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IMPACT OF LOW DOSES OF GAMMA IRRADIATION ON SHELF LIFE AND CHEMICAL QUALITY OF STRAWBERRY (*Fragariaxananassa*) CV. 'CORONA'

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ABSTRACT

Post-harvest quality losses of fruits and vegetables during storage are global horticultural problems. The use of synthetic chemicals and fumigation to minimize such losses and to extend shelf life of fresh produce are primarily effective strategies; however they are vigilantly accepted by consumers because of potential health risks and environmental problems they pose. The aim of this study was to evaluate gamma irradiation doses 0.5, 1.0 and 1.5 kGyfor their effect on shelf life and chemical attributes of Strawberry (*Fragariaxananassa*) cv. Corona stored for nine days at room temperature. Berries irradiated with 1.0 and 1.5 kGy showed significantly prolonged storage life (5.75 and 7.75, days respectively) when compared to non-irradiated control fruits (3.25 days). Non-radiated fruit samples showed maximum decay (94.5 %) and weight loss (58 %) at 9th day of storage; however, irradiation significantly reduced these two quality parameters especially at higher doses which corresponded to lower weight loss and fruit decay. Neither radiation treatment nor storage period had significant effect on total soluble solids, titratable acidity and pH of fruits. Results indicated that radiation doses 1.0 and 1.5 kGymight be used as consumers' acceptable doses for shelf life extension, minimum weight loss and decay, without affecting the chemical quality of strawberry.

Keywords: Ionizing radiation, microbial disinfection, titratable acidity, total soluble solids.

INTRODUCTION

Strawberry (*Fragariaxananassa)* in family Rosaceae is an important and widely consumed fruit in Pakistan and elsewhere. The fruit is highly perishable with a shelf life of 2-3 days at room temperature and is vulnerable to post-harvest decay due to its high respiration rate, environmental stresses and pathogenic attacks (Zhang *et al*., 2003). In fact, post-harvest decay of fruits and vegetables triggered by inappropriate storage conditions, pathogenic attacks, mechanical injuries and environmental stresses are serious problems causing substantial losses of fresh produce every year (Zhang *et al*., 2011). Losses are generally greater in the developing countries due to their lack of experience in handling such losses and the unavailability of post-harvest storage facilities as compared to the developed countries (Jeffries andJeger, 1990).

To reduce post-harvest losses and extend shelf life of fresh produce, different post-harvest management techniques such as low temperature storage (Wiley, 1994) control atmosphere packaging (Holcroft and Kader, 1999; Wszelaki and Mitcham, 2003) and surface treatment with synthetic chemicals (Geransayeh *et al*., 2012) have been widely practiced. Controlled atmosphere packaging and low temperature storage techniques are effective and popular strategies for shelf life extension of fresh commodities (Wiley, 1994); however, in many reports it has been documented that these methods may not be able to control certain pathogenic fungi and bacteria in the prevailing storage conditions (Berrang*et al*., 1989; Sumner and Peters, 1997). Previously it has been reported that CO_2 enriched environment with low level of O_2 in the controlled atmosphere packaging have drastic impact on ascorbic acid and anthocyanin contents of strawberry with deteriorated fruit color and quality (Holcroftand Kader, 1999). Furthermore, there is an increasing demand from consumers to use pesticides free alternative methods to control post-harvest decay of fruits and vegetables (Lichter *et al*., 2006).

Gamma irradiation has been successfully used as an alternative treatment formicrobial disinfection (Hallman, 2008) and longevity of shelf life of fresh produce (Parkash *et al*., 2000). Previously several studies have been conducted on the efficacy of low doses of gamma irradiation on post-harvest ripening (Couture *et al*., 1990), decay (Silva *et al*., 2009) and on flavonoids of strawberry (Breitfellner *et al*., 2002) with beneficial and effective results. Furthermore, international atomic energy association has recommended doses up to 3 kGy of gamma irradiation associated with low temperature storage (1-5°C) for extending shelf life and for delaying the growth of grey mould (*Botrytis cinerea*) and *Rhizopus* rot on strawberries and fresh produce (IAEA, 1994). The aim of this work was to evaluate low doses of gamma irradiation for their effects on shelf life, and some chemical attributes of strawberryunder local environmental conditions.

MATERIALS AND METHODS

Fruits of freshly harvested and mature strawberry (*Fragariaxananassa* cv. Corona) were collected from Agriculture Research Institute, Tarnab, Peshawar and samples were graded out. Twenty fruits (weighing approximately 500 g) of uniform size were placed in transparent perforated plastic boxes. Each box had a length 12 inches and width 6 inches. The fruit samples were subjected to gamma irradiation doses (0.5, 1.0 and 1.5kGy) from a Co^{60} gamma radiation unit at Nuclear Institute for Food and Agriculture (NIFA) in Peshawar. The irradiated samples along with control (non-radiated) were stored for nine days at room temperature (16-18ºC) during February, 2011 at Botany Department, University of Peshawar.

Weight loss was calculated by the following formula as described by Akhtar *et al*. (2010).

Weight loss (%) = $[(a-b)/a]$ x 100, where a and$b$ represent initial and final fruit weights, respectively.

Percent 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.

For determination of total soluble solids, titratable acidity and pH, 5 fruits were randomly taken from each treatment and blended in an electrical blender, then filtered through double layer of cheese cloth to obtain clear juice of homogenate. Total soluble solids (TSS) were determined by a digital refractometer and data were expressed as percent TSS. Titratable acidity was calculated by titrating 10 ml of clear juice of strawberry diluted in 100 ml of deionized water against 0.1 N NaOH solution at pH 8.1 (AOAC, 1995) and the results were expressed as percentage citric acid. pH of the samples was calculated by a digital pH meter. All evaluations were carried out four times during study i.e., at day 0, 3, 6 and 9 after storage at room temperature (16-18 ºC).

Statistical analysis: The experiment was conducted in a randomized complete block design (RCBD) manner. Each box containing twenty berries was considered asa single experimental unit which was further replicated four times. Data was statistically analyzed by analysis of variance (ANOVA) technique. Least Significant Difference (LSD) technique was used to test the significant effect of radiation doses on the studied parameters at $p \leq 0.05$.

RESULTS AND DISCUSSION

Shelf life: Significantly increased shelf life of 5.75 and 7.75 days were recorded in samples irradiated with 1.0 and 1.5 kGy respectively when compared to control and 0.5 kGy where storage life of test fruit was almost 3 days (Fig. 1). In control treatment, after third day of storage sensory attributes of berries gradually deteriorated making them unacceptable. Similar results were obtained for 0.5 kGy treated samples, though at this dose shelf life slightly but insignificantly increased. Results showed that radiation doses 1.0 and 1.5 kGy were effective in prolonging the storage life of test fruit while lower dose (0.5 kGy) had no significant effects on this parameter.

Weight loss: Effect of storage intervals and radiation doses (especially higher doses) had significant effects on weight loss of fruit. Weight loss at 3, 6 and 9^{th} day of storage varied considerably. Maximum weight loss occurred in control and 0.5 kGy at 9^{th} day of storage, which accounted for 58 and 57.5 % loss, respectively (Fig. 2). Conversely, radiation doses 1.0 and 1.5 kGy significantly reduced weight loss at different storage periods. Compared to control, weight loss in fruit samples treated with 1.0 and 1.5 kGy was 50.5 and 38. 25 % at the 9^{th} day of storage period.

Decay: Radiation treatment and storage period significantly altered percent decay of fruits. Decay was greater in control, virtually in every assessment of storage interval than radiation treatments (except 0.5 kGy). In control samples, 21.25, 72 and 94.5 % fruits rotted followed by 20.5, 70.25 and 93.75 % decayed fruits treated with 0.5 kGy at 3, 6 and 9^{th}day of storage, respectively. Increase in radiation dose to 1.0 and 1.5 kGy slowed down decay. At these two levels of doses, percentage of decayed fruits significantly reduced at different storage days. At9^{th} day of storage, 81 % fruits were recorded as decayed from samples treated with 1.0 kGy when compared to control (94.5 %). Radiation dose 1.5 kGy proved effective in controlling fruit decay where only 42.25 % fruits rotted (Fig. 3).

pH, TSS and TA:pH, total soluble solids (TSS) and titratable acidity (TA) of control and irradiated fruits did not change significantly during storage period. Control and irradiated fruit samples showed almost consistent values of pH, TSS and TA at different storage intervals (Table 1).In control samples at first day of storage (d_0), pH value of strawberries was calculated to be 3.40 followed by 3.40, 3.39 and 3.40 at 3^{rd}(d_3), 6^{th}(d_6) and 9^{th}day (d_9) of storage period respectively. Irradiated samples showed similar pH values (3.9) which did not differ significantly from control. Almost similar results were recorded for other treatment at different storage intervals. Results showed thatTSSandTA of control and irradiated berries remained unchanged at different storage periods. TSS and TA values of strawberry varied between 7.48-7.50 % and 0.67-0.68 % respectively at different treatments and storage intervals, which revealed no significant differences.

Shelf life extension of strawberry in present study at high doses (1.0 and 1.5 kGy) may be attributed to the growth inhibition of moulds, *Rhizopus* spp. and other spoilage fungi (IAEA, 1994). These results are in conformity with findings of Yu *et al*. (1995) who reported strawberry irradiated with 1 and 2 kGy of electron beam irradiation showed 2 and 4 days shelf life extension, respectively. In a similar study, Minea *et al*. (1996) achieved shelf life extension of strawberries, cherries, apricots and apples irradiated with 0.1-3 kGy of an electron accelerator, without affecting the sensory qualities and enzymatic activity of studied fruits.

During storage period of fresh produce, respiration rate and senescence process increases, which alter moisture contents of produce and may cause weight loss (Ayranci and Tunc, 2003). Studies show that respiration rate often decreases with irradiation doses, with greater reductions at higher dose level, arguably due to reduced metabolic activities of irradiated samples (Benoit *et al.*, 2000; Boynton *et al*., 2005). Reduction in weight loss at high radiation doses in this study may possibly be due to reduced respiration rate and metabolic activity of irradiated fruits. These results are compared to findings of Hussain *et al*. (2008). They reported that radiation doses 1.2-1.4 kGy maintained TSS, reduced weight loss and prolonged the decay of fruits of peach (*Prunuspersica* cv. Elberta) from 6 to 20 days at room temperature and refrigerator respectively.

Efficacy of gamma irradiation on minimizing decay of fruits and vegetables may be associated to its ability of penetration deep into tissues and destroying spoilage microorganism harbored in wounds or inside host tissues, thus preventing or minimizing the decay process by inhibiting the growth of these microbes (Barkai-Golan, 2001). Previously, significantly reduced rotting (decay) has been reported in strawberries treated with 2.0 and 2.5 kGy, stored for two weeks (Silva *et al*., 2009) and in peach (*Prunuspersica*) exposed to gamma irradiation doses ranging 1.0-2.0 kGy (Hussain *et al*., 2008).

It is widely accepted that physicochemical changes of fresh produce during storage are linearly correlated to nature of fruit, senescence, respiration rate and storage environment (Lee *et al*., 1995). In climacteric fruits, respiration rates are higher during storage period (Saltveit, 1997) resulting in increase in vital metabolic activities associated with release of carbon dioxide and ethylene which may trigger changes in pH, acidity and sugars of stored produce (Gorny *et al*., 2002). Conversely, non-climacteric fruits show slower respiration rate and hence lesser deterioration of food reserves occur during storage period (Watada and Qi, 1999; Gorny *et al*., 2002). In present work, no significant changes in pH, TSS, and TA were measured in strawberries treated with different doses of gamma irradiation as well as control samples stored for ninedays at room temperature. This may partly be due to the non-climacteric nature of strawberry and partly due to relatively lower temperature during storage period (experiment was conducted in February 2011 at room temperature i.e., at 16-18°C). Similarly, gamma irradiation has been reported in several studies to have beneficial effects on fruits, vegetables and other commodities contributing to lower respiration rate (Benkeblia *et al*., 2000), extending shelf life without any drastic effects on the chemical parameters of stored produce (Bolyston *et al*., 2002; Moy and Wong, 2002). These results are in agreement with findings of Couture *et al*. (1990) who reported no significant changes in TA and pH of strawberry subjected to gamma irradiation doses 0-4kGy and stored at 10°C. In a similar study, Bolyston*et al*. (2002) studied the effects of X-irradiation (0-0.75 kGy) on papaya (*Caricapapya*), rambutans (*Nepheliumlappaceum*) and ka'u gold oranges (*Citrus* sp.) with no significant effects on pH, TSS, TA, ascorbic acid contents and carotenoid contents of the studied fruits.

In summary, lower dose (0.5 kGy) did not cause any significant changes in shelf life, decay percent, weight loss or the studied chemical attributes. However, gamma irradiation doses 1.0 and 1.5 kGy effectively extended shelf life of strawberry, maintained its chemical attributes and retarded decay and weight loss to significant extent without causing any apparent damage to fruits. Thus, results of present work suggests that gamma irradiation doses up to 1.5 kGy may be effectively used for shelf life extension and for minimizing postharvest decay and weight loss of strawberry without causing drastic changes in its pH, TSS and TA.

Table 1: Effect of gamma irradiation and storage period on pH, TSS and TA of strawberry.

Treatments	Storage period (days)											
	d_0	d_3	d_6	d_9	d_0	d_3	d_6	d_9	d_0	d_3	d_6	d_9
	pH				TSS (%)				TA (%)			
Control	3.40	3.40	3.39	3.40	7.48	7.50	7.49	7.50	0.68	0.68	0.67	0.68
0.5 kGy	3.39	3.40	3.39	3.41	7.49	7.49	7.49	7.49	0.68	0.68	0.68	0.68
1.0 kGy	3.39	3.39	3.39	3.39	7.49	7.48	7.50	7.50	0.68	0.68	0.68	0.69
1.5 kGy	3.30	3.40	3.40	3.40	7.49	7.49	7.50	7.49	0.67	0.68	0.68	0.67

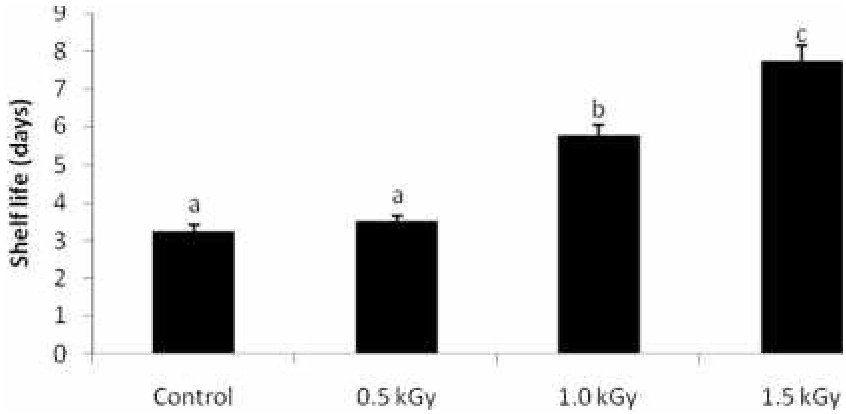

Fig. 1: Gamma irradiation effect on shelf life of strawberry stored at room temperature. Bars topped by different alphabets differ significantly at p≤0.05 as revealed by LSD

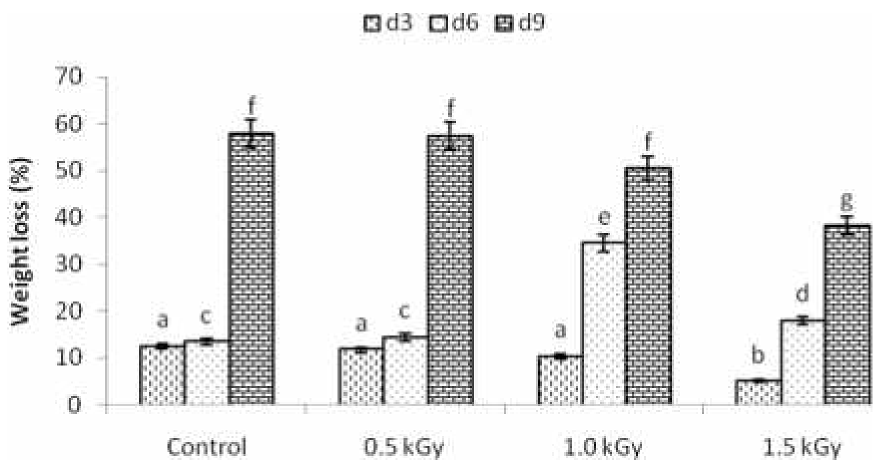

Fig. 2:Effect of different doses of gamma irradiation on weight loss of strawberry at different storage period. Bars of the same color topped by similar letter are not significantly different (p≤0.05)

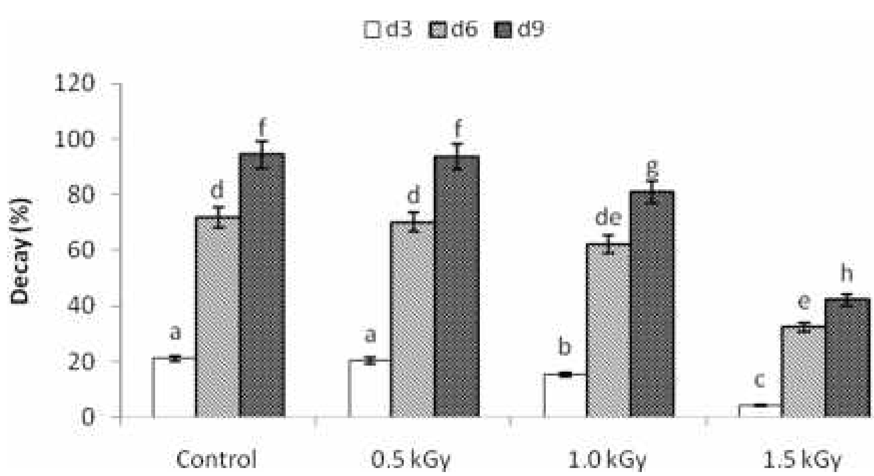

Fig. 3: Effect of gamma irradiation on decay of strawberry at different storage period. Bars of the same color topped by similar letter do not differ significantly (p≤0.05).

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