International Research Journal of Natural and Applied Sciences
ISSN: (2349-4077)
Impact Factor- 5.46, Volume 4, Issue 10, October 2017
Website- www.aarf.asia, **Email** : editor@aarf.asia , editoraarf@gmail.com

INVESTIGATION OF PHYSIO-CHEMICAL QUALITY OF KIWIFRUIT IRRADIATED BY GAMMA RADIATION

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ABSTRACT

Food irradiation is one of the processing technologies that can be used to increase the microbiological safety and shelf-life of a wide range of foods. In the present study, kiwi fruit was exposed to gamma radiation of doses 1-3kGy. Irradiated kiwifruits appeared softer compared to non-irradiated kiwifruits. The color and organic acid content of kiwifruits were minimally affected by the irradiation. Irradiation of kiwifruit up to 3 kGy had negative effects on vitamin C content and antioxidant activity, but it contributed to improving sensory quality.

Keywords: Ionizing Gamma Radiation, organic acid, ascorbic acid, overall acceptability, decay percentage

INTRODUCTION

Recently kiwifruit has gained much importance due to its rich nutritional values. Its high level of vitamin C content and strong antioxidant capacity has made it a popular choice in human diet which led to its great potential for industrial exploration [Cassano et al., 2006, Cano Pilar, 1991]. But due to high moisture content and the presence of macronutrients like sugar has made, this fruit easily vulnerable to spoilage while the fruit is still in orchards, during harvesting, transport, processing, therefore limiting its shelf-life and marketability

[Rodrigueza et al.,2006]. Postharvet rotting of the fruit due to many fungal pathogens has become a potentially serious problem in storage of the fruit leading to huge market loss [Hawthorne et al.,1982, Lee et al., 2001]. Thus, the aim of the fruit production is to minimize the risk of spoilage or any kind of contamination and thus increase its shelf-life without affecting its nutritional value much.

The basic purpose of irradiating fresh fruits is delaying the process of ripening and decaying resulting in significant increase in shelf -life of the fruit after post harvest. This has been recognized as a new technology for the elimination of pathogenic micro-organisms from fresh fruits and vegetables [Morehouse, 2002]. Thus, food irradiation has always remained a subject of intense research for many years. In 1986, the Food and Drug Administration (FDA) approved the use of radiation treatment of up to 1kGy on fruits and vegetables. Since about 1990, the amount of commercially irradiated food products available worldwide has increased. Irradiation can be an effective way in reducing various food borne diseases by effective killing, sterilizing or preventing further development of a wide variety of insect pests of quarantine importance on perishable fruits and vegetables. The application of gamma rays to improve fruit storability has been studied from the standpoint of controlling certain physiological disorders as well as reducing spoilage caused by fungal pathogens. In general, the process of irradiation with acceptable dose can cause little chemical changes in foods, whereas the food nutritional quality is not much affected than when it is treated with other conventional methods of preservation (Villavicencio et al.,1998; Wiendl 1997).

The kiwi fruit, rich mainly in vitamin C and fibres, calcium, iron and phosphorous, turns out to be an excellent nutritional option. It contains an enzyme called actinine which helps in softening of meat while cooking. This enzyme also prevents the coagulation of gelatin in dairy products [Carvalho,2000]. Pectin found in kiwi fruit helps in lowering blood cholesterol level. Other bioactive compounds found in kiwifruit are phenolic flavanoids, amino acids such as arginine and glutamate and chlorophyll. All these compounds present in kiwi fruit provide a potential anticancer and anti-inflammatory quality thereby increasing immunity in the body.

The literature survey indicates that there hardly seems any information available till date regarding the radiation processing of kiwifruit of Uttarakhand origin. Therefore, present study was conducted to investigate the effect of gamma radiation on storage quality, shelf life extension and facilitating the marketing of fresh kiwis from Uttrakhand to distant places other than local markets. In the present study, fruits have been exposed to radiation doses of 1-3 kGy and then, the irradiated samples were studied for color loss, hardness, organic acid content, ascorbic acid content, overall acceptability and percentage decay under both the storage conditions.This study investigates the suitable irradiation dose of gamma radiation for the decontamination and physiochemical quality of kiwifruit.

MATERIALS AND METHODS

Mature but unripe kiwifruits were collected from different orchards of Uttarakhand region. The fruits were packed in polythene film at 0^oC and kept at room temperature for 1 day before irradiation. The packed samples (5 per pack) were irradiated in a cobalt-60 irradiator at BARC, New Delhi with 0, 1, 2, 3kGy absorbed doses. The samples were turned 360^o continuously during the irradiation process to achieve uniform target doses and the non-irradiated control was placed outside the irradiation chamber to have the same environmental temperature effect with the irradiating samples.

After gamma irradiation, kiwifruits were stored and ripened at room temperature (20 ± 2^oC), refrigerated condition and post refrigerated condition for 3 weeks. There were 100 kiwifruits for each treatment. Twenty five fruits were used in replication . Fifteen fruits were used in each replication for color, hardness and sensory evaluation. And others were used in the rest of the analysis. All samples were evaluated at 0(irradiation day), 1, 2 and 3 weeks after irradiation.

Fruit Analysis

The interior of the fruits color expressed as Hunter *L**, *a** and *b** values using Hunter colorimeter. The color of kiwifruit slices were measured as middle portion (between the core and the peel). A standard white tile was used for calibration prior to color measurements and a black tile was used for reflectance calibration. The values of *L** (lightness), *a** (redness to greenness) and *b** (yellowness to blueness) were recorded for each sample. Eight replications were made for each treatment (irradiated and non-irradiated)

The hardness of kiwifruits was measured using a texture analyzer with a maximum cell load of 5kg. Each fruit was peeled, cut into 1 cm pieces and placed on a stationary steel plate. Optimized test conditions were as follows: probe, P/5(5mm diameter); penetrate the cut surface in two opposite locations in mesocarp tissue to a depth of 7mm. Twelve measurements were performed for each treatment (irradiated and non-irradiated) upto 3 weeks. All tests were conducted at room temperature.

Organic acid content was determined by titrating 1 gm of freeze-dried kiwifruit with 0.1 N alkali (NaOH) (AOAC, 1980). One gram of freeze-dried kiwifruit was diluted to 100 ml with distilled water and approximately 1.2 μL of phenolphthalein was added with 10 ml of diluted sample. The sample was stirred and titration was made 0.1 N NaOH until a pink color persisted for 30 sec. Results were expressed in terms of dominant acid as citric acid.

Ascorbic acid contents (vitamin C) were measured by titrimetric methods (Jun et al 2005). The method for ascorbic acid utilizes 2,6-dicholorophenol indophenols dye. This method determines ascorbic acid (a reduced form) in the kiwifruit and not dehydroascorbic acid which is in oxidized form. The reduction of 2,6-dicholorophenol indophenols by ascorbic acid in the titrimetic method is specific for ascorbic acid. Because over 88% of the total ascorbic acid in kiwi fruit is in reduced form, this method is used (Agar et al 1999). Sample (5gm) was mixed with 100 mL of a mixture of metaphosphoric acid and acetic acids (30 gm of metaphosphoric acid and 80 mL of acetic acid were massed up to 1L of distilled water). Sample –acid mixture (10 mL) was titrated with indophenols (50 mg of sodium carbonate and 50 mg of indephenol were massed up to 200 mL distilled water).

The combined effect of irradiation dose and storage time on the sensory quality of the kiwifruits was evaluated by 5 panelists. The kiwifruit were cut into 1cm thick disks for presentation. The samples were placed on top of white paper plates identified by 3 digits and randomly placed in trays. Each panelist was presented with 4 samples (3 irradiated plus 1 control) at every week. They were rated on a five-point scale for color, flavor, overall taste, texture and overall acceptability; a score of 5 represented "most like" and a score of 1 represented "most disliked" for color, flavor, overall taste and overall acceptability; 1 (soft) to 5 (firm) for texture. Scores from 2.5 to 5 were considered acceptable.

Percentage decay was calculated by visual observation of each sample as described by Zheng et al (2007). A fruit with visible brown spot and softened area was regarded as decayed and results were expressed as percentage of decayed fruits.

Decay percentage = n/N *100

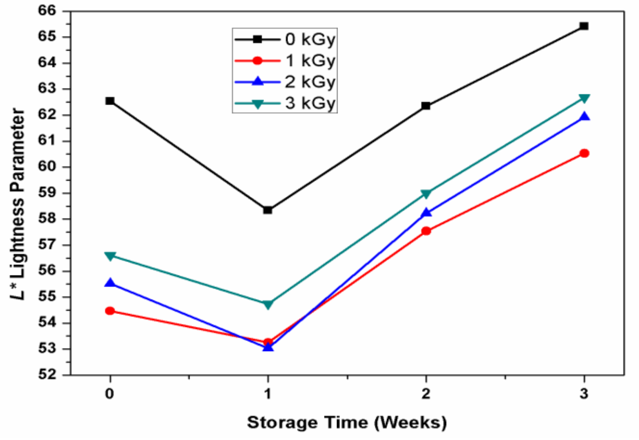
Where N= total number of fruits

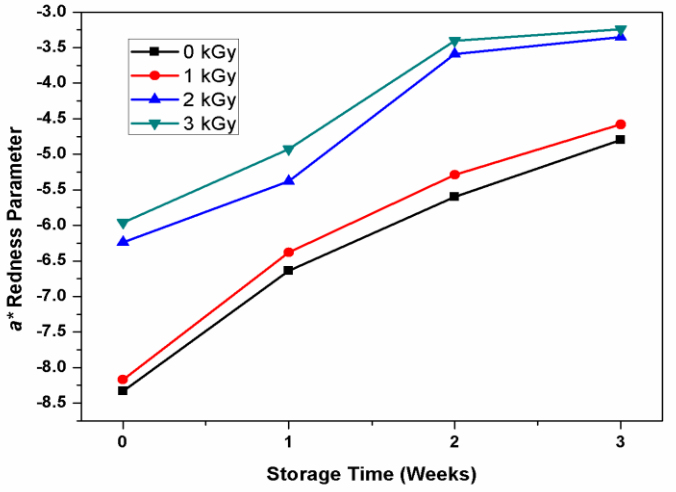
n=number of decayed fruits

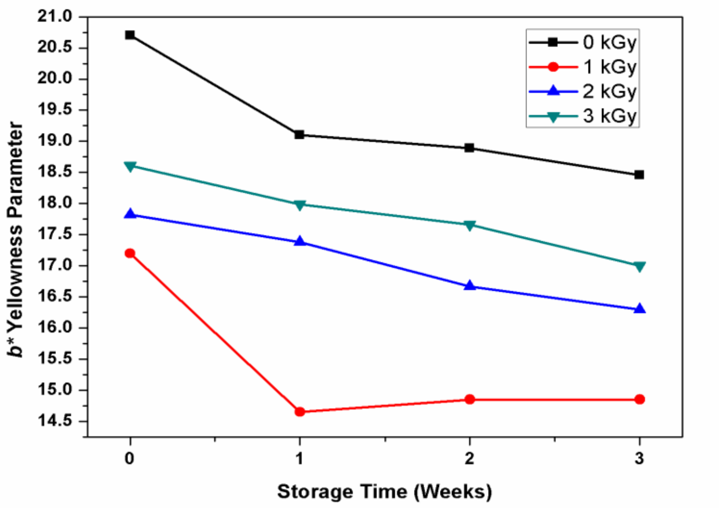
RESULTS AND DISCUSSIONS

Color

Irradiated fruits had lower *L** values than non-irradiated during early storage period. But a radiation dose of 3 kGy fruits had higher *L** values than 1 and 2 kGy irradiated fruits. Throughout storage, control fruits decreased *L** values at week 1 and increased at week 2. Irradiated fruits showed no consistent changes in *L** values. Control and1 kGy irradiated fruits had lower *a** values than 2 and 3 kGy irradiated fruits. Throughout storage, *a** values increased in all samples. Irradiated fruits had lower *b** values than control at zero time and *b** values for all samples decreased with longer storage periods. In conclusion, irradiation decreased *L* and b** values and increased *a** values during the storage period and these results are in agreement with the results from sensory studies

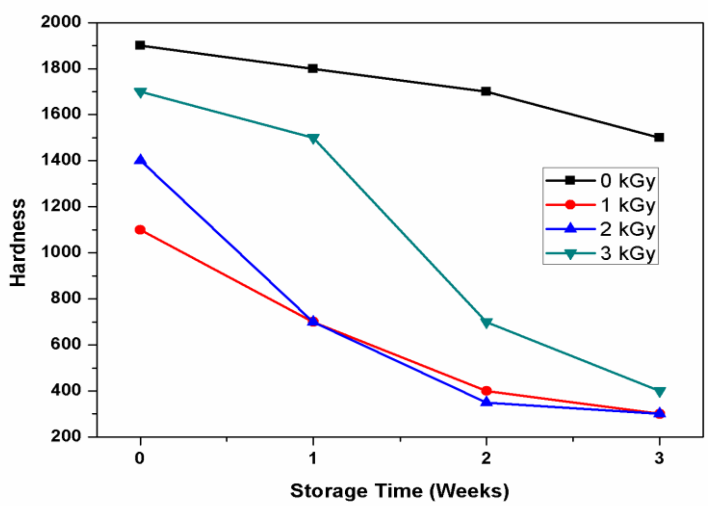






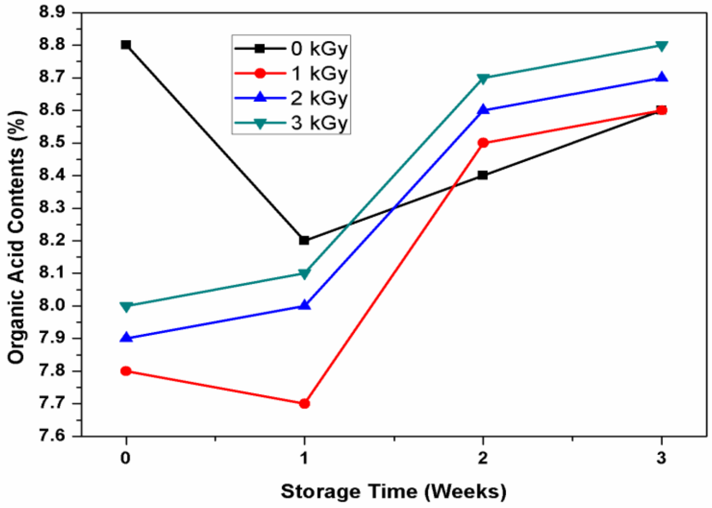
Texture

Changes in the texture of kiwifruits are an important index for determining the degree of ripening. Irradiation treatment caused significant decrease in hardness values of kiwifruits either at zero time or during storage time. This decline in hardness was reduced with the increment of the irradiation dose. Throughout storage, rate of softening of irradiated fruits was great on week 1 and 2 but that of the control fruits was great on week 3. Radiation-induced texture change has been associated with changes in pectin substances. There was an interaction between irradiation dose and storage time for hardness. Exposure to gamma irradiation from 1 up to 3 kGy induced a significant ($p<0.05$) softening of the kiwifruits throughout the entire storage periods.



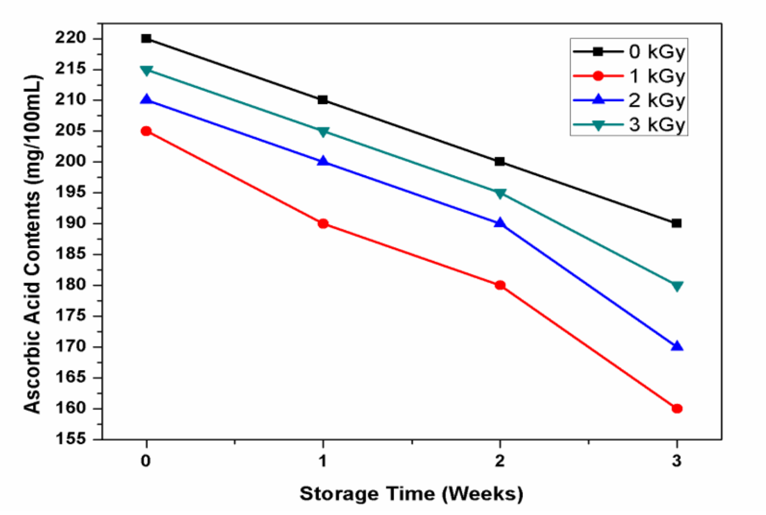
Organic Acid

In control fruits, there was no significant change in acidity content with extension of storage. Slight variations was observed among the different samples during storage. Irradiated fruits showed lower organic acid content than control at week 0 and showed an increasing trend during storage period. At the harvest , kiwifruit contain 40-50% as citrate, 40-50% as quinate and 10% as malate. Irradiation decreases the pH value significantly which increases some other organic acids such as citric, quinic and succinic acids. Irradiation seems to accelerate the loss of malic acid during storage, which could be due to increased respiration and other metabolic acid.



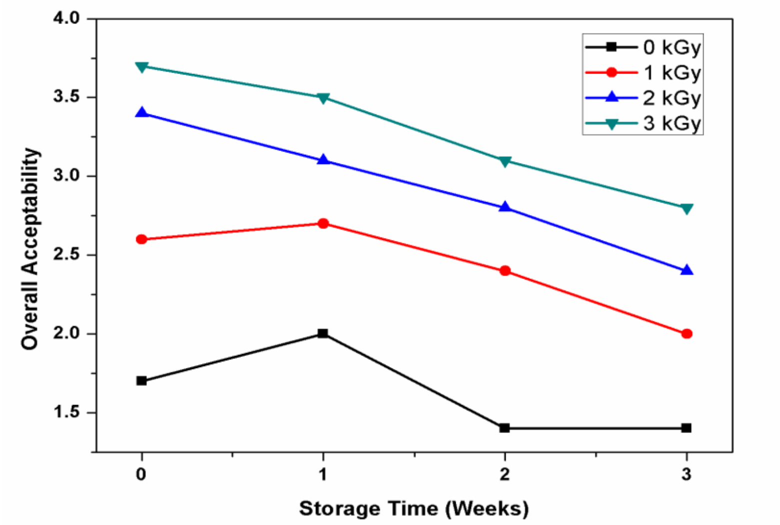
Ascorbic Acid Content

Kiwifruits are known to be rich in vitamin C and various other antioxidant components. Ascorbic acid is the most sensitive water-soluble vitamin to irradiation and is highly sensitive to various modes of degradation. The ascorbic acid content of kiwifruits irradiated at the 1 and 2 kGy dose and control had no significant variation, but samples irradiated with the 3 kGy dose had a significant reduction in contrast to all other treatments. The ascorbic acid content of kiwifruits decreased at irradiation dosesof 3 kGy. During the entire storage period, irradiated fruits had lower ascorbic acid content than the control. At the end of the storage period, all samples showed a high content of ascorbic acid.



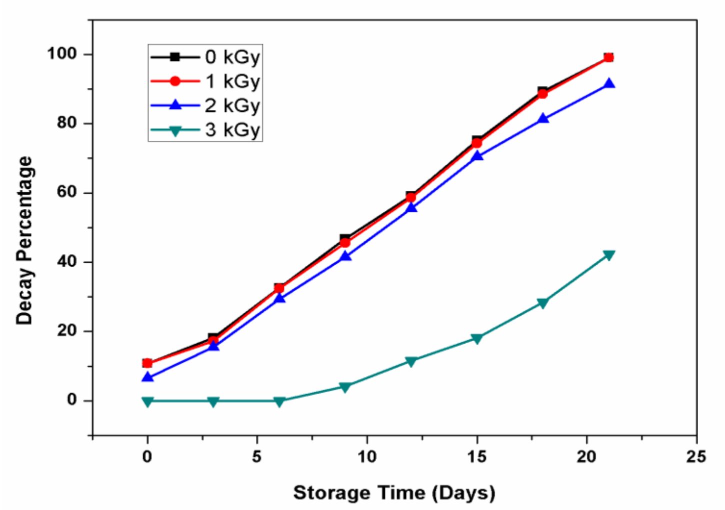
Overall Acceptability

Irradiation of kiwifruits upto 3 kGy had stronger preference for the control (non-irradiated) in the sensory quality of the fruits. Irradiation at high dose (3kGy) did not cause a detrimental change on the sensory quality of kiwifruits. The panelists had strong preference for irradiated kiwifruit in sweetness, overall taste and overall acceptability. In textural quality, irradiation showed a significant ($p<0.05$) decrease in hardness throughout the entire storage time. Whereas, the controlled samples were within the acceptability limit (2.5) but the textural quality (hardness) of the control samples hardly decreased throughout the entire storage time. These results indicated that non-irradiated kiwifruit did not reach the ripe stage by the end of storage and irradiation will accelerate the ripening process of kiwifruit.

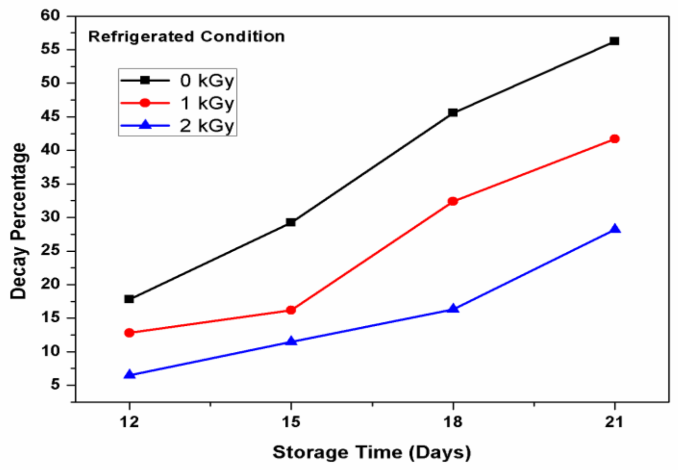


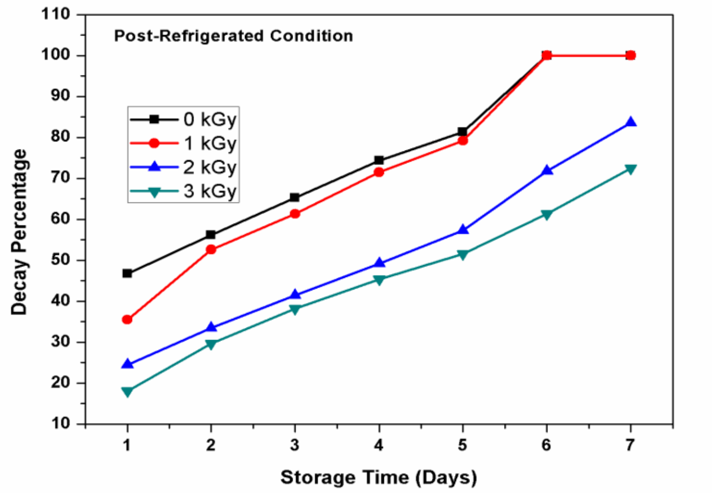
Decay Percentage

Effect of gamma irradiation treatments on decay percentage of kiwifruits with control and irradiated under ambient, refrigerated and post-refrigerated storage conditions is shown in Fig.3.4-3.5. From Fig. 3.4, it is seen that under ambient conditions, control and irradiated with 1- 2 kGy samples started decaying after 3 days and were almost fully decayed after 21 days(i.e 3 weeks) of storage. Samples irradiated with 3 kGy started decaying after 7days and were decayed to the extent of 42% approx. up to 3 weeks.



Under refrigerated conditions, control and 1- 2kGy irradiated samples started decaying after 12days of storage. Control samples decayed up to an extent of 17 +- 2 % while the decay percentage of irradiated samples is significantly low. For samples irradiated at 3 kGy no decay was recorded up to 21 days of storage after that sample starts decaying. The samples were then taken out from the cold storage and kept under ambient conditions to monitor the further decay. Control and 1 kGy irradiated samples were fully decayed after 6 days of post refrigerated storage at 25 + - 2 ^{o}C. For samples treated with 2- 3 kGy decay percentage is low as compared to control and 1 kGy treated samples.





CONCLUSSIONS

The present study showed that gamma irradiation treatment of kiwifruits at doses 1 kGy was not found effective with respect to delaying the plant fungal pathogen growth and shelf life extension. Radiation treatment of kiwifruits at 2 and 3 kGy proved to be quite effective in maintaining the storage quality and significantly delaying the fungal decay of the kiwifruits under both the storage conditions. However, dose of 3kGy was found to be better compared to 2kGy, as no decay was recorded up to 21 days of refrigerated storage after that sample starts decaying. Thus it was concluded that gamma irradiation was able to inactive the pathogens which inhibited the post-harvest rotting of the fruit. Irradiation decreased *L** and *b** values and increased *a** values during the storage period. Irradiated kiwifruits were softer than untreated kiwifruits. Irradiated kiwifruits showed little effects on the organic contents. Kiwifruits exposed to gamma irradiation had negative effect on vitamin C content and textural property but had beneficial effect on sensory quality and hygienic quality by controlling the indigenous microbial population. Thus, it was established that irradiating kiwifruit with dose of 3 kGy can prove beneficial in facilitating the marketing of the fruit to distant places other than the local markets, thereby benefiting the growers.

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