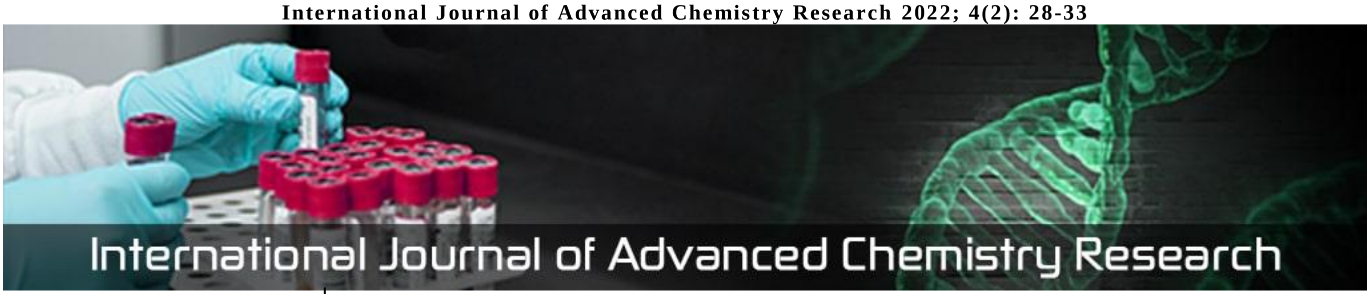
International Journal of Advanced Chemistry Research 2022; 4(2): 28-33



ISSN Print: 2664-6781
ISSN Online: 2664-679X
Impact Factor: RJIF 5.32
IJACR 2022; 4(2): 28-33
www.chemistryjournals.net
Received: 26-06-2022
Accepted: 11-08-2022

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Studies on use of plant extracts as natural coatings for enhancing shelf life and quality of banana fruits

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DOI: https://doi.org/10.33545/26646781.2022.v4.i2a.73

Abstract
Banana being a climacteric fruit have a very short shelf life. The extension of fruit shelf life is an important goal to be attained. One such natural method of extending post-harvest shelf life of fruits is the use of the formulated edible coatings of natural plant extracts. Natural coatings have long been known to protect perishable food products from deterioration by retarding dehydration, suppressing respiration, improving textural quality, helping retain volatile flavour compounds, and reducing microbial growth. Recently, the uses of plant-based products have been started in fresh fruits and vegetables as bio-preservatives. Aloe-vera gel is one of the promising bio-preservative, which has a great potential to become a common use for most fresh fruits and vegetables. Starch is the storage polysaccharide found in legumes, cereals, and tubers vegetables, like potato, cassava, corn, rice, banana etc. It is a good barrier to oxygen transmission but poor to water vapour. The presence of turmeric extract added to edible film can function as an antioxidant due to the presence of curcumin. Banana peel can be used as a potential source to preserve banana with extended shelf stability and reduce microbial growth. Pomegranate peel has antifungal and antibacterial property which provides a defensive barrier against microbial contamination of fruits and vegetables the effect of essential oils and their constituents reduce post-harvest diseases of horticultural products and fruits. Among different treatments, the highest phenol content and lowest microbial count, disease score and disease index was recorded in T2 (Aloe-vera gel (20%)) respectively.

Keywords: Banana fruits, plant extracts, microbial count load, disease score, disease index and phenolic compounds

Introduction

Banana (*Musa spp*.) is the most widely cultivated and consumed fruit in the tropical and subtropical regions of the world where they constitute a major staple food crop for millions of people (Deka and Choudhury, 2018) [9]. India is the largest producer of fruits in the world and banana tops the list with respect to production and area of cultivation (TIFAC Report cited in Surendranathan *et al.,* 2004) [32]. Bananas contain nutrients in more balanced proportion than many other fruits. They have nearly all the essential nutrients, including minerals and vitamins (Prodhan *et al.,* 2017) [23]. Bananas are unique due to their high calories and nutritive values.

India is the largest producer of fruits and vegetables in the world with the production of 97.35 MMT of fruits and 184.39 MMT of vegetables in 2019-20 (Jha., 2021) [13]. Unfortunately India also occupies the top position in harvest and post-harvest losses of horticultural produce. It is estimated that about 16 per cent of fruits and vegetables, worth Rs 40,811 crores are lost annually (Jha., 2021) [13]. This is due to improper post-harvest handling during storage, packaging and transportation, incidence of diseases and limited storage facilities are some of the major reasons for such high post- harvest losses.

Fruits and vegetables are highly perishable commodities, because these contain high amount of water content. Once these are harvested or detached from mother plants, water quickly evaporates, resulting in shrivelling, loss of quality and poor shelf life of product. Flaccidity, wilting, shrivelling and decay are some of the major problems that occur during postharvest handling of fruits and vegetables that ultimately prioritize their marketability and consumer preference (Lerdthanangkul and Krochta, 2016) [16]. Majorly, postharvest losses are caused by weight loss, fungal diseases, physiological disorders and pests. In order to maintain freshness and quality, the fruits and vegetables must be handled carefully.

Food appearance remains the most required attribute, strongly affecting the consumer decision to buy it or not. In addition, food texture is also a fundamental feature in determining product acceptability. Both appearance and texture of a fruit or vegetable tissue strictly depends on genetic, environmental, postharvest handling and storage factors. Now-a-days consumers have become more health conscious and demand fresh fruits and vegetables, which have driven researchers to develop eco- friendly coatings and packaging technology for prolonging the shelf-life of these products. Therefore, the precise knowledge of the processes leading to the appearance and textural modifications is of crucial importance in developing effective approaches to manage above said factors that improves quality and shelf-life of these products.

There are distinct preservation methodologies available for the post-harvest management of fruits. One such natural method of extending post-harvest shelf life of fruits is the use of the formulated edible coatings of natural plant extracts (Baldwin *et al.,* 2018) [5]. In post-harvest technology, bio-preservation aims at extending storage/shelf life of fruits and vegetables by utilizing natural plant-based products. To effectively extend the shelf life of fruits, edible coating solution as a relatively convenient and safe measure, is more and more concerned in food industry in recent years. Another advantage of this coating is that it is totally harmless to the environment. In fact it can be considered as a green alternative to synthetic coatings and other postharvest chemical treatments. Use of edible coatings over fruits is used to improve their quality and shelf-life. These can be also safely eaten as part of the product and do not add unfavourable properties to the foodstuff. Recently, there has been increased interest in using Aloe-vera gel as an edible coating material for fruits and vegetables driven by its antifungal activity.

Edible coating is defined as a thin layer of material which can be eaten and provides a barrier to moisture, oxygen and solute movement for the fruit (Mchugh and Senesi, 2000) [18]. The protective function of edible films is to prevent oxidation, moisture absorption and desorption, contamination, microbial growth and sensory change (Thakur *et al.,* 2019) [35]. In the recent time, application of different plant extracts is getting significant interest to the researcher for extending the shelf life of different fruits and vegetables e.g., pomogranate leaf and banana pulp extracts for mango (Sarmin *et al.*, 2018) [28] etc.

The use of natural coatings might be a good alternative to synthetic fungicides, which in turn fulfills the consumer requirements for more natural and healthy foods. Protective edible coatings and waxes are applied as part of the post-harvest treatment to fresh fruits and vegetables for their preservation. Plant based natural coatings as an effective preservative aiming at the safety, quality and functionality of fresh fruits and vegetables. In postharvest technology, extending the storage life of fruits and vegetables by utilizing plant-based products have been practiced for a long time. Recently, the uses of plant-based products have been started in fresh fruits and vegetables as bio-preservatives. Aloe-vera gel is one of the promising bio- preservative, which has a great potential to become a common use for most fresh fruits and vegetables. Aloe-vera gel (100%) has been used to preserve papaya fruit at room temperature 25-29°C and 82-84% RH and it was reported that, uncoated papaya showed 22.5% loss in weight, whereas the weight losses of coated fruit was 7.93% (Brishti *et al*., 2013) [7].

Interestingly, the Aloe-vera gel coating was effective in controlling microbial growth of „Crimson‟ table grape (Ali *et al*., 2016). In case of Aloe-vera coated banana fruits, no disease symptoms were observed until 1 week after of the storage period. At the end of the storage period, 100% disease incidence was observed in uncoated fruits, whereas for Aloe gel coated fruits disease incidence was only 27% (Brishti *et al.,* 2013) [7]. This was due to the anti-microbial potentiality of coated materials. The antifungal activity of fresh juice and aqueous extracts of turmeric and ginger against the fungi *Aspergillus niger* and *Penicillium digitatum* has been reported (Kapoor, 1997) [14]. The effect of natural plant products has also been reported on storage rot of mangoes, where the fruits dipped in the plant extracts showed reduction in the disease incidence (Anjum *et al.*, (2016) [3].

The presence of turmeric extract added to edible film can function as an antioxidant. This trait will minimize the process of respiration that occurs so that the quality and storability of fruits becomes longer. The addition of active components in edible films can add value to the edible film function. Addition of turmeric extract to edible starch films and aloe vera will have an effect on the mechanical properties of edible films. It is 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 (colour, flavour etc.). It has antifungal and antibacterial property which provides a defensive barrier against microbial contamination of fruits and vegetables. Belgacem *et al*. (2021) [6] stated that, pomegranate peel extracts as safe natural treatments to control plant diseases and increase the shelf-life and safety of fresh fruits and vegetables.

Starch is the storage polysaccharide found in legumes, cereals, and tubers vegetables, like potato, cassava, corn, rice, banana etc. It is a good barrier to oxygen transmission but poor to water vapour. It used for coating vegetables and fruits which shows high respiration rate. Sapper and Chiralt (2018) [27] explained about different starch-based coatings used to preserve the fruits and vegetables along with the factors affecting the coating efficiency

Minimally processed pummelo (*Citrus maxima Merr*.), coated with starch- based coatings (derived from cassava and rice) had a lower weight loss of 4.8–7.7% compared to the non-coated minimally processed pummelo (Kerdchoechuen *et al.,* 2011) [15]. Rahman *et al*. (2020) [25] conducted a study to assess the effect of banana peel extract (BPE) on shelf life and quality characteristics of ripe banana (cultivar: sagar). This study revealed that, banana peel can be used as a potential source to preserve banana with extended shelf stability. The effect of essential oils and their constituents on post-harvest diseases of horticultural products has been investigated for pears, citrus, bananas, strawberries, tomato, cherries and grapes (Tzortzakis, 2007) [36]. Banana being a climacteric fruit can ripe in the plant itself as well as after harvesting by the application of various chemicals and plant materials. The extension of fruit shelf life is an important goal to be attained. Many storage techniques have been developed to extend the marketing distance and holding periods for commodities after harvest. Different preservation methodologies have been studied. One method of extending postharvest shelf life is the use of the edible coatings. Use of edible coatings is a common issue that is beneficial to protect nutrients of food, especially fruits and vegetables, and provide a long durability (Gol *et al.,* 2021). Edible coatings have long been known to protect perishable food products from deterioration by retarding dehydration, suppressing respiration, improving textural quality, helping retain volatile flavor compounds, and reducing microbial growth (Debeaufort *et al.,* 2020) [8].

Material and methods

An investigation entitled "Studies on use of plant extracts as natural coatings for enhancing shelf life and quality of banana fruits" was carried out in the Department of Post-Harvest Technology, College of Horticulture, Bagalkote, Karnataka during the year 2020-21. The details of the experimental material used and methods adopted in the investigation are presented in this chapter. The experiment was conducted in Completely Randomized Design with fourteen treatments and three replications.

Methodology

Starch aqueous extract: Corn starch (2.5) g was dissolved in water and agitated well. By addition of glycerol, the PH was adjusted and thus corn starch solution was prepared

Aloe-vera gel aqueous extract: Fresh aloe-vera leaves were washed to remove dust, cut with knife and scooped to extract clean gel. The fresh gel was mixed thoroughly and strained through muslin cloth to remove thick particles. Aloe-vera gel matrix was separated from the outer cortex of leaves and the colour less hydro parenchyma was mixed in a blender. The resulting mixture was filtered to remove the fibres. The liquid obtained constituted fresh aloe vera gel. The gel matrix was pasteurized at 50°C for few min. Then the selected fingers are dipped into gel for 5 min and allowed it to dry for a period of 10 min.

Banana peel aqueous extract: Fresh banana peels were coarsely chopped and sun dried. Then, the powder was sieved through a mesh, were kept in 70% ethyl alcohol. Then the entire mixture was homogenized in blender and kept in shaker for about 48 hrs. Later the entire slurry was filtered through Whattman filter to get banana peel aqueous extract.

Pomegranate peel aqueous extract: The fine peel powder was obtained in an electric blender after tray-drying the peels at 40℃ for 24 hrs. Then, the powder was sieved through a mesh. This powder (10g) was extracted with 250 ml of 80% methanol and kept in shaker for 48 hrs. Then final extract was then filtered and then used.

Turmeric extract: Six grams of turmeric powder was dissolved in 100 ml 80% of methanol and kept in shaker for 48 hrs. Later the entire slurry was filtered through Whattman filter to get turmeric extract.

Observations recorded

Total phenolic compounds (mg GAE/100 mL)

Total phenols were estimated according to procedure given by singleton and Rossi (1965). One gram sample was extracted with 20 ml 80% methanol. The extracts (0.5 ml) were taken in the test tubes and were added with 0.2 ml of Folic and Ciocalteau"s Phenol reagent (IN). To that, 3.25 ml of distilled water was added and all the tubes were shaken well. Then, 1 ml of Sodium Carbonate (20%) solution was added to all the tubes and kept for incubation at room temperature for 30 minutes. The colour so developed was read by spectrophotometer at 700 nm.

Standard curve was drawn using Gallic acid as standard. Different concentrations of Gallic acid were prepared and O.D (Optical density) was read at 700 nm. The concentration of samples was calculated based on the standard curve.

$$\text{mg Gallic acid equivalence per 100 g} = \frac{\text{O.D x Factor x volume made up x 100}}{\text{Liquot taken x weight of sample x 1000}}$$

General microbial count load (log cfu/g of sample)

The pre-treated banana fruits were subjected to microbial analysis by employing serial dilution method. For enumeration of yeast and mould counts, a 10 g sample of banana fruits was weighed aseptically and was diluted in 100 ml sterile water and subsequent dilutions were prepared up to 10-3 by transferring 1ml aliquot from 10-1 to 9 ml water blank. The sample was serially diluted to 10-1, 10-2, 10-3 and used for enumerating yeast and mould population by planting on suitable media. The culture media used were yeast extract agar and martins rose bengal agar for total counts of yeast and mould, respectively. Required dilution, 1 ml was transferred to sterilized petri plates and 15-20 ml of media was poured to it. The plates were rotated clockwise and anticlockwise direction to attain uniform distribution of dilution to the culture media.. The plates were then allowed to solidify the media and incubated for 3- 5 days at 26 ± 2º C. The plates were observed after the incubation period for yeast and mould colonies. The total colonies in each dilution plate were counted and results expressed as colony forming units (log cfu/g of sample) using the following formula given below.

$$\text{Total Microbial Count} = \frac{\text{Total no of colonies x dilution factor}}{\text{Weight of sample}}$$

Disease scoring (%)

Disease scoring on fruits was by visual inspection of fruits during storage. For the disease score, damage caused by fungi or mould was considered based on scale mentioned below.

Disease scale: 0-5 scale is used 0 - No lesions
1 - 5 to 15% lesions
2 - 15 to 25% lesions
3 - 25 to 50% lesions
4 -50 to 75% lesions

Finally disease scoring was calculated with the following formula (Narasimhudu, 2007) [19].

$$\text{Disease score (\%)} = \frac{\text{Sum of all disease rating x 100}}{\text{Total number of rating x maximum disease grade}}$$

Fruit disease Index

Disease intensity in different treatments was scored using 0-4 scale.

Extent of infection	Severity grade
No infection	0
0.1-25.0% fruit surface infected	1
25.1-50.0% fruit surface infected	2
50.1-75% fruit surface infected	3
>75.0% fruit surface infected	4

Per cent Disease Index (PDI) of post-harvest disease was calculated by using the formula given below.

$$\text{Disease score (\%)} = \frac{\text{Sum of all disease rating}}{\text{Total number of rating x maximum disease grade}} \text{ x 100}$$

Observations were recorded on Phyto-chemical parameters of banana fruits coated with plant extracts like total phenol content (mg GAE/100 mL), microbial count load (log cfu/g), disease score (%) and disease index (%).

Results and Discussion

Total phenol content (mg GAE/100 mL)

The data pertaining to total phenols (mg/100 g) as influenced by different plant extracts coating on banana fruits did not vary significantly (Table 1). Irrespective of the treatments, total phenols (mg/100 g) mean was noted to decrease gradually along the storage period of 7 days (Initial – 17.41, 3 DAS-13.59, 5 DAS-12.62, and 7 DAS-11.72). Maximum phenol content was noted in T2 (3 DAS -16.26, 5 DAS-14.96, and 7 DAS-14.10). Minimum phenol content was recorded in T14 (3 DAS-11.28, 5 DAS-11.33, and 7 DAS-10.57).

In the present investigation, total phenolic content was recorded more in coated fruits as compared to control fruits, the coatings may have formed a protective barrier on the surface of fruit and reduced the supply of oxygen for enzymatic oxidation of phenolics, resulting in better retention of total phenols as compared to control. Rehman *et al*. (2020) studied on the effect of postharvest application of aloe-vera gel on shelf life, activities of anti-oxidative enzymes, and quality of banana fruit. The aloe-vera gel-treated fruits showed reduced increments in total sugar, malondialdehyde and total carotene contents compared to untreated controls. Aloe vera gel-treated fruits exhibited higher contents of ascorbic acid, flavonoids (quercetin and rutin) and total phenolics in comparison to control fruits. Edible coatings have effect and ability to increase the antioxidant and also total phenolic content in harvested horticultural commodities showed same effect as antioxidants.

Microbial count load (log cfu/g of sample)

The data did not reveal significant differences among different plant extracts coating on banana fruits with respect to microbial count studies (log cfu/g of sample) (Table 2). Irrespective of the treatments, microbial count load mean was found to increase gradually along the storage period of 7 days (Initial – Nil, 3 DAS-2.24, 5 DAS-6.17 and 7 DAS – 9.21). However, microbial count was minimum in T2 (3 DAS-0.00; 5 DAS-3.33 and 7 DAS-7.00) followed by T4 and T8. Similarly, maximum microbial count was observed in T14 (3 DAS - 4.00; 5 DAS - 8.33 and 7 DAS-14.00).

Total microbial count increased and showed non- significant differences with the advancement of the storage period particularly in uncoated fruits. Fruits treated with starch, aloe-vera gel and different concentrations of peel extracts numerically reduced microbial population under ambient storage condition. The treatments coated with different edible coatings recorded lower level of microbial load in comparison to control treatment. Ali *et al*. (2016) reported that the Aloe-vera gel coating was effective in controlling microbial growth of banana fruits. The lowest microbial population in coated fruits may be attributed due to antimicrobial activity of these coating materials, reduced microbial population in fruits and vegetables (Habeeb *et al.*, 2007, Tajkarimi and Ibrahim 2011 and Pokhrel *et al.,* 2015) [11, 34, 20].

Mould: Microbial mould count was not observed during storage of banana fruits by coating with plant extracts and the banana fruits were totally free with mould count throughout the storage period of 7 days under ambient conditions.

Disease score (%)

The data revealed a significant differences among the different plant extracts coating on banana fruits with respect to disease score (%) (Table 3). Irrespective of the treatments, mean disease score was found to increase gradually along the storage period of 7 days (Initial – NIL, 4 DAS – 19.96 %, 6 DAS – 38.44 % and 7 DAS – 55.49 %). At 4 days after storage (DAS), significantly lowest disease score (%) was reported in T2 (12.07 %), which was statistically similar with T3 (12.13 %) and the highest disease score (%) was registered in T14 (33.26 %). At 6 DAS, the lowest disease score (%) was registered in T2 (20.67 %) which, was on par with T3 (23.23 %) and the highest disease score (%) was reported in T14 (52.83 %). At 7 DAS, the lowest disease score (%) was reported in T1 (32.47%) which was statistically similar with T2 (34.46 %), whereas the highest disease score (%) was noticed in T14 (76.38%).

Fruits lose quality after harvest due to environmental stress and pathogen infection (Lai *et al.*, 2011). Lipid oxidation and microbial contamination are the primary variables that determine the loss of and quality and shelf life (Rozman and Jersek, 2009) [26]. The existence of spoilage microorganisms in fruits and vegetables is the consequence of contamination of their surfaces; therefore, contamination must be reduced by ensuring that the fruit and vegetables are sanitized (Potter and Hotchkiss, 1993 and Magashi and Bukar, 2017) [22, 17]. Crown rot and anthracnose are the main post- harvest diseases of banana (Stover, 1972; Stover and Simmonds, 1972) [31]. These two disease complexes differ in one important respect. Anthracnose is a latent infection that occurs in the plantation, while the crown rot organisms enter after harvest, usually as a result of mechanical injury to the fruit (Simmonds, 1966) [29]. Fruits coated with different plant extracts (alove-vera gel (20%), starch (2%), turmeric powder (6%), pomegranate peel extract (4% dry powder), bananas peel extract (20% dry powder) and sesame oil recorded minimum microbial count. The application of edible coating extends the banana shelf life up to 7 days with no disease incidence.

Disease index (%)

The data pertaining to disease index as influenced by different plant extracts coating varied significantly (Table 4). Irrespective of the treatments, disease index increased gradually along the storage period of 7 days (Initial – 0.00, 3 DAS-0.61, 5 DAS-1.16 and 7 DAS-2.60). At 3 DAS, significantly maximum disease index was noted in T14 (1.14) and minimum disease index was noted in T2 (0.21). At 5 DAS, significantly maximum disease index was documented in T14 (2.51) and minimum disease index was registered in T2 (0.53). At 6 DAS, significantly highest disease index was recorded in T14 (5.44) and lowest disease index was noted in T2 (1.51).

The control samples (without any treatment) showed the highest disease index rate compared to coated samples. (Table 4). The lowest disease index was recorded for the samples treated with (Alove-vera gel (20%), starch (2%), turmeric extract (6%), pomegranate peel extract (4% dry powder), bananas peel extract (20% dry powder) and sesame oil. The antimicrobial activity of (Alove- vera gel (20%), turmeric extract (6%), pomegranate peel extract (4% dry powder), bananas peel extract (20% dry powder) had an impact on lowering disease index. Tabassum *et al*. (2018) [33], Hossain and Iqbal (2016) [12] and Bagwan (2001) [4] reported the same in case of disease index rate and severity of banana samples with clear identification of better acceptability for treated samples than control samples.

Table 1: Effect of natural plant extract coatings on total phenols (mg GAE/100 mL) of banana fruits under ambient storage condition

Treatments	Total phenols (mg GAE/100 mL)			
	3 DAS	5 DAS	7 DAS	
Initial	**17.41**			**Mean**
T1	13.02	13.15	12.05	12.74
T2	16.26	14.96	14.10	15.10
T3	12.44	11.71	10.70	11.61
T4	12.67	11.16	10.01	11.2
T5	12.36	11.41	10.69	11.48
T6	14.04	13.18	12.40	13.20
T7	13.72	12.82	11.97	12.83
T8	13.50	12.44	11.55	12.49
T9	12.60	12.13	11.21	11.98
T10	14.83	13.54	12.59	13.65
T11	14.46	13.11	12.18	13.25
12	13.53	12.46	11.57	12.52
T13	14.44	13.26	12.57	13.42
T14	11.28	11.33	10.57	11.06
Mean	13.59	12.62	11.72	
S.Em±	0.46	0.47	0.45	
CD@1%	NS	NS	NS	

Table 2: Effect of natural plant extract coatings on microbial count load (log cfu/g) of banana fruits under ambient storage condition

Treatments	Microbial count load (log cfu/g) (yeast)				
	3 DAS	5 DAS	7 DAS	Mean	Mould
Initial		**NIL**			
T1	0.33	5.00	6.33	3.88	NIL
T2	0.00	3.33	7.00	3.44	NIL
T3	1.33	4.67	5.67	3.89	NIL
T4	2.67	3.68	4.00	3.45	NIL
T5	1.33	5.67	7.02	4.67	NIL
T6	2.33	5.66	9.33	5.77	NIL
T7	2.34	7.67	11.67	7.22	NIL
T8	2.00	4.00	5.00	3.66	NIL
T9	3.33	7.67	13.00	8.00	NIL
T10	2.66	7.50	12.33	7.49	NIL
T11	3.31	7.83	12.00	7.71	NIL
T12	2.67	8.00	8.67	6.44	NIL
T13	3.00	7.33	13.00	7.77	NIL
T14	4.00	8.33	14.00	8.77	
Mean	2.24	6.17	9.21		
S.Em±	0.68	1.19	1.09		
CD@1%	NS	NS	NS		

Table 3: Effect of natural plant extract coatings on disease score (%) of banana fruits under ambient storage condition

Treatments	Disease score (%)			Mean
	4 DAS	6 DAS	7 DAS	
Initial		**NIL**		
T1	16.30	23.37	32.47	24.04
T2	12.07	20.67	34.46	22.40
T3	12.13	23.23	42.46	25.94
T4	14.03	31.81	43.17	29.67
T5	16.53	30.15	44.44	30.37
T6	15.67	42.07	65.13	40.95
T7	21.98	46.69	68.13	45.60
T8	25.79	48.36	68.47	47.54
T9	13.49	33.80	42.79	30.02
T10	22.17	45.79	62.13	43.36
T11	28.44	48.74	67.61	48.26
T12	23.81	44.80	61.80	43.47
T13	23.81	45.84	65.47	45.04
T14	33.26	52.83	76.38	54.15
Mean	19.96	38.44	55.49	
S.Em±	0.39	0.75	1.46	
CD@1%	1.23	2.94	5.70	

Table 4: Effect of natural plant extract coatings on disease index (%) of banana fruits under ambient storage condition

Treatments	Disease index (%)			Mean
	3 DAS	5 DAS	7 DAS	
Initial		**0**		
T1	0.45	0.57	7.13	0.88
T2	0.21	0.53	6.14	0.75
T3	0.32	0.61	6.55	0.88
T4	0.45	0.60	5.22	1.01
T5	0.47	0.65	6.32	0.96
T6	0.60	0.70	4.48	0.98
T7	0.61	1.27	5.32	1.52
T8	0.74	1.49	6.32	1.62
T9	0.58	0.73	5.22	1.07
T10	0.72	1.82	6.33	1.95
T11	0.78	1.51	5.32	1.87
T12	0.75	1.47	6.23	1.86
T13	0.76	1.80	4.33	1.98
T14	1.14	2.51	5.79	3.03
Mean	0.61	1.16	0.10	
S.Em±	0.04	0.07	0.38	
CD@1%	0.14	0.29	0.53	

T1. Starch (2%)
T2. Aloe-Vera extract - (AVE) (20%)
T3. Banana peel extract – (BPE) (20% dry powder)
T4. Pomegranate peel extract – (PPE) (4% dry powder)
T5. Turmeric extracts (6%)
T6. Sesamum oil (2%)
T7. BPE + Starch (20% + 2%)
T8. BPE + AVE (20% + 20%)
T9. PPE + Starch (4% + 2%)
T10. PPE + AVE (4% + 20%)
T11. Turmeric extract (6%) + Sesamum oil (2%) + Starch (2%)
T12. Turmeric extract (6%) + Sesamum oil (2%) + AVE (20%)
T13. Turmeric extract (6%) + Sesamum oil (2%)
T14.. Control

Conclusion

Results revealed that among different treatments, the highest phenol content were noticed in Treatment T2 (Aloe-vera gel 20%), respectively and Treatment T2 recorded lowest value in all the parameters *i.e.,*microbial count load, disease score and disease index. From this, it may be concluded that banana fruits coated with 20 percent of aloe-vera gel extract is considered best with respect to phyto chemical properties.

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