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Original article

Evaluation of microbial potential, sensory and nutritional quality of mangoes following gamma irradiation

Roheena Abdullah, Maryam Suman, Shagufta Naz, Mehwish Iqtedar, Afshan Kaleem, Mahwish Aftab

Department of Biotechnology Lahore College for women university, Lahore, Pakistan - E-mail: roheena_abdullah@yahoo.com

Summary. Foodborne diseases pose a widespread threat to human health and they are an important cause of reduced economic productivity. The postharvest diseases are considered worldwide as the major issue for postharvest facilities. Although there are various methods to decrease postharvest losses, consumers are looking for agricultural product free of chemicals. In the present study impact of gamma radiations on microflora, sensory and nutritional quality of mango cultivar chaunsa was evaluated. The samples was subjected to various irradiation doses (0.25, 0.5 and 1.25) and stored at refrigerated temperature. Sensory, microbiological and proximate analysis was estimated on weekly intervals for the treated and control samples. The microbial flora eliminated to maximum extent at dose 0.5 kGy without any significant change in sensory properties. However, prominent sensory changes were observed at dose >1 kGy. Proximate analysis showed 0.5kGy does not cause any significant changes in moisture, ash, fat, fiber and protein content. So, 0.5kGy was found optimum for chaunsa that increase the shelf-life up to 7 days without causing any damage to fruit.

Key words: gamma irradiation, safety, quality, mango

Introduction

Mango (*Mangifera indica)* is a fruit crop which belongs to the family of *Anacardiaceae,* it is the second most significant fruit mostly cultivated in the tropical and sub-tropical regions of the world (1). It has become a foremost fruit crop of Asia, where the mango is commonly known as the king of fruits. It contains amino acids, carbohydrates, fatty acid, minerals, organic acid, proteins and vitamin C. The annual estimated global production of mango is over 25-million tonnes. Mostly, over-ripening and rotting by microorganisms or insects decreases the shelf-life of mangoes (3). It has been reported that surface of mango is usually sustained by significant amount of microbial load, including several species of bacteria, fungi and yeasts (4). The losses of mango fruit usually occurs due to post harvest losses of mango. The most frequent post-harvest losses include harvesting mango at improper maturity, invasive field handling, mechanical injury, fruit softening, and decay of mango due to pest or disease damage (2). Different post-harvest preservation techniques have been reported which involves hot water treatment, cold water treatment, chemical treatment or a combination of these (2). The chemical application on mangoes is prohibited in U.S.A. So alternative methods to control pathogens were investigated (5).

Several investigations were made to find out a save and appropriate way to decrease the post-harvest loses and to increase the shelf life of certain fruits and vegetables, in addition to improve the nutritive value of the product. Gamma radiation was considered to be the most suitable process. Gamma irradiation uses ionizing radiations to change or break the DNA of pests making them germ-free. The gamma rays which are used for food processing are usually from cobalt-60

(Co-60) or cesium-137 (Ce-137). The gamma radiations have been legally authorized by United States (6). It is helpful in extending shelf life of some vegetable and fruits by minimizing damage due to several bacteria, fungi and molds. Subsequently, the product which is irradiated can be accessible for a greater time, nevertheless conserving pleasant and attractive sensory qualities for a long time than non-irradiated manufactured goods (7).

Materials and Methods

Sample collection, packaging, gamma radiation treatment and storage

The mango cultivar Chaunsa was collected from local market of Lahore. The fruits samples were divided into two groups; experimental and control. All the samples were weighed before subjecting to gamma irradiation, packaged in polythene bags, and labeled. The experimental group was subjected to gamma radiation at Pakistan Radiation Services (PARAS) Lahore, Pakistan using Cobalt-60. After irradiation fruit were stored in refrigerated conditions and were evaluated at 7 day interval for physical, microbial and proximate analysis (8). Fruits of both groups were subjected to sensory evaluation to determine fruit color, texture and visual defects.

Determination of microbial flora

For microbial flora determination serial dilution method was used (4). Each sample was washed with 100 ml of sterilized saline water. Different dilutions were prepared from this wash. 0.1 ml of each dilution was transferred to the petriplates containing Nutrient agar, MacConkey agar, *Salmonella Shigella Agar* and potato dextrose agar. Plates containing Nutrient agar, MacConkey agar and SS agar were incubated at 37°C for 24 h. However, PDA plates were incubated at 30°C for 3-4 days for the growth of fungal colonies. After specific time total viable bacterial and fungal count was calculated (9-10). The API-20E test kit was used for the identification of enteric bacteria. Fungal species were identified on the basis of micro and macroscopic characteristics.

Proximate Analysis

Determination of crude fiber, protein moisture and ash content

Crude fiber, protein, moisture and ash content was determined according AOAC (2005) official methods (11).

Determination of carbohydrates and energy value: According to Muller and Tobin (1980) the total carbohydrate content value was determined (12). According to Mukhtar *et al*. (2010) the total energy was calculated (9).

Statistical analysis: The results obtained were analyzed by Costat version 6.4 using completely randomized block design and mean values were compared using Duncan's New Multiple Range test at $p \leq 0.05$ with five replicates. The mean square error of replicates from mean value was also calculated.

Results and Discussion

Sensory evaluation of chaunsa

Mango cultivar Chaunsa was irradiated at 0.25, 0.50 and 1.25 kGy. The low doses showed better results than that of higher doses in case of sensory evaluation (Table1). At 0.5kGy Chaunsa showed no change in color and texture throughout 21 days. The browning of the peel and pulp was produced at doses >1kGy probably it was due to increased activity of enzymes such as polyphenoloxidase and phenylalanine ammonium lyase (PAL). Irradiation stimulates production of phenolic compounds and increased the activity of PAL resulting in browning of fruits (13). The browning and necrotic decay of the tissue might be also related with the stress conditions induced in the mango at high irradiation doses (14). Textural softening is a worthy indicator of shelf-life potential. Pectin degrading enzymes such as pectin methyl esterase, polygalacturonase, rhamnogalacturonase, and lyase have been known to be very effective in fruit-tissue softening (15). Irradiation changed the synthesis of these enzymes and hence saved the texture of the fruits (16). The results in the present study indicate that shelf life in Chaunsa was extended about 7 days at 0.5kGy.

Table 1. Sensory evaluation of control and irradiated samples of Chaunsa

Days of storage	Sensory characters	Radiation doses (kGy)			
1st		**Control**	**0.25**	**0.5**	**1.25**
	Mango cultivar	Chaunsa	Chaunsa	Chaunsa	Chaunsa
	Texture	Hard	Hard	Hard	Hard
	Color	No color change	No color change	No color change	No color change
	Visual defects	No blistering with black spot	No blistering with black spot	No blistering with black spot	blistering started
7th		**Control**	**0.25**	**0.5**	**1.25**
	Mango cultivar	Chaunsa	Chaunsa	Chaunsa	Chaunsa
	Texture	Soft	Hard	Hard	Soft
	Color	No color change	Yellowish brown	No color change	Browning
	Visual defects	No blistering with black spot	No blistering with black spot	No blistering with black spot	blistering started
14th		**Control**	**0.25**	**0.5**	**1.25**
	Variety	Chaunsa	Chaunsa	Chaunsa	Chaunsa
	Texture	Soft	Hard	Hard	Soft
	Color	No color change	Yellowish brown	No color change	Browning
	Visual defects	No blistering with black spot	No blistering with black spot	No blistering with black spot	blistering started
21st		**Control**	**0.25**	**0.5**	**1.25**
	Mango cultivar	Chaunsa	Chaunsa	Chaunsa	Chaunsa
	Texture	Soft	Hard	Hard	Soft
	Color	Yellowish brown	Browning	No color change	Brownish black
	Visual defects	blistering with black spot	blistering w/black spot	No blistering w/ black spot	blistering w/ black spots

Microbial analysis

Enumeration of microbes on nutrient agar

The effect of gamma irradiation on the total viable count of bacteria on the Chaunsa was evaluated (Fig. 1a). During the first week of analysis, chaunsa cultivar kept at refrigerated temperature showed that total viable count was reduced from 1.80×10^5 to 9.0×10^4 cfu/ml at 0.5kGy. However, samples treated with 1.25kGy dose had 5.2×10^4 total viable count on first day of analysis which was lesser than control. Viable count of bacteria in control on 14th day was increased up to 2.10×10^5 which decayed on 21st day. However, 0.5 kGy radiated sample remained with a minimum viable count of bacteria 7.0×10^4 cfu/ml. It was observed that irradiation doses of 0.5kGy and 1.25kGy were able to remove number of viable cells after immediate irradiation. This might be due to reason irradiation cause radiolysis of H_2O molecules by the ionizing radiation which produces free radicals, destroying the DNA in addition to other organelles in microorganisms, thus inactivating or eliminating the microorganism (17).

Enumeration of microbes on MacConkey agar

The Figure 1b depicted the effect of gamma irradiation on the gram negative bacterial count of control and irradiated samples (0.25, 0.5, and 1.25kGy. During the first week of analysis, Chaunsa cultivar kept at refrigerated temperature showed that total viable bacterial count was reduced from 3.4×10^4 to 0.9×10^4 cfu/ml at 0.5kGy. However, samples treated with 1.25kGy dose had no growth of gram negative bacteria on first day of analysis. Total coliform count in control on 14th day was increased upto 3.9×10^4 which decayed on 21st day. However, after

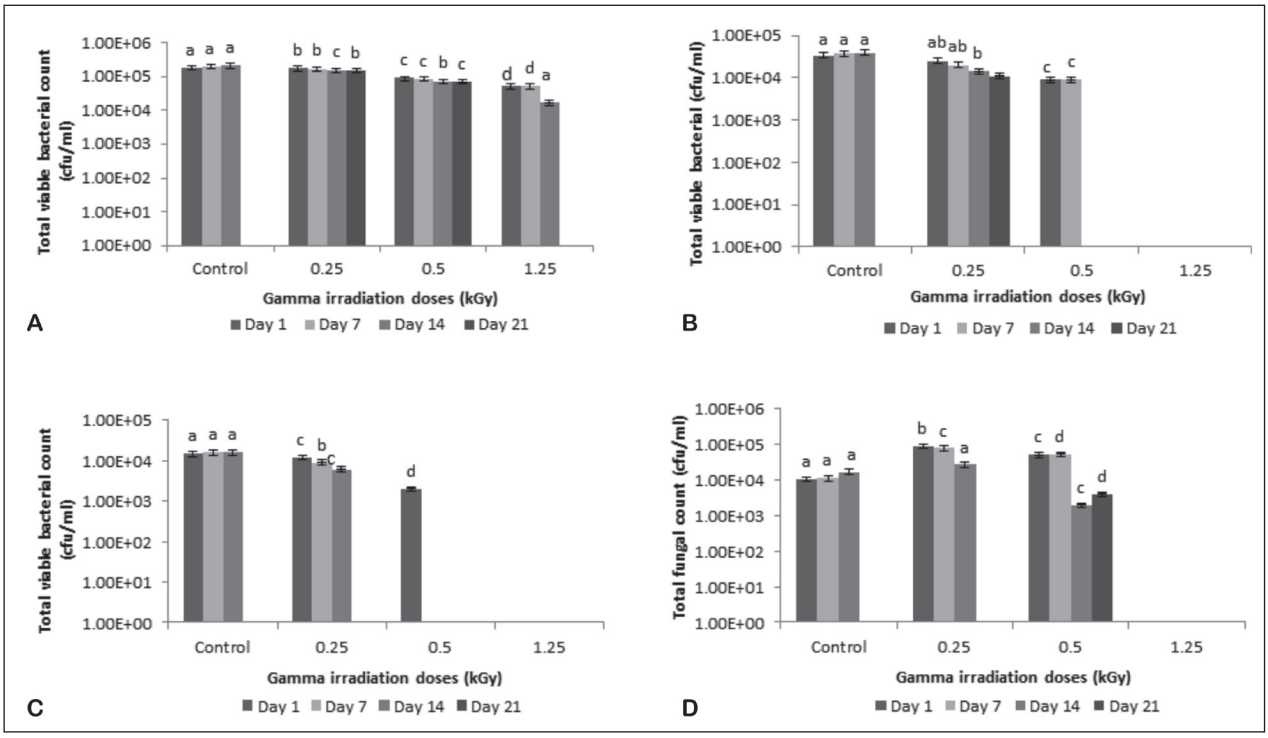

Figure 1. A) Total viable bacterial count of control and irradianted Chaunsa on nutrient agar; B) Total viable bacterial count of control and irradianted Chaunsa on MacConkey agar; C) Total viable bacterial count of control and irradianted Chaunsa cultivar on Salmonella shigella agar; D) Total fugal count of control and irradiated Chaunsa on potato dextrose agar.

14th, and 21st day of storage at refrigerated temperature, 0.5kGy radiated sample contain no growth.

Enumeration of microbes on Salmonella Shigella agar

The effect of gamma irradiation on the *Salmonella shigella* count of control and irradiated samples (0.25, 0.5, and 1.25kGy) was examined (Fig. 3c). Doses of 0.5 and 1.25kGy were able to eliminate all enterobacteriaceae after 7 days storage at refrigerated temperature. But 1.25kGy dose might destroy the appearance causing browning of peel. In the control sample bacterial growth on SS agar mostly consisted of *Escherichia coli* and *Shigella* colonies Shigellosis is the enteric infectious disease caused by *Shigella sonnei* in both developed and under-developing countries and has been the most common cause of endemic in those areas. *S. sonnei* is referred to be a major food-borne threat to public health in many developed countries where the issues of sanitation are strictly regulated (18). The growth of *Shigella sonnie* was inhibited through the irradiation in combination with refrigerated temperature.

Enumeration of microbes on potato dextrose agar

Figure 1d depicted total fungal count on control and irradiated (0.25, 0.5, and 1.25 kGy) Chaunsa cultivar. The present study revealed total fungal count observed on control sample was higher from the samples irradiated at 0.25 kGy 0.5kGy and 1.25 kGy. In the present study isolated and identified fungal species included *Aspergillus niger, Fusarium sp, Alternaria sp, Aspergillus flavus, Rhizopus stolonifer, Mucor spp*. Our findings are in accordance with El-Samahy *et al*. (2000) who isolated 14 fungal *species* belonging to five different genera *i.e. Penicillium, Aspergillus, Fusarium, Cladosporium,* and *Scoplariopsis* (19). It is therefore important to control these pathogenic fungi for the prevention of post-harvest losses. Irradiation has been used to extend the shelf-life of mangos by controlling fungal disease. The current study showed the control group remained free of any decay incidence up to 14 days, as compared to fruits irradiated at 0.25 and 0.5kGy which remained free for 21 days.

Proximate analysis

Effect of gamma radiations on moisture content

Figure 2 depicted the effect of gamma irradiation on moisture content of chaunsa. Proximate analysis showed that moisture content presented slight reduction with increase radiation doses during storage up to 21 days. Moisture content of chaunsa was reduced from 81.52 g/100g to 76.53g/100g at 0.5kGy. The reduction might be due to maximum increase in water loss due to degenerative changes of the skin with the time interval resulting from both respiration and transpiration processes (20).

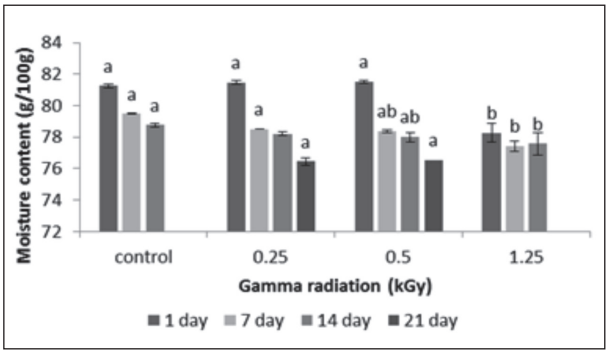

Figure 2. Effect of different gamma radiation doses on moisture content of Chaunsa

Effect of gamma radiations on ash content

Figure 3 illustrates the effects of irradiation on ash content of chaunsa. In Chaunsa ash content was reduced from 0.422 to 0.356 g/100g, while on 21st day control sample was decayed. However, ash of 0.5kGy irradiated sample was 0.256g/100g. Ash content was reduced from 0.356 to 0.256 g/100g at 0.5kGy.Ash content is the minerals which decrease slightly at high dose treatments and with the passage of time**.** The reason might be that the decrease was due the conversion of minerals into toxic substances with the time.

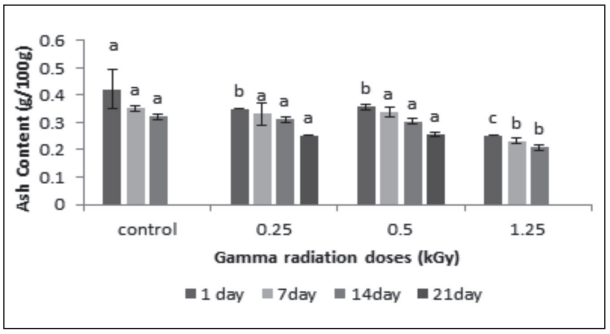

Figure 3. Effect of different gamma radiation doses on ash content of Chaunsa

Effect of gamma radiations on fat and protein content

Figures 4 - 6 indicate effect of gamma irradiation on fat and protein contents of mangoes. In present study crude fat and protein contents showed a slight decrease as irradiation doses increases. The observed change in fat content could be due to the formation of free radicals during irradiation, which in turn increase the lipid oxidation (21). Fat concentration also decreases with storage; this was agreed with a general observation that there is a link between lipid content and flavor development of the mango. A slow decrease in crude fat content on prolonged storage might be due to decreased citrate level, which was the instant source of acetyl coenzyme A, require for biosynthesis of triglyceride and fatty acid (22). A decrease in protein content was observed; the results showed that protein content of control Chaunsa was reduced from 1.01 to 0.86g/100g when irradiated at 0.5kGy. At 1.25kGy protein was reduced to

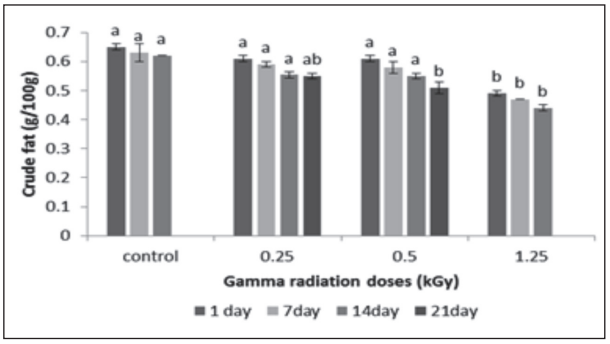

Figure 4. Effect of different gamma radiation doses on fat content of Chaunsa

0.71g/100g, as compared to control sample. Probably, this change in protein value was due to the increases in irradiation dose. Our finding in accordance with Fan and Sommers (2006) who reported that lower and medium doses bring only small breakdown of proteins present in food into amino acids and lower molecular weight protein parts (23).

Effect of gamma radiations on fiber content

Figure 5 depicted effect of gamma irradiation on fiber content. In present study crude fiber showed no significant change with increase in irradiation dose, however minor change was observed with the time interval. The reason might be characterized by a decrease in insoluble pectin which is associated with an increase in soluble pectin with storage period (24).

Effect of gamma radiations on carbohydrate content and energy values

In the present study increase in carbohydrate content (Fig. 7) and energy value (Fig. 8) was observed, both parameters are interrelated with each other. At low doses of 0.25 and 0.5kGy minor changes were observed, which might be due to more rapid and partial breakdown of non-reducing sugars and other polysaccharides and their subsequent inversion to reducing sugars (25). Generally, irradiation up to 3kGy modifies Mono and polysaccharides, resulting in the increase of carbohydrate content (26).

Conclusions

It was concluded optimized gamma radiations dose destroy all the pathogenic microorganism without altering the sensory properties and quality of mango cultivar chaunsa. Gamma irradiation is safe as compared to chemical treatments.

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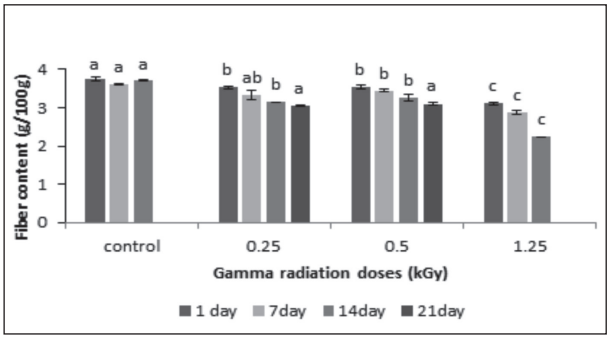

Figure 5. Effect of different gamma radiation doses on fiber content of Chaunsa

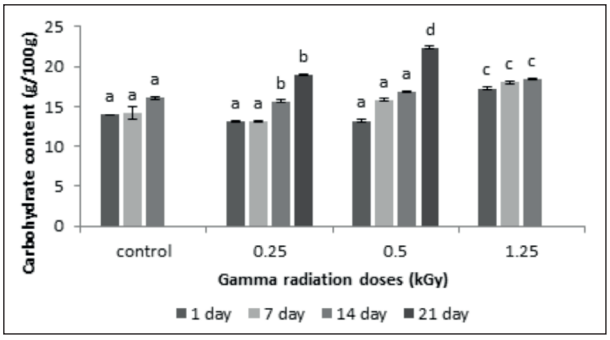

Figure 7. Effect of different gamma radiation doses on carbohydrate content of Chaunsa

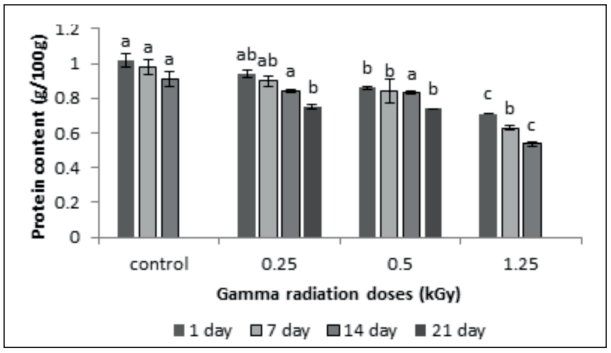

Figure 6. Effect of different gamma radiation doses on protein content of Chaunsa

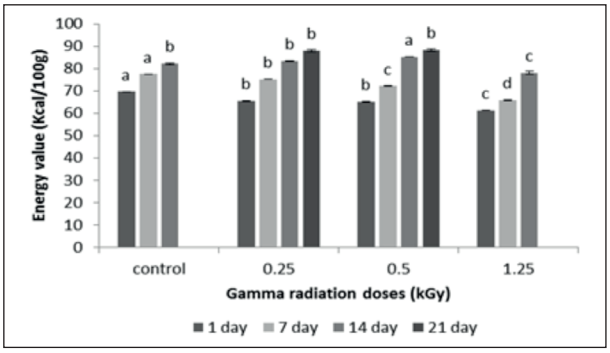

Figure 8. Effect of different gamma radiation doses on energy value of Chaunsa

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Correspondence:
Roheena Abdullah
Department of Biotechnology Lahore College
for women university, Lahore, Pakistan.
E-mail: roheena_abdullah@yahoo.com