Plant Archives Vol. 24, No. 2, 2024 pp. 1187-1192 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org

DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2024.v24.no.2.168

MAINTAINING THE POST-HARVEST QUALITY OF LITCHI (*LITCHI CHINENSIS* SONN.) CV. ROSE SCENTED BY USING GAMMA IRRADIATION AND EDIBLE COATINGS

Nikesh Chandra[1, 2]*, Satish Chand[1], Bhawana Mamgain[3], Rohit Sharma[2] and Sampurna Nand Singh[1]

[1]Department of Horticulture, G.B. Pant University of Agriculture and Technology, Pantnagar - 263 145, Uttarakhand, India.

[2]Department of Agriculture, Mata Gujri College, Fatehgarh Sahib - 140 406, Punjab, India.

[3]Department of Agriculture, Alpine Group of Institutes, Dehradun - 248 007, Uttarakhand, India.

*Corresponding author E-mail : nikesh2chandra@gmail.com

(Date of Receiving-08-05-2024; Date of Acceptance-18-07-2024)

ABSTRACT

After conducting a study, it was discovered that a method involving the use of radiation combined with edible coatings can effectively preserve the quality of litchi cv. Rose Scented after it has been harvested. The study involved analyzing various physical and biochemical parameters and the findings revealed that a treatment involving 1.0 kGy of radiation was particularly effective. This treatment helped reduce weight loss and maintain the fruit's overall quality over a 20-day storage period. Additionally, it was beneficial for important biochemical parameters such as total soluble solids (TSS) and acidity.

Key words : Gamma radiation, *Litchi chinensis* Sonn, Edible coatings, Post-harvest.

Introduction

The litchi (*Litchi chinensis* Sonn.) is the most important fruit in the Sapindaceae (soapberry) family and is widely consumed by humans. It is currently India's leading commercial fruit crop due to high seasonal demand and export potential (Sahni *et al*., 2020). Litchi fruit has a short shelf life of 2–4 days at room temperature, which limits its marketability in local and big-city markets (Jiang and Jiang, 2005). Researchers are working on developing new strategies to preserve fruit quality and extend shelf life due to the increasing demand for high-quality fresh fruits without chemical treatments (Mahajan *et al*., 2018). The combination of edible coatings and gamma radiation offers a promising and environmentally friendly solution to the issue of short shelf life and nutritional deterioration of fruits (Sousa-Gallagher *et al*., 2016). In food processing and preservation, the use of radiation is gaining traction (Lima *et al*., 2018). The FAO, IAEA and WHO joint expert committee has approved a permissible dose of up to 10 kGy in food processing due to the absence of adverse effects on nutrition or microbes (Khalil *et al*., 2009). A thin layer of edible material, such as chitosan and Aloe vera gel, when applied to the fruit's surface, helps to maintain fruit quality for a longer time (Ahmed *et al*., 2009). Chitosan, derived from chitin, is a modified natural carbohydrate polymer that reduces physiological weight loss and ripening processes while maintaining firmness, total soluble solids, titratable acidity, and other desirable qualities (Shiekh *et al*., 2013). The use of chitosan in the food industry to preserve fresh fruits during refrigeration seems highly promising (Bola et al., 2017). Aloe vera, renowned for its numerous medicinal benefits, has a long history in both writing and praise as an all-purpose herbal plant (Eshun and He, 2005).

Materials and Methods

The present study was conducted at the Horticultural Research Centre and Department of Horticulture, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, U.S. Nagar (Uttarakhand), India. The research center is situated in the Tarai region of the Himalayas with a humid subtropical climate. The gamma radiation was applied to samples weighing 2 kg each (0.8

kGy, 1.0 kGy and 1.2 kGy) in the Radiations and Isotopic Tracer Laboratory (RITL, College of Basic Science and Humanities, Pantnagar). Then, chitosan (1.0% and 1.5%) and *Aloe vera* gel (10%, 25% and 50%) coatings were applied to the radioactive samples as per treatment combinations. All 19 treatments one is untreated fruits (T_1- control), three treatments of gamma radiation (T_2- 0.8 kGy, T_3- 1.0 kGy and T_4- 1.2 kGy) and 6 treatments with combination of chitosan (T_5-0.8 kGy + 1.0% chitosan, T_6-1.0 kGy + 1.0% chitosan, T_7- 1.0 kGy + 1.0% chitosan, T_8- 0.8 kGy + 1.5% chitosan, T_9- 1.0 kGy + 1.5% chitosan, T_{10}- 1.0 kGy + 1.5% chitosan) and with *Aloe vera* gel (T_{11}- 0.8 kGy + 10 % *Aloe vera* gel, T12- 1.0 kGy + 10% *Aloe vera* gel, T_{13}- 1.2 kGy + 10% *Aloe vera* gel, T_{14}- 0.8 kGy + 25% *Aloe vera* gel, T_{15}- 1.0 kGy + 25% *Aloe vera* gel, T_{16}- 1.2 kGy + 25% *Aloe vera* gel, T_{17}- 0.8 kGy + 50% *Aloe vera* gel, T_{18}- 1.0 kGy + 50% *Aloe vera* gel, T_{19}- 1.2 kGy + 10% *Aloe vera* gel) all samples were stored at a low temperature of 2°C in perforated plastic bags and evaluated at alternate intervals of four days until 20 days of storage.

Aloe vera gel coating preparation

The *Aloe vera* gel is extracted from the leaves using a filtering method. The leaves are carefully chosen based on their uniform maturity, size, color, and freshness. They are washed with tap water and then rinsed with distilled water to ensure cleanliness. The colorless hydro parenchyma, which represents the separated gel matrix, is ground from the Aloe vera leaves in a blender. The resulting mixture is then filtered to remove fibers, resulting in 100% pure Aloe vera gel. Citric acid is added to the gel to lower the pH to 4 and then the gel is pasteurized for 45 minutes at 70°C (Maughan, 1984). The prepared gel extract is stored in cold storage and it can be used to coat fresh fruits (Marpudi *et al.*, 2011).

Chitosan coating preparation

The coating solution was created by dissolving 15 and 20 g of chitosan powder in 900 mL of distilled water, 50 mL of glacial acetic acid was added to dissolve the chitosan, creating 1.5% and 2.0% chitosan solutions in 1 L and pH was adjusted to 5.0 with 0.1M NaOH.

Physiological loss in weight (%)

The weight of litchi fruits was taken just after coating and 0, 4, 8, 12, 16 and 20th days intervals after treatment and the percentage of physiological weight loss of fruit was calculated with the help of the following formula.

$$\text{PLW (\%)} = \frac{\text{Initial weight of fruits} - \text{Final weight}}{\text{Initial weight of fruit}} \times 100$$

Marketable fruit (%)

The marketable fruit percentage was determined by dividing the percentage of fruits without any browning (browning scale = 0) by the total quantity of fruits. This calculation provides an assessment of the proportion of fruits that are considered marketable based on their absence of browning (Zhang *et al.*, 2015).

Total soluble solids (°B)

The selected fruits were taken for juice extraction using a muslin cloth and the total soluble solids (TSS) of the litchi juice were determined by using a Hand Refractometer and expressed in °B.

Titratable acidity (%)

To determine the acidity of the fruit, the juice extracted from 5 g of the sample was first filtered through a muslin cloth. Then, it was diluted to a known volume of 25 mL with distilled water. Subsequently, the diluted juice was titrated against standard NaOH solution, with the aid of Phenolphthalein as an indicator. The endpoint was indicated by the appearance of a light pink color, which was then recorded. The acidity value was expressed as a percentage, representing the concentration of acidity present in the fruit.

Results and Discussion

Effect on physiological loss in weight (%)

Upon analyzing the data presented in Table 1, regarding the physiological loss in weight of the fruit, significant observations were recorded. In the first year of the experiment in 2022, a consistent trend of increasing physiological loss in weight was observed across all treatments from 0 days to the 20th day of storage. In the 1st 8 days, there is no significant difference has been observed except for T_1 (control). The data indicated that untreated fruits T_1 (control) experienced the maximum physiological loss in weight, 36.16%, followed by T_8 (1.2 kGy + 1.5% chitosan) *i.e.*, 23.41% after a 20-day storage period. The integrated approach involving chitosan did not yield favorable results, potentially due to the thickness of the coating affecting the fruit's quality. A thicker coating can hinder the supply of oxygen and water vapor to the fruit. Throughout the course of the research, the treatment involving T_3 (1.0 kGy) consistently displayed superior results, with the minimum physiological loss in weight recorded at 13.72%, followed by T_{12} (1.0 kGy + 10% Aloe vera gel) at 15.87%. Weight loss in litchi fruits is a significant concern due to its association with lipid peroxidation and changes in pericarp permeability. Various metabolic processes continue to occur in the fruit even after it is harvested. Enzymatic activities, such as those involved in cell wall degradation and other biochemical

Table 1 : Effect of gamma irradiation fortified with edible coatings on physiological loss in weight (%) of litchi Rose Scented.

Year	**Pooled data (2022 and 2023)**					
Treatments	**Storage intervals (days)**					
	0	**4**	**8**	**12**	**16**	**20**
T_1- Control	0.00^{a*}	1.063^{a}	4.20^{a}	12.88^{a}	25.66^{a}	36.16^{a}
T_2- 0.8 kGy	0.00^{a}	0.00^{a}	1.40^{b}	4.29^{bcde}	9.12^{fg}	18.01^{ij}
T_3- 1.0 kGy	0.00^{a}	0.00^{a}	0.75^{b}	2.57^{e}	6.13^{h}	13.72^{l}
T_4- 1.2 kGy	0.00^{a}	0.00^{a}	1.20^{b}	3.60^{cde}	10.57^{ef}	19.81^{gh}
T_5- 0.8 kGy + 1.0% chitosan	0.00^{a}	0.00^{a}	1.53^{b}	4.48^{bcd}	10.87^{de}	22.69^{bc}
T_6- 1.0 kGy + 1.0% chitosan	0.00^{a}	0.00^{a}	1.70^{b}	4.92^{bcd}	11.68^{cde}	20.9^{defg}
T_7- 1.2 kGy + 1.0% chitosan	0.00^{a}	0.00^{a}	1.66^{b}	4.90^{bcd}	12.23^{cd}	21.97^{bcdef}
T_8- 0.8 kGy + 1.5% chitosan	0.00^{a}	0.00^{a}	1.92^{b}	5.54^{b}	13.07^{bc}	23.41^{b}
T_9- 1.0 kGy + 1.5% chitosan	0.00^{a}	0.00^{a}	1.99^{b}	5.11^{bcd}	13.82^{b}	22.36^{bcde}
T_{10}- 1.2 kGy + 1.5% chitosan	0.00^{a}	0.00^{a}	1.86^{b}	5.31^{bc}	14.21^{b}	22.86^{bc}
T_{11}- 0.8 kGy +10% *Aloe vera* gel	0.00^{a}	0.00^{a}	1.43^{b}	4.32^{bcde}	8.97^{fg}	17.32^{j}
T_{12}- 1.0 kGy +10% *Aloe vera* gel	0.00^{a}	0.00^{a}	1.18^{b}	3.39^{de}	8.25^{g}	15.87^{k}
T_{13}- 1.2 kGy +10% *Aloe vera* gel	0.00^{a}	0.00^{a}	1.36^{b}	4.67^{bcd}	9.16^{fg}	18.94^{hi}
T_{14}- 0.8 kGy +25% *Aloe vera* gel	0.00^{a}	0.00^{a}	1.69^{b}	4.70^{bcd}	10.93^{de}	22.5^{bcd}
T_{15}- 1.0 kGy +25% *Aloe vera* gel	0.00^{a}	0.00^{a}	1.62^{b}	4.12^{bcde}	9.06^{fg}	20.53^{fg}
T_{16}- 1.2 kGy +25% *Aloe vera* gel	0.00^{a}	0.00^{a}	1.44^{b}	4.41^{bcd}	10.05^{ef}	20.85^{efg}
T_{17}- 0.8 kGy +50% *Aloe vera* gel	0.00^{a}	0.00^{a}	1.85^{b}	4.65^{bcd}	10.04^{ef}	22.67^{bc}
T_{18}- 1.0 kGy +50% *Aloe vera* gel	0.00^{a}	0.00^{a}	1.49^{b}	4.52^{bcd}	11.10^{de}	21.29^{cdefg}
T_{19}- 1.2 kGy +50% *Aloe vera* gel	0.00^{a}	0.00^{a}	1.62^{b}	4.94^{bcd}	11.07^{de}	21.37^{cdefg}

*same alphabet in a column show no significance difference

reactions, can contribute to the breakdown of cellular components, leading to weight loss, as noted by Bhushan *et al*. (2019). This issue negatively impacts both the postharvest quality and aesthetic appeal of the fruits, as highlighted by Kumar and Ray (2020). Also, Majeed *et al*. (2014) found that radiation doses of 1.0 and 1.5 kGy had a substantial effect in reducing weight loss during various storage periods. Similarly, Singh *et al*. (2018) reported that *Aloe vera*-treated fruits exhibited minimal physiological weight loss, with a mere 15.15% reduction in weight.

Effect on Marketable fruit %

The determination of marketable fruit percentage involved the calculation of the proportion of fruits without any browning (browning scale = 0) about the total quantity of fruits. The results of the study, as depicted in Table 2, reveal that there were no statistically significant differences observed among the various treatments, except the control group, following a storage period of 4 days. However, it is noteworthy that the treated fruits exhibited considerable positive responses even after an extended storage duration of 12 days, indicating their potential for effectively maintaining marketable quality. Following this period, a slight decrease in the marketable fruit percentage was observed across all treatments. Notably, after 12 days of storage, the control fruits (T_1) were no longer considered suitable for market preference due to significant quality deterioration. In contrast, the T_3 (1.0 kGy) demonstrated the highest marketable fruit percentage at 37.50%, highlighting its effectiveness in preserving fruit quality during the 20-day storage period followed by T_{12} (1.0 kGy + 10% Aloe vera gel) *i.e.*, 25.00%. Weight loss, resulting from lipid peroxidation and changes in pericarp permeability, is a critical concern in litchi fruits, as it diminishes their postharvest quality and aesthetic appeal. These findings highlight the importance of effective postharvest strategies to minimize weight loss and preserve the marketability of litchi fruits (Zhang *et al*., 2015; Bhusan *et al*., 2019; Kumar and Ray, 2020). Panou *et al*. (2019) results suggest that irradiation at this dose can be a beneficial technology for improving quality and marketability.

Effect on TSS (°Brix)

The results presented in Table 3, clearly demonstrate that the TSS of the fruits was significantly influenced by both the applied treatments and the storage duration across all treatments. A distinct pattern emerged, revealing a gradual increase in TSS from the initial storage day up

Table 2 : Effect of gamma irradiation fortified with edible coatings on Marketable fruit % of litchi cv. Rose Scented.

Year	**Pooled data (2022 and 2023)**					
Treatments	**Storage intervals (days)**					
	0	**4**	**8**	**12**	**16**	**20**
T_1- Control	100.00^{a*}	75.00$_b$	50.00^d	25.00^f	0.00^e	0.00^e
T_2- 0.8 kGy	100.00^a	100.00^a	75.00^c	62.50^c	25.00^d	12.50^c
T_3- 1.0 kGy	100.00^a	100.00^a	87.50^a	75.00^a	50.00^a	37.50^a
T_4- 1.2 kGy	100.00^a	100.00^a	81.25^b	68.75^b	25.00^d	12.50^c
T_5- 0.8 kGy + 1.0% chitosan	100.00^a	100.00^a	81.25^b	62.50^c	37.50^b	12.50^c
T_6- 1.0 kGy + 1.0% chitosan	100.00^a	100.00^a	81.25^b	62.50^c	31.25^c	6.25^d
T_7- 1.2 kGy + 1.0% chitosan	100.00^a	100.00^a	81.25^b	56.25^d	37.5.0^b	12.50^c
T_8- 0.8 kGy + 1.5% chitosan	100.00^a	100.00^a	75.00^c	56.25^d	31.25^c	0.00^e
T_9- 1.0 kGy + 1.5% chitosan	100.00^a	100.00^a	75.00^c	50.00^e	25.00^d	0.00^e
T_{10}- 1.2 kGy + 1.5% chitosan	100.00^a	100.00^a	75.00^c	50.00^e	25.00^d	0.00^e
T_{11}- 0.8 kGy +10% *Aloe vera* gel	100.00^a	100.00^a	75.00^c	62.50^c	37.50^b	12.50^c
T_{12}- 1.0 kGy +10% *Aloe vera* gel	100.00^a	100.00^a	87.50^a	75.00^a	37.50^b	25.00^b
T_{13}- 1.2 kGy +10% *Aloe vera* gel	100.00^a	100.00^a	81.25^b	68.75^b	37.50^b	12.50^c
T_{14}- 0.8 kGy +25% *Aloe vera* gel	100.00^a	100.00^a	81.25^b	62.50^c	37.50^b	12.50^c
T_{15}- 1.0 kGy +25% *Aloe vera* gel	100.00^a	100.00^a	81.25^b	62.50^c	37.5.00^b	12.50^c
T_{16}- 1.2 kGy +25% *Aloe vera* gel	100.00^a	100.00^a	81.25^b	56.25^d	37.5.00^b	12.50^c
T_{17}- 0.8 kGy +50% *Aloe vera* gel	100.00^a	100.00^a	81.25^b	62.50^c	37.5.00^b	12.50^c
T_{18}- 1.0 kGy +50% *Aloe vera* gel	100.00^a	100.00^a	81.25^b	68.75^b	37.5.00^b	12.50^c
T_{19}- 1.2 kGy +50% *Aloe vera* gel	100.00^a	100.00^a	81.25^b	68.75^b	37.5.00^b	12.50^c

*same alphabet in a column show no significance difference.

to the 20th day. Notably, the findings indicate that the TSS content of uncoated control fruits (T_1) exhibited a relatively rapid increase from 16.45 to 20.45 °Brix by the 8th day of storage, followed by a decrease to 11.98 °Brix by the 20th day. In contrast, the treated fruits displayed a slower rate of TSS increase compared to the control group, although after a 12-day storage period, TSS levels in the treated fruits began to rise. The maximum TSS value of 21.10 °Brix was observed after a 20-day storage period in the case of T_3 treatment (1.0 kGy), which was statistically *at par* with T_{12} treatment (1.0 kGy + 10% *Aloe vera* gel) *i.e.*, 20.85 °Brix. The rapid TSS increment observed in untreated fruits during the initial 8 days can be attributed to their accelerated ripening process. This supports the hypothesis that treated fruits experience delayed ripening, thus effectively maintaining the TSS levels for an extended duration. This observation can be attributed to the accelerated conversion of starch into saccharine compounds caused by moisture loss, as reported by Soares *et al*. (2007). This phenomenon could be attributed to the hydrolysis of complex sugars and dehydration of the fruits. However, as time intervals advanced, TSS gradually decreased, possibly due to a higher respiration rate and senescence, as documented by Kaur *et al*. (2009) and Bal *et al*. (2010). The study conducted by Moreno *et al*. (2006) further supports our findings, as they also observed a decline in TSS levels over time, indicating that irradiation had a retarding effect on the ripening process.

Effect on titratable acidity (%)

The analysis of the experimental data presented in Table 4, demonstrates the significant impact of all treatments on litchi fruits, except the control group. The observed pattern indicates a decline in titratable acidity from the initial day to the 20th day of the storage period. maximum titratable acidity (0.25%) was recorded in T_3(1.0 kGy), which is statistically *at par* with T_{12} (1.0 kGy +10% *Aloe vera* gel) *i.e.* 0.24% showed better retention of titratable acidity. The least titratable acidity was recorded in T_1 (control) *i.e.*, 0.10%. The observed decrease in titratable acidity can be attributed to the utilization of organic acids during the physiological activity of the fruit. Previous studies, such as Srinivasa *et al*. (2002) have reported a similar declining trend in acidity, which is linked to the hydrolysis of organic acids into sugars and their subsequent utilization in the metabolic processes of the fruit. These findings align with the research conducted by Debeaufort *et al*. (1998), who noted that the application of edible coatings resulted in a reduction in the transpiration rate, thereby decreasing the availability of organic acids for enzymatic reactions involved in respiration. It is hypothesized that coatings

Table 3 : Effect of gamma irradiation fortified with edible coatings on TSS (°Brix) of litchi cv. Rose Scented.

Year	**Pooled data (2022 and 2023)**					
Treatments	**Storage intervals (days)**					
	0	**4**	**8**	**12**	**16**	**20**
T_1- Control	16.45[a*]	19.23[a]	20.45[a]	16.40[g]	14.72[h]	11.98[g]
T_2- 0.8 kGy	16.45[a]	17.19[bcd]	18.01[d]	18.10[cdef]	19.85[efg]	18.79[ef]
T_3- 1.0 kGy	16.45[a]	16.93[bcd]	18.01[d]	18.85[def]	21.04[ab]	21.10[a]
T_4- 1.2 kGy	16.45[a]	17.00[bcd]	18.89[bc]	19.62[abcd]	19.89[efg]	19.29[cde]
T_5- 0.8 kGy + 1.0% chitosan	16.45[a]	17.70[bc]	18.69[bcd]	19.55[abcde]	19.49[fg]	18.30[f]
T_6- 1.0 kGy + 1.0% chitosan	16.45[a]	17.02[bcd]	18.54[cd]	19.67[abc]	19.84[efg]	18.89[def]
T_7- 1.2 kGy + 1.0% chitosan	16.45[a]	17.14[bcd]	18.48[cd]	20.01[ab]	19.78[efg]	18.34[f]
T_8- 0.8 kGy + 1.5% chitosan	16.45[a]	16.91[cd]	18.75[bcd]	19.92[ab]	19.26[g]	18.39[f]
T_9- 1.0 kGy + 1.5% chitosan	16.45[a]	17.43[bcd]	18.19[cd]	19.94[ab]	19.24[g]	18.19[f]
T_{10}- 1.2 kGy + 1.5% chitosan	16.45[a]	17.47[bc]	18.14[cd]	20.29[a]	20.06[def]	19.15[cde]
T_{11}- 0.8 kGy +10% *Aloe vera* gel	16.45[a]	17.44[bcd]	18.46[cd]	18.83[ef]	20.75[abcd]	20.51[ab]
T_{12}- 1.0 kGy +10% *Aloe vera* gel	16.45[a]	16.63[d]	18.08[cd]	18.37[f]	21.20[a]	20.85[a]
T_{13}- 1.2 kGy +10% *Aloe vera* gel	16.45[a]	17.11[bcd]	18.57[bcd]	18.85[def]	20.85[abc]	20.38[ab]
T_{14}- 0.8 kGy +25% *Aloe vera* gel	16.45[a]	17.73[b]	18.39[cd]	19.22[bcde]	20.06[def]	19.66[cd]
T_{15}- 1.0 kGy +25% *Aloe vera* gel	16.45[a]	17.62[bc]	19.31[b]	19.64[abcd]	20.33[bcde]	19.57[cd]
T_{16}- 1.2 kGy +25% *Aloe vera* gel	16.45[a]	17.27[bcd]	18.56[bcd]	19.95[ab]	20.39[bcde]	19.25[cde]
T_{17}- 0.8 kGy +50% *Aloe vera* gel	16.45[a]	17.25[bcd]	18.47[cd]	19.67[abc]	20.12[cdef]	19.32[cde]
T_{18}- 1.0 kGy +50% *Aloe vera* gel	16.45[a]	17.01[bcd]	18.44[cd]	19.43[bcde]	20.42[bcde]	19.91[bc]
T_{19}- 1.2 kGy +50% *Aloe vera* gel	16.45[a]	17.31[bcd]	17.98[d]	19.36[bcde]	20.38[bcde]	19.46[cde]

*same alphabet in a column show no significance difference.

Table 4 : Effect of gamma irradiation fortified with edible coatings on acidity of litchi cv. Rose Scented.

Year	**Pooled data (2022 and 2023)**					
Treatments	**Storage intervals (days)**					
	0	**4**	**8**	**12**	**16**	**20**
T_1- Control	0.44[a*]	0.33[b]	0.26[d]	0.18[d]	0.14[d]	0.10[d]
T_2- 0.8 kGy	0.44[a]	0.36[ab]	0.31[bcd]	0.25[bc]	0.20[cd]	0.17[c]
T_3- 1.0 kGy	0.44[a]	0.41[a]	0.37[a]	0.31[a]	0.27[a]	0.25[a]
T_4- 1.2 kGy	0.44[a]	0.37[ab]	0.28[cd]	0.25[bc]	0.23[abc]	0.19[bc]
T_5- 0.8 kGy + 1.0% chitosan	0.44[a]	0.35[ab]	0.30[bcd]	0.24[cd]	0.20[cd]	0.18[c]
T_6- 1.0 kGy + 1.0% chitosan	0.44[a]	0.36[ab]	0.31[bcd]	0.26[abc]	0.22[abc]	0.19[bc]
T_7- 1.2 kGy + 1.0% chitosan	0.44[a]	0.37[ab]	0.29[cd]	0.25[bc]	0.20[cd]	0.16[cd]
T_8- 0.8 kGy + 1.5% chitosan	0.44[a]	0.37[ab]	0.30[bcd]	0.26[abc]	0.21[bc]	0.17[c]
T_9- 1.0 kGy + 1.5% chitosan	0.44[a]	0.40[a]	0.32[abcd]	0.23[cd]	0.20[cd]	0.17[c]
T_{10}- 1.2 kGy + 1.5% chitosan	0.44[a]	0.36[ab]	0.32[abcd]	0.25[bc]	0.20[cd]	0.16[cd]
T_{11}- 0.8 kGy +10% *Aloe vera* gel	0.44[a]	0.37[ab]	0.33[abc]	0.26[abc]	0.20[cd]	0.16[cd]
T_{12}- 1.0 kGy +10% *Aloe vera* gel	0.44[a]	0.39[ab]	0.36[ab]	0.31[ab]	0.27[ab]	0.24[ab]
T_{13}- 1.2 kGy +10% *Aloe vera* gel	0.44[a]	0.37[ab]	0.32[abcd]	0.26[abc]	0.24[abc]	0.19[bc]
T_{14}- 0.8 kGy +25% *Aloe vera* gel	0.44[a]	0.38[ab]	0.31[abcd]	0.23[cd]	0.21[abc]	0.18[c]
T_{15}- 1.0 kGy +25% *Aloe vera* gel	0.44[a]	0.36[ab]	0.33[abc]	0.26[abc]	0.22[abc]	0.17[c]
T_{16}- 1.2 kGy +25% *Aloe vera* gel	0.44[a]	0.37[ab]	0.32[abcd]	0.27[abc]	0.24[abc]	0.17[c]
T_{17}- 0.8 kGy +50% *Aloe vera* gel	0.44[a]	0.38[ab]	0.30[bcd]	0.23[cd]	0.21[abc]	0.19[bc]
T_{18}- 1.0 kGy +50% *Aloe vera* gel	0.44[a]	0.37[ab]	0.32[abcd]	0.25[bc]	0.21[abc]	0.19[bc]
T_{19}- 1.2 kGy +50% *Aloe vera* gel	0.44[a]	0.41[a]	0.32[abcd]	0.25[bc]	0.20[cd]	0.16[cd]

*same alphabet in a column shows no significance difference.

can also slow down the rate of respiration, thereby delaying the utilization of organic acids. Nevertheless, the results of the present study indicate that the acidity levels in the control fruits were significantly lower compared to those of the coated fruits. In line with previous studies conducted by Sharmin *et al*. (2015), our research findings also indicate a decrease in titratable acidity over time. Additionally, the work of Hazare *et al*. (2010) supports our findings and suggests that irradiation can influence the acidity of litchi fruit juice during prolonged storage. Drake *et al*. (2003) on apples reported that irradiation did not lead to any noticeable alterations in the levels of titratable acidity.

Conclusion

In conclusion, our study highlights the effectiveness of the 1.0 kGy irradiation followed by 1.0 kGy integrated with 10% *Aloe vera* gel treatment in significantly maintaining physiological and biochemical activities of litchi fruits, during refrigerated storage at 2°C for 20 days. Consequently, the study concludes that litchi cv. Rose Scented treated with 1.0 kGy proved most effective in maintaining postharvest quality attributes and extending their shelf-life by 3 to 4 times more when compared to uncoated control fruits. This finding holds considerable significance for enhancing the preservation and marketability of litchi fruits under refrigerated storage condition.

References

Ahmed, M.J., Singh Z. and Khan A.S. (2009). Postharvest *Aloe vera* gel coating modulates fruit ripening and quality of ‘Arctic Snow’ nectarine kept in ambient and cold storage. *Int. J. Food Sci. Technol*., **44(5)**, 1024-1033.

Bal, J.S., Randhawa J.S. and Boora R.S. (2010). Studies on post-harvest life of ber fruits treated with growth regulators and stored in different packages at cool temperature. *National Seminar on Impact of Climatic Change on Fruit Crops* (in press).

Bhushan, B., Kumar S., Mahawar M.K., Jalgaonkar K., Dukare A.S., Bibwe B. and Pal A. (2019). Nullifying phosphatidic acid effect and controlling phospholipase D associated browning in litchi pericarp through combinatorial application of hexanal and inositol. *Sci. Rep*., **9(1)**, 2402.

Bola, P.K., Jain S.K. and Anupama (2017). Chitosan and Shelf Life of Fruits: A review. *Chem. Sci. Rev. Lett*., **6(21)**, 371-375.

Chand, S., Sharma R., Srivastava R. and Chandra A.K. (2020). Impact of pre-harvest fruit bagging technology on growth and quality traits in litchi cv. Rose Scented under Indian prospective.

Debeaufort, F.J., Quezada-Gallo A. and Voilley A. (1998). Edible films and coatings: tomorrow‘s packaging: a review. *Crit. Rev. Food Sci. Nutr.* **38**, 299–313.

Drake, S.R., Neven L.G. and Sanderson P.G. (2003). Carbohydrate concentrations of apples and pears as influenced by irradiation as a quarantine treatment. *J. Food Process. Preserv*., **27(3)**, 165-172.

Eshun, K. and He Q. (2005). *Aloe vera*: A valuable ingredient for the food, pharmaceutical and cosmetic industriessa review. *Crit. Rev. Food Sci. Nutr*., **44**, 91-96.

Jiang, Y., Li J. and Jiang W. (2005). Effects of chitosan coating on shelf life of cold-stored litchi fruit at ambient temperature. *LWT-Food Sci. Technol*., **38(7)**, 757-761.

Kaur, M., Kumar A. and Kumar M. (2009). Storage studies of ber in polymeric films. *J. Agric. Eng*., **50(4)**, 38-49.

Khalil, S.A., Hussain S., Khan M. and Khattak A.B. (2009). Effect of gamma irradiation on quality of Pakistani blood red orange (*Citrus sinensis* L. Osbeck). *Int. J. Food Sci. & Tech*., **44**, 927-931.

Kumar, M. and Ray P.K. (2020). Litchi production and marketing in India: recent trends and important issues. *Acta Hortic.*, **1293**, 47-54.

Lima, F., Vieira K., Santos M. and de Souza P.M. (2018). Effects of radiation technologies on food nutritional quality. *Descriptive Food Science*, **1(17)**, 10-5772.

Majeed, A., Muhammad Z., Majid A., Shah A.H. and Hussain M. (2014). Impact of low doses of gamma irradiation on shelf life and chemical quality of strawberry (*Fragaria x ananassa*) cv.’corona’. *Japs: J. Anim. Plant Sci*., **24(5)**, 1531-1536.

Moreno, M.A., Castell-Perez M.E., Gomes C., Da Silva P.F. and Moreira R.G. (2007). Quality of electron beam irradiation of blueberries (*Vaccinium corymbosum* L.) at medium dose levels (1.0–3.2 kGy). *LWT-Food Sci Technol*., **40(7)**, 1123-1132.

Panou, A.A., Karabagias I.K. and Riganakos K.A. (2020). Effect of gamma-irradiation on sensory characteristics, physicochemical parameters, and shelf life of strawberries stored under refrigeration. *Int. J. Fruit Sci*., **20(2)**, 191-206.

Sahni, R.K., Kumari S., Kumar M., Kumar M. and Kumar A. (2020). Status of litchi cultivation in India. *Int. J. Curr. Microbiol. Appl. Sci*., **9(04)**, 1827-1840.

Sharmin, M.R., Islam M.N. and Alim M.A. (2015). Shelf-life enhancement of papaya with *Aloe vera* gel coating at ambient temperature. *J. Bangladesh Agril. Univ*., **13(1)**, 131–136.

Shiekh, R.A., Malik M.A., Al-Thabaiti S.A. and Shiekh M.A. (2013). Chitosan as a novel edible coating for fresh fruits. *Food Sci. Technol. Res*., **19(2)**, 139-155.

Singh, N., Misra K.K., Dongariyal A., Rani A. and Nirgude V. (2018). Response of different coating materials on post-harvest life and quality of guava (*Psidium guajava* L.). *Int. J. Chem. Stud*., **6(2)**, 2635-2639.

Soares, F.D., Pereira T., Marques M.O. and Monteiro A.R. (2007). Volatile and non-volatile chemical composition of the white guava fruit (*Psidium guajava* L.) at different stages of maturity. *Food Chem*., **100**, 15–21.

Sousa-Gallagher, M.J., Tank A. and Sousa R. (2016). Emerging technologies to extend the shelf life and stability of fruits and vegetables. In : *The stability and shelf life of food* (pp. 399-430). Woodhead Publishing

Srinivasa, P., Baskaran C.R., Ramesh M.N., Prashantand K.V.H. and Tharanthan R.N. (2002). Storage studies of mango packed using biodegradable chitosan film. *Eur. Food Res. Technol*., **215**, 504–508.

Zhang, Z., Huber D.J., Qu H., Yun Z.E., Wang H., Huang Z. and Jiang Y. (2015). Enzymatic browning and antioxidant activities in harvested litchi fruit as influenced by apple polyphenols. *Food Chem*., **171**, 191-199.