked slightly, 5 = neither liked nor disliked, 6 = liked slightly, 7 = liked, 8 = liked very much, 9 = liked extremely.

Figure 7. Mean hedonic values consumers assigned for the texture analysis of food preservatives treated pineapple at different days on storage condition

4.2.3 Taste analysis

Significant effect of taste analysis of fresh cut fruits was recorded due to effect of different preservatives (Figure 8). From the experiment result revealed that the maximum hedonic values for taste analysis (8.00,7.30 and 6.30) at 1st, 2nd and 3rd days respectively was observed in T_6 treatment at storage condition which was statistically similar with T_4 treatment (7.90 and 7.30) at 1st and 2nd days storage condition. While the minimum hedonic values for taste analysis (4.50, 2.50 and 1.00) at 1st, 2nd and 3rd days respectively was recorded in T_0 treatment at storage condition.

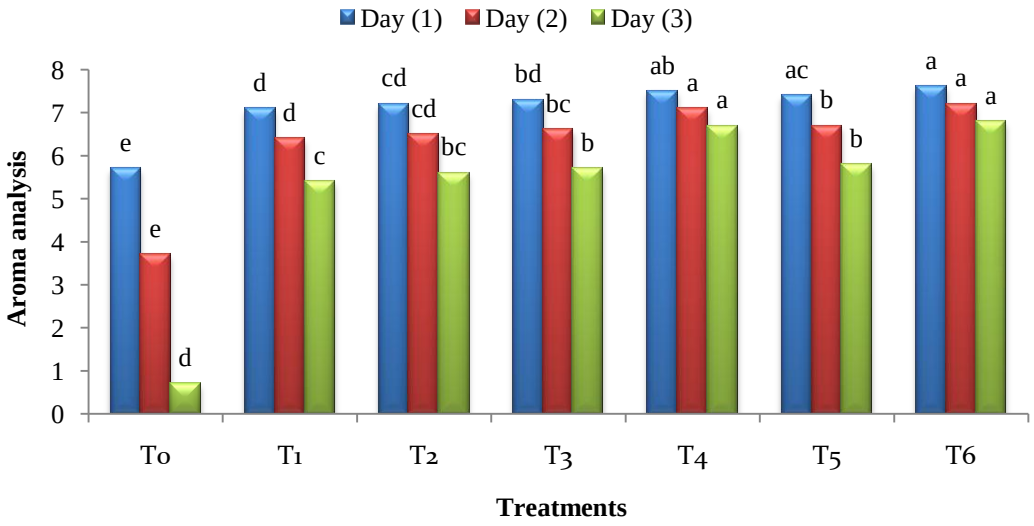


Here, T_0: Control. T_1: 0.5% Ascorbic acid, T_2: 1 % Ascorbic acid, T_3: 0.5 % Citric acid, T_4: 1 % Citric acid, T_5: 1 % calcium chloride and T_6: 2 % calcium chloride. Hedonic values: 1 = disliked extremely, 2 = disliked very much, 3 = disliked, 4 = disliked slightly, 5 = neither liked nor disliked, 6 = liked slightly, 7 = liked, 8 = liked very much, 9 = liked extremely.

Figure 8. Mean hedonic values consumers assigned for the taste analysis of food preservatives treated pineapple at different days on storage condition

4.2.4 Aroma analysis

Significant effect of aroma analysis of fresh cut fruits was observed due to effect of different preservatives (Figure 9). From the experiment result revealed that the maximum hedonic values for aroma analysis (7.60, 7.20 and 6.80) at 1st, 2nd and 3rd days respectively was observed in T_6 treatment at storage condition which was statistically similar with T_4 treatment (7.50, 7.10 and 6.70) at 1st, 2nd and 3rd days storage condition and with T_5 (7.40) treatment at 1st day storage condition. While the minimum hedonic values for aroma analysis (5.70, 3.70 and 0.70) at 1st, 2nd and 3rd days respectively) was observed in T_0 treatment at storage condition. Liu *et al* (2007) reported that Fresh-cut pineapples exhibited wet surface and off-flavour after storage at 4°C for 3 days, while the pretreatment and modified atmosphere packaging maintained the quality for up to 7 days.

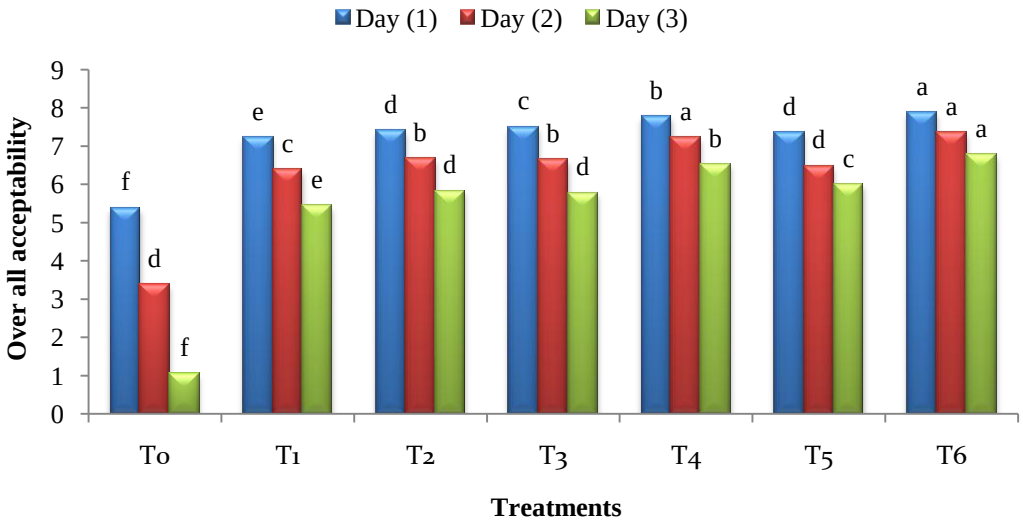


Here, T_0: Control. T_1: 0.5% Ascorbic acid, T_2: 1 % Ascorbic acid, T_3: 0.5 % Citric acid, T_4: 1 % Citric acid, T_5: 1 % calcium chloride and T_6: 2 % calcium chloride. Hedonic values: 1 = disliked extremely, 2 = disliked very much, 3 = disliked, 4 = disliked slightly, 5 = neither liked nor disliked, 6 = liked slightly, 7 = liked, 8 = liked very much, 9 = liked extremely.

Figure 9. Mean hedonic values consumers assigned for the aroma analysis of food preservatives treated pineapple at different days on storage condition

4.2.5 Overall acceptability

Significant effect of overall acceptability of fresh cut fruits was observed due to effect of different preservatives (Figure 10). From the experiment result revealed that the maximum hedonic values for overall acceptability (7.88, 7.35 and 6.78 at 1st, 2nd and 3rd days respectively) was observed in T_6 treatment at storage condition which was statistically similar with T_4 treatment (7.23) at 2nddaystorage condition. While the minimum hedonic values for overall acceptability (5.38, 3.38 and 1.05) at 1st, 2nd and 3rd days respectively was observed in T_0 treatment at storage condition. Gupta and Kumari (2015) reported that the most effective preservative for pineapple pack was citric acid (1%) providing a shelf- life of 5 days.



Here, T_0: Control. T_1: 0.5% Ascorbic acid, T_2: 1 % Ascorbic acid, T_3: 0.5 % Citric acid, T_4: 1 % Citric acid, T_5: 1 % calcium chloride and T_6: 2 % calcium chloride. Hedonic values: 1 = disliked extremely, 2 = disliked very much, 3 = disliked, 4 = disliked slightly, 5 = neither liked nor disliked, 6 = liked slightly, 7 = liked, 8 = liked very much, 9 = liked extremely.

Figure 10. Mean hedonic values consumers assigned for the overall acceptability of food preservatives treated pineapple at different days on storage condition

CHAPTER V

SUMMARY AND CONCLUSION

An experiment was conducted in the Horticultural Biotechnology and Stress Management Lab incentral laboratory of Sher-e-Bangla Agricultural University, Dhaka-1207, during the month of November-December 2020 to study the effect of different preservatives on quality analysis of fresh cut pineapple (*Ananas comosus*) fruit. The experiment consisted of single factors and was laid out in a Completely Randomized Design (CRD) with three replications. Factor-A (7) *viz*: T_0: Not treated. T_1 : Treated with 0.5% ascorbic acid solution, T_2 : Treated with 1.0% ascorbic acid solution, T_3 : Treated with 0.5% citric acid solution, T_4 : Treated with 1.0% citric acid solution, T_5 : Treated with 1.0% calcium chloride solution, T_6 : Treated with 2.0% calcium chloride solution. Data on different characters were recorded to find out the effective preservatives for fresh cut fruits preservation.

Different preservatives applied on fresh cut pineappleshowed significant variations in respect of most of the quality analysis characteristics of fresh cut pineapple in storage condition. From the experiment result revealed that the maximum maximum pH (3.71, 3.76 and 3.87) at 1, 2 and 3 days respectively was recorded in T_0treatmentatstorage condition. The maximum total soluble solid (12.10, 12.30 and 13.00) °Brix was observed in T_6 treatment at 1-3days storage condition. The maximum moisture content (83.95%, 78.57% and 72.97%) at 1^{st}, 2^{nd} and 3^{rd} days respectively was observed in T_6 treatment at storage condition. The maximum vitamin C content (35.00, 42.00 and 46.80 mg) at 1^{st}, 2^{nd} and 3^{rd}daysrespectively was recorded in T_2 treatment at storage condition. The maximum titratable acidity (1.79, 1.02 and 0.89 %),β-carotene content (0.96, 0.91 and 0.77 mg),reducing sugar (8.81, 4.58 and 2.49 %), microbial content (34.70, 37.30 and 44.70CFU/ml)were recorded in T_0at 1^{st}, 2^{nd} and 3^{rd} days respectively. The maximum hedonic values for color analysis (8.20, 7.60 and 7.30), texture analysis (8.20, 7.60 and 7.30),taste analysis (8.00,7.30 and 6.30), aroma analysis (7.60, 7.20 and 6.80) and overall acceptability (7.88, 7.35 and 6.78) at 1^{st}, 2^{nd} and 3^{rd} days respectively were observed in T_6 treatment at storage condition. While the pH (3.24) was observed in T_4treatmentat 1^{st} day storage condition. At 2^{nd} and 3^{rd} day storage condition minimum pH (3.34 and 3.39) was recorded in T_6treatment.The minimum total soluble solid (9.60, 8.13 and 7.00°Brix)

was recorded in T_0treatment.The minimum moisture content (54.43, 60.43 and 44.60), vitamin C (8.00, 7.00 and 4.00 mg) were recorded in T_0 treatment at storage condition at 1st, 2nd and 3rd days respectively. The minimum titratable acidity (0.45, 0.35 and 0.32 %), β-carotene content (0.43, 0.35 and 0.30 mg), reducing sugar (1.80, 1.77 and 1.48 %) and microbial content (28.70, 31.00 and 32.00CFU/ml) were recorded in T_6treatmentatstorage condition at 1st, 2nd and 3rd days respectively. The minimum hedonic values for color analysis (5.80, 3.80 and 1.80), texture analysis (5.80, 3.80 and 1.80), taste analysis (4.50, 2.50 and 1.00), aroma analysis (5.70, 3.70 and 0.70) and overall acceptability (5.38, 3.38 and 1.05) at 1st, 2nd and 3rd days respectively were observed in T_0 treatment at storage condition.

Conclusion

- The presence of the edible preservatives affect the pH and ºBrix , vitamin-C, titratable acidity (%),β-Carotene content, and reducing sugar of fresh-cut pineapple during storage. Moreover, moisture content retention was enhanced during storage time due to the application of the different preservatives. Treated samples retained moisture, which translated into less juice leakage.
- A consumer acceptance test using five panelists confirmed that consumers can accept the presence of the edible preservatives on the fresh-cut fruit as long as the color, odor and flavor parameters are not affected by it. The flavor of 2.0% calcium chloride solution based treated samples was acceptable to panelists up to day 3, when the control sample began to show signs of deterioration.
- Microbiological analyses demonstrated the effectiveness of the preservatives as a carrier of antimicrobial compounds and the effectiveness of this compound against microbial growth as well.
- The best formulation of the edible preservative in terms of the preservation of quality attributes of fresh-cut pineapple is 2.0% calcium chloride solution This particular treatment showed to be an effective alternative to maintain pineapple original quality and to preserve it for longer (3 days), making the shelf-life extension a fact.

Recommendation

2.0% calcium chloride solution can be used as effective preservatives for the preservation of fresh cut fruits (pineapple) in 4 ^{0}C storage condition of Bangladesh.

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APPENDICES

Appendix I. Map showing the experimental location under study

Appendix II. Analysis of variance of the data of total soluble solid (TSS) content of fresh cut pineapple at different days

Mean square at				
Source	**DF**	Day (1)	Day (2)	Day (3)
Treatment	6	2.49267**	2.49267**	12.1041**
Error	14	0.00571	0.00571	0.0057
Total	20			

**: Significant at 1% level of probability

Appendix III. Analysis of variance of the data of pH measuring of fresh cut pineapple at different days

Mean square at				
Source	**DF**	Day (1)	Day (2)	Day (3)
Treatment	6	0.10207**	0.06987**	0.08750**
Error	14	0.00001	0.00013	0.00143
Total	20			

**: Significant at 1% level of probability

Appendix IV. Analysis of variance of the data of titrable acidity (%) of fresh cut pineapple at different days

Mean square at				
Source	**DF**	Day (1)	Day (2)	Day (3)
Treatment	6	0.66569**	0.15097**	0.11329**
Error	14	0.00013	0.00023	0.00013
Total	20			

**: Significant at 1% level of probability

Appendix V. Analysis of variance of the data of Vitamin-C (mg/100g) content of fresh cut pineapple at different days

Mean square at				
Source	**DF**	Day (1)	Day (2)	Day (3)
Treatment	6	270.429**	524.714**	687.474**
Error	14	0.286	0.321	0.143
Total	20			

**: Significant at 1% level of probability

Appendix VI. Analysis of variance of the data of reducing sugar (%) content of fresh cut pineapple at different days

Mean square at				
Source	**DF**	Day (1)	Day (2)	Day (3)
Treatment	6	18.8055**	3.03504**	0.32089**
Error	14	0.0024	0.00166	0.00036
Total	20			

**: Significant at 1% level of probability

Appendix VII. Analysis of variance of the data of β-Carotene content of fresh cut pineapple at different days

Mean square at				
Source	**DF**	Day (1)	Day (2)	Day (3)
Treatment	6	0.10424**	0.10819**	0.07214**
Error	14	0.00013	0.00013	0.00006
Total	20			

**: Significant at 1% level of probability

Appendix VIII. Analysis of variance of the data of moisture content (%) of fresh cut pineapple at different days

		Mean square at		
Source	**DF**	Day (1)	Day (2)	Day (3)
Treatment	6	387.133**	121.047**	242.055**
Error	14	0.143	0.571	0.286
Total	20			

**: Significant at 1% level of probability

Appendix IX. Analysis of variance of the data of microbial load content of fresh cut pineapple at different days

		Mean square at		
Source	**DF**	Day (1)	Day (2)	Day (3)
Treatment	6	12.0286**	14.1471**	84.4086**
Error	14	0.0700	0.0129	0.0271
Total	20			

**: Significant at 1% level of probability

Sensory data analysis

Appendix X. Analysis of variance of the data of taste of fresh cut pineapple at different days

		Mean square at		
Source	**DF**	Day (1)	Day (2)	Day (3)
Treatment	6	4.18857**	7.94429**	9.53429**
Error	14	0.00571	0.00893	0.00156
Total	20			

**: Significant at 1% level of probability

Appendix XI. Analysis of variance of the data of color of fresh cut pineapple at different days

		Mean square at		
Source	**DF**	Day (1)	Day (2)	Day (3)
Treatment	6	2.08857**	5.19714**	10.3900**
Error	14	0.00820	0.00766	0.0136
Total	20			

**: Significant at 1% level of probability

Appendix XII. Analysis of variance of the data of texture of fresh cut pineapple at different days

		Mean square at		
Source	**DF**	Day (1)	Day (2)	Day (3)
Treatment	6	1.70857**	4.98714**	13.0286**
Error	14	0.01201	0.00714	0.0132
Total	20			

**: Significant at 1% level of probability

Appendix XIII. Analysis of variance of the data of aroma of fresh cut pineapple at different days

		Mean square at		
Source	**DF**	Day (1)	Day (2)	Day (3)
Treatment	6	1.25429**	4.25429**	12.9286**
Error	14	0.00720	0.00594	0.0077
Total	20			

**: Significant at 1% level of probability

Appendix XIV. Analysis of variance of the data of overall acceptability of fresh cut pineapple at different days

Mean square at				
Source	**DF**	Day (1)	Day (2)	Day (3)
Treatment	6	2.13127**	5.40090**	11.3875**
Error	14	0.00097	0.00680	0.0023
Total	20			

**: Significant at 1% level of probability