



# Effect of $\gamma$ irradiation on the physico-mechanical and chemical properties of potato (*Solanum tuberosum* L), cv. 'Kufri Chandramukhi' and 'Kufri Jyoti', during storage at 12 °C

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## HIGHLIGHTS

- Sprouting completely inhibited at 0.05 kGy during storage at 12 °C.
- Irradiated (0.05–0.5 kGy) tubers looked firm and retained high textural parameters.
- Micrographs showed no damage to the cell walls at doses upto 0.5 kGy.
- No loss of tubers due to rotting was observed at 0.05 and 0.15 kGy.
- Dose-dependent accumulation of reducing and total sugars.

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## ABSTRACT

The study was carried out on two important cultivars of potato, 'Kufri Jyoti' and 'Kufri Chandramukhi', to evaluate the effectiveness of low dose gamma irradiation (0.05, 0.15 and 0.5 kGy) in maintaining the tuber qualities in terms of textural parameters (puncture force, shear force, work done, cohesiveness and gumminess), microstructure, sugar content and storage losses during storage of 120 days at 12 °C. Sprouting was completely inhibited even at the lowest dose studied, i.e., 0.05 kGy. All the irradiated tubers looked firm with no deterioration in appearance. The irradiated tubers retained higher textural parameters compared to the unirradiated controls. It was interesting to observe a noticeable increase in the textural parameters of the irradiated specimens of 'K. Chandramukhi'. The scanning electron micrographs showed all the irradiated specimens with rigid cell walls. A dose dependent accumulation of reducing and total sugars was observed. Minimum accumulation of sugars occurred at 0.05 kGy. No loss of tubers due to rotting was observed at 0.05 and 0.15 kGy as compared to 6% loss observed in unirradiated controls. Thus, low dose irradiation (up to 0.15 kGy) with storage at 12 °C is an effective postharvest method for preserving the tuber qualities in potato.

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## 1. Introduction

India is the largest potato producer of South West Asia but potato storage is a major problem for the country (Ezeta, 2008). Cold storage at 2–4 °C is the most commonly used method that successfully provides solutions to many problems such as sprouting, rotting, tuber moth damage and weight loss but accumulation of reducing sugars makes the tubers unsuitable for processing purpose (Van Es and Hartmans, 2008). The distribution of cold storages is uneven in the country (Johl and Dahiya, 2002). Cold

storage is high energy consuming that also makes it costly. Storage at 10–12 °C is less energy consuming and prevents undesirable accumulation of reducing sugars so potatoes for the processing purpose are stored at this temperature but requires application of sprout suppressants. The use of chemical sprout suppressants has also raised concern regarding their harmful residual effects (Kleinkopf et al., 2003). Gamma irradiation is a safe and effective method of sprout inhibition that allows potatoes to be stored at high temperatures (Siddiqui et al., 1973; Thomas, 1984; Hossain et al., 1995; Frazier et al., 2006). The number of  $\gamma$  irradiation facilities is also growing in the country as the technique is steadily gaining worldwide acceptance (EIR, 2008).

The radiation induced sprout inhibition is probably as a result of DNA damage, affecting the biosynthesis of certain plant growth

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hormones and enzymes, thus interfering with the normal metabolism of the tuber (Diehl, 1995). The interaction of high energy radiations with the structural and chemical components of potato can also affect the tuber qualities. A number of studies have been reported on the effect of gamma irradiation on different tuber qualities such as sugar content, vit C content, chipping quality etc. (Frazier et al., 2006; Ezekiel et al., 2008a, 2008b; Rezaee et al., 2011, 2013). Texture is an important quality parameter that determines the acceptability and shelf-life of a fresh horticulture produce. It is primarily determined by the structural integrity of the cell wall and middle lamella as well as turgor pressure of the cells (Jackman and Stanely, 1995; Van Buggenhout et al., 2009). Insoluble starch granules stored in the tubers also play important role in potato texture (Singh et al., 2005). The mechanical properties of stored potatoes is influenced by the physiological changes involving structural components of the tissues in relation to loss of cell water by evaporation and production of cell water by respiration (Gao et al., 1989; Alvarez and Canet, 2000). The increased physiological losses at higher storage temperature reduce their storability that ranges between 3 and 4 months at 10 °C (Eltawil et al., 2006). A good postharvest technology should minimize storage losses and physico-chemical changes during storage. So, the present study was carried out to evaluate its effectiveness of gamma irradiation in maintaining tuber qualities in terms of textural parameters, micro-structure, sugar content and storage losses during storage at 12 °C.

## 2. Materials and methods

### 2.1. Potato harvest and packaging

'K. Chandramukhi' and 'K. Jyoti' were procured from the farms of Bidhan Chandra Krishi Viswavidyalaya. The tubers were harvested during the months of February and March respectively, and kept in an airy room (22–27 °C) for about a week for curing. The properly cured, well suberised samples were transported to the laboratory packed in nylon bags and were stored on the floor of a cool, airy, dry room (20–22 °C). The potatoes were irradiated after 30 days of harvest.

For irradiation, equal sized potatoes (55–60 g) of each cultivar were packed separately in aerated low density polyethylene (LDPE) bags (thickness: 44 µm) measuring 21.5 cm × 15 cm. Holes were cut in the bags to facilitate gaseous exchange. Six bags each containing eight to ten potatoes were included at each dose. Six such bags were kept unirradiated as control (0 kGy).

### 2.2. Gamma-irradiation

Gamma irradiation was carried out at the Food Irradiation Laboratory, NIL Campus, Jadavpur University, Kolkata using Co-60 gamma cell (Model: Gamma Chamber 5000, BRIT, Mumbai) with source strength of 499.5 TBq. The dose rate during the study was 2.6 Gy/s. The potatoes were irradiated with varying low doses of  $\gamma$ -ray (0.05 kGy, 0.15 kGy and 0.5 kGy).

### 2.3. Storage

The unirradiated and the irradiated samples of potatoes were stored in a humidity cabinet (Prime Instruments) for 120 days at  $12 \pm 1$  °C (RH: 85–90%). The physico-chemical and textural observations were performed on 0 day, 60 days and 120 days of storage.

### 2.4. Sprout percentage

Tuber having at least one sprout of 0.5 cm length or more was recorded as sprouted (Mehta and Kaul, 2002), and the percentage of sprouting was calculated for each dose.

### 2.5. Rotting percentage

Any tuber showing a sign of soft rot or mould was considered as decayed. The percentage of rotting was calculated for each dose.

### 2.6. Total and reducing sugars

The reducing and total sugar content of the unirradiated and irradiated samples were determined during storage by the di-nitro salicylic acid (DNSA) method (Plummer, 2008). Calibration plot was drawn using a standard glucose solution in the range of 0–1.0 g/L. 10 g of peeled potato was cut and ground with a pestle and mortar. The homogenized paste was suspended in 20 mL of distilled water, filtered through a muslin cloth and centrifuged at  $2516 \times g$  for 15 min. The supernatant was used to determine the reducing sugars. For the estimation of total sugar, 200 µL of the supernatant was added to 800 µL of distilled water in a test tube and hydrolyzed with 172 µL of 12 N HCl at 68 °C for 8 min. The hydrolyzed sample after neutralization with 20% NaOH, was used for the determination of total sugars. OD was measured spectrophotometrically (Spectrophotometer U-1800, Hitachi) at 540 nm. The reducing sugar (mg/kg) on a fresh weight basis and total sugar content (mg/kg) on a fresh weight basis was calculated from the standard plot of glucose.

### 2.7. Textural analyses

Texture analyses of the unirradiated and irradiated potato tubers were done by puncture test, shear test and double compression test using Instron Universal Testing Machine (Model 4301, Instron Ltd. UK).

#### 2.7.1. Puncture test

The whole potato tuber was placed on the base plate and punctured along its width from one end to another by a cylindrical puncture probe of 6 mm diameter driven through the potato from one end to another at a crosshead speed of 0.25 mm/s under the working load of 100% of 100 N load cell. The highest peak required to puncture through the flesh of the tuber was recorded in Newton (N), indicating tuber firmness. The work done (or toughness) to puncture the tuber was calculated as the area under the force–distance graph obtained, expressed in Newton metre (N m) (Rosenthal, 1999).

#### 2.7.2. Shear test

The whole potato tuber was placed on the base plate and cut through its cross section by "V" shaped Warner–Bratzler Meat Shear Compressive type blade driven at the speed of 0.25 mm/s under the working load of 20% of 1000 N load cell. The force–distance graphs obtained were compared by the peak force (N) required to shear through the flesh of the tuber. The work done (or toughness) to shear the potato was calculated as the area under the graph obtained, expressed in N m.

#### 2.7.3. Double compression test

Double compression test was performed using 50% working load of 1000 N load cell on cylindrical samples (2.5 cm dia × 1 cm) that were compressed (25% compression) on a non lubricated platform using flat disc probe of 40 mm diameter moving at a speed of 0.25 mm/s. The cohesiveness and gumminess were determined from the Texture Profile Analysis (TPA) graphs (Bourne, 1978). Cohesiveness is expressed as the dimensionless quotient of the areas represented by the work to be done for two bites. Gumminess

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