EFFECT OF ORGANIC COATINGS ON SHELF-LIFE AND POSTHARVEST QUALITY OF BANANA

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CERTIFICATE

This is to certify that the thesis entitled "EFFECT OF ORGANIC COATINGS ON SHELF-LIFE AND POSTHARVEST QUALITY OF BANANA" submitted to the DEPARTMENT OF HORTICULTURE, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment 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 BILASH CHANDRA MANDAL, REGISTRATION NO. 10-03863 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.

Dated: June, 2016
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Dedicated To
My Beloved Parents

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ABSTRACT

An experiment was carried out at the laboratory of Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka to study the effect of organic coatings on shelf-life and postharvest quality of banana. The experiment consists of two factors as varieties *viz*. (i) V_1: Amritsagar and (ii) V_2 : Sabri and six organic coating treatments *viz*. (i) T_0 : Control, (ii) T_1 : Aloe-vera gel, (iii) T_2:Ginger oil, (iv) T_3: Garlic extract, (v) T_4: Onion extract and (vi) T_5: Neem extract. The two-factor experiment was laid out in completely randomized design with three replications. The collected data on various parameters were statistically analyzed. The experiment was continued to 12 Days After Storage **(**DAS) from sample collection. Results revealed that among two varieties, V_2 (Sabri) showed the highest shelf life (10.3 days) where V_1 (Amritsagar) showed (9.2 days). Among the different treatments, T_1 (Aloe-vera gel) treatment gave the best performance (11.7 days) on shelf life compared to control. In terms of combination effect V_2 (Sabri) with T_1 (Aloe-vera gel) treatment (V_2T_1) gave the highest shelf life(12.0 days). It also gave the lowest total weight loss (8.1%), highest moisture content (65.7%), lowest TSS (34.5%) and lowest pulp to peel ratio (3.8) and also lowest diseases incidence and severity of banana during postharvest storage.

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ABBREVIATIONS AND ACRONYMS

AEZ	=	Agro-Ecological Zone
BBS	=	Bangladesh Bureau of Statistics
BCSRI	=	Bangladesh Council of Scientific Research Institute
CV %	=	Percent Coefficient of Variation
DAS	=	Days After Storage
DMRT	=	Duncan's Multiple Range Test
et al.,	=	And others
e.g.	=	exempli gratia (L), for example
etc.	=	Etcetera
FAO	=	Food and Agricultural Organization
LSD	=	Least Significant Difference
SAU	=	Sher-e-Bangla Agricultural University
var.	=	Variety
NaOH	=	Sodium hydroxide
GM	=	Geometric mean
P	=	Phosphorus
K	=	Potassium
Ca	=	Calcium
µg	=	Microgram
USA	=	United States of America
WHO	=	World Health Organization
TSS	=	Total Soluble Solid

CHAPTER I

INTRODUCTION

Banana (*Musa* sp, family Musaceae) is the common name for herbaceous plants of the genus Musa and for the fruit they produce. They are native to the tropical region of Southeast Asia, and are likely to be first domesticated in Papua New Guinea. Bananas were introduced to the Americas by Portuguese sailors who brought the fruits from West Africa in the 1500s. The word banana is of West African origin, from the Wolof language, and passed into English via Spanish or Portuguese (Economic Botany Textbook, 2009 and Online Etymology Dictionary, 2005). Banana is one of the tallest of the herbaceous plants with a pseudostem and it is possibly the world's oldest cultivated crop (Rahman *et al*., 2006).

It is one of the most economically important fruits in the world with a huge consumption demand, as since bananas are a valuable source of vitamin B6, vitamin C, and potassium. Bananas consist mainly of sugars (glucose, fructose and sucrose) and fiber, which makes them ideal for an immediate and slightly prolonged source of energy. Rather than its consumption as raw fruit, they are also processed in fried, jam and pancake style (The Australia and Pacific Science Foundation, 2002; Agroforestry net, 2010; Banana web, 2010; Economic Botany Textbook, 2009; Online Etymology Dictionary, 2005).

Bananas were reported to be a well stress relieving agent and reduce the incidence of depression, stroke risk, anemia, constipation and diarrhea, heartburn, smoking ulcers, maintain healthy bones and a healthy kidney function, decrease the blood pressure and provide eyesight protection. (Banana web, 2010).

The climate and soil of Bangladesh are congenial for banana cultivation. Hence, banana is growing throughout the year although there is a distinct harvesting season from September to November. Bangladesh produces 818254 metric tons of bananas from 53948.54 ha of land (BBS, 2010). Varieties of banana grown in

Bangladesh are Amritasagar, Mehersager, Sabri, Champa, ChiniChampa, Kabuli, Jahaji, Agnishwar, Basrai, Seeded banana, Anaji or Kancha Kola and Singapuri, etc. (Haque, 1988). Banana fruits are usually harvested at physiologically mature stage. It does not ripe adequately and uniformly on the tree because of climacteric respiration. Non- uniformly ripened fruits are characterized by poor external color, texture, taste and odor.

In respect of total production, it ranks top position among the major fruits grown in Bangladesh and comprises about 42% of the total production. Losses of banana occur between harvest and consumption. Banana takes 6-8 days during summer and 13-15 days during winter to ripen. Nowadays, demand of banana consumption is increasing day by day due to its high caloric and nutritional value. Appropriate storage facilities and knowledge about storage are insufficient. This loss occurs during transporting and marketing due to adverse physiological changes (loss of weight due to increased respiration and transpiration), softening of flesh and lack of resistance capacity against microbial attack. Recently Hassan (2010) reported that the postharvest loss of banana is 24.62% which accounts for 56.7 crore taka annually.

Bananas should be harvested at appropriate stage of maturity for transport, handling and storage. Postharvest loss of banana is also occurred due to inappropriate postharvest handling and very poor knowledge in the field of postharvest technology as well as postharvest pathology. The postharvest losses of banana can be reduced considerably by applying improved technologies. The use of synthetic chemicals for the reduction of postharvest losses and extrusion of shelf life of perishables is a threat to human health and environment. Efforts should be made to optimize or develop suitable alternatives such as modified atmosphere packaging with or without ethylene scavenging compounds, hot water treatments, cooling, coating with organic compounds etc. for postharvest reduction loss of banana extension of shelf life with retained quality.

Banana is a climacteric fruit and its rate of respiration is minimum at maturity and the rate rises up to the peak during ripening. A high rate of respiration is usually associated with a short storage life. Soft texture and high moisture content makes banana with a high chance to be wounded and contaminated during handling and transportation and this may be worsened by high temperature and relative humidity. Hence care should be taken to reduce respiration rate during storage especially in tropical and subtropical countries like Bangladesh. Thus prolonging storage life of a fruit consists of slowing down the processes leading to ripening and senescence after ripening.

Improvement of shelf life may be done with the application of a good skin coating as it reduces respiration rate and with some physical and chemical measures (Pantastico, 1975). Skin coating to prolong the shelf life of fruits is being practiced in the world. Desai *et al*. (1989) reported that banana treated with wax emulsion and thickener (Tal prolong) gave the best results with regard to shelf life. But information regarding the effect of different coating materials on shelf life of banana in our local context is scanty. Coating the fruit prior to ripening initiation delays the rapid ethylene production, thus delaying the ripening process and the chlorophyll loss which normally accompanies ripening (Banks, 1985).

Therefore, improvement of shelf life of banana is an urgent need to reduce the postharvest losses and contribute to the uplift of the national economy. Keeping these points in view, the present experiment was undertaken with the following specific objectives:

i) to investigate the effect of organic coatings on shelf life of banana
ii) to investigate the effect of organic coatings on other postharvest qualities of banana

CHAPTER II

REVIEW OF LITERATURE

New technological advances in plant extract edible coatings for food may hold promise in extending shelf life, reducing packaging layers, meeting food safety and quality requirements. Emerging research shows all natural coatings that have unrealized potential in food preservation. Recently, interest has increased in using plant extract base edible coating material for fruits and vegetables. Although banana is an important fruit of tropics and sub-tropics, considerable literature dealing with extending shelf life, reducing post harvest losses and physico-chemical changes during ripening of banana is very limited. An attempt has been made in this chapter to review the pertinent research work related to the present study under following headings.

2.1 Role of plant extract as coating materials for prolonging shelf life

Consumers around the world demand for food of high-quality, without chemical preservatives, and an extended shelf life. Therefore, an increased effort has been made to develop new natural preservatives and antimicrobials (Lin and Zhao, 2007). Many storage techniques have been developed to extend the marketing distances and holding periods for commodities after harvest. Different preservation methodologies have been developed. One method of extending post harvest shelf life is the use of the edible coatings (Baldwin *et al*., 1995) applied to the product surface in addition to or as a replacement for natural protective waxy coatings and provide a barrier to moisture, oxygen and solute movement for the food (Avena-Bustillos*et al*., 1997 and Mchugh*et al*., 2000). They are applied directly on the food surface by dipping, spraying or brushing (Mchugh*et al*., 2000). Edible coatings are used to create a modified atmosphere and to reduce weight loss during transport and storage (Baldwin *et al*., 1995).

Edible coatings are generally used for retarding gas transfer, reducing moisture and aroma loss, delaying color changes, and improving the general appearance of fruits, vegetables and minimally processed fruits through storage. The layer of edible coating applied on the surface of fruits, vegetables or their fresh-cut products aim to extend their shelf life (Olivas*et al*., 2005).

Edible coatings with different composition have been tested and used to prolong storage life of fruit because they can provide an additional protective coating, retarding microbial growth, and can also create a protective barrier to reduce respiration and transpiration rates, retarding senescence. According to their components, edible coatings can be divided into three categories: hydrocolloids, lipids, and composites. Hydrocolloids include proteins and polysaccharides. Lipids include waxes, acylglycerols, and fatty acids. Composites contain both hydrocolloid components and lipids (Vargas *et al*., 2008 and Lin and Zhao, 2007).

The effect of essential oils and their constituents on postharvest diseases of horticultural products has been investigated for pears, citrus, bananas, strawberries, tomato, cherriesand grapes (Tzortzakis, 2007).

Recently, one of the first works concerning the utilization of essential oils into edible coatings was explored by Pranoto*et al*. (2005). These authors reported the antibacterial activity of garlic oil added to alginate-based film against *Staphylococcus aureus* and *B. cereus*, using agar diffusion method. Garlic oil was also assayed by Seydim and Sarikus (2006) by incorporation in whey protein isolate films, although it was demonstrated to be much less active than oregano essential oil against *Escherichia coli*, *Staphylococcus aureus*, *Salmonella enteritidis*, *Listeria monocytogenes*and*Lactobacillusplantarum*.

Adetunji*et al*. (2012) conducted a study to evaluate the effect of Aloe vera gel as an edible coating on weight loss, ascorbic acid, pH and firmness in order toextend the shelf-life of pineapple stored at ambient temperature of (27^{o}C) and relative

humidity of 55-60% for seven weeks. The above parameters which are related to post-harvest quality loss were however significantly controlled in the pineapple coated with Aloe vera gel. The storability of orange fruits was also extended by seven weeks. It was concluded that A. vera gel used as a coating for pineapple could serve as an alternative to post-harvest chemical treatments.

Alberio*et al*. (2015) conducted a study o observe the effect of an edible film obtained from a commercial Aloe vera extract, on the quality maintenance of minimally processed grapes belonging to three different cultivars (Sugar One, Victoria and Black Magic). All the analyzed parameters were measured in extracts obtained from minimally processed grapes packaged in ordinary atmosphere and stored at 24°C for 15 days. Samples dipped into Aloe vera showed significant differences (p.0.05) compared to untreated ones. The determination of such parameters and the evaluation of consumer acceptability were helpful to determine the effectiveness of the post-harvest treatment with Aloe vera for a storage period of 15 days.

Borah *et al*. (2016) found that Aloe vera has antimicrobial properties and does not add unfavourable properties to the food. A study was carried out by them to evaluate the combined effect of Aloe vera gel coating and bagging of mature unripe fruits in enhancing the shelf life of tomato. Untreated control tomato fruits stored at ambient temperature exhibited the shelf life of 8 days . When Aloe vera gel coating was applied on mature unripe tomato fruits, ripening was delayed by 4 days and fruits could maintain consumer acceptable quality for 12 days. It was interesting to note that combined effect of Aloe vera coating of mature unripe fruits followed by their bagging had tremendous effect on delaying the ripening process and fruits exhibited the shelf life of 40 days. Aloe vera coating followed by bagging of fruits had inhibitory effect on polygalacturonase activity, respiratory and transpirational loss in fruit weight, chlorophyll breakdown and consumer acceptable fruit texture could be maintained for 40 days. From the results, it was

concluded that the application of edible Aloe vera gel coating combined with bagging of mature unripe fruits may be potentially applicable for commercial acceptability, for extending the shelf life and marketing of climacteric fruits.

Akter*et al*. (2013) observed varietal performance on shelf life of banana with some post harvest operations. They observed that Sabri, Champa and Amritasagar showed significant differences in time periods to reach successive stages of ripening. Longer period was required to reach ripening stages in variety Sabri than those of Champa and Amritasagar. Postharvest treatments and varieties were found to exhibit significant variation in total soluble solids (TSS) content during storage. The variety Sabri had the highest TSS content than that of Champa and Amritasagar. An increasing trend in TSS contents was observed in all varieties at all stages of ripening. Disease incidence was the lowest in Sabri variety than that of Champa and Amritasagar. Results also showed that the shelf lives of bananas of the variety Sabri, Amritasagar and Champa were 10.81, 9.00 and 10.11 days, respectively. Sabri had the longest shelf life (16.25 days) than two other varieties. Postharvest treatments exerted significant effects to extend shelf life of bananas.

Misir*et al*. (2014) stated that Aloe vera gel has been proven one of the best edible and biologically safe preservative coatings for different types of foods because of its film-forming properties, antimicrobial actions, biodegradability and biochemical properties. It is composed mainly of polysaccharides and acts as a natural barrier to moisture and oxygen, which are the main agents of deterioration of fruits and vegetables. They also found that Aloe vera gel has the ability to prolong shelf life of the fruits and vegetables by minimizing the rate of respiration and maintaining quality attributes (color, flavor etc.). It has antifungal and antibacterial property which provides a defensive barrier against microbial contamination of fruits and vegetables.

Abundo*et al*. (2011) studied to explore the possibility of using different Neem extracts as natural pesticides against mango hoppers (*Typhlocybanigrobilineata*). There are three kinds of Neem extract to be tested: the Neem seed methanolic extract, Neem seed kernel methanolic extract and the Neem leaf powder in aqueous solution. Dried individual Neem powders are diluted in their respective solvents with a ratio of 1:9 (percent by mass). This constitutes a 10% spray. The solvents for both the neem seed extract and the Neem seed peeling extract is methanol (CH_3OH), while for the Neem leaf extract, distilled water is used instead. Fifteen mango hoppers are each placed in identical glass containers, making a total of 6ty insects, fifteen each for each different treatment and the remaining fifteen used as control (treatment). There are two trials, and both trials results show that the most effective of the three treatments is the Neem seed extract followed by the Neem seed peelings extract and finally, the Neem leaf powder extract. Observation is done solely on the mortality of the test insects at one hour intervals, until no insect is left alive.

Hossain (2007) conducted an experiment and showed that tablets of garlic clove extract were evaluated for controlling Phomopsis blight and fruit rot of brinjal cv. Laffa (s) caused by Phomopsisvexans. Five different doses of garlic tablet viz. 1:1, 1:2, 1:3, 1:4 and 1:5 were applied at pre flowering, fruiting and ripening stage. The entire dose showed good result. The lowest percent leaf infection (11.49%), percent leaf area diseased (1.7%), percent fruit infection (26.33%) and lesion size ($1cm^2$) was recorded in 1:4 Spray dose.

Amin (2006) carried out an experiment to study the effect of four doses of garlic tablet (1:3, 1:4, 1:5, and 1:6) against seed born fungal diseases (*Aspergillusflavus*, *Aspergillusniger*, *Fusariumoxysporum*, *Fusariummoniliforme*, *Penicillium* spp., *Doratomycetes* sp. and *Rhizopusstolonifer*) of cucumber. The highest germination was recorded 80% at 1:3 dose of garlic tablet following blotter incubation method. In pot experiment, 3 dose also performed best to yield the lowest percentage of

dead seed damping off, blighted seedlings, tip over and seedlings with highest seed germination.

Awal (2005) conducted an experiment and stated that garlic tablet treatments of eggplant seeds, cv Singnath was found effective at concentration 1:4 up to the 30 Days age, there after its effect gradually decreased and was replaced by concentration 1:3. fresh tablet to 30 days old age at concentration 1:4 treatments gave the highest seed germination, vigor index and eliminating damping off, seedling blight and tip over completely. Islam (2005) tested 11 botanical extracts to control Phomopsis blight and fruit rot of eggplant. Out of 11 botanicals, garlic bulb extracts were found promising in arresting mycelia growth and inhibition of spore germination of Phomopsisvexans in vitro and controlled Phomopsisvexans in the field significantly. He also found that combination of apparently healthy seed, seed treated garlic bulb extract and soil treated with Trichodermaharzianum completely controlled damping off, tip over and seedling blight in nursery bed in the net house and increased germination by 48.83% over control.

2.2 Effect of plant extract on physico-chemical changes

2.2.1 Weight loss

Weight loss mainly occurs due to water loss by transpiration and loss of carbon reserves due to respiration (Vogler and Ernst, 1999). The rate at which water is lost depends on the water pressure gradient between the fruit tissue and the surrounding atmosphere. Aloe gel based edible coating act as barrier, thereby restricting water transfer and protecting fruit skin from mechanical injuries.

Aloe vera gel (100%) has been used to preserve papaya fruit at room temperature 25°C-29°C and 82-84% RH. All samples demonstrated a gradual loss of weight during storage. Throughout storage, the weight loss of uncoated fruit (sample) was significantly greater than that of Aloe gel coated fruit. At the end of the storage, uncoated papaya showed 22.5 % loss in weight, whereas the weight losses of

samples coated with Aloe vera gel was 7.93% (Brishti*et al*., 2013). An experiment has also been carried out to maintain quality and safety of table grapes by coating with Aloe vera gel in cold storage (1°C, 95%). Weight loss increased during cold storage and it was significantly greater in control (uncoated fruits) than in Aloe-coated grapes. At the end of cold storage, control fruits lost 15.51 ± 0.32%, whereas the loss of weight in Aloe-treated grapes was 8.13 ± 0.59% (Tripathi and Dubey, 2004).

The development and use of alternative post harvest control options, involving biological agents or natural plant extracts, have become important since it is perceived as being environmentally safer and more acceptable to the general public (Janisiewicz and Korsten, 2002). According to Aborisade and Ajibade (2010) and Romero *et al*. (2011), it has been mentioned that, weight loss continuously increased during fruit storage

Bisen*et al*. (2011) conducted an experiment to assess the influence of chemical and oil coatings on storage life of lime. Fruits were harvested at physiological light green mature stage and treated with different concentrations of edible coatings *viz*., (coconut oil, mustard oil, sesamum oil, castor oil and liquid paraffin wax). The results revealed that edible oil emulsion coating particularly coconut oil had significantly effect on reduction of the physiological loss in weight (9.67%) and maximum marketable fruits retained (70%).

Shindem*et al*.(2009) reported that the fruits treated with different plant extracts and wrapped in different wrapping materials, showed lower and slower rate m physical and chemical changes than control fruits. The fruits treated with neem oil 10 per cent proved to be most effective with respect to lower physiological loss in weight and higherfirmness of fruits.

The lowest physiological weight loss recorded in 2000 (3.5%) was from the treatment with pre-cooling followed by fruits coated with 1.5% neem oil. These

results are possibly due to the reduction of both the rate of metabolism and prevention of water loss as reported by Bhardwaj and Sen (2003).

Singh *et*al. (2000) studied the effect of GA_3 and plant extract, castor oil and neem oil on storage behaviour of mango Mangi/era indica cv. Langra and reported that the treatment of neem oil (10%) showed the minimum physiological weight loss when compared to other treatments and controls, wherein, the maximum physiological weight loss (17.28%) was recorded on the 12^{th} day of storage.

2.2.2 Color

Visual assessment is the first impression and a key feature in the choice of fruits. Color is one of the most important visual attributes of fruits. According to reference (Ergun and Satici, 2012), Aloe vera gel treatment delayed the green color loss on the fruit skin of apples stored at 2°C for 6 months. Skin color of table grapes showed lower increases in Aloe treated than in control (untreated) fruits. Table grapes are rich in anthocyanin compounds, which account for their red color. The ripening process of table grapes has been correlated to the anthocyanin content (Cantos *et al*., 2002). At the end of cold storage (1°C, 95% RH), control fruits exhibited a redder and darker color than Aloe-treated ones, showing the aspect of overripe fruit, which is considered to be detrimental to color quality (Tripathi and Dubey, 2004).

The modified atmosphere created by the Aloe vera gel coating material retarded the ethylene production rate, therefore, delaying ripening, chlorophyll degradation, anthocyanin accumulation and carotenoid synthesis thus ultimately delaying color change of fruits (Carrillo-Lopez *et al*., 2000).

2.2.3 Moisture content of fruit pulp

Wijewardane and Guleria (2009) conducted an experiment on various coating oil where, the surface-coating of apple with 2% neem oil were significant on moisture content. Correa *et al.* (2008) conducted an experiment to assess respiration and chemical changes of papaya fruit in relation to room temperature (40, 45, 50, 55 and 60°F) and reported that moisture content decreased with decreasing temperature.

Moisture content of fruit was slightly decreased at the end of storage period. This may be due to the slower loss of moisture from pre-cooled commodities when higher relative humidity is maintained in the storage atmosphere. Such conditions can easily be achieved by lowering the temperature as the storage environment tends to be more saturated simply by reduction in temperature (Lurie and Ben, 1990). The results of the present study revealed that coating of fruits with neem extract was more helpful on moisture content.

Many workers have determined the per cent of moisture content of fruit at different places of the world. Morton (1987) reported that 81.3 to 91.2% moisture in pineapple fruit pulp. According to Purseglove (1985), pineapple fruits contain approximately 85% moisture.

Salunkhe and Desai (1984) stated that 81.2 to 86.2% moisture in pineapple fruits. Samson (1986) found that fresh pineapple fruits contain 80 to 85% moisture.

Rahman*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, but the difference was not very significant. According to their investigation the fruits showed a slightly increase in moisture content towards the end of the storage.

2.2.4 Total soluble solid (TSS) content

Reni *et al*. (2000) evaluated the storage stability of 12 papaya cultivars and after 4 months they observed that TSS in pulp decreased during storage with the ripening total soluble solids in the peel of papaya increased. Aziz *et al*. (1975) noticed that in mature papaya total soluble solids showed a slight and gradually increase up to the end of storage at 10°C or 15°C for 16-20 days.

Aguaya*et al*. (2004) reported that the papaya stored at 15°C and ripened thereafter registered the highest values of quality parameters like TSS, reducing and non-reducing sugars, total sugars and ascorbic acid.

Barakat*et al*. (2012) reported that the Biological control of postharvest treatments significantly increased TSS content of fruits and reduced fruit firmness and its contentsof total acidity.

Naher (2000) evaluated the pattern of physico-chemical changes and shelf life of papaya under different storage conditions including cold temperature and reported that less weight compared to room temperature, increased sugar content and TSS while titratable acidity decreased under low temperature.

1`Abd El-Naby (2010) reported that the biological postharvest viz. mandarinvcltile oil relatively more effective on TSS/titratable acidity ratio were used as good criterion of evaluating the ripening.

Wijewardane and Guleria (2009) conducted an experiment on various coating oil where, the surface-coating of apple with 2% neem oil were significant on TSS and titratable acidity. The increase in TSS and sugar content may be due to the hydrolysis of insoluble polysaccharides into simple sugars. Such changes are expected to be slower and more gradual when the metabolism of the commodity is slowed down by the application of various coating treatments viz. 1.5-2% neem oil, pre-cooling and under low temperature storage.

Shindem*et al*. (2009) were studied to increase the shelf life and to minimize the post harvest losses in mango cv. 'KESAR', under the influence of various plant extract treatments. The fruits treated with different plant extracts and wrapped in different wrapping materials, the fruits treated with neem oil 10 per cent proved to be most effective with respect to slower increase in TSS, while slower decrease in ascorbic acid and acidity during storage. Mia (2003) noted that total soluble solids increased significantly during storage in all treated and untreated fruits.

An experiment was carried out by Chadha*et al.* (1972), at Banglaore in India, with pineapple fruits of different stage of maturity in respect of physico-chemical changes in them, concludedthat very young pineapple had ahigh TSS.

2.2.5 Pulp to peel ratio

Uddin and Hossain(1993) earned out an experiment on the pineapple fruits (cv. Giant Kew) in the field laboratory of BARI at Joydebpur. They found that pulp to peel ration increased up to 15 days of storage after which it decreased slightly.

Tripathi*et al*. (1981) mentioned an increase in pulp to peel ration during ripening. The reason for this was explained by him that the pulp increase in weight due to an increase in water content. This water is obtained from the peel and probably also from the stalk. This causes weight loss in peel with concomitant rise in pulp to peel ratio.

2.2.6 Effect of plant extract on disease incidence and severity

Muniz *et al*. (2003) conducted an experiment to identify the fungal diseases on eight different fruit cultivars during storage. The fungi were isolated on PDA medium and their pathogencity was tested by wound inoculation on several healthy fruits which was the identified fungi,*Colletotrichumgloeosporioides*(*Glimerellacingulata*)was the most frequently isolated which was the causal agent of anthracnose of papaya

andAcrernoniumsp**,** F, anthophilurnandF. equisetiwere the causal agents of diseases associated with postharvest decay on tropical fruits.

Dantas*et al*. (2003) reported that fungal diseases constitute one of the main causes of loss during commercialization of tropical fruits. Papaya fruits were analyzed in relation to disease incidence and frequency of the pathogenic species for 6 months, in Pernambuco, Brazil. A great diversity of diseases occurred in papaya fruits, where incidences ranged from 39.71 to 80.07%, with the higher level for stem end rot. The pathogens that presented higher frequencies were Colletotrichumgloeosporioides (Glomerellacingulata) (44. 95%) in papaya.

Raheja and Thakore (2002) reported that extracts from medicinal plants like Allium sativum (cloves), Azadirachtaindica (leaves), Menthaarvensis (leaves) and Psoraleacorylifolia (seeds) were found most effective to check the mycelial growth of C. gloeosporioides followed by Curcuma longa (Rhizomes), Coriander sativum(leaves) and Lantana camara (leaves and flowers).

Obagwu and Korsten (2003) conducted an experiment to test the efficacy of water and ethanol extracts of garlic cloves in the control of Pencilliumdigitatum and P. italicum, the cause of citrus green and blue mold, respectively. They applied the extracts to artificially inoculated citrus fruits (orange and grape fruit). Alam (1990) reported that neem (Azadirachtaindica) had good properties in controlling plant parasitic nematodes.

Singh *et al.* (2000) studied the effect of plant extract, castor oil and neem oil on storage behaviour of mango (*Mangiferaindica*) cv. Langra and reported that the treatment of neem oil (10%) showed the minimum physiological weight loss when compared to other treatments and controls, wherein, the maximum physiological weight loss (17.28%) was recorded on the 12^{th} day of storage.

Maqbool*et al*. (2011) were studied on the management of anthracnose caused by Colletotrichum spp. Antifungal effects of gum arabic (GA) (10%), lemongrass oil

(LG) (0.05%), cinnamon oil (CM) (0.4%), and their combinations were investigated in vitro and in vivo for controlling postharvest anthracnose of banana and papaya. LG at 0.05% and 0.4% CM showed fungicidal effects against Colletotrichummusae and Colletotrichumgloeosporioides, causal organisms of banana and papaya anthracnose, respectively. The results suggest the possibility of using 10% gum arabic combined with 0.4% cinnamon oil as a biofungicide for controlling postharvest anthracnose in major tropical fruit such as banana and papaya.

Anthracnose, caused by Colletotrichumgloeosporioides, a fungal pathogen. It infects new flushes of leaves or may occur at the various stages of development from fruit set to maturity. The disease is common during wet season as it spreads and reproduces rapidly specially in warm areas. At present, pesticide is the most widely recommended and adopted method of controlling the pest. Ines *et*al. (2008) evaluated the efficacy of promising plant materials against anthracnose of Hawaiian and native mango seedlings. The Plant materials evaluated were neem(Azadirachtaindica A.Juss), 'Malunggay (Moringaoleifera L.), and garlic (Allium sativum). The effect of the Plant extracts was compared with those of untreated plants and fungicide-treated plants.

Meah (2007) stated that garlic clove completely arrested that mycelia growth and spore germination of Phomopsisvexans and produced larger inhibition zeones (5.7 cm and 5.5 cm diameter, respectively) in in vitro tests. In the nursery, garlic bulb extracts completely controlled damping off and seedling blight and promoted seed germination.

Hossain (2007) conducted an experiment and showed that tablets of garlic clove extract were evaluated for controlling Phomopsis blight and fruit rot of brinjal cv. Laffa(s) caused by Phomopsisvexans. Five different doses of garlic tablet viz. 1:1, 1:2, 1:3, 1:4 and 1:5 were applied at pre-flowering, fruiting and ripening stage. All

the doses showed good results. The lowest percent leaf infection (11.49%), percent leaf area diseased (1.07%), percent fruit infection (26.33%) and lesion size (1 cm^2) was recorded in 1:4 spray dose.

Inoculating orange fruits with the Trichodermahamatum, Trichodermaharzianum and Bacillus subtilis as biological control agents reduced the severity of fruit rot, with considerable decrease in fruit acidity. These changes differed according to the concentration of the tested biological control agents (Eisa*et al*., 2001; Abd-El-Aziz and Mansour, 2006).

Dhali (2006) showed that garlic tablets treatment controlling Phomopsis blight and fruit rot of Solanummelongena cv. Dohazari caused by Phomopsisvexans was evaluated different doses (1:1, 1:2, 1:3 and 1:4 w/v) at three crop growth stage. Among four doses, 1:4 w/v concentration garlic was found most effective to reduce incidence and severity of leaf and fruit infection. The effect of allamanda extract was also promising against fungi (Khan, 1999; Meah*et al*., 2002).

Hemandez-Castro *et al*. (2005) conducted an experiment on the effect of neem extracts on feeding behavior of Aphis nerii, as well as Papaya Ringspot Virus (PRSV-p) transmission, was determined. We evaluated papaya seedlings sprayed under laboratory conditions with a 10% aqueous extract of unpeeled neem seed and with a water control. Two time periods, exploratory (0 to 3 min) and feeding (>3 to 20 min), were used to evaluate aphid feeding behavior. Aphid mortality was determined 24 h after spraying. Viral transmission was measured by ELISA tests. No significant differences ($p > 0.05$) were obtained in the exploratory feeding behavior. However, significantly more aphids ($p < 0.05$) stopped feeding on neem-sprayed plants from the >3 to 20 min period. Also, higher ($p < 0.05$) aphid mortality (37% vs. 10%) was found in neem-sprayed plants. However, no significant differences ($p > 0.05$) were found in PRSV-p transmission, thus indicating that neem seed aqueous extracts did not prevent viral transmission.

Bagwan (2001) stated that treatment of banana fruits with neem extract (*Azadirachtaindica*) for 5 minutes were most effective for controlling various post harvest disease of banana. The use of crude plant extracts as an alternative to commercial fungicides in the control of capsicum anthracnose as estimated by (Singh *et al*., 1999) 5000ppm on capsicum annum was compatible with the fungicide carbendazim (Bavistin) at 1000 ppm.

Ashrafuzzaman and Khan (1992) studied the sclerotial formation and mycelia growth of Rhizoctoniasolani in vitro. They found no sclerotial formation using garlic extract against abundant sclerotial formation in case of control. However, the effects of garlic extract on postharvest disease reduction is scantly.

Fakir and Khan (1992) reported that seed treatment with garlic bulb extracts at different concentrations significantly reduced seed borne infection of Macrophominaphaseolina, Colletotrichumcorchori and Fusarium spp. in jute. Both concentration of garlic extract and vitavax 200 were more or less equally effective in controlling Macrophominaphaseolina reducing 90.9% and 87.9% seed borne infection respectively. More than 80% control of seed borne infection of Fusarium spp. was achieved with 1:4 garlic extract.

Emeruwa (1982) reported that the ripe and unripe Carica papaya fruits (epicarp, endocarp, seeds and leaves) were extracted separately and purified. All the plant extracts except that of leaves produced very significant antibacterial activity on *Staphylococcus aureus, Bacillus cereus, Escherichia coli, Pseudomonas aeruginosa* and *Shigellaflexneri*. The MIC of the substance was small (0.2-0.3 mg/ml) for gram-positive bacteria and large (1.5-4 mg/ml) for gram-negative bacteria. The substance was bactericidal and showed properties of a protein. Other proteins previously found in C. papaya did not show antibacterial activity.

Sing and Dwivedi (1987) observed that hyphal dry weight and sclerotic production of *Sclerotiumrolfsii*sace were significantly reduced by leaf extracts of

neem. They conducted an experiment to compare antifungal property of garlic clove juice with recommended dose of fungicidal treatments against Fusarium wilt of watermelon. They reported that garlic extract inhibited spore germination and mycelial growth of *Fusariumoxysporum*, *F. niveum* in extent similarly to five different fungicides.

2.2.7 Effect of plant extract on shelf life

Shelf life is the period of time which start from the tune of harvesting and extend up to the start of rotting of fruit (Mondal, 2000), and it is the basic quality of fruit as well as it is the most important parameter in loose of reduction biochemical reaction of fruit. Bose and Mitra (1996) stated that in tropical climate pineapple fruits could be stored for up to 10 days under ambient condition.

Wijewardane and Guleria (2009) were investigated on the use of natural flora as one of the sources for crop protection. The fruits were analyzed for physicochemical and physiological characters such as loss in weight, fruit firmness, total soluble solids (TSS) content, titratable acidity (TA), pH, content of reducing sugars etc. The results revealed that, the surface-coating of apple with 2% neem oil together with shrink-wrapped tray packing provided better retention of storage life of fruit and the treatment effect on physico-chemical characteristics of fruits were significant.

An experiment was conducted by Shakila and Anburani (2009) to know the effect storage temperature (5, 10, 15, 25°C and at ambient temperature or control) on quality and shelf life of papaya. It was observed that fruits subjected to storage temperatures of o and 10°C failed to ripen, while fruits stored at 15°C ripened normally. The fruits stored at 25°C and at ambient temperatures ripened on 7^{th} and 5^{th} day after storage respectively. Assessment of quality parameters like TSS, reducing and non-reducing sugars, total sugars and ascorbic acid revealed that

fruits stored at 15°C and ripened thereafter registered the highest values for all the quality parameters.

Singh *et al*. (2003) also reported the effect of various plant extracts such as neem leaves, castor oil and neem oil on citrus fruits and identified neem leaf extract as the best in retaining most of the biochemical characteristics and shelf life.

The shelf life of fruits was maximum (19.33 days) at 13°C followed by zero energy cool chamber (8.33 days) and the least was under ambient condition (8.67 days) compared to control. Non significant variation was observed for total soluble solids (TSS) of fruits under all the 3 storage conditions. The acidity increased gradually up to the end of green life and the decreased or remained the same until the end of yellow life. Reducing sugars and total sugars increased gradually throughout the storage period and was maximum in the control (Narayana*et al*., 2002).

Biochemical reaction known to continue in harvested fruit until ripened, this process cannot be stopped. These biochemical reactions decreased free energy and increase the randomness of the system (Salunkhe and Desai, 1984). Geetha and Thirumaran (2010) concluded that the shelf life of the fruits increased under vacuum packing with room and refrigeration temperatures for one and four weeks, respectively. During storage moisture, acidity, vitamin C and total sugar decreased whereas reducing sugar and total soluble solids (TSS) increased.

An experiment was conducted by Rahman*etal*. (1979) with pineapple fruits (cv. Gian, Kew) at BCSIR laboratory to study the changes in physiological and characteristics in full-ripe fruits during storage and observed that the fruits retained then shelf life for 12 days when stored under ambient temperature of between 30-32°C.

From the above reviews, it is clear that quite large volumes of works have been done in different parts of the world. Different issues related to the physico-

chemical changes, shelf life extension, and diseases have been cited in the above. The similar reports are scanty in Bangladesh. Very little information available in Bangladesh with the regards to the use of plan, extracts as a postharvest treatment on physico-chemical changes, shelf life and diseases during storage and ripening. Hence, the present study attempts to investigate the physico-chemical changes, shelf life and duality maintenance of papaya using different promising postharvest treatments of plant extract.

CHAPTER III

MATERIALS AND METHODS

This chapter presents a brief description about experimental period, site description, climatic condition, crop or planting materials, treatments, experimental design and layout and data collection and statistical analyses.

3.1 Experimental location

The experiment was conducted at the laboratory of Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka during the period from 16 March 2016 to 27 March 2016. The maximum and minimum temperatures as well as relative humidity in the storage room were 29.3°C and 20.2°C and 85% and 50% respectively (Appendix I). Temperature and relative humidity of the storage room were recorded with a digital Temperature-humidity recorder (Thermo, Germany).

3.2 Experimental materials

Fully matured banana bunches cv. Amritasagar and Sabri of uniform size, shape and colour were used for the study. Freshly harvested bananas *viz.*Amritsagar and Sabri of uniform size, shape and color were collected fromShibpurupazilla ofNarshingdi district. Two varieties of banana were harvested in the morning hours and transferred to the Department as early as possible with careful handling to avoid injury and placed in the central Laboratory, Sher-e-Bangla Agricultural University. Immediately after collection, the bunches were pre-cooled by fan to remove the field heat. A short description of the two cultivars of banana fruits included in the present study is given below.

3.2.1 Amritasagar

Amritasagar is the best table banana of this country and is considered as the leading commercial variety in Bangladesh. The bunches of this variety are

pendant. Peduncle and rachis are pubescent to some extent. Each bunch has 6 to 8 hands and each hand has 12-13 fingers. The finger is long and distinctly curved at the middle. Pedicel of the finger is short and apex prominently nippled. The pericarp is medium thick. This banana when ripe has soft pulp with fine textures and good aroma and is completely seedless.

3.2.2 Sabri

Sabri is one of the most important commercial varieties in Bangladesh and is considered even better than Amritasagar by many consumers. Bunches are pendant and peduncles pubescent. There are 7-10 hands per bunch and each bunch possesses 11-16 fingers. Finger is medium long with curvature less distinct than Amritasagar. Peduncle is short and apex slightly nippled. Pericarp is medium thick and pulp of the ripe fruit is soft with mild to distinct aroma.

3.3 Experimental design

The two-factor experiment was laid out in completely randomized design (CRD) with three replications of 4 fruits per replication.

3.4 Methods

Matured banana, approximately more or less uniform in size, shape and colour were selected. A total number of 108 fingers were carefully selected from each of the varieties for conducting the experiment. The skins of banana were cleaned with the help of soft tissue paper just before setting.

3.5 Experimental treatments (coating materials)

The experiment consists of two factors as follows;

Factor A: Varieties

1. V_1 = Amritsagar
2. V_2 = Sabri

Factor B: Different organic coating

1. T_0 = Control
2. T_1 = Aloe-vera gel
3. T_2 = Ginger oil
4. T_3 = Garlic extract
5. T_4 = Onion extract
6. T_5 = Neem extract

3.6 Application of experimental treatments

The selected banana fruits were randomly assigned in the study for the post harvest treatments. After the application of treatments, the fruits were kept on a brown paper previously placed on the table in the laboratory at room temperature. The procedures of applying the postharvest treatments to the fruits of each variety were as follows.

3.6.1 Control

About a number of 18 fingers of each variety were selected and arranged with replication and kept on the brown paper placed on the table in the laboratory.

3.6.2 Aloe-vera gel

The number of fruits treated with Aloe-vera gel was 18 from each variety. The separated fruits were then individually dipped in prepared Aloe-vera gel extract and placed on the laboratory table at ambient condition for observation.

Aloevera pulp was collected from 30 Aloe-vera leaves.Then the pulp was blended with a blender machine and filtered with a clean sterilized cloth. Thus the aloe-vera gel was prepared. Then the selected fingers were dipped into the gel for 5 minutes and allowed to air dry for a period of 10 min and then kept onbrown paper for observation at ambient condition.

3.6.3 Ginger oil

The number of fruits treated with ginger oil was 18 from each variety. The separated fruits were then individually dipped in prepared ginger oil extract and placed on the laboratory table at ambient condition for observation.

Ginger oil was collected from the market. The fruits were then dipped into the treatment solutions for 5 minutes to ensure that enough quantity of extract being absorbed. The treated fruits were allowed to air dry for a period of 10 min and then kept onbrown paper for observation.

3.6.4 Garlic extract

The number of fruits treated with garlic extract was 18 from each variety. The separated fruits were then individually dipped in prepared garlic extract and placed on the laboratory table at ambient condition for observation.

Initially stock garlic extract (400 g garlic cloves and 400 ml water) was prepared by crushing the fresh doves in water using a blender and then cheesed. The stock extract was then used to prepare treatment concentrations of 1:1 (400 ml stock: 400 ml water). The fruits were then dipped into the treatment solutions for 5 minutes to ensure that enough quantity of extract being absorbed. The treated fruits were allowed to air dry for a period of 10 min and then kept onbrown paper for observation.

3.6.5 Onion extract

The number of fruits treated with onion extract was 18 from each variety. The separated fruits were then individually dipped in prepared onion extract and placed on the laboratory table at ambient condition for observation.

Initially stock of onion bulb extract (500 g onion bulb and 500 ml water) was prepared by crashing the fresh bulbs using a blender and then cheesed. The stock extract was then used to prepare treatment concentrations of 1:1 (500 ml stock: 500 ml water). The fruits were then dipped into the treatment solutions for 5 minutes to ensure that enough quantity of extract being absorbed. The treated fruits were allowed to air dry for a period of 10 min and then kept on brown paper for observation.

3.6.6 Neem extract

The number of fruits treated with neem extract was 18 from each variety. The separated fruits were then individually dipped in prepared neem extract and placed on the laboratory table at ambient condition for observation.

Initially stock of neem extract (400 g leaves crushed) was prepared by crashing the fresh leaves using a blender and then cheesed. The stock extract was then used to prepare treatment concentrations of 1:1 (400 ml stock: 400 ml water). The fruits were then dipped into the treatment solutions for 5 minutes to ensure that enough quantity of extract being absorbed. The treated fruits were allowed to air dry for a period of 10 min and then kept on brown paper for observation.

3.7 Observation

During the entire storage period, the fruits, used for the experiment, were keenly observed everyday anddata was recorded on TSS as well as physico-chemical changes during 3, 6, 9 and 12 days after storage (DAS) as influenced by different treatments.

3.8 Parameters studied

In the experiment the following parameters were studied:

1. External fruit characters (Appearance/color)
2. Total weight loss (%)
3. Moisture content (%)
4. Total soluble solids (TSS) content of banana pulp
5. Pulp to peel ratio
6. Disease incidence (percentage of fruits infected)
7. Disease severity (percentage of fruits skin infected)
8. Shelf life

3.9 Methods of studying the physico-chemical parameters

3.9.1 External fruit characters (color)

External fruit characters such as shape, size and thickness were recorded just after harvesting the fruits, changes in skin color were recorded during storage by matching the pericarp colours with a standard colour chart (RHS, 1995).

3.9.2 Determination of weight loss (%)

The banana hands used in this study were weighed using a top balance and kept for storage. Percent total weight loss was calculated at intervals of 3, 6, 9 and 12 days of storage using the following formula:

$$\text{Percent weight loss (\%WL)} = \frac{IW - FW}{IW} \times 100$$

Where,

% WL = Percentage total weight loss
IW= Initial fruit weight and
FW= Final fruit weight

3.9.3 Moisture content

Five grams of banana pulp were weighed in a petridish from each treatment out of each replication. The petridish was placed in an electric oven at 80°C for 72 hours until the weight became constant. It was then cooled and weighed again.

Finally, the per cent moisture content of banana pulp was calculated using the following formula:

$$\text{Percent moisture} = \frac{\text{IFW-FOW}}{\text{IFW}} \times 100$$

Where,

IFW =Initial fresh weight of pulp, and

FOW =Final weight of oven dried pulp

3.9.4 Total soluble solids (% Brix)

Total soluble solids (TSS) content of banana fruit pulp was estimated by using Abbe's refractometer. A drop of banana juice squeezed from the fruit pulp on the prism of the refractometer. Percent TSS was obtained from direct reading of the instrument.

3.9.5 Pulp to peel ratio

The fruits were peeled at the intervals of 3, 6, 9 and 12 days of storage from each replication. After separation of peel from pulp, the peel and pulp weights were also taken separately by using an electric balance and then the pulp to peel ratio was calculated.

The pulp to peel ration was calculated with the following formula:

$$\text{Pulp to peel ration} = \frac{\text{Weight of fruit pulp}}{\text{Weight of peel}}$$

3.9.6 Assessment of percent diseaseincidence

The incidence of fruitdiseases was recorded every 2nd day. The fruit rot of banana under observation was identified by the visual comparison with those of the symptoms already published. The incidence of fruit rot was calculated as follows-

$$\text{\% Disease incidence} = \frac{\text{Number of infected fruits}}{\text{Total number of fruits under the study}} \times 100$$

3.9.7 Assessment of percent disease severity

The percentage fruit skin disease was recorded five times starting at the 6th day of storage. All the infected fruits were selected to determine percent fruit area infected. The percentage fruit area diseased was measured based on eye estimation. The mean values regarding infectedfruit area were calculated, presented and discussed in result and discussion chapter.

3.9.8 Isolation and identification of causal pathogens

Diseased samples from each infected fruits were collected and carried to the Plant Pathology Laboratory of the Plant Pathology Department of Sher-e-Bangla Agricultural University, Dhaka, for isolation and identification of the organisms. The collected samples were kept in the refrigerator overnight. The visible symptoms and signs on the diseased samples were studied in detail. Diseased fruit samples with typical symptoms were selected and several pieces from the diseased area of the fruit were cut in such a way so that each cut piece possess diseased and healthy tissues. The cut pieces were then surface sterilized in 0.1 percent

$HgCl_2$solution for three seconds. After disinfection, the materials were washed thrice in sterile water. After wards, the pieces were placed in PDA (Potato Dextrose Agar) plate. Five pieces were placed in each plate and were incubated at room temperature for seven days to grow the pathogen. Seven days after inoculation, a temporary or semi permanent slide was prepared from the culture. Then the prepared slides were observed under compound microscope for studying the pathogenic structures. The pathogen was identified on the basis of its vegetative and reproductive structures.

3.9.9 Shelf life

Shelf life of banana fruits as influenced by different storage treatments and variety was calculated by counting the days required to ripe fully as to retaining optimum marketingand eating qualities.

3.10 Statistical analysis

The collected data on various parameters were statistically analyzed using MSTAT statistical package program. The means for all the treatments were calculated and analysis of variances (ANOVA) for all the parameters were performed by F-test. The significance of difference between the pairs of means was compared by least significant difference (LSD) test at the 1% and 5% levels of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

This chapter comprises the presentation and discussion of the results obtained from the present investigation. The effect of different treatments in respect of physicochemical changes and shelf life of banana were presented in this chapter. Qualitative evaluations of external and internal characters of fruits and general ripening behaviour observed during the period of the study have also been briefly mentioned.

4.1 External fruit characteristics (appearance/color)

Different external features of banana as size, shape and peel colour of 2 varieties were under investigation after harvest. Good colour is the sign as the criteria of quality of most of the fruits. The changes in the colour of the banana peel from green to yellow are the most obvious change which occurs during the storage of fruits. Changes in peel colour during ripening and senescence of fruits involved either chlorophyll degradation or qualitative and quantitative alterations of green pigment into other pigment. During colour change pulp become softer and sweeter as the ratio of sugars to starch increases and the characteristics aroma is produced (Robinson, 1996). The fruit character showed a gradual increase in colour development in each of 2 varieties under different treatment. The increasing rate of colour development is faster in Amritasagar and comparatively slower in Sabri (Plate 1-10). Here, 10 plates are represented to show color changes with the increase of storage time. Plate 1-2 show banana at first day of storage, Plate 3-4 show banana at 3^{rd} day of storage, Plate 5-6 show banana at 6^{th} day of storage, Plate 7-8 show banana at 9^{th} day of storage, Plate 9-10 show banana at 12^{th} day of storage.

V_1T_0

V_1T_1

V_1T_2

V_1T_3

V_1T_4

V_1T_5

Plate 1. Peel colour of banana (cv. Amritsagar) at 1st day of storage as influenced by different organic coatings

V_1 = Amritsagar, V_2= Sabri

T_0 = Control, T_1 = Aloe-veragel , T_2 = Ginger oil, T_3 = Garlic extract, T_4 = Onion extract, T_5 = Neem extract

V_2T_0 V_2T_1 V_2T_2

V_2T_3 V_2T_4 V_2T_5

Plate 2. Peel colour of banana (cv. Sabri) at 1st day of storage as influenced by different organic coatings

V_1 = Amritsagar, V_2= Sabri

T_0 = Control, T_1 = Aloe-veragel , T_2 = Ginger oil, T_3 = Garlic extract, T_4 = Onion extract, T_5 = Neem extract

V_1T_0

V_1T_1

V_1T_2

V_1T_3

V_1T_4

V_1T_5

Plate 3. Peel colour of banana (cv. Amritsagar) at 3rd day of storage as influenced by different organic coatings

V_1 = Amritsagar, V_2= Sabri

T_0 = Control, T_1 = Aloe-veragel , T_2 = Ginger oil, T_3 = Garlic extract, T_4 = Onion extract, T_5 = Neem extract

V_2T_0 V_2T_1 V_2T_2

V_2T_3 V_2T_4 V_2T_5

Plate 4. Peel colour of banana (cv. Sabri) at 3rd day of storage as influenced by different organic coatings

V_1 = Amritsagar, V_2= Sabri

T_0 = Control, T_1 = Aloe-veragel , T_2 = Ginger oil, T_3 = Garlic extract, T_4 = Onion extract, T_5 = Neem extract

V_1T_0

V_1T_1

V_1T_2

V_1T_3

V_1T_4

V_1T_5

Plate 5. Peel colour of banana (cv. Amritsagar) at 6th day of storage as influenced by different organic coatings

V_1 = Amritsagar, V_2= Sabri

T_0 = Control, T_1 = Aloe-veragel , T_2 = Ginger oil, T_3 = Garlic extract, T_4 = Onion extract, T_5 = Neem extract

V_2T_0

V_2T_1

V_2T_2

V_2T_3

V_2T_4

V_2T_5

Plate 6. Peel colour of banana (cv. Sabri) at 6th day of storage as influenced by different organic coatings

V_1 = Amritsagar, V_2= Sabri

T_0 = Control, T_1 = Aloe-veragel , T_2 = Ginger oil, T_3 = Garlic extract, T_4 = Onion extract, T_5 = Neem extract

Shelf-life was ended in 7th day

Self-life was ended in 8th day

V_1T_0 V_1T_1 V_1T_2

V_1T_3 V_1T_4 V_1T_5

Plate 7. Peel colour of banana (cv. Amritsagar) at 9th day of storage as influenced by different organic coatings

V_1 = Amritsagar, V_2= Sabri

T_0 = Control, T_1 = Aloe-veragel , T_2 = Ginger oil, T_3 = Garlic extract, T_4 = Onion extract, T_5 = Neem extract

Shelf-life was ended in 7th day		**Self-life was ended in 8th day**
V_2T_0	V_2T_1	V_2T_2
		
V_2T_3	V_2T_4	V_2T_5

Plate 8. Peel colour of banana (cv. Sabri) at 9th day of storage as influenced by different organic coatings

V_1 = Amritsagar, V_2= Sabri

T_0 = Control, T_1 = Aloe-veragel , T_2 = Ginger oil, T_3 = Garlic extract, T_4 = Onion extract, T_5 = Neem extract

Shelf-life was ended in 7th day

V_1T_0

V_1T_1

Self-life was ended in 8th day

V_1T_2

V_1T_3

Self-life was ended in 10th day

V_1T_4

V_1T_5

Plate 9. Peel colour of banana (cv. Amritsagar) at 12th day of storage as influenced by different organic coatings

V_1 = Amritsagar, V_2= Sabri

T_0 = Control, T_1 = Aloe-veragel , T_2 = Ginger oil, T_3 = Garlic extract, T_4 = Onion extract, T_5 = Neem extract

Shelf-life was ended in 7th day

Self-life was ended in 8th day

V_2T_0 V_2T_1 V_2T_2

Self-life was ended in 10th day

V_2T_3 V_2T_4 V_2T_5

Plate 10. Peel colour of banana (cv. Sabri) at 12thday of storage as influenced by different organic coatings

V_1 = Amritsagar, V_2= Sabri

T_0 = Control, T_1 = Aloe-veragel , T_2 = Ginger oil, T_3 = Garlic extract, T_4 = Onion extract, T_5 = Neem extract

4.2 Changes in physical characters during storage

4.2.1 Total weight loss

In respect of weight loss of banana significant variation was observed among the varieties each of the days of storage period (Appendix- II). The higher weight loss (4.1, 9.4, 11.1 and 15.1% at 3, 6, 9 and 12 DAS respectively) was recorded in V_1 (Amritsagar) to which treatment was applied before ripening. Again, V_2 (Sabri) showed the lower %weight loss(3.4, 7.2, 8.3 and 9.1 % at 3, 6, 9 and 12 DAS respectively) (Table. 1).

The different postharvest treatments showed evidence of more evident effect on weight loss of banana during storage. Variation among the treatments was highly significant during each days of storage (Table 1 and Appendix II). Total weight loss on treated and untreated banana was increased with the duration of storage. The maximum weight loss (14.5%) in control treatment at 6^{th}days of storage was recorded.Among the treated banana, T_1 (Aloe-vera gel) gave the best performance on % weight loss and gave the minimum %weight loss(2.8, 4.9, 6.7 and 8.9% at 3, 6, 9 and 12 DAS respectively) which was closely followed by T_3(Garlic extract).

The combined effect of two varieties and postharvest treatments were statistically significant at each day of observation (Appendix II). The higher level of weight loss (15.8%) was recorded in V_1 (Amritsagar) with control treatment (V_1T_0) at 6^{th}days of storage and 9 and 12^{th}days of storage was not observed due to rotting. At 12^{th}days of storage, the maximum weight loss (20.3%) was in V_1 (Amritsagar) with T_5 treated fruits (V_1T_5) followed by (15.5%) in V_1 (Amritsagar) with T_3 treated fruit and minimum (8.1%) was observed in V_2 (Sabri) with T_1 treated fruits (V_2T_1) (Table 1).

Table 1. Effects of varieties and different organic coating on percent total weight loss of banana at different days after storage (DAS)

Treatment	% Total weight loss			
	3 DAS	6 DAS	9 DAS	12 DAS
Effect of variety				
V_1	4.1	9.4	11.1	15.1
V_2	3.4	7.2	8.3	9.1
$LSD_{0.05}$	0.15	0.62	0.58	0.64
CV(%)	4.31	5.61	3.22	3.76
Effect of different organic coating				
T_0	5.0	14.5	--	--
T_1	2.8	4.9	6.7	8.9
T_2	4.4	9.5	14.7	--
T_3	2.9	6.2	7.5	12.5
T_4	3.9	8.0	11.5	9.5
T_5	3.2	6.7	8.3	14.7
$LSD_{0.05}$	0.18	0.48	0.47	1.11
CV(%)	4.31	5.61	3.22	3.76
Combined effect of variety and different organic coating				
V_1T_0	5.1	15.8	--	--
V_1T_1	3.1	5.9	7.1	9.6
V_1T_2	4.7	9.3	14.8	--
V_1T_3	3.2	7.5	8.5	15.5
V_1T_4	4.8	10.2	15.4	--
V_1T_5	3.5	8.3	9.8	20.3
V_2T_0	4.9	13.3	--	--
V_2T_1	2.6	4.4	6.3	8.1
V_2T_2	4.1	9.7	14.5	--
V_2T_3	2.7	4.8	6.4	9.4
V_2T_4	3.1	5.9	7.5	9.5
V_2T_5	2.9	5.1	6.7	9.2
$LSD_{0.05}$	0.14	0.21	0.32	1.02
CV(%)	4.31	5.61	3.22	3.76

V_1 = Amritsagar, V_2= Sabri

T_0 = Control, T_1 = Aloe-veragel , T_2 = Ginger oil, T_3 = Garlic extract, T_4 = Onion extract, T_5 = Neem extract

4.2.2 Moisture content

The result showed that there were significant differences between the varieties (Appendix III). The higher % moisture content was recorded in V_2 (Sabri) (69.4%, 64.3%, 63.5% and 61.3% at 3, 6, 9 and 12 DAS respectively) and the lower (64.0%, 59.6%,58.0% and 54.9% at 3, 6, 9 and 12 DAS respectively) in V_1 (Amritsagar). The decreasing rates of % moisture content were rapid in V_1 (Amritsagar) than V_2 (Sabri) (Table 2).

During the whole storage period the % moisture content from the pulp of banana decreased. The variation was recorded among the different postharvest treatments and the result was statistically significant at each day of observation (Table 2 and Appendix III). The highest % moisture content was recorded in T_1 (75.7%) at 3rd day followed by T_5 (Neem extract) and T_4 (Onion extract), while the lowest moisture content was recorded in control treatment (T_0) (53.2% and 50.7% at 3rd and 6th DAS respectively)

The combined effects of varieties and treatments were found to be statistically significant at all days of storage (Table 2 and Appendix III). The highest % moisture content was registered in V_2T_1(79.6%) at 3rd DAS followed by V_2T_3, V_2T_5 and V_1T_1whereas the lowest (50.75% and 48.9% at 3rd and 6th DAS respectively) was in V_1T_0.

Table 2. Effects of varieties and different organic coating on percent moisture content of banana at different days after storage (DAS)

Treatment	% Moisture content			
	3 DAS	6 DAS	9 DAS	12 DAS
Effect of variety				
V_1	64.0	59.6	58.0	54.9
V_2	69.4	64.3	63.5	61.3
$LSD_{0.05}$	1.37	1.11	2.02	3.23
CV(%)	6.36	7.11	6.18	5.21
Effect of different organic coating				
T_0	53.2	50.7	--	--
T_1	75.7	70.6	67.6	62.6
T_2	62.2	56.5	51.6	--
T_3	74.9	69.1	65.8	61.5
T_4	65.1	60.4	56.6	53.2
T_5	69.4	64.5	62.1	54.5
$LSD_{0.05}$	1.43	1.21	1.11	2.38
CV(%)	6.36	7.11	6.18	5.21
Combined effect of variety and different organic coating				
V_1T_0	50.7	48.9	--	--
V_1T_1	71.7	67.7	65.2	59.4
V_1T_2	61.7	55.7	50.7	--
V_1T_3	70.9	66.6	62.8	58.5
V_1T_4	63.2	57.9	53.4	--
V_1T_5	65.8	60.5	57.7	46.9
V_2T_0	55.7	52.4	--	--
V_2T_1	79.6	73.4	69.9	65.7
V_2T_2	62.7	57.3	52.4	--
V_2T_3	78.8	71.6	68.8	64.4
V_2T_4	66.9	62.8	59.7	53.2
V_2T_5	72.9	68.5	66.5	62.0
$LSD_{0.05}$	1.25	1.06	1.43	2.34
CV(%)	6.36	7.11	6.18	5.21

V_1 = Amritsagar, V_2= Sabri

T_0 = Control, T_1 = Aloe-veragel , T_2 = Ginger oil, T_3 = Garlic extract, T_4 = Onion extract,T_5 = Neem extract

4.2.3 Total soluble solid (TSS) content of banana pulp

The different varieties used in the investigation showed statistically significant effect on total soluble solid content of banana (Appendix IV). The variety, V_1 (Amritsagar) had higher TSS content (24.8, 29.6, 32.7 and 36.5% at 3, 6, 9 and 12 DAS respectively) and the variety V_2(Sabri) had lower TSS content (23.7, 28.5, 31.4 and 36.5%at 3, 6, 9 and 12 DAS respectively) (Table 3).

The different treatments used in the investigation showed statistically significant variation in relation to percent TSS at different days of storage (Table 3 and Appendix VII). Control treatment, T_0 showed the highest TSS content (26.3 and 36.7%at 3^{rd} and 6^{th} DAS respectively). But under the treated terms, T_2 (Ginger oil) showed the highest TSS content followed by T_4 (Onion extract) where the lowest TSS content was achieved by T_1 (Aloe-vera gel) (21.8, 26.1,30.3 and 35.1at 3, 6, 9 and 12 DAS respectively) followed by T_3 (Garlic extract).

It was found that the combined effects of varieties and postharvest treatments were statistically significant (Table 3 and Appendix VII). It was found that control treatment with V_1 (Amritsagar) and V_2 (Sabri) showed the highest TSS content at 3^{rd} and 6^{th} DAS. At 9^{th}day the highest va;ue was recorded in V_2T_2 (34.4%) and at 12^{th}days of storage, the highest value was recorded in V_2 (Sabri) with T_3 (Garlic extract) combination (V_2T_3) (39.6%). Results also revealed that the lowest TSS content was found from V_2T_1 (20.2, 25.5, 30.1 and 39.6 at 3, 6, 9 and 12 DAS respectively) followed by V_2T_3. This observation is somewhat similar to Pinaki*et al*. (1997).

Table 3. Effects of varieties and different organic coating on TSS of banana pulp at different days after storage (DAS)

Treatment	TSS			
	3 DAS	6 DAS	9 DAS	12 DAS
Effect of variety				
V_1	24.8	29.6	32.7	36.5
V_2	23.7	28.5	31.4	35.5
$LSD_{0.05}$	1.01	NS	0.26	2.12
CV(%)	6.32	5.83	4.92	3.74
Effect of different organic coating				
T_0	26.3	36.7	--	--
T_1	21.8	26.1	30.3	35.1
T_2	25.5	29.9	34.6	--
T_3	23.5	26.4	30.8	38.2
T_4	24.6	28.3	32.7	36.8
T_5	23.9	27.2	31.8	36.1
$LSD_{0.05}$	1.12	0.54	0.62	1.34
CV(%)	6.32	5.83	4.92	3.74
Combined effect of variety and different organic coating				
V_1T_0	26.5	36.8	--	--
V_1T_1	23.5	26.6	31.0	35.6
V_1T_2	25.6	30.1	34.8	--
V_1T_3	24.1	27.3	31.4	36.4
V_1T_4	24.8	28.8	33.2	--
V_1T_5	24.6	28.2	33.0	37.4
V_2T_0	26.1	36.6	--	--
V_2T_1	20.2	25.5	29.6	34.5
V_2T_2	25.3	29.6	34.4	--
V_2T_3	22.8	25.5	30.1	39.6
V_2T_4	24.4	27.8	32.2	36.8
V_2T_5	23.2	26.1	30.5	34.7
$LSD_{0.05}$	0.43	0.36	0.53	0.43
CV(%)	6.32	5.83	4.92	3.74

V_1 = Amritsagar, V_2= Sabri

T_0 = Control, T_1 = Aloe-veragel , T_2 = Ginger oil, T_3 = Garlic extract, T_4 = Onion extract, T_5 = Neem extract

4.2.4 Pulp to peel ratio

The varieties were found to be significant at different storage period (Table 4 and Appendix V). The variety, V_1 (Amritsagar) had higher pulp to peel ratio (3.5, 4.4, 4.5 and 4.6 at 3, 6, 9 and 12 DAS respectively) and the lower pulp to peel ratio was found in V_2 (Sabri1) (3.3, 4.0, 4.1 and 4.3 at 3, 6, 9 and 12 DAS respectively) (Table 4).

The postharvest treatments showed a noticeable effect on pulp to peel ratio and variation among the treatments were statistically significant at different days of storage (Table 4 and Appendix V). Control treatment, T_0 showed the highest pulp to peel ratio (4.4 and 6.25) at 3^{rd} and 6^{th} DAS. But under the treated treatments, T_2 (Ginger oil) showed the highest pulp to peel ratio (3.7, 4.4 and 4.9 DAS respectively) followed by T_4 (Onion extract) where the lowest pulp to peel ratio was achieved by T_1 (Aloe-vera gel) (2.9, 3.3, 3e.7 and 3.9 at 3, 6, 9 and 12 DAS respectively) followed by T_3 (Garlic extract).

The combined effects of varieties and postharvest treatments were statistically significant (Appendix V). The lowest ratio (4.1) was found in V_2(Sabri) with T_1 (Aloe-vera gel) treatment and the highest ratio (2.8) was recorded in V_1 (Amritsagar) with T_0 (Control) treatment combination (Table 4). It was found that control treatment with V_1 (Amritsagar) and V_2 (Sabri) showed the highest pulp to peel ratio at 3^{rd} and 6^{th} DAS. At 9^{th} and 12^{th} days of storage, the lowest value was recorded in V_2 (Sabri) with T_1 (Aloe-vera gel) combination (V_2T_1) (3.5 and 3.8).The increase in pulp to peel ratio during ripening was recorded by Tripathi*et al.* (1981), Simmonds (1996) and Krishnamurthy (1993). The increased ratio during storage may be related to the change in sugar concentration in the pulp compared to the peel thus contributing to different change in osmotic pressure. Water is lost from the peel of banana both by transpiration and osmosis. As a result the peel weight is reduced and pulp to peel ratio increases.

Table 4. Effects of varieties and different organic coating on pulp to peel ratio of banana at different days after storage (DAS)

Treatment	Pulp to peel ratio			
	3 DAS	6 DAS	9 DAS	12 DAS
Effect of variety				
V_1	3.5	4.4	4.5	4.6
V_2	3.3	4.0	4.1	4.3
$LSD_{0.05}$	0.26	0.36	0.48	0.55
CV(%)	3.54	5.22	4.56	3.64
Effect of different organic coating				
T_0	4.4	6.3	--	--
T_1	2.9	3.3	3.7	3.9
T_2	3.7	4.5	4.9	--
T_3	3.0	3.4	3.8	4.1
T_4	3.3	3.9	4.3	4.3
T_5	3.1	3.7	4.1	4.4
$LSD_{0.05}$	0.61	0.54	0.34	0.43
CV(%)	3.54	5.22	4.56	3.64
Combined effect of variety and different organic coating				
V_1T_0	4.4	6.4	--	--
V_1T_1	3.0	3.5	3.9	4.0
V_1T_2	3.7	4.6	5.0	--
V_1T_3	3.1	3.5	3.9	4.2
V_1T_4	3.5	4.2	4.5	--
V_1T_5	3.2	4.0	4.3	4.8
V_2T_0	4.3	6.1	--	--
V_2T_1	2.8	3.1	3.5	3.8
V_2T_2	3.6	4.4	4.8	--
V_2T_3	2.8	3.2	3.6	3.9
V_2T_4	3.1	3.7	4.0	4.3
V_2T_5	2.9	3.4	3.8	3.9
$LSD_{0.05}$	0.12	0.24	0.27	0.31
CV(%)	3.54	5.22	4.56	3.64

V_1 = Amritsagar, V_2= Sabri

T_0 = Control, T_1 = Aloe-veragel , T_2 = Ginger oil, T_3 = Garlic extract, T_4 = Onion extract, T_5 = Neem extract

4.2.5 Disease incidence

Bananas in the storage were infected with anthracnose disease caused by *Colletotrichummusae*. Disease in post harvest banana during ripening considered significant at different stages (Table 5 and Appendix VI). Results indicated that V_1 (Amritsagar) was more susceptible than V_2 (Sabri). During storage shelf life of V_1 (Amritsagar) extended to 9^{th} DAS where V_2 (Sabri) extend 12^{th} DAS on account of disease incidence.

The postharvest treatments showed a noticeable effect on disease incidence and variation among the treatments were statistically significant at different days of storage (Table 5 and Appendix VI). Results revealed that control treatment, T_0 showed the highest disease incidence (33.3% and 95.8%) at 3^{rd} and 6^{th} DAS and resulted as rotten within 7 day of storage. But under the treated conditions, the highest disease incidence (25.0 and 79.2% at 3 and 6 DAS respectively) was found in T_2 (Ginger oil) followed by T_4 (Onion extract) where the lowest disease incidence was achieved by T_1 (Aloe-vera gel) (4.2, 29.2, 32.5 and 75.0% at 3, 6, 9 and 12 DAS respectively) followed by T_3 (Garlic extract) and T_5 (Neem extract).

The combined effects of varieties and postharvest treatments were statistically significant (Appendix VI). The highest disease incidence (33.3% and 100% at 3 and 6 DAS respectively) was found in V_1 (Amritsagar) with control treatment followed by V_1T_2, V_1T_4, V_2T_0 and V_2T_2 where the lowest disease incidence (0, 25, 41.7 and 75% at 3, 6, 9 and 12 DAS respectively) was observed in V_2 (Sabri) with T_1 (Aloe-vera gel) treatment combination (V_2T_1) followed by V_2T_3 and V_2T_5 (Table 5).

Table 5. Effects of varieties and different organic coating on disease incidence of banana at different days after storage (DAS)

Treatment	% Disease incidence			
	3 DAS	6 DAS	9 DAS	12 DAS
Effect of variety				
V_1	18.1	72.2	88.9	
V_2	11.1	51.4	64.6	86.1
$LSD_{0.05}$	1.118	3.549	1.031	NS
CV(%)	4.758	4.115	5.631	3.528
Effect of different organic coating				
T_0	33.3	95.8	--	--
T_1	4.1	29.2	62.5	75.0
T_2	25.0	79.2	--	--
T_3	4.2	45.8	75.0	91.7
T_4	16.7	70.8	83.3	--
T_5	4.2	50.0	83.3	91.7
$LSD_{0.05}$	2.359	3.627	4.836	2.559
CV(%)	4.758	4.115	5.631	3.528
Combined effect of variety and different organic coating				
V_1T_0	33.3	100	--	--
V_1T_1	8.3	33.3	83.3	--
V_1T_2	25.0	83.3	--	--
V_1T_3	8.3	66.7	91.7	--
V_1T_4	25.0	83.3	--	--
V_1T_5	8.3	66.7	91.7	--
V_2T_0	33.3	91.7	--	--
V_2T_1	0	25.0	41.7	75.0
V_2T_2	25.0	75.0	--	--
V_2T_3	0	25.0	58.3	91.7
V_2T_4	8.3	58.3	83.3	--
V_2T_5	0	33.3	75.0	91.7
$LSD_{0.05}$	1.389	2.446	3.554	1.112
CV(%)	4.758	4.115	5.631	3.528

V_1 = Amritsagar, V_2= Sabri

T_0 = Control, T_1 = Aloe-veragel , T_2 = Ginger oil, T_3 = Garlic extract, T_4 = Onion extract, T_5 = Neem extract

4.2.6 Disease severity

Disease severity in postharvest banana during ripening considered significant at different stages (Table 6 and Appendix VII). Results indicated that V_1 (Amritsagar) was more susceptible than V_2 (Sabri). During storage shelf life of V_1 (Amritsagar) extended to 9^{th} DAS where V_2 (Sabri) extend 12^{th} DAS on account of disease severity. V_1 (Amritsagar) showed more disease severity than other variety V_2 (Sabri).

The postharvest treatments showed a noticeable effect on disease severity and variation among the treatments were statistically significant at different days of storage (Table 6 and Appendix VII). Results revealed that control treatment, T_0 showed the highest disease severity (21.7% and 97.5%) at 3^{rd} and 6^{th} DAS and resulted as rotten within 7 day of storage. But under the treated conditions, the highest disease severity was found in T_2 (Ginger oil) followed by T_4 (Onion extract) where the lowest disease severity was achieved by T_1 (Aloe-vera gel) (0, 14.2, 66 and 90%T_4 (Onion extract) at 3, 6, 9 and 12 DAS respectively) followed by T_3 (Garlic extract) and T_5 (Neem extract).

The combined effects of varieties and treatments were statistically significant (Appendix VII). The highest disease severity (28.3% and 100% at 3 and 6 DAS respectively) was found in V_1 (Amritsagar) with control treatment(V_1T_0) followed by V_1T_2, V_1T_4, V_2T_0 and V_2T_2 where the lowest disease severity (0, 10, 60.7 and 90% at 3, 6, 9 and 12 DAS respectively) was observed in V_2 (Sabri) with T_1 (Aloe-vera gel) treatment combination (V_2T_1) followed by V_2T_3 and V_2T_5 (Table 6).

Table 6. Effects of varieties and different organic coating on disease severity of banana at different days after storage (DAS)

Treatment	% Disease severity			
	3 DAS	6 DAS	9 DAS	12 DAS
Effect of variety				
V_1	10.0	61.1	76.0	--
V_2	3.9	38.5	67.4	93.3
$LSD_{0.05}$	2.634	3.112	5.876	--
CV(%)	5.221	6.319	5.781	3.112
Effect of different organic coating				
T_0	21.7	97.5	--	--
T_1	0.0	14.2	66.0	90.0
T_2	8.3	65.0	--	--
T_3	2.5	31.3	72.3	95.0
T_4	5.8	53.3	71.7	--
T_5	3.3	37.5	74.7	95.0
$LSD_{0.05}$	1.244	1.358	2.119	2.476
CV(%)	5.221	6.319	5.781	3.112
Combined effect of variety and different organic coating				
V_1T_0	28.3	100.0	--	--
V_1T_1	0	18.3	71.3	--
V_1T_2	10.0	68.3	--	--
V_1T_3	5.0	51.2	76.3	--
V_1T_4	10.0	71.2	--	--
V_1T_5	6.7	56.2	80.3	--
V_2T_0	15.0	95.0	--	--
V_2T_1	0	10.0	60.2	90.0
V_2T_2	6.7	61.2	95.0	--
V_2T_3	0	11.0	68.3	95.0
V_2T_4	1.2	35.0	71.7	--
V_2T_5	0	18.3	69.0	95.0
$LSD_{0.05}$	1.454	2.119	2.533	1.114
CV(%)	5.221	6.319	5.781	3.112

V_1 = Amritsagar, V_2= Sabri

T_0 = Control, T_1 = Aloe-veragel , T_2 = Ginger oil, T_3 = Garlic extract, T_4 = Onion extract, T_5 = Neem extract

4.2.7 Shelf life

Shelf life is the period of time which start from the time of harvesting and extend up to the start of rotting of fruit (Mondal, 2000) and it is the basic quality of fruit as well as it is the most important parameter in loss of reduction biochemical reaction of fruit. Result showed that there were significant differences among the varieties (Appendix VIII). The longer shelf life (10.3 days) was observed in V_2 (Sabri) and lower (9.2) in V1 (Amritsagar) (Table7).

The effect of different postharvest treatments used in the present study was highly significant in respect of shelf life of banana (Table 7 and Appendix VIII). The maximum shelf life (11.7 days) was recorded in T1 (Aloe-vera gel) coatingtreated fruits whereas minimum shelf life (6.5 days) was recorded in control (T_0) followed by T_2 (Ginger oil) treated fruits (8.3 days).

The combined effect between varieties and different treatments were highly significant in case of shelf life of banana (Table 7 and Appendix VIII). The maximum shelf life (12.0 days) was found in V_2 (Sabri) with T_1 (Aloe-vera gel) treated fruits combination (V_2T_1) followed by V_2T_3, V_2T_5, V_1T_1 and V_2T_4. The minimum shelf life (6.0 days) was recorded in V_1 (Amritsagar) with control treatment (V_1T_0) (Table 7) followed by V_2T_0, V_1T_2, V_2T_2 and V_1T_4. Supported results was obtained by Mohadded (1995).

Table 7. Effects of varieties and different organic coating on shelf life of banana at different days after storage (DAS)

Treatment	Shelf life
Effect of variety	
V_1	9.2
V_2	10.3
$LSD_{0.05}$	1.02
CV(%)	4.58
Effect of different organic coating	
T_0	6.5
T_1	11.7
T_2	8.3
T_3	11.3
T_4	9.8
T_5	10.7
$LSD_{0.05}$	1.32
CV(%)	4.58
Combined effect of variety and different organic coating	
V_1T_0	6.0
V_1T_1	11.3
V_1T_2	8.0
V_1T_3	11.0
V_1T_4	8.6
V_1T_5	10.0
V_2T_0	7.0
V_2T_1	12.0
V_2T_2	8.6
V_2T_3	11.6
V_2T_4	11.0
V_2T_5	11.3
$LSD_{0.05}$	0.54
CV(%)	4.58

V_1 = Amritsagar, V_2= Sabri

T_0 = Control, T_1 = Aloe-veragel , T_2 = Ginger oil, T_3 = Garlic extract, T_4 = Onion extract, T_5 = Neem extract

CHAPTER V

SUMMARY AND CONCLUSION

5.1 Summary

An experiment was conducted at the laboratory of Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka to study the effect of organic coatings on shelf-life and postharvest quality of banana. Fully matured banana bunches cv. Amritasagar and Sabri of uniform size, shape and colour were used for the study. The two-factor experiment was laid out in completely randomized design (CRD) with three replications. The experiment consists of two factors asvarieties*viz*. (i) V_1 = Amritsagar and (ii) V_2= Sabri and different organic coating *viz*. (i) T_0 = Control, (ii) T_1 = Aloe-vera gel, (iii) T_2= Ginger oil, (iv) T_3 = Garlic extract, (v) T_4 = Onion extract and (vi) T_5 = Neem extract. Data were recorded on External fruit characters (Appearance/color), Total weight loss (%), Moisture content (%), Total Soluble Solids (TSS) content of banana pulp (% Brix), Pulp to peel ratio, Disease incidence (percentage of fruits infected), Disease severity (percentage of fruits skin infected) and Shelf life. The collected data on various parameters were statistically analyzed. The experiment was continued to 12 DAS form sample collection.

Considering varietal performance, results indicated that in maximum case V_2 (Sabri) gave better performance than V_1 (Amritsagar) for all the parameters studied. V_1 (Amritsagar) gave the highertotal weight loss (15.1%), lower moisture loss (54.9 %), higher Total Soluble Solids (TSS) (36.5 %), and higher pulp to peel ratio (4.6) where V_2 (Sabri) gave the lowertotal weight loss (9.1%), higher moisture content (61.3%), lower TSS (35.5 %) and lower pulp to peel ratio(4.3). In terms of disease incidence (percentage of fruits infected) and disease severity

(percentage of fruits skin infected), V_1 (Amritsagar) was highly influenced by disease and storage was continued to 9^{th} DAS among 12 DAS where storage of

V_2 (Sabri) was continued to 12^{th} DAS. In view of shelf life, V_2 (Sabri) was better than V_1 (Amritsagar).

In case of different treatments for increasing shelf life, T_1 (Aloe-vera gel) gave the best performance for all the parameters studied compared to control. Banana treated with T_1 (Aloe-vera gel) gave the lowest total weight loss (8.9%), highest moisture content (62.6%), lowest TSS (35.1%) and lowest Pulp to peel ratio (3.8) where control treatment gave the lowest performance with this regard. Under the treated banana, T_1 (Aloe-vera gel) showed the best performance where T_2 (Ginger oil) gave the lowest performance. T_1 (Aloe-vera gel) showed thelowest disease incidence and disease severity compared to control and T_2 (Ginger oil) treatment. Considering shelf life, T_1 (Aloe-veragel) showed highest result (11.7 days) where T_2 (Ginger oil) showed only 8.3 days of shelf life.

In terms of combination of variety with organic coating treatments, the lowest total weight loss (8.1%), highest moisturecontent (65.7%), lowest TSS (34.5%) and lowesPulp to peel ratio (3.8) of banana was obtained from V_2 (Sabri) with T_1 (Aloe-vera gel) treatment (V_2T_1) compared to control with V_1 (Amritsagar) and V_2 (Sabri) where V_1T_2 (Amritsagar-ginger oil) gave the lowest performance among the treatment combination and also observed that with this treatment combination (V_1T_2) shelf life of banana was continued 8^{th} day where V_2T_1 showed the highest shelf life (12.0 days). In case of diseases incidence and severity of banana during post harvest storage, V_2T_1 also showed best performance comapared to control and V_1T_2.

5.2 Conclusion

From the above discussion it can be concluded that organic coating showed significant performance on shelf life of banana. Among the two tested variety, V_2 (Sabri) with organic coating T_1 (Aloe-vera gel) gave longest shelf life (12.0 days) where control treatment with V_1 (Amritsagar) gave the lowest (6.0 days) shelf life. Treatment T_3 (Garlic extract) and T_5 (Neem extract) with V_2 (Sabri) also showed promising result on shelf life of banana.T_1(Aloe-vera gel) can be recommended to extend of banana shelf life.

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APPENDICES

Appendix I. Recorded air temperature and relative humidity during the study period from 14 March 2016 to 25 March 2016

Year	Month	Date	Air temperature (°C)			Relative humidity (%)
			Max.	Min.	Avg.	
2016	March	16/3/16	19.8	20.2	20.0	50
2016	March	17/3/16	20.5	21.6	21.1	54
2016	March	18/3/16	21.8	22.6	22.2	58
2016	March	19/3/16	23.1	24.5	23.8	62
2016	March	20/3/16	24.8	25.2	25.0	67
2016	March	21/3/16	25.5	26.4	25.9	71
2016	March	22/3/16	26.6	26.9	26.8	75
2016	March	23/3/16	27.2	27.5	27.4	75
2016	March	24/3/16	27.9	28.3	28.1	78
2016	March	25/3/16	28.6	28.9	28.8	80
2016	March	26/3/16	29.1	29.2	29.2	85
2016	March	27/3/16	29.2	29.4	29.3	82

Appendix II. Effects of varieties and different organic coatings on percent total weight loss of banana at different days after storage

Source of variation	Degrees of freedom	Mean square of % Total weight loss			
		3 DAS	6 DAS	9 DAS	12 DAS
Factor A	1	1.227**	3.271**	2.671**	0.014**
Factor B	5	6.318*	7.598***	5.359**	2.613*
AB	5	4.119**	4.176*	2.174**	0.559**
Error	24	1.034	2.016	1.388	0.004

* = 5% Level of significance, ** = 1% Level of significance, NS = Non significant

Appendix III. Effects of varieties and different organic coating on percent moisture content of banana at different days after storage

Source of variation	Degrees of freedom	Mean square of % Moisture content			
		3 DAS	6 DAS	9 DAS	12 DAS
Factor A	1	0.066**	6.389*	2.045*	0.114**
Factor B	5	8.715*	12.553*	6.317*	1.783**
AB	5	5.229*	7.369*	1.529**	0.059**
Error	24	0.265	3.119	1.226	0.007

* = 5% Level of significance, ** = 1% Level of significance, NS = Non significant

Appendix IV. Effects of varieties and different organic coatings on Total Soluble Solid of banana pulp at different days after storage

Source of variation	Degrees of freedom	Mean square of TSS			
		3 DAS	6 DAS	9 DAS	12 DAS
Factor A	1	0.133**	NS	2.809*	0.642**
Factor B	5	5.252*	4.103*	10.041*	3.701**
AB	5	5.111**	8.741*	18.661*	4.808**
Error	24	1.016	1.603	2.313	0.061

* = 5% Level of significance, ** = 1% Level of significance, NS = Non significant

Appendix V. Effects of varieties and different organic coatings on Pulp to Peel ratio of banana at different days after storage

Source of variation	Degrees of freedom	Mean square of Pulp to peel ratio			
		3 DAS	6 DAS	9 DAS	12 DAS
Factor A	1	0.216**	0.344**	1.668**	0.227**
Factor B	5	2.614**	3.512**	5.318*	2.559**
AB	5	3.117*	4.834*	3.228*	1.261**
Error	24	0.016	1.219	1.614	0.126

* = 5% Level of significance, ** = 1% Level of significance, NS = Non significant

Appendix VI. Effects of varieties and different organic coatings on disease incidence of banana at different days after storage

Source of variation	Degrees of freedom	Mean square of % Disease incidence			
		3 DAS	6 DAS	9 DAS	12 DAS
Factor A	1	0.142**	5.566*	3.849*	NS
Factor B	5	7.259*	11.14*	12.05*	8.751*
AB	5	5.311*	9.747*	17.583*	5.864**
Error	24	1.604	2.683	4.317	0.151

* = 5% Level of significance, ** = 1% Level of significance, NS = Non significant

Appendix VII. Effects of varieties and different organic coatings on disease severity of banana at different days after storage

Source of variation	Degrees of freedom	Mean square of % Disease severity			
		3 DAS	6 DAS	9 DAS	12 DAS
Factor A	1	1.135*	3.592*	2.843**	NS
Factor B	5	8.26*	9.573*	14.64*	8.33**
AB	5	7.319*	11.73*	9.557*	6.874**
Error	24	2.667	1.674	2.314	0.561

* = 5% Level of significance, ** = 1% Level of significance, NS = Non significant

Appendix VIII. Effects of varieties and different organic coatings on shelf life of banana at different days after storage

Source of variation	Degrees of freedom	Mean square of Shelf life
Factor A	1	0.052**
Factor B	5	1.376**
AB	5	3.524*
Error	24	1.311

* = 5% Level of significance, ** = 1% Level of significance, NS = Non significant