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Effect of Gamma Irradiation and Edible Coatings on the Post-harvest Quality of Litchi (*Litchi chinensis* Sonn.) cv. Rose Scented

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ABSTRACT: In response to the escalating global demand for chemical-free, premium-quality fresh fruits with enhanced nutritional value, researchers and industry stakeholders are facing mounting pressure to develop preservation techniques that extend shelf life and maintain the quality of fruits for longer periods because litchi fruits have a very short shelf life 2 to 4 days at room temperature. To address this critical need, the present study focused on the post-harvest preservation of litchi cv. Rose Scented fruit through the innovative application of gamma radiation and edible coatings treatments. Through comprehensive assessments of various quality parameters, it was found that the application of 1.0 kGy gamma irradiation treatment at a storage temperature of 2 °C proved remarkably effective in preserving the fruit's overall acceptability, decay resistance, total sugar content, while 1.0 kGy gamma irradiation combined with 10 % *Aloe vera* gel maintained maximum ascorbic acid levels for an impressive duration of up to 20 days.

Keywords: Gamma radiation, *Litchi chinensis* Sonn, edible coatings, organoleptic, post-harvest, quality.

INTRODUCTION

Litchi (*Litchi chinensis* Sonn.) is the most important member of the Sapindaceae (soapberry) family and the most famous fruit fit for human consumption. It is regarded as the queen of fruits because of its alluring deep pink/red hues, mouthwatering candy, and juicy arils. Due to its high season demand and export potential, litchi is now India's crucial commercial fruit crop. Over the past three decades, litchi production and growing space have increased significantly in India (Sahni *et al*., 2020). Litchi fruit has a limited shelf life when left at room temperature without any treatments (2–4 days). During peak season, too many fruits are available in the local markets, leading to significant amounts of fruit waste and significant postharvest losses (Jiang and Jiang 2005). Fruits and vegetables have been heavily treated with irradiation to extend shelf life and maintain quality standards while being stored (Sousa-Gallagher *et al*., 2016). Although irradiation technology is not widely used in northeast India. In general, the implementation of composite edible coating and gamma radiation, which will demonstrate an environmentally friendly solution to this problem, can solve the issue of short shelf life and degradation of the nutritional value of fruits, the potential for radioactivity in food processing and preservation is growing food industry (Lima *et al*., 2018). Edible coatings are a thin layer of edible material applied to the product's surface in place of a natural protective waxy layer like chitosan and *Aloe vera* gel (Ahmed *et al*., 2009). Chitosan is a modified natural carbohydrate polymer derived from chitin, which can be found in a variety of natural sources, including crustaceans, fungi, insects, and some algae (Shiekh *et al*., 2013). Chitosan coatings could increase the amount of time that fruits can be kept fresh because they minimize physiological weight loss, spoilage, and ripening processes. As a result, the use of chitosan in the food industry to preserve fresh fruits during refrigeration appears to be very promising (Bola *et al*., 2017). *Aloe vera* commonly referred to as a "medicinal plant", is known for its wide range of therapeutic properties. It is mentioned throughout recorded history and has been given a high ranking as an all-purpose herbal plant (Eshun and He, 2005).

MATERIAL 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). The research centre 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 10% *Aloe vera* gel coatings were applied to the radioactive samples as per treatment combinations. All 10 treatments (T_1- control), three treatments of gamma irradiation (T_2- 0.8 kGy, T_3- 1.0 kGy and T_4- 1.2 kGy) and 6 treatments with combination chitosan and *Aloe* *vera* gel (T_5-0.8 kGy + 1.0% chitosan, T_6-1.0 kGy + 1.0% chitosan, T_7- 1.2 kGy + 1.0% chitosan, T_8- 0.8 kGy + 10 % *Aloe vera* gel, T_9- 1.0 kGy + 10% *Aloe vera* gel and T_{10}- 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.** *Aloe vera* gel is extracted from the leaves using the filtration method. The leaves are chosen, washed with tap water, and then rinsed with distilled water to ensure uniform maturity, size, colour, and freshness. *Aloe vera* leaves in a blender, the colourless hydro parenchyma that represented the separated gel matrix was ground. Filtration was used to remove fibres from the resulting mixture, yielding 100% pure *Aloe vera* gel. The prepared *Aloe gel* was pasteurized for 45 minutes at 70°C (Maughan, 1984). The prepared gel extract is kept chilled for storage. Fresh fruits have been dunked in this gel to coat them (Marpudi *et al*., 2011).

Chitosan coating preparation. The coating solution was made by dissolving 10g of chitosan powder in 900 ml of distilled water, 50 mL of glacial acetic acid was added to dissolve the chitosan to prepare 1 L of 1.0 % chitosan solution, and pH was adjusted to 5.0 with 0.1M NaOH and the solution was made up to 1L (Jiang and Li., 2001).

Physicochemical parameters. Decay percentage: The percentage of spoilage was calculated based on the number of spoiled fruits (unfit for human consumption) seen at each 4 days intervals, and the spoiled fruits were then discarded.

Ascorbic acid (mg/100g): The ascorbic acid content of litchi fruits was determined by using 2, 6-dichlorophenol-indophenol visual titration method described by Ranganna (2001).

Ascorbic acid content was expressed as mg/100 g of pulp.

$$\text{Ascorbic acid (mg/100g)} = \frac{\text{Titre value} \times \text{dye factor} \times \text{volume made up} \times 100}{\text{Weight or volume of sample taken} \times \text{volume of aliquot taken}}$$

Total sugar: The Lane and Eynon method estimated the total sugar of litchi fruits. In this method, inverted sugar reduces the copper in Fehling's solution to red insoluble cuprous oxide. The sugar content was estimated by determining the volume of the unknown sugar solution required to completely reduce a measured volume of Fehling's solution (Jayaraman and Jayaraman 1981).

Organoleptic evaluation: Litchi samples were chosen at random for sensory evaluation solely based on their outward acceptability. Fungus and rotten-filled samples were discarded. A panel of ten horticulturists, and food technologists, evaluated the taste of litchi. Overall acceptability was evaluated as a quality attribute. The scoring was done using a (1-9) point hedonic scale, with 1-2 being very poor, 2-4 being poor, 4-6 being fair, 6-8 being good, and 8-9 being very good (Ranganna, 2001).

RESULT AND DISCUSSION

Decay percentage. The results shown in (Table 1) clearly show that each treatment significantly impacted the percentage of decay and increased with the lengthening of the storage period under all the treatments except for the control (4.12%), there was no evidence of decay in any of the treatments on the 4th day of storage, on 12 days of the storage period almost half of the fruit (43.06%) were decayed in untreated control fruits and almost decayed on 16th days of storage, whereas it was lowest (11.81%) in (1.0 kGy) on 20 days of storage period which was followed by(1.0 kGy + 10% *Aloe vera* gel) i.e., 15.97%. These treatments performed better in reducing the decay of litchi fruits as compared to other treatments. An integrated approach with chitosan may not be giving good results because the thickness of the coating affects the quality of the fruit, as the thicker coating can block the amount of oxygen and water vapour so as able to reach the fruit. The development of post-harvest decay in fruits is often associated with pathogen penetration. In the case of litchi fruits, the pericarp has been reported to develop microcracks after harvest and during storage (Underhill and Simons 1993).

Table 1. Decay percentage in gamma-irradiated and edible coating of litchi cv. Rose Scented.

	0 days	4 days	8 days	12 days	16 days	20 days
T1- Control	0.00^{a*}	4.12^{a}	25.69^{a}	43.06^{a}	81.94^{a}	94.45^{a}
T2- 0.8 kGy	0.00^{a}	0.00^{a}	1.39^{b}	4.17^{cd}	11.81^{bc}	23.61^{cde}
T3- 1.0 kGy	0.00^{a}	0.00^{a}	0.00^{b}	1.39^{cd}	6.94^{c}	11.81^{g}
T4- 1.2 kGy	0.00^{a}	0.00^{a}	2.08^{b}	3.47^{cd}	11.81^{bc}	26.39^{bcd}
T5- 0.8 kGy + 1.0% chitosan	0.00^{a}	0.00^{a}	1.39^{b}	5.56^{bcd}	11.11^{bc}	29.16^{b}
T6- 1.0 kGy + 1.0% chitosan	0.00^{a}	0.00^{a}	0.69^{b}	6.25^{bc}	13.89^{b}	28.47^{b}
T7- 1.2 kGy + 1.0% chitosan	0.00^{a}	0.00^{a}	1.39^{b}	9.03^{b}	15.97^{b}	27.08^{bc}
T8- 0.8 kGy + 10 % *Aloe vera* gel	0.00^{a}	0.00^{a}	2.08^{b}	3.47^{cd}	11.11^{bc}	20.14^{ef}
T9- 1.0 kGy + 10% *Aloe vera* gel	0.00^{a}	0.00^{a}	0.00^{b}	0.69^{d}	6.94^{c}	15.97^{fg}
T10-1.2 kGy + 10% *Aloe vera* gel	0.00^{a}	0.00^{a}	0.69^{b}	2.78^{cd}	13.19^{b}	22.22^{de}

*Same letter in a column showing no significant difference between the treatments

In the present study, gamma irradiation and *Aloe vera* treatments performed well than other treatments in controlling the expression of protein genes related to pathogenesis, which play a signalling role in creating resistance to pathogen attacks (Raskin, 1992). Silva *et al.* (2008); Hussain *et al*. (2008) also reported irradiation was effective in preventing decay and maintaining the quality of fruits during storage.

Ascorbic acid. The ascorbic acid concentration of all control and treated litchi fruits decreased over the course of the current investigation period. Ascorbic acid activity decreased more quickly in the control litchi fruits. According to the results of the current study (Table 2), the ascorbic acid content slightly decreased after 4 days of the storage period in all the treated and untreated fruit while after 12 days of storage treated fruit slightly manage the ascorbic acid level except untreated fruit. The treatment (1.0 kGy + 10% *Aloe vera* gel) was very effective at preserving the ascorbic acid (27.38mg/100gm) which was followed by 0.8 kGy and 1.2 kGy + 10% *Aloe vera* gel i.e., 22.00 mg/100g and 22.00 mg/100g respectively, during its 20 days of storage. The ascorbic acid level was reduced to very low in control untreated fruits on the 20th day (10.10 mg/100g). Our results are in line with those reported by Pandey *et al.* (2013); Hazare *et al*. (2010) who observed considerably lower Vitamin C values in irradiated samples on the thirteenth day of storage at 4°C. Conversely, the study conducted by Sau *et al*. (2018) suggests that gamma radiation treatment can effectively maintain ascorbic acid content in guava fruits during storage under ambient temperatures.

Total sugar. The current study's findings showed (Table 3) that during the 20 days of storage at 2 °C, (1.0 kGy) was very effective in preserving the total sugar of litchi fruit (17.18%), which is followed by (1.0 kGy + 10% *Aloe vera* gel) i.e., 16.53%. Fruit without treatments (12.15%) had the lowest total sugar levels after 20 days of storage. Total sugar level increased in untreated control fruits during 1st 8 days of storage and then decreased during further storage. From the result, we concluded that irradiated and integrated irradiated had a significant impact on total sugar to maintain their viability for a long time. These significant increases could be the result of the litchi fruit being mature when the study started and the metabolic process slowing down significantly during maturity. Some of the irradiated litchi samples had higher total and reducing sugar levels, which may have been caused by the breakdown of starch and other carbohydrates into simple sugars. As a result of the breakdown of starch and other carbohydrates into simpler sugars, Lee *et al*. (2009) discovered that irradiated litchi samples had higher levels of total and reducing sugar. According to Campestre *et al*. (2002), the trend of rising total sugar content during the storage period is caused by polysaccharides being hydrolyzed into soluble sugars. Qamar *et al*. (2018) observed favourable outcomes with the implementation of *Aloe vera* gel coating, as it effectively retained the sugar content of the fruits.

Table 2: Ascorbic acid (mg/100g) in gamma-irradiated and edible coatings of litchi cv. Rose Scented.

	0 days	4 days	8 days	12 days	16 days	20 days
T1- Control	46.75^{a*}	31.38^{d}	25.64^{d}	18.17^{d}	13.68^{d}	10.10^{d}
T2- 0.8 kGy	46.75^{a}	38.79^{b}	33.92^{b}	26.58^{bc}	23.92^{b}	22.00^{b}
T3- 1.0 kGy	46.75^{a}	36.95^{bc}	31.17^{bc}	26.42^{bc}	23.50^{b}	19.00^{bc}
T4- 1.2 kGy	46.75^{a}	37.87^{bc}	32.10^{bc}	24.77^{bc}	20.08^{c}	20.00^{b}
T5- 0.8 kGy + 1.0% chitosan	46.75^{a}	38.78^{b}	32.08^{bc}	27.67^{b}	22.50^{bc}	16.00^{c}
T6- 1.0 kGy + 1.0% chitosan	46.75^{a}	35.12^{c}	30.64^{bc}	25.67^{bc}	21.67^{bc}	18.00^{bc}
T7- 1.2 kGy + 1.0% chitosan	46.75^{a}	35.12^{c}	30.25^{c}	26.58^{bc}	21.21^{bc}	16.50^{c}
T8- 0.8 kGy + 10 % *Aloe vera* gel	46.75^{a}	36.95^{bc}	31.17^{bc}	26.42^{bc}	23.50^{b}	19.00^{bc}
T9- 1.0 kGy + 10% *Aloe vera* gel	46.75^{a}	42.45^{a}	37.58^{a}	31.17^{a}	29.19^{a}	27.38^{a}
T10-1.2 kGy + 10% *Aloe vera* gel	46.75^{a}	37.12^{bc}	32.10^{bc}	23.58^{c}	23.83^{b}	22.00^{b}

*same letter in a column showing no significant difference between the treatments

Table 3: Total sugar (%) in gamma-irradiated and edible coating of litchi cv. Rose Scented.

	0 days	4 days	8 days	12 days	16 days	20 days
T1- Control	10.02^{a}	11.52^{a}	13.02^{a}	11.91^{d}	12.30^{e}	12.15^{f}
T2- 0.8 kGy	10.02^{a}	10.62^{bc}	11.93^{b}	12.69^{bc}	11.30^{e}	11.15^{f}
T3- 1.0 kGy	10.02^{a}	10.41^{c}	11.45^{b}	13.30^{a}	15.32^{a}	17.18^{a}
T4- 1.2 kGy	10.02^{a}	10.90^{bc}	11.82^{b}	12.74^{bc}	13.96^{cd}	15.17^{de}
T5- 0.8 kGy + 1.0% chitosan	10.02^{a}	10.82^{bc}	11.84^{b}	12.63^{bc}	13.86^{d}	15.60^{cd}
T6- 1.0 kGy + 1.0% chitosan	10.02^{a}	11.02^{b}	11.76^{b}	12.26^{cd}	13.57^{d}	15.21^{cde}
T7- 1.2 kGy + 1.0% chitosan	10.02^{a}	10.72^{bc}	11.92^{b}	12.43^{cd}	13.72^{d}	14.89^{e}
T8- 0.8 kGy + 10 % *Aloe vera* gel	10.02^{a}	10.78^{bc}	11.77^{b}	12.62^{bc}	13.62^{d}	15.21^{cde}
T9- 1.0 kGy + 10% *Aloe vera* gel	10.02^{a}	10.54^{bc}	11.75^{b}	13.18^{ab}	14.77^{b}	16.53^{b}
T10-1.2 kGy + 10% *Aloe vera* gel	10.02^{a}	10.57^{bc}	11.93^{b}	12.10^{ab}	14.46^{bc}	15.75^{c}

*Same letter in a column showing no significant difference between the treatments

Overall acceptability. The current study's findings showed that fruits left untreated for 8 days were no longer fit for human consumption due to their unpleasant texture while in the case of treated fruit even after 12 days of storage fruit is in good condition to consume. Fruit exposed to 1.0 kGy (4.83) alone in maintaining the fruit's overall acceptability for 20 days which was statistically *at par* with 1.0 kGy + 10% *Aloe vera* gel, i.e., 4.67, respectively. All the treated fruit comes under the range of fair (4-6) except control. The fruits without treatment had acceptability levels only until 8 days of storage (4.33). According to Pandey *et al*. (2013), non-irradiation fruits were graded on the 24th day between 0-4.1 (extremely bad) while irradiated samples were graded between 5.92 and 7.72. (Fair-good). Similarly, results were found by Hazare *et al*. (2010) where irradiated litchi cv. 'China' received sensory scores in the range of 4.5 to 5.5 (good to very good) on day 28. Eshghi *et al*. (2021) investigated the efficacy of a chitosan-based formula with or without gum treatment in preventing sensory quality loss in coated grapes. Shahbaz *et al.* (2016) found that irradiation positively impacted the sensory profile of the fruit.

Table 4: Overall acceptability in gamma-irradiated and edible coating of litchi cv. Rose Scented.

	0 days	4 days	8 days	12 days	16 days	20 days
T1- Control	9.00[a*]	6.50[c]	4.33[c]	1.67[c]	1.00[d]	1.00[c]
T2- 0.8 kGy	9.00[a]	7.67[ab]	6.67[b]	5.33[b]	4.83[abc]	3.83[b]
T3- 1.0 kGy	9.00[a]	8.33[a]	7.83[a]	6.33[a]	5.50[a]	4.83[a]
T4- 1.2 kGy	9.00[a]	8.17[ab]	7.00[b]	5.50[b]	4.67[bc]	3.33[b]
T5- 0.8 kGy + 1.0% chitosan	9.00[a]	7.67[ab]	6.83[b]	5.33[b]	4.67[bc]	3.50[b]
T6- 1.0 kGy + 1.0% chitosan	9.00[a]	7.50[b]	6.50[b]	5.33[b]	4.67[bc]	3.67[b]
T7- 1.2 kGy + 1.0% chitosan	9.00[a]	7.67[ab]	6.50[b]	5.33[b]	4.50[c]	3.67[b]
T8- 0.8 kGy + 10 % *Aloe vera* gel	9.00[a]	7.67[ab]	6.67[b]	5.50[b]	4.83[abc]	3.67[b]
T9- 1.0 kGy + 10% *Aloe vera* gel	9.00[a]	8.00[ab]	7.67[a]	6.17[a]	5.33[ab]	4.67[a]
T10-1.2 kGy + 10% *Aloe vera* gel	9.00[a]	7.83[ab]	7.00[b]	5.50[b]	4.83[abc]	3.67[b]

*same letter in a column showing no significant difference between the treatments

CONCLUSIONS

From the aforementioned experiments, it can be inferred that an integrated approach using gamma irradiation (1.0 kGy) combination with 10% Aloe vera gel proved to be beneficial in marinating the nutritional quality of litchi, especially vitamin C. Both radiation 1.0 kGy and *Aloe vera* gel were found significantly superior to other treatments in maintaining storage quality and external shelf life to 20 at 2°C. These findings underscore the potential of gamma irradiation as a valuable tool in preserving the quality and extending the shelf life of litchi fruits, presenting promising implications for the fruit industry and offering consumers access to fresh and nutritious produce for an extended period.

Conflict of Interest. None.

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