EFFECT OF CHITOSAN COATING ON POSTHARVEST QUALITY AND SHELF LIFE OF DRAGON FRUITS (*Hylocereus spp.*) AT AMBIENT CONDITION

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A Thesis

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June, 2024

Dedicated to

My

Beloved Parents

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June, 2024 The Author

ABASTRACT

The study was carried out at Molecular Horticulture Laboratory of Agrotechnology Discipline, Khulna University, Khulna during November 2022 to April 2023 to investigate the effect of chitosan coating on postharvest quality and shelf life of dragon fruits at ambient condition. The experiment consisted of four treatments with three varieties of dragon fruits and laid out in a Completely Randomized Design with three replications for the treatments. The treatments were four levels of chitosan solution viz. T_1 = control, T_2 = 0.1%, T_3 = 0.3% and T_4 = 0.5% concentration and the three varieties of dragon fruits were V_1 = pink fleshed, V_2 = white fleshed and V_3 = yellow fleshed. There was significant difference in respect of all the physico-chemical parameters viz. weight loss, firmness, total soluble solids, titratable acidity, vitamin-C content, total flavonoid, antioxidant, total carotenoid content and shelf life. At 9 DAS, the highest firmness (3.07 N), TA (0.13%), Vit C (19.61 mg/100g), total flavonoid content (2.58 mg/100g), total carotenoid content (28 mg/100g) and antioxidant (67.50%) were observed in pink fleshed fruits coated by 0.5% chitosan coating and those were the lowest in white fleshed uncoated fruits. On the other hand, the lowest weight loss (3.2%) and TSS content (10.67) was found in pink fleshed 0.5% chitosan coated fruits and those were the highest in white fleshed uncoated fruits. It was revealed from the results of the experiment that pink fleshed dragon fruit coated with 0.5% chitosan solution performed better in respect of all desirable parameters studied. So, it could be concluded that pink fleshed dragon fruit with 0.5% chitosan solution may be suggested for storing dragon fruits at ambient condition.

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CONTENTS

CHAPTER I

INTRODUCTION

Dragon fruit (*Hylocereus* spp.) is an exotic fruit produced by epiphytic, night blooming *Hylocereus cactaceae* of tropical origin. Also known as pitaya, pitahaya, strawberry, pear and thang loy. Dragon fruits are oblong oval with bright red skin covered with green bracts or scales (Lobo et al., 2013; Paull, 2011). Dragon fruit has gained global attention due to its prominent vivid (pink and yellow) color, delicate flavor and nutritional value. The flesh is sweet, delicate, white or red-purple and contains numerous tiny black seeds. The fruit is non-climacteric and has the best flavor when harvested at full red color (Nerd et al.,1999). Dragon fruit is grown commercially in Israel, Vietnam, Taiwan, Nicaragua, Australia, Malaysia, Thailand, Philippines and the United States (Merten, 2003). Three species *H. undatus, H. costaricensis* and *H. megalanthus,* and their hybrids comprise most of the production in the world. Dragon fruit is enjoyed as a fresh fruit or juice and also be valued as a natural food color. Dragon fruit contains some substances that regulate blood sugar, asthma, chronic cough and high antioxidants which prevent free radicals, cancer cells of human body. Dragon fruit may helpful for eye health (Luu et al., 2021).

Postharvest loss of fruits and vegetables is one of the major problems for any country whose economy is based on agriculture. Because of the high moisture content horticultural crops like fruits and vegetables are highly perishable commodity that required much careful handling to minimize loss under tropical condition (Thumula, 2006).

Postharvest loss management is a major concern worldwide due to growing population and shrinking resources (e. g. land, water). Cultivation of dragon fruit has expanded greatly in developing countries like Bangladesh, but postharvest management strategies have remained largely the same. In peak season due to improper handling, packaging problems, transportation difficulties, unavailability of preservatives and marketing problems around 16-36% of fruit spoils in general (Kader and Saltveit, 2002). Previous researchers have claimed that in India every 1% reduction in loss will save 5 million tons of fruits per year (Saraswathi et al., 2018).

In Bangladesh huge quantity of dragon fruits are spoiled due to high temperature, humidity, inappropriate postharvest handling (Khatun et al., 2022). The spoilage of the fruit attributed to adverse physiological changes, namely loss of weight due to respiration and transpiration, loss of flesh hardness and loss of resistance to microbial attack. Such spoilage can occur either during transportation and in the market resulting considerable economic loss to farmers, importers and retailers (Rouf, 2012).

Moreover, there is no known technique to the growers/traders of Bangladesh, in particular to extend the shelf-life of dragon fruits. As a result, a considerable quantity of harvested dragon goes waste due to its perishable nature.

The major constraints in dragon fruit during storage is the short shelf life (Prashanth et al., 2022). It is due to several factors such as high respiration, weight loss and increased ripening process which causes shriveling of fruit after the eighth day of harvesting (Ali et al., 2013). In tropical region, the main factor which reduces the shelf life of fruit is high temperature, which results in high respiration of fruit, rapid ripening and thus early deterioration of fruit quality. The chemical composition of fruit during ripening changes the texture, flavour, titratable acidity and ascorbic acid content.

Many physical and chemical processes have been developed to preserve fresh fruits and vegetables. Among them edible coating is one of the most commonly used technique to improve appearance, delay ripening, reduce water loss and decay and extend shelf life but may also change flavour (Saucedo-Pomp et al., 2007). An edible film is defined as a thin layer of material which can be eaten by the consumer, may be applied on or within the food by wrapping, dipping, brushing or spraying and act as barriers against transmission of gases, vapors and solutes and provide mechanical protection (Wu et al., 2006). Coatings can be formulated from different components such as hydrocolloids (polysaccharides and proteins), lipids (waxes and resins) and synthetic polymers. These edible materials have different barrier properties against gases and physio-chemical and mechanical characteristics. Therefore, the most coating are made of more than one material with the addition of low molecular weight molecules including sorbitol, polyols or glycerol that serves as plasticizers (Olivas and Barbosa-Canovas, 2005).

Chitosan is a natural alkaline polysaccharide which extracted from shrimp shell and crab waste, has become one of the most popular edible film coating materials in recent years owing to its film forming properties, inherent antifungal properties, elicitation of phytoalexins, non-toxicity and superior biocompatibility. Chitosan is good for fresh-cut fruits and vegetables when it is in close contact with the tissue. As it forms semi permeable films, chitosan can modify the internal atmosphere (by altering the permeability to water, oxygen and carbondioxide), thereby decreasing the transpiration loss, reducing respiration rate and delay ripening in fruits, maintaining the quality of harvested fruits and reducing mold growth (Li and Yu, 2001).

Chitosan is widely used as a food additive and a suitable alternative to synthetic fungicides for treating postharvest fruits and vegetables (Romanazzi et al., 2009). The Chitosan coating against a wide variety of microorganisms including fungi, algae and some bacteria had been reported by Ahmed et al. (2014). Chitosan coating had been successfully applied to prolong storage life and control decay of many fruits (Shi et al., 2013). Chitosan as a natural and environmentally friendly compound is obtained from diacetylation of chitin (Khoshgozaran-Abras et al., 2012). Chitosan and its derivatives increase shelf life of a wide range of vegetables and fruits by inhibiting decay. Chitosan coating maintains fruit quality during storage by preventing the loss of fruit weight, soluble solid contents, vitamin C, titratable acidity, and firmness (Chandran, 2009; Romanazzi et al., 2003). Krishna et al. (2014) reported that chitosan treatment (10%) extended the shelf life of guava up to 7 days by delaying ripening and preventing physiological loss in weight. Chitosan formulated with cassava starch significantly preserved fruit weight, color, aroma and texture of mango and increased shelf life by decreasing the respiration rate without negative effect on the fruit ripening. Being able to extend shelf life and save dragon fruits from spoilage using chitosan might be helpful in overcoming existing postharvest management challenges in Bangladesh.

It is revealed from the discussion made above that the same work has been done on storage of dragon fruits using chitosan coating but no such works have been conducted in Bangladesh. So, the present study on effect of chitosan coating on postharvest quality and shelf life of dragon fruits (*Hylocereus spp.*) at ambient condition has been conducted with following objective.

i. To study the impact of chitosan coating on post-harvest quality and shelf life of dragon fruits.

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CHAPTER II

REVIEW OF LITERATURE

The literature available pertaining to the present study has been reviewed in this section.

Introduction

Dragon fruit (*Hylocereus polyrhizus)* is an exotic and nutritionally beneficial fruit which is commonly grown in Southeast Asia. Le Bellec et al. (2006) identified that the most common dragon fruit is the red dragon fruit (red flesh or crimson pulp). The *Hylocereus* genus, which has approximately 16 species, has the most economically grown varieties throughout of the world. Goenaga et al. (2020) reported that there is considerable variation in fruit shape and size among cultivars, ranging from nearly round to oblong and weighing between 70 and 680 g per fruit.

Perween et al. (2018) reported that dragon fruit contains up to 9 g of vitamin C per 100 g, which is the highest among the vitamins found in the fruit. Dragon fruit contains protein, carbohydrate, fat, vitamins A, B_1, B_2 and B_3, E, thiamine, niacin, betacyanin, and flavonoids as reported by Hashim (2018) and Anand and Sati (2013). According to Stintzing et al. (2002), dragon fruit color was most stable at pH 4.5. Additionally, betacyanin was rapidly destroyed at pH 7.0 and above. The fruits color was unaffected by pH changes in the range of 3.0 to 7.0. Fruits pH levels tend to rise as ripeness progressed. This happens as the concentration of organic acids in the fruit decreases and the concentration of soluble solids rises as the fruit ripens as indicated by Faridah et al. (2020). Anthocyanins are pigments that play a part in red coloration and have the potential to become natural food colors, as well as a healthier alternative to synthetic dyes. A rich source of anthocyanins in the red dragon fruit pulp, which has a deep purple color discovered by Santos and Meireles (2010). Moo-Huchin et al. (2014) reported that the 100g of flesh dragon fruit contains total flavonoids content of about 255 mg. The red color of the dragon fruit pulp is due to the presence of nitrogen-containing pigments called betalains.

Dragon fruit has a lot of vitamin C, which helps it have a lot of antioxidant capabilities and water-soluble fiber estimated by Jaafar et al. (2009). According to Nur et al. (2023) described that higher level of vitamin C contained in dragon fruit has a vital function in enhancing the immune system and stimulating the activity of other antioxidants in the body.

Tang et al. (2011) discovered that dragon fruit has a high pectin content. Fruit peel is a substantial source of pectin. It is also a food coloring agent and a basic material for the food coloring industry. The yield of pectin is usually determined by extraction parameters such as temperature, extraction time, pH and the types of extraction solvent as reported by Yeoh et al. (2008). Esquivel et al. (2007) investigated the role of phenolics in the antioxidant activities of purple-red dragon fruit juices and found that betalains were responsible for most of the antioxidant capacity, while non-betalainic phenolic compounds contributed the least. Both the red dragon fruit flesh and peel were high in polyphenols and antioxidants, with the peel having stronger antioxidant activity (Wu et al., 2006).

The factors of postharvest loss

Fruit postharvest physiology, shelf life and decay losses are all interconnected processes and fruit ripening involves different physiological, biochemical and developmental processes that occurred in a coordinated and genetically regulated manner (Stepanova and Alonso, 2005 and Etheridge et al., 2006). Barry and Giovannoni (2007) reported that dragon fruits were rapidly shriveling after harvest, reduced visual quality, storage life and marketability. According to Wall and Khan (2008), the main postharvest problems of the dragon fruits are mechanical injury, chilling injury, decay and water loss. Chandran (2009) stated that an appropriate postharvest handling approaches such as selecting the best storage and transportation conditions works perfectly to extend the shelf life of produce. He also informed that when compared to climacteric fruits, these fruits have slower metabolic rates. Lelievre et al. (1997) described that most non-climacteric fruit can only fully ripen if they are allowed to remain attached to the parent plant; if they are separated, they produce only basal levels of ethylene and even the fruits are not going in ripening stage. Dragon fruit is particularly perishable according to Paull and Duarte (2011), which necessitates extra care throughout harvesting, handling, storage, processing and transportation till market distribution. The rate of softening is the most important aspect in determining the texture of fruit crops (Brummell, 2006). Vicente et al. (2007) reported that inadequate softness aggravates injury from handling reduces the shelf life of fruits and makes them more susceptible to post-harvest infections. Post-harvest losses of fruits and vegetables account for about half of the yield in underdeveloped countries. Due to improper handling, packaging problems, transportation difficulties, unavailability of precooling facilities and marketing problems, around 16-36% of fruit spoils in general 35-40% of its production. As a result, to reduce rapid ripening-associated softening is the obvious target for extending fruits shelf life and reducing post-harvest losses (Seymour et al., 2002). The rate of respiration influences the storage life after harvest. The suggested storage temperature for dragon fruit is 10^0 C with a RH of 85-90% for 14-17 days (Nerd et al., 1999). Bachmann and Earles (2000) described that higher storage temperature increases the respiration rate of dragon fruit, which impacts on transit and postharvest life. Gaffney (1985) said that respiration rate directly related to temperature. They also informed that respiration inside the fruits tends to raise the temperature of the product, boosting the vapor pressure at the surface and promoting transpiration. Varoquaux and Ozdemir (2005) stated that the possible shelf life of plant tissue or plant part after harvest is directly related to its rate of respiration. Halachmy and Mannheim (1991) reported that during respiration the oxidation of carbohydrates creates carbon dioxide, water and heat in the body and the respiratory activity of a commodity affects its storage life. When a commodity is stored at low temperature then respiration rate lowered and senescence prevented so it gets long storage life (Kader and Saltveit, 2002).

Effect of chitosan coating

Chitosan is an organic polysaccharide derived by deacetylation of chitin, the second most abundant natural polymer and found in crustacean shells such as crab and shrimp (Dee et al., 2001; Singla and Chawla, 2001; Yen et al., 2009 and No et al., 2007). Chitosan is composed of β-(1-4)-2-amino 2-deoxy-D-glucopyranose (glucosamine unit). It can be used in agriculture as a seed treatment and bio-pesticide, helping plants to fight off fungal infections and also for various fruit preservation (Hirano et al., 1988).

Chitosan a non-toxic high molecular polymer derived from the outer shell of crustaceans, has become an ideal compound because of its excellent film-forming and bio-chemical properties (Muzzarelli et al., 2012). Chitosan forms a semipermeable film that regulates the gas exchange and reduces transpiration loses and fruit ripening is slowed down (Bautista et al., 2006). Meanwhile, chitosan is characterized by an antimicrobial activity against a wide range of target microorganisms which can be used in controlling postharvest decay of fruits (Aider, 2010 and Zhang et al., 2011). In addition, Chitosan activates several defense processes in the host tissue, acts as a water-binding agent and inhibits various enzymes (Young et al., 1982; El-Ghaouth et al., 1992 and Devlieghere et al., 2004). Until now, chitosan has been used to reduce water loss of longan fruit (Jiang et al., 2005), delayed pericarp browning of litchi fruit (Joas et al., 2005), inhibited decay of sweet cherries (Romanazzi et al., 2003) and extend shelf life of strawberries (Han et al., 2004). Moreover, beneficial effects on fresh-cut fruits by chitosan coating were reported in sliced mango and carrot sticks (Chien et al., 2007 and Simoes et al., 2009).

Edible coating can be defined as a thin layer of material which provides a barrier to moisture, oxygen and solute movement for the food (Gol and Rao, 2013). Lipid-based substances, polysaccharides and protein films are commonly used as edible coatings (Bourtoom, 2008).

Edible coating minimizes the loss of moisture during storage, slow down the respiration, senescence, enzymatic oxidation and also act as a gas barrier (Ghasemnezhad et al., 2013). Color, texture and volatile compounds of fresh fruits and vegetables are also preserved by these edible coatings (Dhall, 2013). Commonly used edible coatings are aloe vera gel, chitosan, twin 80, cellulose, glycerol, bees wax, sunflower oil, tamarind seed powder etc. (Gol and Rao, 2013; Li and Yu, 2001; Mohebbi et al., 2012 and Li and Barth, 1998).

To effectively extend the shelf life of postharvest fruit and vegetables, chitosan-based coating is a relatively convenient and safe measure which attracted more attention of food industries in recent years. To improve the property of chitosan coating it may be applied in combination with organic compounds such as essential oil, organic acid or inorganic compound including metal ions and inorganic nano-material, as well as biological control agents (Jianglian and Shaoying, 2013).

Chitosan coating is one of the promising techniques because of its excellent properties. It has the property to form a thin film on the fruit's surface, surface which reduces the loss of moisture and aromas, inhibit the oxygen penetration to the plant tissue or microbial growth and ensure the safe consumption of the food (Mantilla et al., 2013). The use of active component in the chitosan-based coating is one promising method to improve its antimicrobial and anti-browning activities for the storage of fruits and vegetables (Xing et al., 2016). There is many potential effectiveness of chitosan-based coating on fruits and vegetables. It modifies respiration rate, keeps firmness and weight loss. It also controls decay and rot. It delays senescence and ripening which maintains sensory quality. It reduces nutrients loss and also maintains aroma components (Xing et al., 2016).

Prashanth et al. (2022) found chitosan coating 4% ambient temperature reduce the decrease of PLW, firmness, TSS, TA, ascorbic acid content and improving postharvest quality & increase shelf life of pink fleshed dragon fruits when stored.

Arnon et al. (2014) applied coating of carboxymethyl cellulose and chitosan on citrus fruits oranges and grapes which is more effective to increasing postharvest quality like preventing weight loss, juice content, acidity, gas permeability, flavour quality, fruit gloss than commercial polyethylene wax.

Hossain and Iqbal (2016) said that reduced the post-harvest loss and extending of shelf-life of banana by delayed changes in weight loss, total soluble solids, titratable acidity and external color, disease severity was remarkably reduced respiration activity, thus delaying ripening and the progress of decay due to senescence shrimp chitosan coating.

Jiang et al. (2012) applied chitosan oil coating on the shiitake (*Lentinus edodes*) mushroom which result is maintained tissue firmness, inhibited increase of respiration rate and reduced microorganism counts, such as yeasts and molds and pseudomonad, exhibited significantly higher levels of total phenolics, flavonoids, as well as individual phenolic compounds for that increased postharvest life quality.

Dong et al. (2004) cited that application of chitosan coating retarded weight loss and the decline in sensory quality, with higher contents of total soluble solids, titratable acid, and ascorbic acid, and suppressed the increase in activities of polyphenol oxidase (PPO) and peroxidase (POD). The results showed that application of chitosan coating effectively maintained quality attributes and extended shelf life of the peeled litchi fruits.

From the literatures reviewed above, it is revealed that postharvest treatment like chitosan coating is very effective for maintain the physico-chemical properties of various fruits and vegetables. This post-harvest treatment is also very fruitful for maintaining good postharvest quality of dragon fruits. But very little research has been done in Bangladesh on chitosan coating on dragon fruit. Chitosan coating is safe, hygienic and natural preservative. So, the present study has been attempted to investigate the effect of chitosan coating on post-harvest quality and shelf life of dragon fruits at ambient condition.

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CHAPTER III

MATERIALS AND METHOD

The experiment on physico-chemical quality of dragon fruit varieties that affected by chitosan coating was carried out during November 2022 to April 2023. In this study three varieties of dragon (pink, white and yellow) fruits and effect of four levels of chitosan coating were examined. The dragon fruits were collected from Jhikorgacha Upazila, Jashore, Bangladesh. The collected fruits were brought to the Molecular Horticulture Laboratory, Agrotechnology Discipline, Khulna University, Khulna to assess the effect of chitosan coating on postharvest quality and shelf life of dragon fruits at ambient condition for the improvement of postharvest management technology of dragon fruits pertinent to Bangladesh.

3.1 Experimental design

The two factors experiment was laid out in a Completely Randomized Design (CRD) with three replications. After collection the fruits they were kept in ambient temperature for the study of physico-chemical characteristics.

3.2 Experimental treatments

Factor A: Well matured three types of dragon fruits

- Pink fleshed (*Hylocereus costaricensis*)
- White fleshed (*Hylocereus undatus*)
- Yellow fleshed (*Hylocereus megalanthus*)

Factor B: Four levels of chitosan solution: T_1 = Uncoated fruits, T_2 = 0.1%, T_3 = 0.3% and

T_4 = 0.5% concentrations of chitosan solution.

3.2.1 Preparation of chitosan solution for experimental treatments

To prepare the stock solution of chitosan, 5 g of laboratory synthesized chitosan which was collected from Forestry and Wood Technology Laboratory, Khulna University, Khulna, was weighed using an electric balance, added 250 ml of vinegar and 250 ml of distilled water, and all were mixed thoroughly to make up to a volume 500 ml. Then

0.1%, 0.3% and 0.5% concentration of chitosan solution were prepared from the stock solution to apply on the fruits under study. Untreated fruits were used as control.

3.2.2 Preparation of dragon fruits for the experiment

Fresh, fully matured, uniform sized and disease-free dragon fruits were washed with tap water to remove the dirt and dust particles and dried at room temperature. Each variety of dragon fruits (pink, white and yellow) was divided in four parts for applying four treatments viz. T_1 = control T_2 = 0.1%, T_3 = 0.3%, and T_4 = 0.5% chitosan coating and each parts contains seven fruits. The treatment of chitosan coating to all the samples was done by dipping the fruits for 10 minutes and stored at ambient condition. The data on selected parameters were recorded at 2 days interval.

3.3 Methods of studying parameters

By using the following methods physical and chemical parameters of the collected dragon fruits and their shelf life were studied.

3.3.1 Physical Parameters

3.3.1.1 Determination of weight loss of dragon fruit

The dragon fruit was selected randomly from each treatment to assess the weight after every 2 days interval after storage and compared the weight difference from the fresh weight on the first day. The electric balance was used to measure the weight and expressed the value in percentage. The following formula was used to assess the weight loss

$$\text{Weight loss (\%)} = \frac{M0-M1}{M0} \times 100 \quad \text{........ ....} \quad (1)$$

Where, M_0 = is the fresh weight of dragon fruit on the first day, and M_1 = is the measured weight at different DAS (two days interval).

3.3.1.2 Firmness measurement of dragon fruit

A texture analyzer (Shimadzu EZ-SX, USA) was used to determine the firmness of dragon fruits equipped with a cylindrical probe (2 mm diameter). Each fruit was penetrated four different equilateral locations to assess the firmness. The penetration depth of the probe was 5 mm and the crosshead speed of the texture analyzer was 2 mm/s. The maximum force firmness was stated at $N.cm^{-2}$ from the force vs time curve.

3.3.2 Chemical characteristics

The methods for the estimation total soluble solids (TSS), titratable acidity (TA), Vit-C (Ascorbic Acid) flavonoid, antioxidant and carotenoids of dragon fruits pulp were analyzed following the methods described by Mazumdar and Majumder (2003).

3.3.2.1 Determination of TSS of dragon fruit

A drop of juice from the pulp of dragon fruits were placed on the prism of the refractometer and the percentage of total soluble solid was obtained from direct reading.

3.3.2.2 Determination of TA of dragon fruit

Reagents

A. Sodium hydroxide (NaOH): 0.1 normality (N)
B. Indicator: Phenolphthalein ($C_{20}H_{14}O_4$) [approx. 0.5% in 80% ethanol (W/V)]

Procedure

- 30 g of tissue sample of dragon fruit by weight was taken. This was extracted with distilled water by thorough crushing in blender. Extract was filtered and the filtrate was made up to 100 ml with distilled water.
- 15 ml of aliquot was taken into a conical flask. Three to four drops of phenolphthalein solution were added to this aliquot and shaken well.
- A burette was filled with the sodium hydroxide solution after washing and rinsing.
- Titration was done and end point was determined by the appearance of pink color and its persistence for at least 10 to 15 seconds.

Calculation of TA

In term of citric acid, 1 ml of 0.1 N NaOH solution can neutralize 0.064 g of citric acid. Therefore, percentage of titratable acidity of the sample was as equivalent of citric acid.

$$\text{Titratable acidity (\%)} = 100\times \frac{d\times 0.064\times c}{a\times b} \quad \ldots\ldots (2)$$

Where,

a = Weight of sample, b = Volume of aliquot taken for examination, c = Volume made with distilled water, d = Average burette reading for the sample

3.3.2.3 Determination of vitamin C of dragon fruit

Reagents

1. Meta phosphoric acid (HPO_3): 3 percent in distilled water (W/V).
2. 2,6-dichloro-phenol indophenols solution: 0.025 percent [50 mg 2,6-dichloro-phenol indophenols was weighed and taken in beaker. 42 mg of sodium bicarbonate was added to it. It was dissolved in little amount of distilled water and the volume was made up to 200 ml with distilled water].
3. Standard ascorbic acid solution: 0.01 percent in 3 percent meta- phosphoric acid (W/V).

Procedure

1. 30 g of fruit flesh was weighed and was extracted with 3% meta phosphoric acid by thorough crushing in 100 ml volumetric flask and volume was made by adding 3% meta phosphoric acid.
2. The burette was filled with standardized 2,6-dichlorophenol indophenols dye reagent and 10 cc of filtered solution was taken in a conical flask and titrated immediately against standard dye solution till faint pink color was observed which persisted at least 15 seconds.
3. Standardization of dye solution: 5 ml of standard ascorbic acid solution was taken in a conical flask and 5 ml of 3% meta phosphoric acid solution was added to it It was mixed by shaking and titrated against indophenols dye solution to get pink color end- point which persisted for 15 seconds.

Calculation of Vitamin C

Vitamin C (mg/100g) = $\frac{e \times d \times b}{c \times a}$ .... (3)

Where,

a = weight of sample

b = volume made with metaphosphoric acid

c = volume of aliquot taken for estimation

d = dye factor

e = average burette reading for sample

3.3.2.4 Determination of total flavonoid of dragon fruit

Procedure

1. 10 g of sample was taken and crushed finely.
2. 100 ml of 80% methanol was added to it and kept it in a water bath for 10 hours at 40°C.
3. The whole solution was filtered through a filter paper.
4. The filtrate was transferred to a crucible and then evaporated to dryness over a water bath at room temperature.
5. The final finding was weighed was as flavonoids.

3.3.2.5 Determination of antioxidant of dragon fruit

Antioxidant is the type of molecule that neutralized harmful compounds called free radical that damage living cells, spoil food and degrade materials such as rubber, gasoline and lubricating oil. Antioxidants can take the form of enzymes in the body cells.

Reagents

- Ethanol
- 0.004% DPPH in ethanol
- Ascorbic acid (standard)

Procedure

- At first, 21 test tubes were taken. They were washed properly and rinsed with ethanol.
- Among 21 test tubes, 9 were marked for the extract solution of different concentration (2, 4, 8, 16, 32, 64, 128, 256 and 512 µg/ml) and 9 test tubes were taken to make aliquots of 9 concentration (2, 4, 8, 16, 32, 64, 128, 256 and 512 µg/ml) for ascorbic acid as standard and one for blank solution preparation.
- Plant extract and ascorbic acid were weighed and dissolved in ethanol for the preparation of stock solution.
- From the stock solution, various concentrations were prepared by dilution method for the plant extract and the standard.
- DPPH was weighed and dissolved in ethanol to make 0.004% (w/v) solution.
- 2ml of each concentration for plant extract and standard were taken in a test tube and 6ml of DPPH solution was added to it.
- Then test tubes were kept in dark place for 30 minutes at room temperature.
- DPPH solution was also added to the blank test tube at the same time where only ethanol was taken as blank.
- After 30 minutes, absorbance of each test tube was measured by UV spectrophotometer at 517nm.

Calculation of DPPH

DPPH Scavenged (%) = $((A_C - A_S) / A_S) \times 100$ .... (4)

Where,

A_C = absorbance of the control sample at 517 nm

A_S = absorbance of the test samples including dragon pulp extract at 517nm

3.3.2.6 Determination of total carotenoid of dragon fruit

1. 1 g of finely cut dragon sample was weighed by an electric balance.
2. The dragon sample was mixed well into a clean mortar.
3. The tissue sample was grinded to a fine pulp with addition of 20 ml of 80% acetone

4. It was centrifuged at 5000 rpm for 5 minutes and transferred the supernant to a 100 ml of volumetric flask.
5. The residue was grinded with 20 ml of 80% acetone, centrifuged and transferred the supernant to the same flask.
6. The procedure was repeated until the residue became colorless. The pestle and mortar were washed thoroughly with 80% acetone and the clear washing was collected in the flask.
7. The volume was made to 100 ml with 80% acetone.
8. The absorbance was read at 510 nm and 480 nm against blank.

Calculation of carotenoid

Carotenoid content = $(7.6\ (A480) - 1.49\ (A510) \times d \times FW \times 1000)$ mg g^{-1} FW .... (5)

Where,

V = Final Volume of the carotenoid in 80% acetone

A = Absorbance of the specific wave length.

FW = Fresh weight of the dragon pulp extracted

D = Length of the path of light (1 cm)

3.3 Determination of shelf-life of dragon fruit

The shelf life of dragon fruit was assessed with respect to storage days. The observation was started from the first day of harvesting until the fruits of all treatments lost their consumable condition.

3.4 Statistical analysis

Data were subjected to a two-way analysis of variance (ANOVA) using statistical software Statistix-10 and means were compared by Duncan's Multiple Range Test (DMRT) (Gomez and Gomez, 1989).

CHAPTER IV

RESULT AND DISCUSSION

The results on physio-chemical quality attributes of dragon fruits varieties affected by chitosan coating and their shelf life have been presented and discussed in the following headings and sub- headings:

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4.1 Physical properties of dragon fruit

4.1.1 Weight loss of fruits

The interaction effect of chitosan coating and varieties were found significant in respect of weight loss (Appendix 1) and the weight loss were found at 3, 5, 7 and 9 DAS shown the same trend (Table1).

At 9 DAS, the maximum weight loss (8.67%) was recorded from white fleshed uncoated fruits and the minimum (3.24%) was found in pink fleshed fruits coated with 0.5% chitosan solution which was statistically similar (3.56%) to pink fleshed fruits coated with 0.3% chitosan solution (Table1).

It was revealed from the results of the study that the minimum weight loss was recorded in the varieties of pink fleshed fruits and in treatments 0.5% chitosan coated fruit. Chitosan coating forms a layer on the fruits surface that prevent the reduction or loss of water, inhibit transpiration, reduce respiration that contributes the lower weight loss of fruits (Allegra et al., 2016).

Table1. The interaction effect of variety and chitosan coating on weight loss of dragon fruit at different days after storage (DAS).

Treatments	Weight loss (%)			
Interaction (A×B)	3 DAS	5 DAS	7 DAS	9 DAS
V_1T_1	0.55e	1.12def	2.54g	4.97fg
V_1T_2	0.53e	1.05efg	2.42g	4.63g
V_1T_3	0.53e	1.00fg	2.06h	3.56h
V_1T_4	0.45f	0.95g	1.75i	3.24h
V_2T_1	0.84a	2.11a	4.76a	8.67a
V_2T_2	0.81a	2.06a	4.61b	7.66b
V_2T_3	0.75b	2.05a	4.58b	7.33b
V_2T_4	0.73bc	1.89b	4.35c	7.31b
V_3T_1	0.68cd	1.34c	3.60d	6.70c
V_3T_2	0.67d	1.21cd	3.08e	6.21d
V_3T_3	0.67d	1.17def	3.00e	5.62e
V_3T_4	0.66d	1.14def	2.80f	5.35ef
Level of significance	*	**	**	**
CV (%)	5.05	6.41	2.43	3.98

V_1 = Pink fleshed dragon fruit, V_2 = White fleshed, V_3 = Yellow fleshed, T_1 = Control, T_2 = 0.1%, T_3 = 0.3%, T_4 = 0.5%. Data are means of three replications. In a column * and ** = significant at $p < 0.05$ and 0.01, respectively. CV = Coefficient of variation.

4.1.2 Firmness of fruits

The interaction effect of chitosan coating and varieties were found significant in respect of firmness at all DAS except 5 DAS (Appendix 2) and the firmness were found at 3, 5, 7 and 9 DAS follow the same trend (Table 2).

At 9 DAS, the highest firmness value (3.07) was found in pink fleshed fruits coated with 0.5% chitosan solution which was statistically similar to (3.02) in pink fleshed fruits coated with 0.3% chitosan solution and the lowest value (2.28) was found in uncoated white fleshed fruits which was statistically similar to (2.24) in white fleshed fruits coated with 0.5% chitosan solution and (2.24) in yellow fleshed uncoated fruits (Table 2).

From the above results, it can be concluded that the effect of 0.5% chitosan coated pink fleshed fruits was cleared the best performance in firmness of dragon fruits. The highest firmness is the cause of low rate of respiration due to applying surface coating which slow down the metabolic activity of dragon fruits. This finding was similar with the findings of Ali et al. (2013) and Krishna and Rao (2014).

Table 2. The interaction effect of variety and chitosan coating on firmness of dragon fruit at different days after storage (DAS).

Treatments	Firmness (kg/cm^2=N)			
Interaction: A×B	3DAS	5DAS	7DAS	9DAS
V_1T_1	5.12cd	3.28	3.04efg	2.64bc
V_1T_2	5.30abcd	3.40	3.13de	2.96ab
V_1T_3	5.22bcd	4.17	3.99a	3.02a
V_1T_4	5.65a	4.30	4.01a	3.07a
V_2T_1	4.22g	3.10	2.81g	2.28d
V_2T_2	5.48ab	3.34	3.08ef	2.46cd
V_2T_3	5.37abc	3.92	3.36bcd	3.07a
V_2T_4	4.35fg	4.12	3.41bc	2.24d
V_3T_1	4.66ef	3.28	2.82fg	2.24d
V_3T_2	4.99de	3.40	3.02efg	2.44cd
V_3T_3	5.14bcd	3.93	3.16cde	2.91ab
V_3T_4	5.08cd	4.16	3.59b	2.88ab
Level of significance	**	NS	*	*
CV (%)	4.07	2.35	4.78	7.18

V_1 = Pink fleshed dragon fruit, V_2 = White fleshed, V_3 = Yellow fleshed, T_1 = Control, T_2 = 0.1%, T_3 = 0.3%, T_4 = 0.5%. Data are means of three replications. In a column *, ** and NS = significant at $p < 0.05$, 0.01 and nonsignificant, respectively. CV = Coefficient of variation.

4.2. Chemical properties of dragon fruits

4.2.1 Total soluble solids (TSS) of fruits

The interaction effect of chitosan coating and varieties were found significant in respect of TSS (Appendix 4) and the TSS at 3, 5, 7 and 9 DAS were followed the same trend (Table 3).

At 9 DAS, the maximum TSS value (20.56) was found in uncoated white fleshed fruits and that was the lowest (10.67) in pink fleshed fruits coated with 0.5% chitosan solution (Table 3).

Results showed that increasing chitosan concentration was successfully retarded the increase of TSS. Chitosan coating could provide a semipermeable film around the fruit surface which modifies the internal atmosphere by reducing oxygen and elevating carbon dioxide levels, decreasing the respiration rate and metabolic activity of fruits hence retarded the fruits ripening and senescence process as reported by Vargas et al. (2008) and Das et al. (2013). Similar views were also expressed by Ali et al. (2011) that chitosan coating effectively changed soluble solids content of papaya during 5 weeks of storage.

Table 3. The interaction effect of variety and chitosan coating on TSS of dragon fruit at different days after storage (DAS).

Treatments	TSS (°Brix)			
Interaction A×B	3DAS	5DAS	7DAS	9DAS
V_1T_1	11.80h	12.43h	13.98i	15.10i
V_1T_2	11.70h	12.20i	13.87j	11.98j
V_1T_3	11.40i	12.14i	12.96k	11.20k
V_1T_4	11.30i	11.42j	11.67l	10.67l
V_2T_1	18.50a	18.85a	19.34a	20.56a
V_2T_2	18.13b	18.61b	19.13b	19.98b
V_2T_3	18.00b	18.42c	18.94c	19.08c
V_2T_4	17.31c	18.12d	18.36d	17.89d
V_3T_1	15.90d	16.54e	16.89e	17.00e
V_3T_2	15.60e	16.30f	16.71f	16.40f
V_3T_3	15.30f	16.26f	16.50g	16.20g
V_3T_4	14.75g	14.87g	14.90h	15.89h
Level of significance	**	**	**	**
CV (%)	0.58	0.48	0.26	0.6

V_1 = Pink fleshed dragon fruit, V_2 = White fleshed, V_3 = Yellow fleshed, T_1 = Control, T_2 = 0.1%, T_3 = 0.3%, T_4 = 0.5%. Data are means of three replications. In a column * and ** = significant at $p < 0.05$ and 0.01, respectively. CV = Coefficient of variation.

4.2.2 Titratable acidity (TA) of fruits

The interaction effect of chitosan coating and varieties were found significant in respect of TA at 7 and 9 DAS (Appendix 5). At all the DAS TA were found similar trend of changes (Table 4).

At 9 DAS, the lowest TA value (0.13%) was recorded from pink fleshed fruits coated with 0.5% chitosan solution and the maximum TA value (0.33%) was observed in white fleshed uncoated fruits (Table 4).

TA of fruits decreased due to the increase of soluble sugars during ripening. The TA decreasing was observed in the increasing of concentration of coating compared to uncoated fruits. Similar results also reported by Ali et al. (2013) in dragon fruits, Baviskar et al. (1995) in ber fruits and Kittur et al. (2001) in banana fruits.

Table 4. The interaction effect of variety and chitosan coating on TA of dragon fruit at different days after storage (DAS).

Treatments	TA (%)			
Interaction A×B	3DAS	5DAS	7DAS	9DAS
V_1T_1	0.37	0.35	0.24e	0.21efg
V_1T_2	0.34	0.30	0.22e	0.20fg
V_1T_3	0.31	0.26	0.21e	0.18g
V_1T_4	0.30	0.24	0.20e	0.13h
V_2T_1	0.50	0.42	0.37a	0.33a
V_2T_2	0.46	0.42	0.35ab	0.31ab
V_2T_3	0.45	0.40	0.34ab	0.31ab
V_2T_4	0.45	0.38	0.33abc	0.29abc
V_3T_1	0.43	0.37	0.32bcd	0.28bcd
V_3T_2	0.40	0.36	0.31bcd	0.25cde
V_3T_3	0.40	0.36	0.30cd	0.24def
V_3T_4	0.40	0.35	0.29d	0.24def
Level of significance	NS	NS	*	*
CV (%)	7.10	7.64	8.72	10.40

V_1 = Pink fleshed dragon fruit, V_2 = White fleshed, V_3 = Yellow fleshed, T_1 = Control, T_2 = 0.1%, T_3 = 0.3%, T_4 = 0.5%. Data are means of three replications. In a column *, ** and NS = significant at $p < 0.05$, 0.01 and nonsignificant, respectively. CV = Coefficient of variation.

4.2.3 Vitamin C of fruits

It was observed that the differences in Vit. C value of dragon fruits were significant due to the interaction effect of different varieties and chitosan concentrations at all the DAS (Appendix 6).

At 9 DAS, the highest value of Vit. C (19.61) was found in pink fleshed fruits coated with 0.5% chitosan solution and the lowest Vit. C (5.85) was observed in white fleshed uncoated fruits (Table 5).

A similar trend of decreasing Vit. C of fruits with the increase in storage period was observed at 3, 7 and 9 DAS at ambient conditions (Table 5).

The decreasing trend of ascorbic acid in chitosan coated fruits is less than uncoated fruits due to increasing the total soluble sugars in the fruits. Modified atmosphere created by chitosan coating suppressed the loss of ascorbic acid this result was supported by Jagtar et al. (1978) in ber.

Table 5. The interaction effect of variety and chitosan coating on vitamin C of dragon fruit at different days after storage (DAS).

Treatments	Vitamin C (mg/100g FW)		
Interaction: A×B	3DAS	7DAS	9DAS
V_1T_1	5.95ghi	5.58h	6.90fg
V_1T_2	8.15ef	12.80bc	12.5c
V_1T_3	16.25b	13.92b	15.80b
V_1T_4	23.70a	20.95a	19.61a
V_2T_1	5.25gh	5.62h	5.85g
V_2T_2	7.8efg	8.95g	7.84ef
V_2T_3	11.50cd	10.62defg	10.65cd
V_2T_4	12.15c	13.55b	10.93cd
V_3T_1	5.75gh	5.95h	6.75fg
V_3T_2	7.3fgh	9.52fg	9.6de
V_3T_3	9.8de	9.67fg	11.33cd
V_3T_4	13.0c	12.27bcd	11.55c
Level of significance	**	**	**
CV (%)	12.98	10.93	10.56

V_1 = Pink fleshed dragon fruit, V_2 = White fleshed, V_3 = Yellow fleshed, T_1 = Control, T_2 = 0.1%, T_3 = 0.3%, T_4 = 0.5%. Data of means are three replications. In a column * and ** = significant at $p < 0.05$ and 0.01, respectively. CV = Coefficient of variation.

4.2.4 Total flavonoid of fruits

It was observed that the differences in total flavonoid value of dragon fruits were significant due to interaction of different varieties and chitosan concentrations at all of the DAS.

At 9 DAS, the highest total flavonoid value (23.97) was observed in pink fleshed fruits coated with 0.5% chitosan solution which was statistically similar to (23.3) pink fleshed fruits coated with 0.3% chitosan solution and the lowest total flavonoid value (1.67) was found in white fleshed uncoated fruits (Table 6).

A similar trend of decreasing flavonoid of fruits with the increase in storage period was observed at 3, 5, 7 and 9 DAS at ambient conditions (Table 6).

fleshed fruits coated with 0.3% chitosan solution and the minimum antioxidant (23.02) in white fleshed uncoated fruits (Table 7).

A similar trend of decreasing antioxidant of fruits with the increase in storage period was observed at 3, 5, 7 and 9 DAS at ambient conditions (Table 7).

The antioxidant capacity of fruits is related to the modification of internal atmosphere. The fruits coated by chitosan leading to reduction of the gas exchange like oxygen for that delaying antioxidant degradation process (Silva et al., 2018). Similar phenomena of antioxidant decreasing due to chitosan treatment was reported by Formica-Oliveira et al. (2016).

Table 7. Interaction effect of variety and chitosan coating on antioxidant of dragon fruit at different days after storage (DAS).

Treatments	Antioxidant (%)			
Interaction: A×B	3DAS	5DAS	7DAS	9DAS
V_1T_1	36.20c	33.93e	32.20d	30.37d
V_1T_2	70.10ab	60.40c	54.70c	50.07c
V_1T_3	70.00ab	69.20ab	68.01a	66.03a
V_1T_4	70.90a	69.50a	68.03a	67.50a
V_2T_1	36.10c	35.06e	28.07e	23.02f
V_2T_2	69.83ab	57.63d	54.10c	51.70c
V_2T_3	70.83ab	68.20ab	67.09ab	65.30a
V_2T_4	69.77ab	66.97b	65.20b	62.10b
V_3T_1	36.30c	33.02e	29.10e	25.90e
V_3T_2	36.80c	34.70e	33.41d	32.90d
V_3T_3	69.70b	68.01ab	67.60ab	67.00a
V_3T_4	70.77ab	68.97ab	67.00ab	66.50a
Level of significance	**	**	**	**
CV (%)	1.15	2.62	2.85	3.03

V_1 = Pink fleshed dragon fruit, V_2 = White fleshed, V_3 = Yellow fleshed, T_1 = Control, T_2 = 0.1%, T_3 = 0.3%, T_4 = 0.5%. Data are means of three replications. In a column * and ** = significant at $p < 0.05$ and 0.01, respectively. CV = Coefficient of variation.

4.2.6 Total carotenoid of fruits

It was observed that the differences in carotenoid of dragon fruits were significant due to interaction of different varieties and chitosan concentrations at all the DAS (Appendix 7).

At 9 DAS, the maximum total carotenoid value (28) was observed in pink fleshed fruits coated with 0.5% chitosan solution which was statistically similar (26.7) to pink fleshed fruits coated with 0.3% chitosan solution and in pink fleshed fruits coated with 0.1% chitosan solution (26.4) and the minimum total carotenoid value (15.03) was found in white fleshed uncoated fruits (Table 8).

A similar trend of decreasing carotenoid of fruits with the increase in storage period was observed at 3, 5, 7 and 9 DAS at ambient conditions (Table 8).

Table 8. Interaction effect of variety and chitosan coating on total carotenoid of dragon fruit at different days after storage (DAS).

Treatments	Total carotenoid (mg/100g FW)			
Interaction: A×B	3DAS	5DAS	7DAS	9DAS
V_1T_1	29.73ab	28.00ab	26.60a	23.00b
V_1T_2	30.20a	28.60a	27.03a	26.40a
V_1T_3	30.20a	29.50a	28.40a	26.70a
V_1T_4	30.70a	30.00a	28.50a	28.00a
V_2T_1	18.00d	17.00c	16.60d	15.03de
V_2T_2	18.30d	17.30c	17.20cd	16.10cd
V_2T_3	29.67ab	25.97ab	21.43b	16.20cd
V_2T_4	30.40a	26.07ab	21.70b	17.20c
V_3T_1	18.20d	17.50c	17.67cd	16.50cd
V_3T_2	22.27cd	19.13c	16.67d	13.13e
V_3T_3	25.57bc	24.10b	19.80bc	16.57cd
V_3T_4	30.40a	28.50a	28.00a	27.80a
Level of significance	**	*	**	**
CV (%)	10.37	10.45	7.76	6.31

V_1 = Pink fleshed dragon fruit, V_2 = White fleshed, V_3 = Yellow fleshed, T_1 = Control, T_2 = 0.1%, T_3 = 0.3%, T_4 = 0.5%. Data are means of three replications. In a column * and ** = significant at $p < 0.05$ and 0.01, respectively. CV = Coefficient of variation.

Carotenoid increased with the maturity of fruits. Dragon fruit being a non-climacteric fruit showed a continuous decrease in carotenoid after harvest. Increased respiration rate of fruit increases the degradation of carotenoid due to cellular break down (Ali et al., 2013). Similar results were also reported that chitosan coating regulates the carotenoids of fruits by producing ethylene (Zuppini et al., 2003; Bramley, 2002; Alba et al., 2005 and Liu et al., 2015).

4.3 Shelf-life of fruits

The interaction effect of dragon fruit varieties and chitosan coating was found insignificant in respect of shelf life but the effect of chitosan coating was significant (Appendix 8). In case of chitosan coating, the maximum shelf life (16.67days) was recorded from 0.5% chitosan coated fruits, followed by 0.3% chitosan coated fruits (13.56 days) and 0.1% chitosan coated fruits (11.67 days) and the minimum (9.11days) was found in uncoated fruits (Fig. 1).

The present results of difference in shelf life of fruits coated with different levels of chitosan concentration are similar with the findings of Chutichudet and Chutichude (2011) in dragon fruit, Hening (1975) in apple ber, Sandeep and Bal (2003) in apple ber, Sabir and Sabir (2009) and Romanazzi et al. (2009) in table grape.

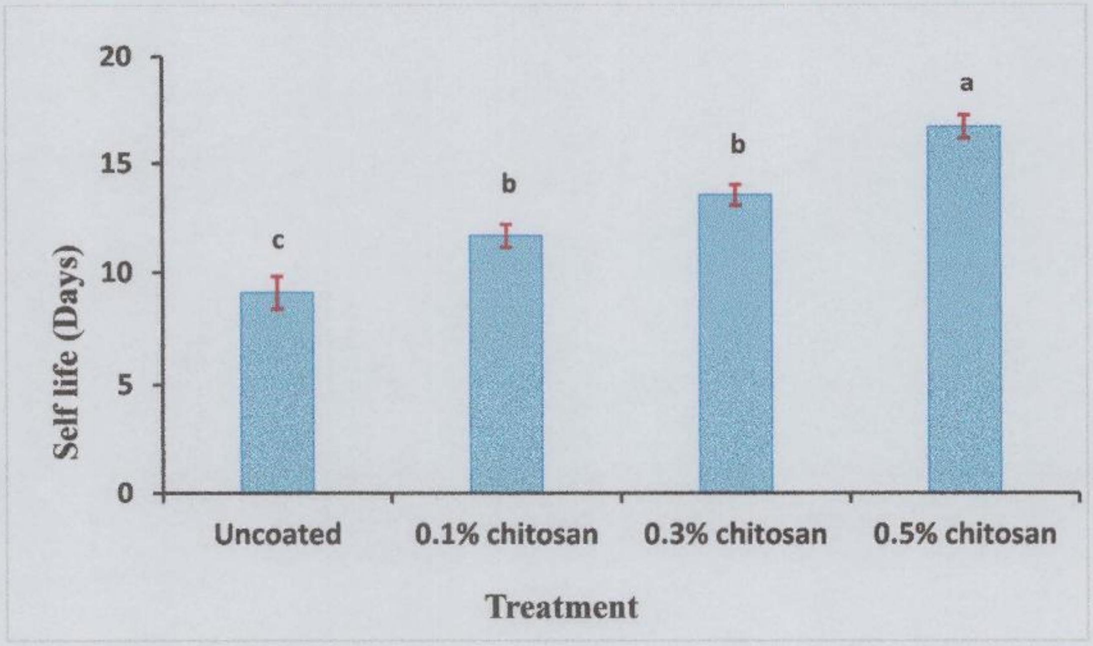

Figure 1. Effect of chitosan coating on shelf life of dragon fruit at different days after storage (DAS).

CHAPTER V

SUMMARY AND CONCLUSION

5.1 Summary

The experiment on physico–chemical quality of dragon fruits as affected by chitosan coating was carried out during November 2022 to April 2023. The collected fruits were brought to the Molecular Horticulture Laboratory, Agrotechnology Discipline, Khulna University, Khulna to assess the effect of chitosan coating on postharvest quality and shelf life of dragon fruits varieties at ambient condition of postharvest management of dragon fruits in Bangladesh.

The two factors of experiment viz. Factor A: variety and Factor B: level of chitosan was laid out in a Completely Randomized Design (CRD) with three replications for the treatments. Well matured three types of dragon fruits (pink fleshed (*Hylocereus costaricensis*), white fleshed (*Hylocereus undatus*) and yellow fleshed (*Hylocereus megalanthus*)) were used as variety. Chitosan solutions viz. T_1 = control, T_2 =0.1%, T_3 =0.3% & T_4=0.5% concentration were used as the levels of chitosan. Also, uncoated dragon fruits were kept in normal temperature ($24 \pm 1°$ C) at open space was considered as control.

Physical characteristics of dragon fruits were determined under quantitative characters such as weight loss and firmness of dragon fruits. Chemical characteristics of selected dragon fruits were estimated based on some parameters, such as, total soluble solids, titratable acidity, vitamin C, total flavonoid, antioxidant and total carotenoid content. The shelf life of fruit varieties due to allocation of chitosan coating was also determined until the fruits of all treatments lost their consumable condition.

Significant interaction effects of all the parameters were observed such as weight loss, firmness, TSS, TA, antioxidant, total flavonoid, total carotenoid except shelf life.

At 9 DAS, the highest weight loss value (8.67%) was observed in white fleshed uncoated fruits and the lowest weight loss (3.2%) was found in pink fleshed fruits coated with 0.5% chitosan.

At 9 DAS, the highest firmness (3.07 N) was found in pink fleshed fruits coated with 0.5% chitosan coating and the lowest firmness (2.28 N) was observed in white fleshed uncoated fruits. At 9 DAS, the highest TSS (20.56) was observed in white fleshed uncoated fruits and the lowest TSS (10.67) was found in pink fleshed fruits coated with 0.5% chitosan coating.

At 9 DAS, the highest TA (0.33%) was found in white fleshed uncoated fruits and the lowest TA value (0.13%) was observed pink fleshed fruits coated with 0.5% chitosan coating. At 9 DAS, the highest Vit. C (19.61) was found in pink fleshed fruits coated with 0.5% chitosan coating and the lowest Vit. C value (5.8) was observed in white fleshed uncoated fruits.

At 9 DAS, the highest total flavonoid content (2.58) was observed in pink fleshed fruits coated with 0.5% chitosan coating and the lowest total flavonoid content (1.6) was recorded from white fleshed uncoated fruits. At 9 DAS, the highest antioxidant (67.50%) was found in pink fleshed fruits coated with 0.5% chitosan coating and the lowest antioxidant (23.02%) in white fleshed uncoated fruits. At 9 DAS, the highest carotenoid content (28) was found in pink fleshed fruits coated with 0.5% chitosan coating and the lowest carotenoid content (15.03) was observed in white fleshed uncoated fruits.

The maximum shelf life (16.67 days) was found in 0.5% chitosan coated fruits and the minimum shelf life (9.11 days) was observed in uncoated fruits. Interaction effect of variety and chitosan coating on shelf life were insignificant.

5.2 Conclusion

It can be concluded from the present study that the application of chitosan coating on dragon fruits, especially coated with 0.5% chitosan solution on pink fleshed dragon fruits gave significantly better results in all of the parameters studied, such as minimum weight loss, maximum firmness and highest chemical properties - TSS, TA, total flavonoid, antioxidant and total carotenoid content and shelf life of fruits.

Recommendation

1. Further study is needed to validate the results of the present study with different concentration of chitosan coating in different environmental conditions.

CHAPTER VI

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Appendix 1. Analysis of variance of weight loss of fruits.

Source of variation	Degree of Freedom	Mean Square			
		3DAS	5DAS	7DAS	9DAS
Variety	2	0.11589*	0.41291*	4.28147*	16.9675*
Treatment	3	0.06919*	1.82572*	7.79483*	13.5831*
Interaction	6	0.00443*	0.10917*	0.84075*	3.0187*
Error	22	0.00110	0.00832	0.00643	0.0550

Appendix 2. Analysis of variance of firmness of fruits.

Source of variation	Degree of Freedom	Mean Square			
		3DAS	5DAS	7DAS	9DAS
Variety	2	0.67962*	0.08484*	0.59510*	0.53274*
Treatment	3	0.96934*	2.00534*	1.17414*	0.6119*
Interaction	6	0.33165*	0.01306	0.10363*	13.59*
Error	22	0.04225	0.00759	0.02461	0.03718

Appendix 3. Analysis of variance of total soluble solids of fruits.

Source of variation	Degree of freedom	Mean Square			
		3DAS	5DAS	7DAS	9DAS
Variety	2	33.5471*	36.8806*	36.0209*	89.8875*
Treatment	3	58.3372*	55.5496*	43.3373*	49.3391*
Interaction	6	2.3464*	3.5156*	3.5166*	5.0431*
Error	22	0.0076	0.0056	0.0018	0.0115

Appendix 4. Analysis of variance of titratable acid of fruits.

Source of variation	Degree of freedom	Mean Square			
		3DAS	5DAS	7DAS	9DAS
Variety	2	0.00639*	0.00658*	0.00576*	0.01161*
Treatment	3	0.3464*	0.03071*	0.02694*	0.02624*
Interaction	6	0.00163	0.00053	0.00349*	0.00317*
Error	22	0.00081	0.00072	0.00064	0.00066

Appendix 5. Analysis of variance of vitamin C of fruits.

Source of variation	Degree of freedom	Mean Square		
		3DAS	7DAS	9DAS
Variety	2	70.1199*	29.7413*	32.1045*
Treatment	3	80.5905*	58.4386*	62.4217*
Interaction	6	50.9689*	34.4675*	21.6937*
Error	22	1.6669	1.3406	1.3862

Appendix 6. Analysis of variance of antioxidant of fruits.

Source of variation	Degree of freedom	Mean Square			
		3DAS	5DAS	7DAS	9DAS
Variety	2	281.76	170.83	129.98	88.31
Treatment	3	2341.70	2459.30	2913.06	3226.37
Interaction	6	273.51	145.36	110.46	101.73
Error	22	0.46	2.12	2.27	2.37