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## EFFEECT OF GAMMA RADIATION ON POST HARVEST SPOILAGE OF SPINACH

MUNIR N\*, PERVAIZ S, HAQ R, BASHIR R\* AND NAZ S

Department of Biotechnology, Lahore College for women university, Lahore, Pakistan

\*Corresponding author: [neelma.munir@yahoo.com](mailto:neelma.munir@yahoo.com); [rashidasbs@yahoo.com](mailto:rashidasbs@yahoo.com)

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### ABSTRACT

Spinach (*Spinacia oleracea*,) is a member of family Amaranthaceae. The spinach crop plays an important role in human diet because it is an important source of iron. Food irradiation is the process of intentionally exposing good-quality food to a controlled source of ionizing radiation for such purposes as pathogen reduction, shelf-life extension, and insect disinfestation. Gamma irradiation of foods is an important source of food sterilization as they kill the microorganisms responsible for the spoilage of food. However, there are concerns about the effect of gamma radiation on nutritional value of the irradiated food. Furthermore, it is very important to determine the optimum dose of gamma radiation to achieve this objective. In the present study, spinach were exposed to three doses of gamma radiation i.e. 1, 0.75, 0.5 kGy. The nutritional value of spinach after radiation was analyzed to determine the change in proximate composition. In light of result, it was evaluated that 0.75 kGy is optimized dose that has little effect on the nutritional value of spinach. At 0.75 kGy the sensory properties remain unchanged and the shelf life of spinach was increased up to 4 days at room temperature. The results obtained from moisture test, ash test, protein test, fat test, crude fiber test and carbohydrate test at 0.75kGy do not affect its nutritional effect and moisture content decreased so it can be easily stored and preserved. Hence present study will be important in shelf life enhancement of spinach for export purpose.

**Keywords:** Spinach, proximate analysis, gamma irradiation, sterilization, nutritional value

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## INTRODUCTION

Pakistan is a big market where a huge amount of fruits and vegetables are grown. However, the marketing system is deficient in proper storage facilities and hence considerable post-harvest loss occurs. Spinach is a delicate crop therefore it is difficult to store the spinach. It is inhabitant to central and southwestern Asia. It is an annual plant, which grows to a height of up to 30 cm. Spinach may stay alive over winter in temperate regions. (Hedges *et al.*, 2007).

Common spinach, *Spinacia oleracea*, was long considered to be in the Amaranthaceae family under the family name 'Amaranthaceae' in the order Caryophyllales. (Murtaza *et al.*, 2007).

Spinach can be classified into three basic types: Savoy, flat-leaf, and semi-savoy spinach. (Hubert, 2011).

Savoy spinach has curly, deeply crinkly, and dark green leaves and typically sold in groceries and supermarkets in fresh bundles. Flat-leaf, also known as smooth-leaf spinach, can be distinguished by its smooth and broad leaves that make easier to wash and clean compared to the crinkly Savoy varieties. This is typically the type of spinach used in frozen and canned spinach, baby foods, soups, and processed foods. This is the type of spinach

which is mainly used in export majorly in Pakistan.

Spinach store in a plastic bag in your refrigerator for 3-7 days. While it is best to buy and consume spinach the same day. For storage spinach must be washed with water and then dried and stored in refrigerator for 3 to 7 days (Valverde *et al.*, 2008).

Pakistan is the ninth country in a world for the largest production of spinach. Pakistan produce 103,446 tonnes spinach every year. No import of spinach in Pakistan. Pakistan export spinach to many countries but the major countries are Saudi Arab, UAE, UK, Sri Lanka, Australia, Malaysia, USA and Germany (Basher *et al.*, 2001).

## MATERIALS AND METHODS

### Experimental site

The experiments were carried out at Pakistan Radiation Services (PARAS) Lahore and Lahore College for Women University, Lahore. Gamma radiation was given at PARAS and proximate analysis was done at Lahore College for Women University.

### Sample collection:

Sample was collected from the village near the KASUR named as BEHRAM K. Sample was then packed in brown bags. All the samples were divided into two groups, viz. control and irradiated.

**Gamma irradiation:**

Gamma irradiation was carried out in a cobalt-60 Food Package Irradiator at PARAS. Samples were irradiated at a dose of 1, 0.75 and 0.5 kGy. Following irradiation, the samples were stored in refrigerator. During the storage, samples were analyzed for their nutritional quality.

**Proximate Analysis**

The spinach samples were analyzed for moisture, crude protein, crude fat, chlorophyll and ash on a dry weight basis, according to AOAC (2005).

**Determination of moisture content**

Percentage of moisture was calculated by

$$M.C = (W_w - W_d) / W_w \times 100$$

**Determination of Ash**

Weight of ash was calculated by

$$\text{Weight of ash} = \text{weight of crucible} + \text{ash} - \text{weight of crucible}$$

% of ash was calculated as

$$\text{Ash \%} = \text{wt. of ash (g)} / \text{wt. of sample} * 100$$

**Determination of crude Fat (Soxhlet****Method)**

Loss of weight was calculated as

$$\text{Loss in weight} = \text{wt. of thimbles} + \text{demoistured sample} - (\text{weight of thimbles} - \text{fat free sample})$$

$$\text{Fat \%} = \text{loss in weight (g)} / \text{wt. of sample} * 100$$

**Determination of crude Fiber**

% of fiber was calculated by

$$\text{Wt. of oven dried sample} = (\text{wt. of crucible} + \text{filter paper demoisture}) - (\text{wt. of crucible} + \text{filter paper} + \text{ash})$$

$$\text{Weight of ash} = (\text{wt. of crucible filter paper} + \text{ash}) - (\text{wt. of crucible} + \text{wt. of filter paper})$$

$$\text{Loss in weight} = \text{wt. of oven dried sample} - \text{wt. of ash}$$

$$\% \text{ of fiber} = \text{wt. of sample (g)} - \text{loss in weight (g)} / \text{wt. of sample} * 100$$

**Protein determination**

Titrate the boric acid solution by using standard solution of N/70 HCl till the original color of boric acid solution restore. The amount of N/70 HCl used will be noted and the protein is determined.

**Carbohydrates determination**

By difference the carbohydrate content was determined

$$\% \text{ carbohydrate} = 100 - (\% \text{Moisture} + \% \text{Ash} + \% \text{Fat} + \% \text{Crude protein} + \% \text{Crude fiber})$$

**Determination of chlorophyll content**

Laura (2010) according to the method content was determined with some modifications. Spinach leaves were dried, centrifuge for 5 minutes at 10000-13000rpm then observe under UV light and chlorophyll was determined.

**RESULTS**

The effect of different doses of gamma radiation was recorded on different physicochemical characteristics of spinach as given in Table 1.

**Effect of gamma radiation on colour of spinach stored at room temperature**

The sample was stored at room temperature and the color was examined every day. In

case of leaves color variation was noted due to different doses of irradiation. Flat leaves spinach irradiated with the dose of 1.0 kGy retained their green color up to the 3rd day of storage and after that 100% leaves of spinach spoiled whereas spinach leaves treated with gamma rays 0.75 kGy retained their color up to 7<sup>th</sup> day and after that 100% leaves spoiled and spinach leaves treated with 0.5 kGy gamma rays retained their color up to 5<sup>th</sup> day and after that it completely spoiled. The non-irradiated spinach leaves remained green up to 4th day and then turned brown and spoiled. The spinach leaves change their color from green to brown and then sometimes in to dark brown.

### 1. Determination of moisture

With respect to moisture, the data revealed that as the dose of gamma irradiation increased the moisture content of spinach decreased. Result revealed that the maximum moisture content was recorded in the non-irradiated spinach which was taken from field. At the dose of 1, 0.75 and 0.5 kGy the percentage of moisture in the sample was 88.11, 86.33 and 87.11 g 100g<sup>-1</sup>. However, the control of both localities showed almost similar moisture content. Minimum moisture content was observed in the irradiated spinach of at the dose of 0.75 KGy.

### 2. Determination of ash

According to the data, ash content varies at different doses. The non-radiated sample show maximum ash. at dose of 1, 0.75 and 0.5 kGy, the ash content of sample was 1.90, 1.88 and 1.89 g 100g<sup>-1</sup> respectively. Minimum ash content was recorded in sample at irradiation dose of 2.5 kGy

### 3. Determination of fat

During the storage period the fat content was determined. According to the data given in the table, it showed decrease in fat content after radiation of spinach. The radiated sample have less fat content than the non-radiated sample. As the gamma radiation dose is increased the fat content is increased. Maximum fat content was recorded at lower dose of 0.5 kGy. At dose of 1, 0.75 and 0.5 the fat content was 0.54, 0.55 and 0.56 g 100g<sup>-1</sup> respectively. The fat content in control is 0.55.

### 4. Determination of protein

Analysis of data revealed that gamma irradiation had not a significant effect on protein content of spinach which were stored at room temperature. The data showed a declining trend with the decrease in gamma radiation dose. It is also clear from the results that spinach irradiated with 0.75kGy gamma rays recorded slightest difference in protein content. Other doses of 0.5kGy showed lower protein content. The data revealed with

the increase of day protein content declined. At dose of 1, 0.75 and 0.5 kGy, the protein content is 2.97, 2.99 and 2.96 g 100g<sup>-1</sup> respectively. Optimized dose is 0.75kGy and the protein content observed is 2.99 g 100g<sup>-1</sup>.

### 5. Determination of carbohydrate

The data showed a declining trend with the decrease in gamma radiation dose. Minimum carbohydrates were observed in the sample at dose of 0.5 kGy. At dose of 1, 0.75 and 0.5 kGy, the carbohydrates in a sample was 3.6, 3.49 and 3.3 g 100g<sup>-1</sup> respectively as compared to field sample which was 3.75, 3.54 and 3.21 g 100g<sup>-1</sup> respectively.

### 6. Determination of chlorophyll content

During the storage period the chlorophyll content was determined. According to the data given in the table 1, it showed decrease in chlorophyll content after radiation of spinach. The non-radiated sample have more chlorophyll content than the radiated sample. As the gamma radiation dose is decreased the chlorophyll content is decreased. Minimum chlorophyll content was recorded at lower dose of 0.5. At dose of 1, 0.75 and 0.5 kGy, the chlorophyll content of sample was 4.10, 4.08 and 4.05 g 100g<sup>-1</sup> respectively.

Table 1: Effect of gamma radiation on moisture content of spinach stored at room temperature

Doses	Moisture content (g 100g <sup>-1</sup> )	Ash content (g 100g <sup>-1</sup> )	Fat content (g 100g <sup>-1</sup> )	Protein content (g 100g <sup>-1</sup> )	Carbohydrate content (g 100g <sup>-1</sup> )	Chlorophyll content (g 100g <sup>-1</sup> )
Control	83.9 ± 0.013 <sup>a</sup>	1.92 ± 0.024 <sup>a</sup>	0.55 ± 0.016 <sup>b</sup>	2.93 ± 0.006 <sup>b</sup>	3.68 ± 0.089 <sup>a</sup>	4.7 ± 0.012 <sup>a</sup>
1	88.11 ± 0.018 <sup>b</sup>	1.90 ± 0.018 <sup>a</sup>	0.54 ± 0.026 <sup>b</sup>	2.97 ± 0.013 <sup>a</sup>	3.63 ± 0.017 <sup>a</sup>	4.10 ± 0.015 <sup>d</sup>
0.75	86.33 ± 0.015 <sup>c</sup>	1.88 ± 0.014 <sup>b</sup>	0.55 ± 0.024 <sup>c</sup>	2.99 ± 0.010 <sup>b</sup>	3.69 ± 0.017 <sup>ab</sup>	4.08 ± 0.051 <sup>c</sup>
0.5	87.11 ± 0.089 <sup>d</sup>	1.89 ± 0.028 <sup>c</sup>	0.56 ± 0.014 <sup>a</sup>	2.96 ± 0.025 <sup>c</sup>	3.63 ± 0.015 <sup>b</sup>	4.5 ± 0.011 <sup>b</sup>

All values are the sum of means of five parallel replicates. ± indicates standard deviation (± SD) among the replicates. Mean followed by different letters in the same column differ significantly at P = 0.05 according to Duncan's new multiple range test.

### DISCUSSION

The study was carried out to increase the shelf life of spinach by treatment with gamma irradiation. Furthermore the dose of gamma radiation was optimized that has a minimal effect on the nutritional quality of spinach. Spinach were radiated at different doses of gamma radiation and the dose was optimized that has a less effect on the proximate composition of spinach. During the present work, it was observed that water

protein, carbohydrates as well as fats which are the major nutritional components of any food did not affect significantly with gamma irradiation. During their work Wood and Bruhn (2000) also found that Proteins, fats, and carbohydrate are not notably altered by irradiation.

Spinach irradiated with 0.75 kGy gamma rays retained their green color up to 7th day of storage. Retention of color under doses 0.75 kGy is due to delay in metabolic

activities as well as enzymatic reactions, which leads to slow down the senescence process. These findings on color retention are in agreement with Shirodkar *et al.*, (2002) in capsicum at 0.5 kGy.

It was further observed that spinach irradiated with 0.75 kGy gamma irradiated exhibited maximum value of overall consumer acceptability up to 7th day that is due to slow senescence rate. These results also matched with the finding of Fatima *et al.*, (2013).

The effect of gamma radiation on moisture content of spinach indicated that moisture content decreased after the treatment. This might be due to retardation of senescence and inhibition of metabolic activities that moisture is decreased in the radiated spinach. During their work Wang and Chao (2003) also reported reduction in moisture content at lower dose. Darfour *et al.* (2013) also had similar observations on some irradiated leguminous seeds. Contrary to this this, Lu *et al.* (1988) reported that onions became soft and had more moisture with the high dose of gamma radiation (3.0 kGy).

The effect of gamma radiation on the ash of spinach showed that as the gamma radiation dose was increased the ash content of spinach decreased. Rondey *et al.*, (2013) also reported

in his article that ash is decreased in irradiated spinach at lower dose.

The effect of gamma radiation on fats of spinach showed that as the gamma radiation dose is decreased the fat content of spinach increased. During the work on extension of shelf life of banana by gamma radiation, Zaman *et al.* (2007) found that the fat content of gamma irradiated banana remained almost unaltered as compared to the control banana.

The results of the present study showed no significant change in protein content after radiation. At all the tested doses the data revealed that protein content of radiated samples is almost similar to non-radiated spinach. Claude *et al.* (1983) reported reduction in protein content at higher dose. However, according to Sreenivasan (1974) total proteins in red gram were not changed appreciably by radiation treatment. He also stated in his article that there is a slight degradation of proteins due to irradiation. So degradation is the main cause of decrease in protein content at higher dose.

A decline in carbohydrates though non-significant was recorded after gamma radiation during the present work. The total carbohydrates declined with the decrease in gamma radiation dose in all the samples. According to Lu *et al.* (1988), relatively high carbohydrates invites fungal growth. He also

reported that total carbohydrates tended to be greatest at the 0.75 kGy gamma radiation in Walla Walla onions. Mehta and Nair (2011) also reported decrease in carbohydrate content at lower dose which is in line to the present study.

A decline in chlorophyll though non-significant was recorded after gamma radiation during the present work. The total chlorophyll declined with the decrease in gamma radiation dose in all the samples. The decrease in chlorophyll at low doses could be due to the degradation of chlorophyll molecule as a result of lower energy radiation. Maximum chlorophyll that remains unchanged is observed at dose 0.75 k Gy. Contrary to this, Laura (2010) reported decrease in chlorophyll content after gamma irradiation.

### CONCLUSION

At 0.75 kGy the nutritional value of the entire treated sample is considered acceptable. As the gamma radiation has significant effect on the shelf life of spinach without effecting its chemical composition. The sensory properties of treated samples were also satisfactory. It is concluded that irradiation treatment can be effectively used to protect decay losses and enhance shelf life. As in present work the shelf life of spinach extends up to 4 days. Hence, this process

shows great promise in agriculture for the storage and preservation of food and food p

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