

## EVALUATION OF POSTHARVEST BEHAVIOUR OF BITTER GOURD AS INFLUENCED BY GAMMA IRRADIATION AND MODIFIED ATMOSPHERE PACKAGING

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### Abstract

An experiment was conducted at the Postharvest Laboratory of Horticulture Division, Bangladesh Institute of Nuclear Agriculture during November to December 2022 to examine the effects of different doses of gamma irradiation and Modified atmosphere packaging (MAP) on shelf life and quality of bitter gourd at ambient condition. The experiment comprised ten postharvest treatment viz., T<sub>0</sub> =Control (untreated, unwrapped and non-irradiated); T<sub>1</sub> =Gourds wrapped in Polypropylene (PP) bag; T<sub>2</sub> =Gourds treated with 3% CaCl<sub>2</sub>; T<sub>3</sub> = Irradiated at 1000 Gy, T<sub>4</sub> = Irradiated at 2000 Gy, T<sub>5</sub> =3% CaCl<sub>2</sub>+ PP bag, T<sub>6</sub> = 1000 Gy+ PP bag, T<sub>7</sub> = 2000 Gy+ PP bag, T<sub>8</sub> =3% CaCl<sub>2</sub>, + 1000 Gy+ PP bag and T<sub>9</sub> = 3% CaCl<sub>2</sub> + 2000 Gy+ PP bag. The single-factor experiment was carried out in a completely randomized design with three replications. Parameters investigated were fruit colour, shrinkage, moisture content, dry matter content, weight loss, disease incidence (DI), disease severity (DS) and shelf life. The minimum weight loss (3.49%), shrinkage (0.00%), DI (11.11%), DS (6.67%) and longest shelf life (10 days) were found in bitter gourds treated with T<sub>8</sub> treatment, whereas the maximum weight loss (52.31%), shrinkage (3.89%), DI (77.78%), DS (76.67%) and shortest shelf life (4 days) were T<sub>0</sub> treatment at 8 days after storage. The findings would have great impact in reducing enormous postharvest loss of bitter gourd and maintain their quality during postharvest handling and marketing under ambient condition.

**Key words:** Bitter gourd, Sanitizers, Gamma irradiation, MAP, Polypropylene

### Introduction

Bitter gourd also known as bitter melon (*Momordica charantia*) is a member of cucurbitaceae family and it is one of the most popular vegetable in Bangladesh. The total production of bitter gourd in Bangladesh was about 65421.79 metric tons from 11639.22 hectares of land with an average yield of 5.62 t/ha (BBS, 2022). Emerald green young fruits are eaten as vegetables that turn to orange-yellow when ripe (Grover and Yadav, 2004). The bitter flavor is caused by the alkaloid momordicine generated in fruit and leaves (Din *et al.*, 2011). The fruits are used as antidiabetic, antitumorous, anticancer, anti-inflammatory, antiviral, and cholesterol lowering effects (Ahmed *et al.*, 2001). Bitter gourd is a good source of Vitamin A, Vitamin C, phosphorus and iron (Sultana and Bari, 2003; Paul *et al.*,

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2009). By delaying the ripening and senescence of vegetables, irradiation has been shown to be effective for reducing postharvest losses and extending the shelf life (Mostafavi *et al.*, 2010). Irradiation has been declared a safe and nonchemical technology for use on fruits and vegetables by the World Health Organization, the Food and Agriculture Organization, and the International Atomic Energy Agency (Ben-Fadhelet *et al.*, 2021). Nowadays, postharvest application of different calcium salts such as calcium chloride, calcium phosphate, calcium propionate and calcium gluconate have gained popularity in order to reduce various physiological disorders of fruits and vegetables (Aguayo *et al.*, 2008; Manganaris *et al.*, 2005). Calcium Chloride delayed fruit ripening, improved resistance to fungal attack and maintained structural integrity of cell walls (Mahajan *et al.*, 2004). Modified atmosphere packaging which is commonly known as MAP is used to enhance the shelf life of perishable horticultural products like fruits and vegetables (Kitinoja and Kader 2004). MAP effectively extends the postharvest shelf life of fresh commodities by delaying their enzymatic browning, reducing respiration rate, minimizing metabolic activity and by preserving their visual appearance (Waghmare and Annapure 2013). Recently the application of gamma irradiation on various foods has increased for the reason of its effect on insect disinfestations and improved food security. Ionizing irradiation reduces the spoilage and hence enhances the shelf life of many vegetables and spices (Akhther *et al.*, 2022). High postharvest loss is now a problem worldwide and it is to be minimized by 50% by 2030 to achieve SDG target 12.3. The recent report mentioned that 17-32% of fruits and vegetables are spoiled in Bangladesh (Hassan *et al.*, 2021). Hence, any attempt to reduce postharvest loss warrants investigation through reducing water loss, rates of respiration and ethylene production, chilling injury, and microbial activity. There is scanty of works which have been done regarding the preservation of bitter gourd under different storage conditions as mentioned above. In this regard, modified atmosphere packaging, sanitization and radiation technology were investigated to maintain postharvest quality and reduces losses of bitter gourd.

## **Materials and Methods**

### **Experimental materials**

The experiment was conducted at the Postharvest Laboratory of Horticulture Division, Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh November-December, 2022 to study the standardization of sanitizer, gamma irradiation and modified atmosphere packaging for improving shelf life and quality of bitter gourd. A hybrid variety of bitter gourd, namely Tia, was used for conducting the present experiment. Fruits were harvested at the green stage of commercial maturity (approximately 20 days after pollination) from a farmers' field of Jamalpur District. The collected fruits were sorted into categories of uniform size, shape, and colour, checked to be free from defects or blemishes. After that the desired fruits were washed with tap water, and dried at room temperature for 15 min prior to treatment. The experimental bitter gourds' initial averages (5 gourds) of length, weight, breadth, and colour were 9.26 cm, 207.8 g, 4.33 cm and fully green,

respectively. The experiment comprised the treatments  $T_0$  = Control,  $T_1$  = Bitter gourds wrapped in 25  $\mu$  PP bag,  $T_2$  = Bitter gourds treated with 3%  $\text{CaCl}_2$  for 20 min.,  $T_3$  = Bitter gourds gamma irradiated at 1000 Gy,  $T_4$  = Bitter gourds gamma irradiated at 2000 Gy,  $T_5$  = Bitter gourds treated with 3%  $\text{CaCl}_2$  for 20 min. and wrapped in 25  $\mu$  PP bag,  $T_6$  = Bitter gourds gamma irradiated at 1000 Gy and wrapped in 25  $\mu$  PP bag,  $T_7$  = Bitter gourds gamma irradiated at 2000 Gy and wrapped in 25  $\mu$  PP bag,  $T_8$  = Bitter gourds treated with 3%  $\text{CaCl}_2$  for 20 min., gamma irradiated at 1000 Gy and wrapped in 25  $\mu$  PP bag,  $T_9$  = Bitter gourds treated with 3%  $\text{CaCl}_2$  for 20 min., gamma irradiated at 2000 Gy and wrapped in 25  $\mu$  PP bag. The single-factor experiment was laid out in completely randomized design with three replications of three fruits per replication. Data were analyzed using analysis of variance (ANOVA) by Statistix 10 (Version 10.0 Analytical Software USA). The means for all the treatments were calculated and ANOVA for all parameters was performed by F-test. Statistically significant differences among the different doses were identified by LSD at the 1% and 5% levels of significance as described by Gomez and Gomez (1984).

## Parameters investigated

### Physiological weight loss:

For assessment of physiological weight loss of bitter gourd of each replication of each treatment was separately weighed using digital electronic balance at different days of observations (2, 4, 6 and 8 days after storage). Physiological weight loss was calculated using the following formula (Hassan 1998):

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

Where, PWL = Physiological weight loss. IW = Initial weight (g) and FW = Final weight (g)

### Estimation of moisture and dry matter content:

Ten grams of bitter gourd was taken in a petridish (which was previously cleaned, dried, and weighed) for each replication. The petridish was placed in an electric oven at 80°C for 72 hours until the constant weight attained. It was then cooled in a desiccator and weighed again. Percent moisture content of bitter gourd was calculated using the following formula (Hassan 1998):

$$\text{Moisture content (\%)} = \frac{IW - FW}{IW} \times 100$$

Where, IW = Initial weight of pulp (g), FW = Final weight of oven dried pulp (g)

Percent dry matter content of the bitter gourd was estimated from the data obtained during moisture estimation using the following formula:

Percent dry matter = (100 - percent moisture content).

### Colour and Shrinkage:

The changes in colour of bitter gourd were determined using a numerical rating scale of 0-5, where 0 = fully green, 1= Breaker, 2 = Up to 25% light yellow, 3 = 26-50% yellow, 4 = 51-75% yellow and 5 = 76- 100% yellow. Shrinkage was recorded at the different days (2, 4, 6, and 8) using visual scale where 0 =No shrinkage, 1= 1-25% shrinkage, 2 = 26-50% shrinkage, 3= 51-75% shrinkage and 4 = 76-100% shrinkage. Similar scales were used by Jahan et al. (2020).

### Disease incidence and Disease severity:

Diseases incidence means percentage of fruits infected with disease. This is measured by calculating the percentage of fruits infected in each replication of each treatment. The infected fruits of each replication of each treatment were selected to determine percent fruit area infected and was measured based on eye estimation.

$$\text{Disease incidence (\%)} = \frac{\text{Number of infected fruits in each replication}}{\text{Total number of fruits in each replication}} \times 100$$

Disease severity represents the percent diseased portion of the infected fruits. The infected fruits of each replication of each treatment were selected to determine percent fruit area diseased, and was assessed based on visual observation.

### Shelf life:

Shelf life of fruits were calculated from daily estimation of disease severity on the same fruits from each replication and considered as ended when the fruits had little or no commercial viability as estimated by Rashid *et al.* (2015). Shelf life of bitter gourd as influenced by different postharvest storage treatments were calculated by counting the days required to the final stage having optimum marketing and eating qualities.

## Results and Discussion

### Physiological weight loss

The postharvest treatments used in the present study exhibited significant effect on physiological weight loss of bitter gourds during storage. The physiological weight loss increased with time and ranged between 0.74-53.91% (Table1). The minimum weight loss (3.49%) was found in bitter gourds dipped in 3% CaCl<sub>2</sub>, 1000 Gy gamma irradiated and PP bag wrapped gourds followed by 3% CaCl<sub>2</sub> treated, 2000 Gy gamma irradiated and PP bag wrapped gourds(5.43%) at 8<sup>th</sup> day after storage (Table1). Higher levels of weight losses (52.31%) were recorded in the unwrapped control gourds irrespective of treatments with CaCl<sub>2</sub> and gamma irradiation (Table1). For instance, the maximum weight loss (53.91%) was found in unwrapped CaCl<sub>2</sub> treated gourds which were statistically identical with those of unwrapped gamma irradiated gourds. The finding of the present study were in partial agreement with the findings reported by Bhattacharjee and Dhua (2017). They found that

weight loss decreased by creates a modified atmosphere that reduces the water vapor transmission and therefore slower respiration rates. Banu (2000) reported lower weight loss of pointed gourd and okra when stored in polythene bag.

Table 1. Effect of postharvest treatments on percent physiological weight loss at different days after storage of bitter gourd

Treatments	Physiological weight loss (%) at different days after storage			
	2	4	6	8
T <sub>0</sub>	8.41	23.90	38.36	52.31
T <sub>1</sub>	1.47	0.69	2.21	5.57
T <sub>2</sub>	6.19	25.98	40.83	53.91
T <sub>3</sub>	9.64	28.02	29.86	48.77
T <sub>4</sub>	9.71	18.88	25.65	38.65
T <sub>5</sub>	0.81	3.22	5.34	7.25
T <sub>6</sub>	4.67	6.10	11.79	13.31
T <sub>7</sub>	0.88	2.26	5.41	6.37
T <sub>8</sub>	0.74	0.90	2.12	3.49
T <sub>9</sub>	3.49	3.99	4.74	5.43
LSD <sub>0.05</sub>	4.67	4.67	10.27	16.73

N. B. \*\* = Significant at 1% level of probability.

T<sub>0</sub> = Control, T<sub>1</sub> = wrapped in PP bag (25 μ), T<sub>2</sub> = treated with 3% CaCl<sub>2</sub>, T<sub>3</sub> = Irradiated at 1000 Gy, T<sub>4</sub> = Irradiated at 2000 Gy, T<sub>5</sub> = 3% CaCl<sub>2</sub> + PP bag, T<sub>6</sub> = 1000 Gy + PP bag, T<sub>7</sub> = 2000 Gy + PP bag, T<sub>8</sub> = 3% CaCl<sub>2</sub> + PP bag, T<sub>9</sub> = 3% CaCl<sub>2</sub> + 2000 Gy + PP bag.

### Colour and shrinkage

In case of perishable commodity, colour is one of the most important visual criteria for identifying their freshness quality. It is the important parameters for determination of quality of edible bitter gourd. Due to post harvest treatment the colour is changed from green to fully yellow. At the 2 days of storage, there were no significant changes of colour but with increasing storage time significant changes of colour were observed. The best visual colour (0.00) was observed in gourds wrapped in PP bag (T<sub>1</sub>), gourds gamma irradiated at 2000 Gy and wrapped in PP bag (T<sub>7</sub>) and also gourds dipped in 3% CaCl<sub>2</sub>, 1000 Gy gamma irradiated and PP bag wrapped (T<sub>8</sub>) at 2, 4, 6, and 8 days of storage, respectively which were statistically identical with those of PP bag wrapped, CaCl<sub>2</sub> treated gourds (T<sub>5</sub>). The worst visual colour (4.56) was observed in unsanitized, non-irradiated, unwrapped control at the 8<sup>th</sup> day after storage followed by gamma irradiated gourds at 1000 Gy (Figure1). The increasing in changes of colour with increasing storage period. Shrinkage is one of the most important aspects of fruit quality. It depends on the stages of maturity, environmental factors and different treatments. Similar result was reported by May *et al.* (2023) after 8 days storage of bitter gourd. When bitter gourds harvested, their colour was predominantly fully green, but as the storage days progressed the discolouration due to both

enzymatic reactions. Level of shrinkage increased with duration of storage. The result showed that there were no shrinkage occurred after 2 and 4 days of storage, respectively (Figure 1). The maximum levels of shrinkage (3.9) were occurred in unsanitized, non-irradiated, unwrapped control at the 8<sup>th</sup> day of storage followed by bitter gourds gamma irradiated at 1000 Gy. whereas minimum levels of shrinkage (0.00) were occurred in gourds wrapped in PP bag, sanitized with CaCl<sub>2</sub> and wrapped in PP bag, gamma irradiated at 1000 Gy and wrapped in PP bag, gamma irradiated at 2000 Gy and wrapped in PP bag and gourds dipped in 3% CaCl<sub>2</sub>, 1000 Gy gamma irradiated and PP bag wrapped gourds at the 8<sup>th</sup> day after storage (Table 2). Shrinkage scores slowly increased in the treatments with storage duration. Significantly lower and statistically identical shrinkage were also occurred in 3% CaCl<sub>2</sub>, gamma irradiated 2000 Gy and wrapped in PP bag. Similar results were reported by Benitez *et al.* (2016).

### **Moisture content and dry matter**

Significant variation was observed in respect of moisture content (%) in bitter gourd at the end of shelf life. It was found that during the whole storage period the % moisture content from the pulp of bitter gourd decreased with time and ranged between 94.63-92.10% (Table2). The maximum moisture content (93.87%) was found in bitter gourds dipped in 3% CaCl<sub>2</sub>, 1000 Gy gamma irradiated and PP wrapped gourd followed by 3% CaCl<sub>2</sub> treated and PP bag wrapped gourds at 8<sup>th</sup> day after storage those treatment (Table2). The minimum moisture content was recorded in unsanitized, non-irradiated and unwrapped control at the 2, 4, 6, 8 days, respectively (Table2). The decreased in moisture content were probably due to transpiration and evaporation loss and also starch hydrolysis. It also supported by Ashenafi and Tura (2001).

Dry matter contents of bitter gourd were calculated from percent moisture content. The result showed that there were significant differences among the treatment. During the whole storage period the percent dry matter content from the bitter gourds increased with time and ranged between 5.37-7.90% (Table2). The increase in dry matter content with increasing storage period may be due to osmotic withdrawal of water by transpiration and evaporation. The minimum dry matter content (6.13%) was found in bitter gourds dipped in 3% CaCl<sub>2</sub>, 1000 Gy gamma irradiated and PP bag wrapped gourds at the 8<sup>th</sup> day after storage followed by gourds sanitized with 3% CaCl<sub>2</sub>. The maximum dry matter content (7.90%) was found in unsanitized, non-irradiated and unwrapped control gourds because weight loss was higher due to higher water loss in control at room temperature resulting in higher dry matter content (Table2). The higher levels of percent dry matter content (7.67%) was recorded in the unwrapped gamma irradiated at 2000 Gy and statistically identical with unwrapped 3% CaCl<sub>2</sub> treated (Table2). The results of the present investigation have got support of Debnath (2015) and Parvin (2004). The increase in dry matter content with increasing storage period may be due to osmotic withdrawal of water by transpiration and evaporation.

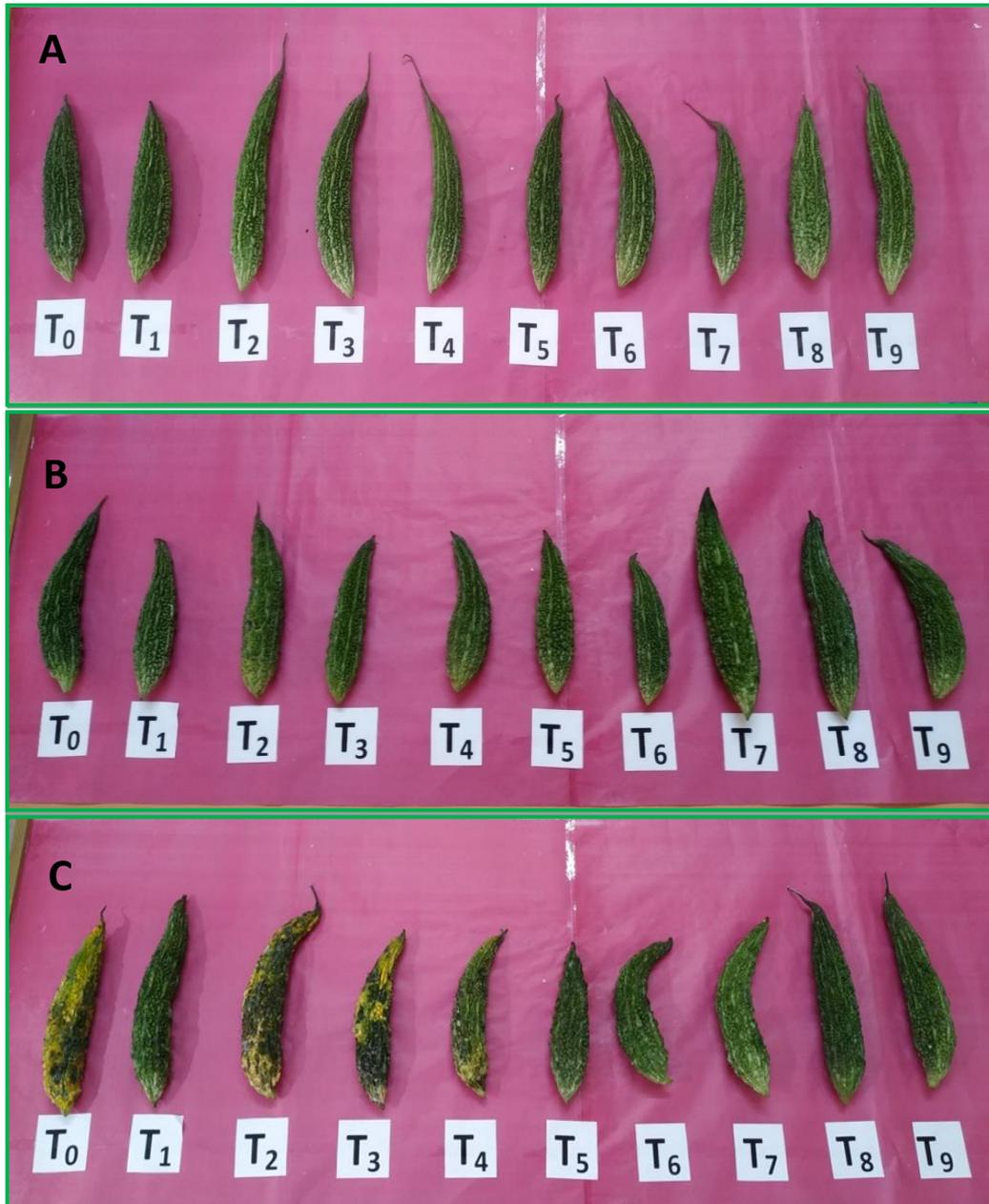


Fig. 1. Pictures showing of bitter gourd at A: 2; B: 4 and C: 8 days after treating.

T<sub>0</sub> = Control, T<sub>1</sub> = wrapped in PP bag (25  $\mu$ ), T<sub>2</sub> = treated with 3% CaCl<sub>2</sub>, T<sub>3</sub> =Irradiated at 1000 Gy, T<sub>4</sub> = Irradiated at 2000 Gy, T<sub>5</sub>=3% CaCl<sub>2</sub> + PP bag, T<sub>6</sub>= 1000 Gy+ PP bag, T<sub>7</sub>=2000 Gy+ PP bag, T<sub>8</sub>= 3% CaCl<sub>2</sub>+ PP bag, T<sub>9</sub>=3% CaCl<sub>2</sub> + 2000 Gy+ PP bag.

Table 2. Effect of postharvest treatments on percent moisture content and dry matter content at different days after storage of bitter gourd

Treatments	Moisture content (%) at different days after storage				Dry matter content (%) at different days after storage				Shrinkage at different days after storage			
	2	4	6	8	2	4	6	8	2	4	6	8
T <sub>0</sub>	92.9	92.6	92.4	92.1	7.1	7.4	7.6	7.9	0.0	0.0	1.2	3.9
T <sub>1</sub>	94.5	94.4	93.9	93.4	5.5	5.6	6.1	6.6	0.0	0.0	0.0	0.0
T <sub>2</sub>	94.5	94.1	93.8	93.5	5.5	5.9	6.2	6.5	0.0	0.0	1.1	2.3
T <sub>3</sub>	93.6	93.2	93.1	92.9	6.4	6.8	6.9	7.1	0.0	0.0	1.3	3.5
T <sub>4</sub>	93.3	93.1	92.7	92.3	6.7	7.0	7.3	7.7	0.0	0.0	0.2	2.83
T <sub>5</sub>	93.7	93.5	93.3	93.0	6.3	6.5	6.7	7.0	0.0	0.0	0.0	0.0
T <sub>6</sub>	94.0	93.8	93.5	93.3	6.0	6.2	6.5	6.7	0.0	0.0	0.0	0.0
T <sub>7</sub>	94.3	94.1	93.7	93.3	5.7	5.9	6.3	6.7	0.0	0.0	0.0	0.0
T <sub>8</sub>	94.6	94.4	94.2	93.9	5.4	5.6	5.8	6.1	0.0	0.0	0.0	0.0
T <sub>9</sub>	94.4	94.0	93.6	93.2	5.6	6.0	6.4	6.8	0.0	0.0	0.0	1.22
LSD <sub>0.05</sub>	0.26	0.35	0.45	0.46	0.26	0.35	0.45	0.46	-	-	0.81	1.61

N. B. \*\* = Significant at 1% level of probability.

T<sub>0</sub> = Control, T<sub>1</sub> = wrapped in PP bag (25 μ), T<sub>2</sub> = treated with 3% CaCl<sub>2</sub>, T<sub>3</sub> = Irradiated at 1000 Gy, T<sub>4</sub> = Irradiated at 2000 Gy, T<sub>5</sub> = 3% CaCl<sub>2</sub> + PP bag, T<sub>6</sub> = 1000 Gy + PP bag, T<sub>7</sub> = 2000 Gy + PP bag, T<sub>8</sub> = 3% CaCl<sub>2</sub> + PP bag, T<sub>9</sub> = 3% CaCl<sub>2</sub> + 2000 Gy + PP bag.

### Disease incidence and severity

Variation in respect of percent disease incidence as influenced by postharvest treatments was found highly significant. Generally, the levels of disease incidence were found to gradually increased as the duration of storage progressed (Figure 2). The maximum disease incidence (77.78%) was recorded in untreated, non-irradiated, unwrapped control and gourds treated with 3% CaCl<sub>2</sub>, respectively at 8 days after storage, whereas the minimum (11.11%) was observed in case of the treatment (gourds dipped in 3% CaCl<sub>2</sub>, 1000 Gy gamma irradiated and PP bag wrapped (T<sub>8</sub>) at the 8 days after storage (Figure 2). Result showed that treatment remarkably suppressed disease levels during the entire period of investigation. Singh *et al.* (2016) stated that pathogen grows both aerobically and anaerobically, but generally grows more slowly under anaerobic conditions. Irradiation and MAP create anaerobic condition and reduce disease incidence which supports the observations of the present study. Variation in respect of disease severity was found to be significant in bitter gourd during storage. Disease severity increased with the advancement of storage period. The higher disease severity (35.43% and 76.67%) were recorded in unsanitized, non-irradiated, unwrapped control at the 6<sup>th</sup>, 8<sup>th</sup> day after storage, respectively followed by CaCl<sub>2</sub> treated gourds. The lower disease severity (3.33% and 6.67%) were found in gourds dipped in 3% CaCl<sub>2</sub>, 1000 Gy gamma irradiated and PP bag wrapped gourds at the 6<sup>th</sup>, 8<sup>th</sup> day, respectively after storage which were statistically identical with those of gourds dipped in 3% CaCl<sub>2</sub>, gamma irradiated at 2000 Gy and PP bag wrapped (Figure 2).

### Shelf life

Shelf life is the basic quality index of fruit. Shelf life period begins from the time of harvesting and extends up to the start of rotting of fruit. In the present investigation significant variation was obtained on the shelf life of bitter gourd as influenced by the postharvest treatments. Significantly the longest shelf life (10 days) was recorded in gourds exposed to gourds dipped in 3% CaCl<sub>2</sub>, gamma irradiated at 1000 Gy and wrapped in PP bag whereas the shortest shelf life (4 days) was recorded in the unsanitized, non-irradiated and unwrapped control (Figure3). Significantly longest and statistically identical shelf lives were also recorded in the treatments T<sub>4</sub>, T<sub>5</sub>, T<sub>6</sub>, respectively (Figure 3). Akhther *et. al.* (2023) found that the t shelf life of Himsagor mango increase by combined effects of gamma irradiation (400 Gy) and LDPE packaging. Devi *et al.* (2019) reported that shelf life of bitter gourd could be prolonged by combined effect of sanitizer and MAP which supports the observations of the present study.

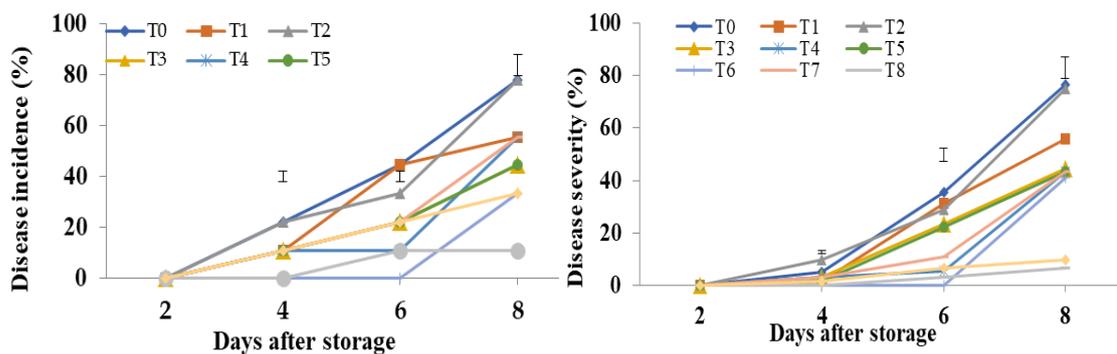


Fig. 2. Effect of postharvest treatments on Disease incidence and disease severity of bitter gourd. At each day, the vertical bar represents LSD at 5% level of significance.

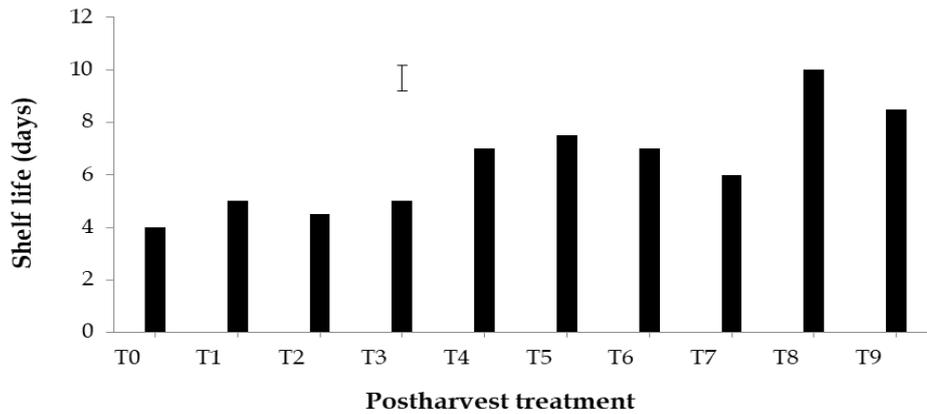


Fig. 3. Effect of postharvest treatments on shelf life of bitter gourd. The vertical bar represents LSD at 5% level.

(Vertical bar represents LSD at 5% level of significance. T<sub>0</sub> = Control, T<sub>1</sub> = wrapped in PP bag (25 μ), T<sub>2</sub> = treated with 3% CaCl<sub>2</sub>, T<sub>3</sub> = Irradiated at 1000 Gy, T<sub>4</sub> = Irradiated at 2000 Gy, T<sub>5</sub> = 3% CaCl<sub>2</sub> + PP bag, T<sub>6</sub> = 1000 Gy + PP bag, T<sub>7</sub> = 2000 Gy + PP bag, T<sub>8</sub> = 3% CaCl<sub>2</sub> + PP bag, T<sub>9</sub> = 3% CaCl<sub>2</sub> + 2000 Gy + PP bag.)

## Conclusion

The postharvest losses of bitter gourd can be reduced remarkably by applying irradiation and MAP. Bitter gourds sanitized with 3% CaCl<sub>2</sub> followed by gamma irradiation at 1000 Gy and wrapping in un-perforated polypropylene (PP) bags had marked effect on extending shelf life through minimizing disease incidence and disease severity and retaining postharvest quality attributes. However, further investigations with more promising postharvest treatments are suggested to carry out to confirm the results of the present study.

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