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# Effect of radiation processing on meat tenderisation

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HIGHLIGHTS

- Effect of radiation processing on tenderness of three meat systems was evaluated.
- Dose dependant reduction in shear force seen in buffalo meat.
- Collagen solubility increased with irradiation.

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ABSTRACT

The effect of radiation processing (0, 2.5, 5 and 10 kGy) on the tenderness of three types of popularly consumed meat in India namely chicken, lamb and buffalo was investigated. In irradiated meat samples dose dependant reduction in water holding capacity, cooking yield and shear force was observed. Reduction in shear force upon radiation processing was more pronounced in buffalo meat. Protein and collagen solubility as well as TCA soluble protein content increased on irradiation. Radiation processing of meat samples resulted in some change in colour of meat. Results suggested that irradiation leads to dose dependant tenderization of meat. Radiation processing of meat at a dose of 2.5 kGy improved its texture and had acceptable odour.

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## 1. Introduction

India has the largest livestock population in the world. Goat, sheep and chicken meat are consumed by a majority of India's meat eating population. However, buffalo meat is the major item of export comprising approximately 50% of the total animal products exported from India. In India, meat production is mostly a by-product system of livestock production. Most of the animals slaughtered are spent animals that are at the end of their productive life and therefore, the meat is dark and tough. An increase in collagen cross linking in older animals is known to contribute towards meat toughness (Nakamura et al., 2010). Meat tenderness is an important organoleptic characteristic which in turn affects consumer acceptability. The natural process of meat tenderisation is very complex and depends on several biological and environmental factors. During the conversion of muscle to meat several changes takes place in the structure of the muscle cell and the proteins, which influence the tenderness. Tenderness development is also dependant on the genetic variation, post mortem storage time, architecture and integrity of the skeletal muscle cell and the activity of enzymes (Lonergan et al., 2010). Several chemical and physical treatments have been employed to improve the tenderness of meat. Marinating with organic acids and treatment with microbial or plant derived proteases are a few of the methods that are being currently employed by the meat industry. Exogenous enzymes tenderise meat through proteolysis. Enzymes such as papain (papaya), ficin (fig) and bromelain (pineapple) are most commonly used for meat tenderisation (Lawrie and Ledward, 2006). Attempts have also been made to physically tenderise meat by electrical stimulation (Gadiyaram et al., 2008), high pressure (Bajovic et al., 2003) and shock wave treatment (Bolumar et al., 2014).

The composition of meat makes it an ideal environment for the growth of spoilage and food-borne pathogens. The risk of food-borne pathogens is increasing due to the emergence of new pathogens and poor sanitary conditions of the slaughterhouses in developing countries. Therefore, it is essential to have appropriate preservation technologies to maintain the safety and quality of meat. Radiation processing has emerged as an efficient technology that eliminates microbial contamination while preserving the freshness and nutritional quality of meat. It is one of the best

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methods available to control pathogenic microorganisms in meat and meat products. About 30 countries including India, have obtained clearances for radiation processing of meat and meat products to improve microbiological safety and shelf-life (http://nucleus.iaea.org/FICDB). Information available on the effect of radiation processing on meat tenderization is scanty (Yoon, 2003; Yook et al., 2001; Lee et al., 1999). The objective of this study was therefore to investigate the effect of irradiation on the tenderness of three types of meat available in India as measured by various physico-chemical parameters.

## 2. Materials and methods

### 2.1. Chemicals

Sodium dodecyl sulphate (SDS), bovine serum albumin (BSA), acrylamide, Comassie Brilliant Blue G-250, were purchased from Sigma Chemical Co. (St. Louis, MO). All other reagents used were of analytical grade and were procured from either S. D. Fine Chemicals (Mumbai, India) or Qualigens Fine Chemicals (Mumbai, India).

### 2.2. Preparation of meat samples

Deboned chicken breast meat (broiler, *Pectoralis major m.*) approximately 2 h after slaughter was obtained from a local poultry farm. The leg region (*M. biceps femoris*) of lamb meat was procured four hours after slaughter and trimmed of all external fat and ligaments. Buffalo meat (*Biceps femoris*) stored at $4 \pm 1$ °C for 24 h post slaughter was obtained from a reputed retail shop in Mumbai. All the three meat samples were transported to the laboratory in chilled condition, cut into ($2.5 \times 2.5 \times 2.5$ cm$^3$) cubes and packed in polythene bags (700 gauge, WVTR 0.4 g/m$^2$/day; OTR 1800 ml/m$^2$/day).

### 2.3. Irradiation

The packed samples were irradiated in insulated boxes containing ice in a Food Package Irradiator (AECL, Ottawa, Canada) with a $^{60}$Co source at a dose rate of 3.4 kGy/h. The samples received average doses of 2.5, 5 and 10 kGy. They were placed in the central region of the product box with overdose ratio of approximately 1.1. Dosimetry was performed by cerric-cerrous dosimeters calibrated with Fricke's dosimeter.

### 2.4. Moisture content and pH of meat

Moisture content of chicken, lamb and buffalo meat was determined by the AOAC (1995) method. To determine pH, meat (10 g) was homogenised with chilled distilled water (50 ml) and measured with a digital pH metre (Control Dynamics, India).

### 2.5. Cooking yield and water holding capacity (WHC)

For determining the cooking yield weighed samples were steamed (1 min) and cooled to room temperature. The samples were then surface dried and again weighed. Cooking yield was calculated as

$$\text{Cooking yield (\%)} = 100 \times (\text{weight of meat after cooking/initial weight})$$

For determining the WHC, NaCl (0.6 M, 30 ml) containing weighed amount of minced meat was stirred with glass rod and kept at 4 °C for 15 min. It was then stirred once more and centrifuged at 2250*g* for 30 min. The volume of supernatant obtained was measured and WHC was calculated as percentage of initial weight.

### 2.6. Warner–Bratzler shear force

Tenderness of meat samples was estimated by the Texture analyser TA-HD Plus (Stable Micro Systems, Surrey, UK) using Warner–Bratzler blade. The blade was pressed at a constant speed of 2 mm/s at six samples (2.5 cm$^3$) of each meat system in a direction perpendicular to the orientation of the muscle fibre. The maximum shear force (*N*) was recorded.

### 2.7. Collagen content

Content of hydroxylproline in meat samples was estimated according to Neuman and Logan (1950). Meat (2 g) was hydrolysed with 6 N HCl (40 ml) for 18 h. Volume of the hydrolysate was adjusted to 50 ml with distilled water and to an aliquot of this $CuSO_4$ (0.01 M), NaOH (2.5 N) and $H_2O_2$ (6%) was added sequentially. The solution was then placed in a water bath (80 °C for 5 min), cooled and 3 N $H_2SO_4$ (4 ml) followed by p-dimethylaminobenzaldehyde was added. The tubes were then placed again in water bath (70 °C for 16 min), cooled and OD taken at 540 nm. Collagen content was calculated by multiplying the hydroxyproline content by factor of 7.14.

### 2.8. Collagen solubility

Solubility of collagen present in meat was estimated according to the method of Mahendrakar et al. (1989). Cooked meat was homogenised with cold distilled water and then centrifuged at 1500*g* for 30 min. Percentage collagen solubility was calculated by multiplying percentage hydroxyproline solubilized by a factor of 7.14.

### 2.9. Protein solubility

Sarcoplasmic, myofibrillar and total protein solubility was determined by the method of Joo et al. (1999). To extract the sarcoplasmic protein minced meat sample was homogenised with cold potassium phosphate buffer (0.025 M, pH 7.2), kept overnight at 4 °C, centrifuged at 1500*g* for 20 min and protein concentration determined by Biuret method. Total protein (sarcoplasmic+myofibrillar) was extracted in a similar way but 1.1 M KI in 0.1 M potassium phosphate buffer was used for homogenisation. Difference between total and sarcoplasmic protein gave the myofirillar protein content.

### 2.10. Trichloroacetic acid (TCA) soluble peptide content

Amount of TCA soluble peptides present in the three meat systems was estimated according to the method of Ketnawa and Rawdkuen (2011). Meat samples were homogenised with TCA (5%), chilled for 1 h and then centrifuged (2500*g* for 15 min). Soluble peptides present in the centrifugate calculated as micromoles of tyrosine/g of sample were estimated by Lowry method.

### 2.11. Colour measurement

Effect of irradiation on the colour of meat samples was evaluated using a colorimeter (Konica Minolta Sensing Inc., CM-3600d, Osaka, Japan; JAYPAK4808 software, Quality Control System, Version 1.2) according to the CIE Lab scale and the results were expressed as $L^*$ (lightness), $a^*$ (redness), $b^*$ (yellowness), $C^*$ (chrome) and $H^*$ (hue angle). The colorimeter was calibrated with black and white standards. $D_{65}$ lamp and 10° viewing angle were used as

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