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Original Research Article

POST-HARVEST EFFECTS OF VARIOUS EDIBLE COATINGS ON SHELF LIFE AND QUALITY OF BITTER GOURD

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Abstract *Due to various factors, including fungal infection, tissue weakening, yellowing, and mass reduction, bitter gourds are susceptible to postharvest losses, particularly when stored at room temperature. To preserve their quality, bitter gourds undergo several treatments during the postharvest stage. The research was designed to determine the effects of several edible coatings on the shelf life and quality of bitter gourd at room temperature. These coatings included Aloe Vera Gel extract, Neem leaf extract, Garlic extract, Ginger extract, and lemongrass leaf extract. Due to various factors, including fungal infection, tissue weakening, yellowing, and mass reduction, bitter gourds are susceptible to postharvest losses, particularly when stored at room temperature. To preserve their quality, bitter gourds undergo several technical treatments during the postharvest. The study was carried out to determine the effects of several edible coatings on the shelf life and quality of bitter gourd at room temperature. These coatings included Aloe Vera Gel extract, Neem leaf extract, Garlic extract, Ginger extract, and Lemongrass leaf extract. The findings showed that the postharvest quality and shelf life of bitter gourd were strongly impacted by edible coating. Coated bitter gourds showed a significant response in weight loss, extended shelf life and visual quality, and postponed color changes or yellowing after 8 days of storage. Furthermore, pH, TSS, titratable acidity, and ash contents respond better than non-treated fruits. These findings were verified by two-factor factorial ANOVA, and LSD examination was implemented to assess the outcomes with a probability of five percent level*.

Keywords: *Bitter gourd, postharvest management, shelf life, quality traits, edible coatings*

Introduction

The bitter gourd, also known as the bitter melon in Pakistan, is botanically known as *Momordica charantia*. It is a member of the Cucurbitaceae family, which also includes melons, cucumbers, and pumpkins. Its primary tropical and subtropical growing regions include Southeast Asia, Africa, and the Caribbean. It grows odd lengthy, rough-looking fruits with a particular, sour flavor (Krawinkel et al, 2006). The high moisture content of bitter gourd makes it vulnerable to microbial development and dehydration. Wilting, shriveling, and a reduction in overall freshness and marketability can result from moisture loss (Kader, 2002). Furthermore, bitter gourds are not suited for long-term storage or long-distance transit due to their poor and short shelf life, which lowers their market value. To preserve the bitter gourd's market value and minimize financial losses, better post-harvest treatment techniques are needed (Sivakumar and Bautista-Banos, 2014). Improving food security is essential to extending the shelf life of perishable crops like bitter gourd, especially in areas where consumers find it difficult to get fresh vegetables. Longer shelf lives make more nutrient-dense veggies more accessible, increasing the year-round reliability of the food supply. In underdeveloped nations, where food distribution systems could be less effective, this is particularly crucial. When there are minimal shortages, a bigger percentage of the population has better access to fresh, high-nutrient products and price stability (Parfitt et al., 2010). Increasing the bitter gourd's shelf life has significant economic advantages. By reducing the pace of deterioration and preserving the produce's functioning for a longer period, producers and merchants may minimize losses and boost earnings. Farmers may become

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more financially independent as a consequence, and the food supply system's overall effectiveness may rise. Additionally, because of better supply chain management and less waste, customers may buy a wider range of high-quality products at a reduced cost (Hodges et al., 2011). The quality as well as fruit and veggie shelf life can be maintained by covering their surface with tiny layers of edible substance (Park, 1999). Chitosan, pectin, aloe vera, and other proteins and polysaccharides are frequently employed in the manufacturing of coated foods. These materials were selected as they are renewable, are capable of creating films, and can increase the duration of consumable products' shelf life (Bourtoom, 2008). The edible coating works by reducing respiration and the rate of transpiration by creating a semi-permeable wall. Moreover, several coatings include antibacterial properties that hinder the growth of diseases and deteriorating organisms on the surface of fruits (Baldwin, 1994). When we use edible coatings it has few benefits, including reduced moisture loss, slower ripening, and increased safety from microbes. Other factors such as the method of application, the type of coating material, and conditions of storage may impact the performance of edible coatings. Additionally, some coatings might change the fruit's flavor, texture, and other sensory qualities, which may affect the fruit's acceptability by consumers (Debeaufort et al., 1998). Aloe vera is being researched extensively as a possible fruit and vegetable with an edible covering with its well-known characteristics like medicinal and physiological characteristics. It helps to keep perishable for a long period if used as an edible coating (Chauhan et al., 2015). As ginger has antioxidant and antibacterial qualities, it is well known due to these qualities. Using ginger as a coating that is edible on fresh produce to keep them fresh for a long time sounds like a good idea (Sivakumar et al., 2005). A Ginger-based coating for food helps bitter gourds retain moisture by covering their surface with a semi-permeable layer that delays ripening and slows respiration. Ginger's antibacterial qualities prevent bacteria and fungi from growing, which lowers the occurrence of spoiling and deterioration. In addition, this barrier helps to maintain the fruit's quality by restricting the flow of gases like carbon dioxide and oxygen (Shukla et al., 2007; Singh et al., 2010). Garlic is appropriate to increase the life span of delicate food because of its strong antioxidant and antibacterial traits. Usually, that solution is mixed with the proper medium or emulsifier and placed on the product's exterior by dipping, spraying, or brushing. After applying this coated fruit and allowing it to dry. A protective coating is formed that helps maintain its quality (Rastogi et al., 2019; Haroon et al., 2024; Hunajid and Gokce, 2024; Sami et al., 2023). Edible coatings based on lemongrass have several advantages, such as biodegradable properties, reduced moisture loss, and natural antioxidant and antibacterial qualities. In addition, strong lemongrass smells or tastes may affect the perception of consumers (Borges et al., 2017). Neem is prized due to many physical traits, including its antioxidant and antimicrobial attributes. Neem extracts are becoming more popular as an edible covering because they can prolong the fruits' and vegetables' storage life (Siddiqui et al, 2017). Edible coatings based on Neem provide a protective layer on fruits along with veggies which helps to lower the loss of moisture as well as decrease respiration. The antibacterial properties of neem stop the growth of germs and fungi, whereas its antioxidant compounds reduce the damage caused by oxidative stress. This combination effect helps coated products stay fresher for the long term and enhance their shelf life (Abbas et al., 2024ab; Arshad et al., 2024; Rehman et al., 2024; Panday et al., 2019; Kumar et al., 2021). It is suggested that using natural extracts such as aloe vera, ginger, garlic, neem, and lemongrass in edible coatings can improve the bitter gourd's quality and post-harvest life. However, there is still not a comprehensive and extensive study on how the natural extract affects bitter gourd crops in Pakistan. Therefore, the goal of this study was to find out how a natural edible covering affected the bitter gourd's quality at room temperature.

Materials & Methods

The research was conducted at the post-harvest lab of the Department of Horticulture Sciences, Faculty of Agricultural Sciences, University of the Punjab, Lahore. This study aimed to investigate the effects of various edible coatings, including Distill water, Garlic extract, Ginger extract, *Aloe vera* gel, Neem leaf extract, and Lemon-grass leaf extract applied to bitter gourd after harvest to evaluate their potential in extending shelf life. After sorting, grading, and washing uniform bitter gourd were selected for this study. The dipping technique was used to apply the painstakingly prepared treatments. This method made it possible to apply the extract evenly and completely on every bitter gourd, the bitter gourds were dipped into the solutions, making sure that the treatment covered every fruit completely for reliable and efficient outcomes. The room temperature is between 32 ±2 degrees Celsius. Throughout the experiment, the bitter gourds were kept this condition. Study was comprised with following treatments, T0= Control, T1= Distilled water, T2=lemon grass leaf extract, T3=Neem leaf extract, T4= Ginger extract, T5= Garlic extract, T6= Alovera gel and each treatment was replicated four time to overcome the study error. The study was evaluated based on the following parameters.

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2.1. Fresh weight loss (%)

Used an extremely accurate, gram-calibrated weighing scale to precisely measure the weight, which is a crucial component in assessing fruit quality. Maintaining the accuracy of our data required this degree of precision.

Fresh weight loss Fresh weight loss was assessed at each sampling interval, and calculated with the following formula. Fresh weight loss (%) = Initial weight - Final weight/ Initial weight × 100

2.2. Fruit firmness

For this used a portable digital penetrometer (FR-5120 PENETOMETER, Tokyo, Japan) to measure the bitter gourd fruits' firmness. To guarantee consistency, measurements of bitter gourd firmness were made from the equatorial region's opposing sides. After testing each bitter gourd twice, the average of the two measurements was determined. As is customary, the mean values were given in SI units, namely newtons (Hasan et al., 2019).

2.3. Organoleptic Parameters

Fruits from each replication were sliced into pieces and given at random to a panel of three experts to assess the organoleptic parameters. Taste, flavour, scent, colour, and general acceptability were among the important sensory qualities evaluated by the panel. Using a scale from 1 to 9, the assessment was carried out following the procedure described by Peryam & Pilgrim (1957). A score of 1 on this scale meant that the quality was low and undesirable, a score of 3 meant that the quality was somewhat good but limited, a score of 5 meant that the quality was good and marketable, a score of 7 meant that the quality was the best, and a score of 9 meant that the quality was superb. The panel was given a standardized evaluation form to record their evaluations of the organoleptic features.

2.4. Total soluble solids (TSS) measurement

Total soluble solids (TSS), an indicator of the quantity of dissolved solids in the fruit's liquid component, a refractometer, a precise device made especially for measuring TSS, was used in this experiment. Bitter gourd samples were taken from each treatment and replication, and the TSS content was examined. The refractive index of the extracted fruit juice, which is directly correlated with the TSS content, was measured using a refractometer.

2.5 pH measurement

For pH measurement, using a mortar and pestle, the bitter gourd samples' juice was first extracted, and then the clear liquid was obtained by filtering. After that, the pH of this juice was determined, yielding important details about the fruit's interior makeup. Following a rigorous routine, measurements were taken on the third, fourth, fifth, tenth, and fifteenth days.

2.6. Ash contents measurement

By burning the dried bitter gourd samples at a high temperature and leaving behind the mineral residue, the amount of ash was ascertained. This methodical technique made it possible to thoroughly examine the effects of ambient storage conditions on the amount of ash in bitter gourds coated with environmentally friendly edible coatings.

2.7. Total phenolics contents

Total phenolic contents were estimated by the method of Ozgen et al. (2008). The extraction solution consisted of 70% methanol, 28% anhydrous ethanol, and 2% formic acid (v/v). A 0.2 g sample was ground with liquid nitrogen and placed in a centrifuge tube. Subsequently, 5 mL of the extraction solution was added, followed by 30 min of ultrasonic extraction. After shaking at 250 rpm at 30°C for 2 h, the extract was centrifuged at 8000 rpm for 10 min at 4°C. The supernatant was then filtered through a 0.45 mm needle tube filter for analysis of phenolic. All procedures were conducted in the dark.

2.8. Statistical Analysis

The experiment was carried out under the factorial experimental layout of a completely randomized design. The factors were sampling intervals and applied treatments. The data were analyzed with two-way analysis of variance and means were differentiated with the least significant difference (LSD) test. The graphs were prepared by using the data of interaction effect (treatments × storage days). The differences were considered statistically significant at 5% probability level.

Results and discussion

3.1 Fresh weight loss (%)

Fresh weight loss of treated and non-treated bitter gourd fruits substantially ($P \leq 0.05$) increased as the storage period progressed from 2th to 8th day (Figure 3.1). The weight loss of untreated bitter gourd fruits was excessively increased as the days under storage progressed especially from 2th day to onwards. On day-8th, control showed a maximum 67.833% decrease in fresh weight and lowest weight reduction on the 8^{th} days was seen in T3=Lemon Grass Extract 75.791% fresh weight loss. Overall edible coating reduced the weight loss in bitter gourd fresh weight in comparison with control (Figure 3.1).

3.2. Bitter gourd Firmness

Randomly chosen bitter gourd were used to gather data on their firmness, statistical analysis showed significant ($P \leq 0.05$) differences among the treatments (Table 3.1) T1= Distill water coated, had the maximum firmness (62.57). The control treatment T0 recorded the lowest bitter gourd fruit firmness (24.128) as shown in Table 4.1.2 that the use of all other edible coatings was improved bitter gourd firmness. The T3 bitter gourd's softening was considerably inhibited and its firmness increased. Tan et al. (1999) similarly observed a sharp decline

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in firmness in bitter gourd fruit that was left untreated and kept at room temperature.

3.3. Bitter gourd color

Statistical analysis regarding bitter gourd fruit color showed a non-significant difference between treatments. The LSD test was used to compare the means of treatments at a 5% level of probability (Table 3.1). The bitter gourd coated with T4= Ginger Extract presented the maximum rating in term of color (7.20). Whereas, control treatment gets the lowest rate in terms of color. The product's color, texture, taste, and aromatic qualities all contribute to its fresh-like freshness, which is a crucial factor in customer satisfaction. The bitter gourd coated with edible coatings such Aloe Vera gel, Neem extract, Lemon grass extract, Ginger, and Garlic extract scored higher on all sensory qualities. Chauhan et al., 2015 and Song et al., 2017 also showed that apple slices covered with Aloe vera gel had a superior sensory quality than those that were not. The positive impact of these coatings on bitter gourd demonstrates how well they maintain their sensory qualities but are not significant in color.

3.4. Bitter gourd appearance

The collected data on bitter gourd appearance was subjected to statistical analysis, findings showed a difference between treatments and non-coated treatments (Table 3.1) T4=Ginger Extract showed the highest fruit look (6.9000) whereas, T0=Control presented the lowest bitter gourd appearance i.e., 6.90. Therefore, all other treatments have a little bit of difference in term of appearance. The product's color, texture, taste, and aromatic qualities all contribute to its fresh-like freshness, which is a crucial factor in customer satisfaction. The bitter gourd coated with edible coatings such Aloe Vera gel, Neem extract, Lemon grass extract, Ginger, and Garlic extract scored higher on all sensory qualities. Chauhan et al., 2015 and Song et al., 2017 also showed that apple slices covered with Aloe vera gel had a superior sensory quality than those that were not. The positive impact of these coatings on bitter gourd demonstrates how well they maintain their sensory qualities, increasing their appeal.

3.5. Total soluble solids (TSS)

Statistical analysis on fruit Total soluble solids (TSS) showed a significant difference, the results showed significant differences between all the studied treatments (Table 3.1). The LSD test was used to compare the treatment means at the 5% probability level. T6= Aloa vera Extract exhibited a maximum bitter gourd fruit TSS (1.0250) followed by 0.2122 in T0 control treatment. Water loss, enzyme activity, and respiration processes that turn stored starch into sugar raise the TSS level in vegetables. In addition to positively inhibiting respiration and ethylene generation, edible coatings alter the internal environment, potentially extending shelf life and maintaining TSS (Bautista-Baños et al., 2006).

Table 3.1. Effect of different edible coating on bitter gourd firmness, fruit color, fruit appearance and fruit total soluble solids under room temperature

Treatment	Fruit firmness	Fruit color	Fruit appearance	TSS
T0= Control	24.12±2.24c	5.47±0.20c	4.35±0.18e	0.21±0.13c
T1= Distill water	62.59±5.05a	5.50±0.18c	5.07±0.055d	0.72±0.23ab
T2= Lemongrass leaf extract	48.96±11.19b	6.37±0.20b	6.00±0.047c	0.46±0.18bc
T3= Neem leaf extract	31.36±0.63c	7.12±0.15a	6.40±0.12b	0.47±0.16bc
T4= Ginger extract	31.88±3.37c	7.20±0.08a	6.90±0.23a	0.96±0.12a
T5= Garlic extract	32.58±1.93c	6.57±0.17b	6.47±0.21b	0.65±0.30abc
T6= Aloevera gel	36.36±3.81bc	5.70±0.10c	6.05±0.07c	1.02±0.08a

Table 3.2. Effect of different edible coating on bitter gourd pH, fruit ash contents and fruit total phenolics under room temperature

Treatment	Fruit pH	Fruit ash contents	Fruit total phenolics
T0= Control	5.68±0.21a	18.65±0.70c	120.43±0.37e
T1= Distill water	5.51±0.31ab	20.94±0.33abc	135.42±0.29d
T2= Lemongrass leaf extract	5.89±0.27a	20.37±1.58abc	150.35±2.43b
T3= Neem leaf extract	5.74±0.34a	20.30±1.60bc	149.98±0.67b
T4= Ginger extract	5.84±0.20a	22.17±0.71ab	142.47±0.38c
T5= Garlic extract	5.39±0.022ab	22.94±0.38a	157.45±0.49a
T6= Aloevera gel	4.79±0.41b	22.22±0.82ab	158.68±0.91a

Figure 3.1. Effect of different edible coating on bitter gourd weight loss (%) under room temperature

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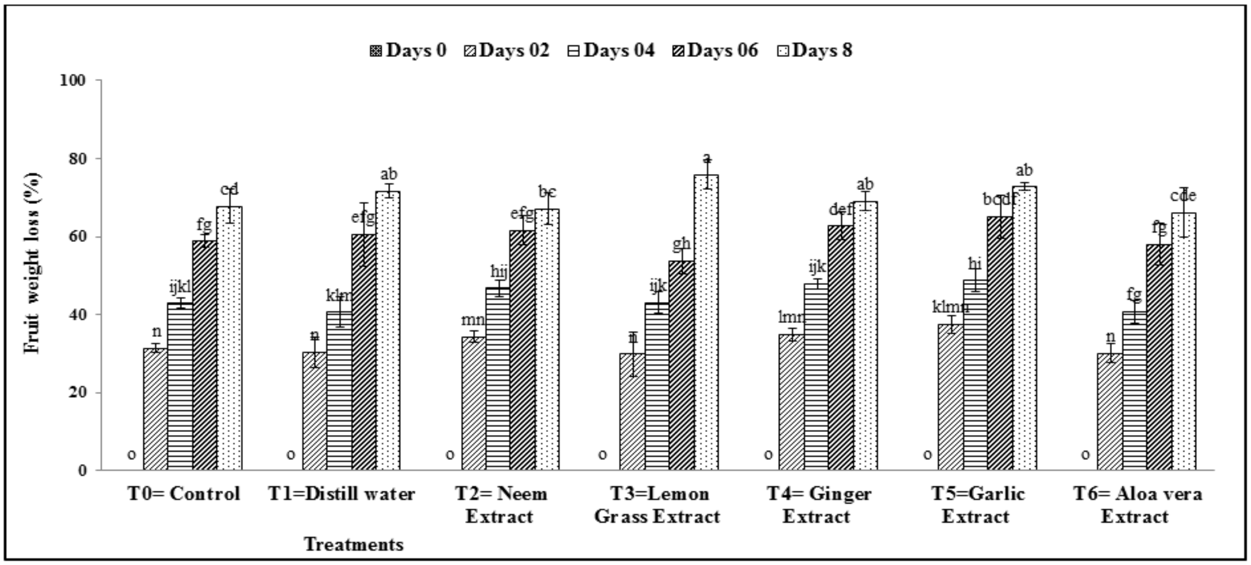

3.6. pH of bitter gourd

The findings of the statistical analysis of the data recorded on the pH of bitter gourd showed a significant difference between all treatments (Table 3.2) The LSD test was used to compare the treatment means at the 5% probability level presented a similar group for all the studied treatment. According to the results, the bitter gourd applied with aloe vera extract possessed the lowest pH (4.7), whereas the vegetable coated with ginger and neem extract had the highest pH (5.8). Fruits and vegetables organic acids have an impact on their pH. Because of a drop in the production of acid and the depletion of some organic acid components A rise in pH during storage denotes a drop in acidity (Angelia, 2017).

3.7. Bitter gourd ash contents

The data regarding bitter gourd ash contents was analyzed by statistical analysis; findings presented a significant difference ($P \leq 0.05$) between the treatments as seen in Table 3.2. T5= Garlic Extract revealed the maximum ash contents of bitter gourd (22.947) followed by T6= Aloa vera Extract coating (22.220) whereas, T4= Ginger Extract coating presented (22.175) ash contents (Table 3.2). The lowest bitter gourd fruit ash contents was (18.658) recorded in T0= Control treatment. Bitter gourd treated with garlic extract has a higher ash level than bitter gourd that has not been treated. The results of another study support earlier studies on other crops, like green beans and carrots, where edible coverings helped to preserve mineral content by functioning as barriers to moisture and oxygen exchange, hence reducing nutrient degradation (Maqbool et al., 2011).

3.8. Bitter gourd total phenolic contents

The data regarding bitter gourd total phenolic contents were subjected to statistical analysis and presented a significant ($P \leq 0.05$) variation among treatments (Table 3.2). Data were compared by using LSD test at the 5% probability level. T6= Aloa vera Extract presented a maximum bitter gourd total phenolic contents (158.68) and the lowest contents were noted in T0 control treatment (120.43). Whereas, T1, T2, T3, T4, T5 presented 135.42, 150.35, 149.98, 142.47, 157.45, respectively.

Conclusion

The edible coating was effective in delaying the ripening/decay of bitter gourd and to maintain quality for eight days under room temperature during summer. Edible coating reduced weight loss and inhibited disease occurrence. The coating little bit delayed color and appearance changes. In addition, edible coating resulted in higher phenolic contents that eventually mitigated oxidative damage during postharvest storage. The coating application helped to improve the shelf life of bitter gourd so, this natural and environmentally friendly edible coating could be considered a potential postharvest treatment to delay ripening and to conserve the quality of harvested bitter gourd.

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