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RESEARCH ARTICLE

# Effect of Gamma Radiation on Sprout Inhibition and Nutritional Value of Potato

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**ABSTRACT**

Potato (*Solanum tuberosum*) is an economical food crop since it provides a cheap source of energy to the human beings. The present study was focused to enhance the shelf life of potatoes by gamma radiation and its effect on the nutritional value of potatoes. The potato samples were irradiated using 0.05, 0.10 and 0.15 kGy of doses and were stored at room temperature after irradiation. Various parameters were studied for both the control and irradiated samples. The study concluded that there was no significant difference in the proximate analysis of potato. At 0.15 kGy the nutritional value of the entire treated sample was considered acceptable as the gamma radiation has significant effect on the shelf life of potatoes without affecting its nutritional composition. The sensory properties of treated samples were also satisfactory. It was also concluded that irradiation treatment could be effectively used to protect from sprouting and enhance shelf life. Samples which were irradiated at dose 0.15 kGy showed 75.45% moisture content after three weeks of storage, 0.70% ash content, 2.3% fiber content, 0.47% fat content, 1.8% protein content and 19.28% carbohydrate content and was optimized as favorable dose for potato to manage the shelf life.

## INTRODUCTION

Potatoes (*Solanum tuberosum*) stand at fourth position in food crop production worldwide after wheat, maize and rice. Potatoes are better in both economy and metabolizable energy than rice and wheat. Potatoes are a cheap source of energy for human diet and they are a good source of vitamins and minerals (Elfaki and Abbsher, 2010). Potato consumption is expanding strongly in developing countries, which now accounts for more than half of the global harvest and where the potato's ease of cultivation and high energy content have made it a valuable cash crop for millions of farmers. The total production of potatoes in Pakistan for the year 2013 is 3802200 tonnes (FAO, 2013). Pakistan is also exporting potatoes to Afghanistan, United Arab Emirates, Iraq, Singapore, Oman and Qatar but the export and average unit price is very low (Khan and Khan, 2010). Major problems associated with the long-term storage of potato are spoilage and sprouting. Sprouting of potatoes during storage can be prevented through different techniques such as use of long dormancy cultivars, controlling of some factors in the stores e.g. storage at low temperature, breeding, light, irradiation, hot water dip and vapor heat treatment, controlled atmosphere, pressure processing, chemical suppressants (Mohammed and Meena, 2012). In addition to the above techniques, food irradiation is a new technique that is used for packed food items. Ionizing radiation like gamma radiation produced from the sources like $Co^{60}$ or $Cs^{137}$ helps in reducing the microbial load attacking the potatoes after postharvest (Asha et al., 2011). This technique is useful as it does not change the nutritional quality of food and can store the food in fresh state. The irradiation technique has many uses such as suppression of sprouts in bulbs and tubers like potato, onion etc. cleaning, diminishing the chances of ripening (Asha et al., 2011).

The potato has a high nutritional value. The proximate constituents in gram per 100 gram of potato are; 78.1 (water contents), 0.1 (total fat contents), 1.9 (total protein contents), 0.9 (total ash contents) 18.6 (total starch contents), 0.9 (total sugar contents), 19.6 (carbohydrates), 2.0 (crude fibres) whereas energy level is 82 kcal or 349 kJ/100gm of Potato (Roe et al., 2013). There are very few reports on the effect of gamma radiation on shelf life enhancement of potato (Rezaee et al., 2013). However, the varietal differences as well as seasonal variations suggest that there should be variation in the optimum dose for shelf life enhancement. The present study hence focused on the dose optimization of gamma radiation to increase the shelf life of potatoes by sprout inhibition. Furthermore, the proximate analysis was also performed to determine the changes in nutritional components of gamma irradiated potatoes.

## MATERIALS AND METHODS

### Sampling

The sample of the potatoes (*Solanum tuberosum*) was taken from the local market of Lahore, Pakistan. Four sets of sample were prepared for one-week analysis and each set contain 2 potatoes as for each test five replicates were used. The surface of samples was cleaned with dry and clean cloth to remove sand and dust particles and then packed them in aerated plastic string bags. Based on the previous literature available, for the present work three doses of gamma ration 0.05 kGy, 0.10 kGy and 0.15 kGy were selected in addition to the control. During the present work, Harwell Amber 3042 dosimeter was used for dose measurement. The measurement uncertainty was 3% at 95% confidence level. The dose uniformity ratio for irradiated sample of potatoes during the present work was 1.6 that was achieved by multi-sided irradiation. Un-irradiated control was kept under identical conditions for comparison. Both control and irradiated potatoes were stored at ambient temperature (30-37°C). Period of storage was a few weeks.

### Evaluation of sensory qualities

The physical conditions like color, firmness, sprouting and weight of sample, before and after irradiation was tested for three weeks.

### Proximate analysis

Proximate analysis of the irradiated samples and non-irradiated samples was performed according to the procedures outlined in table below by Association of Official Analytical Chemists (AOAC, 2005):

| Analysis | Method reference |
|---|---|
| Moisture content | AOAC 934.01, 934.06, 964.22 (Hot air oven) |
| Ash content | AOAC 923.03, 942.05, 945.46 (Muffle furnace) |
| Fiber content | AOAC985.29 or 991.43 (Heating mantle and Muffle furnace) |
| Fat content | AOAC 922.06, 925.12, 989.05, 954.02(Soxhlet method) |
| Protein content | AOAC 991.20(Kjeldahl method) |
| Carbohydrates | AOAC 985 .29 or 991.43 (Differential method) |

### Statistical analysis

Each experiment was performed in five parallel replicates. The data were analyzed statistically by one-way ANOVA and Duncan's Multiple Range tests by using statistical software COSTAT®. The differences between different treatments were considered significant at P≤0.05.

## RESULTS AND DISCUSSION

### Effect of gamma radiation on weight, sensory qualities and sprouting

When the potatoes were irradiated at different doses i.e. 0.05, 0.10 & 0.15 kGy, a very non-significant reduction in weight loss was observed at 5% significant level (Table 1). There was no change in color of potatoes after first and second week of storage in both samples control and irradiated of doses 0.05, 0.10, 0.15 kGy but after third week control and sample irradiated with 0.05 kGy had shown change in color that was the color change to dark (Table 1). Also the firmness was affected in control and the sample that was irradiated with 0.05 kGy after third week while at 0.01 and 0.15 kGy no change in sensory property was observed (Table 1). Afify et al. (2012) observed the capability of gamma irradiation for suppressing sprouting of potato tubers and the most advantageous dose suggested by them was 50Gy that prevented the launch of sprouting throughout the storage period without causing unwanted rotting for potato tubers. Rezaee et al. (2001) carried out experiment on potato stored at 8 ºC and 16 ºC with treatment (0, 50, 100 and 150 Gy) at different dates (10, 30 and 50 days after harvest). They showed that early irradiation decreased sprout, percentage weight loss and specific gravity of tuber.

### Effect of gamma radiation on proximate contents of potato

The proximate analysis (moisture content, ash content, fiber content, fat content, protein content and carbohydrates) of non-irradiated and irradiated potatoes is given in detail with values is given in the table 2. The radiation dose from 0.05 kGy to 0.15 kGy did not show any significant effect on the proximate components of potatoes. The moisture content of non-irradiated and irradiated (0.15 kGy) potatoes ranged from 75.57-75.45g100g$^{-1}$, respectively. Variation in the ash content of non-irradiated and irradiated (0.15 kGy) potatoes was found to be statistically non-significant. The fiber content of non-irradiated and irradiated (0.15kGy) potatoes ranged from 1.8-2.3 g100g$^{-1}$, respectively. The obtained mean of fat content of non-irradiated and irradiated (0.15kGy) potatoes at various doses ranged from 0.40-0.47 g100g$^{-1}$ (Table 2) indicating no statistical differences at 5% significant level. The protein contents of non-irradiated and irradiated (0.15kGy) potatoes ranged from 1.73-1.8g.100g$^{-1}$,

**Table 1: Effect of different doses of gamma radiation on sensory qualities of potatoes**

| Evolution of physiological and sensory qualities | Doses (kGy) | Time Period | | |
|---|---|---|---|---|
| | | Weak 1 (Mean±SD) | Weak 2 (Mean±SD) | Weak 3 (Mean±SD) |
| Physiological loss in weight ($g100^{-1}g$) | 0.0 | 1.8±0.08944$^{a}$ | 2.0±0.08485$^{a}$ | 4.5±0.06325$^{a}$ |
| | 0.05 | 1.7±0.012649$^{ab}$ | 1.8±0.08485$^{a}$ | 2.0±0.02828$^{b}$ |
| | 0.10 | 1.7±0.06325$^{ab}$ | 2.0±0.012649$^{ab}$ | 2.3±0.018974$^{b}$ |
| | 0.15 | 1.5±0.06325$^{b}$ | 1.7±0.012649$^{b}$ | 1.77±0.011314$^{c}$ |
| Color | 0.0 | No change | No change | Color change to dark |
| | 0.05 | No change | No change | Color change to dark |
| | 0.10 | No change | No change | No change |
| | 0.15 | No change | No change | No change |
| Firmness | 0.0 | No change | No change | A little bit change |
| | 0.05 | No change | No change | A little bit change |
| | 0.10 | No change | No change | No change |
| | 0.15 | No change | No change | No change |
| Sprouting | 0.0 | No change | No change | Sprouting occurred |
| | 0.05 | No change | No change | A little bit sprouting occurred |
| | 0.10 | No change | No change | No change |
| | 0.15 | No change | No change | No change |

All the values are sum of means of 5 parallel replicates± SD among the replicates. Means followed by different letters in the same column differ significantly at P=0.05.

**Table 2: Effect of different doses of gamma radiation on nutritional constituents of potatoes**

| Proximate Contents | Doses(kGy) | Time period | | |
|---|---|---|---|---|
| | | Week 1 | Week 2 | Week 3 |
| Moisture content ($g100^{-1}g$) | 0.0 | 75.33±0.06325$^{a}$ | 75.39±0.018974$^{a}$ | 75.57±0.011314$^{a}$ |
| | 0.05 | 75.00±0.012649$^{b}$ | 75.38±0.06325$^{b}$ | 75.41±0.012649$^{b}$ |
| | 0.10 | 76.00±0.08944$^{b}$ | 76.55±0.02828$^{b}$ | 76.78±0.06325$^{b}$ |
| | 0.15 | 75.41±0.08485$^{c}$ | 75.43±0.012649$^{b}$ | 75.45±0.08485$^{b}$ |
| Ash content ($g100^{-1}g$) | 0.0 | 0.8±0.002828$^{a}$ | 0.74±0.008485$^{a}$ | 0.70±0.006325$^{a}$ |
| | 0.05 | 0.67±0.012649$^{ab}$ | 0.64±0.008944$^{a}$ | 0.60±0.008485$^{a}$ |
| | 0.10 | 0.70±0.012649$^{bc}$ | 0.66±0.011314$^{a}$ | 0.64±0.006325$^{a}$ |
| | 0.15 | 0.75±0.018974$^{c}$ | 0.73±0.006325$^{a}$ | 0.70±0.012649$^{a}$ |
| Fat ($g100^{-1}g$) | 0.0 | 0.56±0.008485$^{a}$ | 0.50±0.012649$^{a}$ | 0.40±0.002828$^{a}$ |
| | 0.05 | 0,50±0.008944$^{a}$ | 0.42±0.006325$^{a}$ | 0.31±0.008485$^{ab}$ |
| | 0.10 | 0.40±0.011314$^{a}$ | 0.35±0.006325$^{ab}$ | 0.29±0.012649$^{ab}$ |
| | 0.15 | 0.54±0.012649$^{a}$ | 0.51±0.018974$^{b}$ | 0.47±0.006325$^{b}$ |
| Fibre ($g100^{-1}g$) | 0.0 | 2.9±0.011314$^{a}$ | 2.6±0.08485$^{a}$ | 1.8±0.06325$^{a}$ |
| | 0.05 | 2.6±0012649$^{b}$ | 2.42±0.012649$^{a}$ | 2.0±0.018974$^{b}$ |
| | 0.10 | 2.0±0.02828$^{c}$ | 1.81±0.08485$^{a}$ | 1.5±0.06325$^{c}$ |
| | 0.15 | 2.8±0.012649$^{d}$ | 2.6±0.06325$^{b}$ | 2.3±0.08944$^{d}$ |
| Protein ($g100^{-1}g$) | 0.0 | 1.89±0.011314$^{a}$ | 1.8±0.06325$^{a}$ | 1.73±0.012649$^{a}$ |
| | 0.05 | 1.8±0.018974$^{a}$ | 1.83±0.08485$^{a}$ | 1.8±0.08944$^{a}$ |
| | 0.10 | 1.72±0.02828$^{ab}$ | 1.65±0.08944$^{a}$ | 1.6±0.08944$^{a}$ |
| | 0.15 | 1.86±0.06325$^{b}$ | 1.84±0.011314$^{a}$ | 1.8±0.012649$^{a}$ |
| Carbohydrate ($g100^{-1}g$) | 0.0 | 18.52±0.011314$^{a}$ | 18.97±0.06325$^{a}$ | 19.8±0.012649$^{a}$ |
| | 0.05 | 19.43±0.018974$^{b}$ | 19.31±0.012649$^{ab}$ | 19.88±0.06325$^{ab}$ |
| | 0.10 | 19.04±0.08485$^{c}$ | 18.98±0.02828$^{ab}$ | 18.99±0.012649$^{bc}$ |
| | 0.15 | 18.64±0.06325$^{c}$ | 18.89±0.08485$^{b}$ | 19.28±0.08944$^{c}$ |

All the values are sum of means of 5 parallel replicates±SD among the replicates. Mean followed by different letters in the same column differs significantly at P=0.05.

respectively. The carbohydrate content of non-irradiated and irradiated almonds ranges from 19.8-19.28 $g.100g^{-1}$, respectively.

The results of this study related to proximate analysis is steady with the previous literature which conclude that there is no significant difference in all the proximate components of irradiated and non-irradiated almonds and was previously reported by Rezaee et al. (2001, 2013).

Gamma irradiation was very helpful in inhibiting the sprouting was also reported by Mahto and Das (2014). Frazier et al. (2006) and Mulla et al. (2011) reported that with sprout inhibition; the increased sugar content of the low dose irradiated samples became less significant compared to that of the non-irradiated control samples during storage.

Mahboob et al. (2004) concluded that the irradiation restricted the metabolic rate of the potato and at 0.08–

0.12 kGy preserved the textural characteristics as compared to the control samples.

**Conclusions**

Hence the study clearly showed that the gamma irradiation potential is very effective for the storage of potatoes after postharvest. Low dose irradiation can be effectively used to maintain the sensory as well as proximate content of potatoes as compared to the control non-irradiated samples. At 0.15 kGy the nutritional value as well as the sensory property of the entire treated sample is considered acceptable and has significant effect on the shelf life of potatoes without effecting its proximate composition. It can be concluded that irradiation treatment can be effectively used to protect from sprouting and enhance shelf life. Hence, this process shows great promise in agriculture for the storage and preservation of food and food products.

**Authors' Contributions**

All authors contributed equally in this manuscript.

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