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Evaluation of nutritional content and shelf life enhancement of gamma irradiated broiler chicken meat

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Abstract

Broiler chicken plays an important role in human nutrition. Poultry is the second largest industry of Pakistan and contributes substantially to the income. It contributes to 28.0% of the total meat production in the Pakistan. The aim of this study was to increase the shelf life of Broiler chicken by gamma irradiation thereby increasing its export value. Chicken samples were treated with radiation dose of 0.5kGy, 1kGy and 1.5kGy. Sensory evaluation and proximate analysis were performed for the irradiated and non-irradiated chicken meat sample. Non-considerable changes were observed in nutritional characteristics of broiler chicken meat at optimum doses. The radiation dose of 1.5kGy along with refrigerated storage extended the shelf-life of broiler chicken for 9 days. So, this study can be useful in shelf life enhancement for export purpose.

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Introduction

Chicken is a member of bird class *Aves*, and all breeds of chicken come from the same genus, species, and subspecies of bird *Gallus gallus domesticus* (Hascik *et al*., 2010). An adequate proportion of feed was required for maintenance of the broiler strains that attain the marketable weight of 2 to 2.5 kg within 43-47 days (Griffin and Goddard, 1994). Chicken meat is an important source of essential amino acids, vitamins, minerals and also long chain polyunsaturated fatty acids (Salobir, 2000). The meat is a good source of phosphorus, other minerals, B-complex vitamins and rich in proteins. It has a higher amount of unsaturated fatty acids than saturated fatty acids. Monounsaturated fats constitutes about half of the chicken fat, and only one-third of the less healthy saturated fats. It consists of essential polyunsaturated fatty acids (PUFAs), especially the omega (n)-3 fatty acids (Farrell, 2013)**.** Poultry meat production in the world exceeded 92 million tons in 2009 and constituted one third of global meat production (Kucukyilmaz *et al*., 2012). The major broiler-producing countries in the world, in terms of volume, were the United States, China, Brazil, European Union, Mexico, India, Thailand, Japan, and Canada (Chang, 2007). China, Brazil, USA produced 17%, 18% and 26% of total Broiler meat in the world (Warriss, 2001). In Pakistan, broiler production on commercial scale was initiated in 1963 and broiler production has augmented during the past few decades. Pakistan constitutes 2.5 % of total meat production in Asia. Pakistan is at 11th rank in chicken meat production in Asia (Durrani *et al*., 2006). Per capita poultry meat consumption in Pakistan currently stands at only 13kg per annum, compared with 40 to 55 kg per capita per year in developed countries (Ayyub *et al*., 2014). Commercial poultry farming has become a major industry in Pakistan and it now meets 40% of the total domestic meat consumption. Export of poultry live and meat amounted to Rs365 million in 2011-12. Main markets are Afghanistan, Iran, Vietnam, Bahrain, Turkey and Hong Kong (Chang, 2007). It is a nutritious, protein-rich food which is highly perishable and has a short shelf-life unless preservation methods are used. Shelf life and maintenance of the meat quality are influenced by a number of interrelated factors including holding temperature, which can result in detrimental changes in the quality attributes of meat. Fresh meat has a shelf life of 1 day or less at ambient storage temperatures (20-30°C) (Lambert *et al*., 1991; Olaoye, 2010). The most common method for extending the shelf-life of fresh poultry is storage by refrigeration but its use alone limits shelf life to no more than 4–5 days (Chouliara *et al*., 2008). Microorganisms that contaminate the raw meat and limit its shelf life are *E. coli, Salmonella, Pseudomonas, Campylobacter, Staphylococcus, Listeria momocytogenes* and *Proteus*. Some other microorganisms include *Micrococcus, streptococcus* and *Streptomycin (Sarwar, 2014)(Sarwar, 2014)(Sarwar, 2014)(Sarwar, 2014)(Sarwar, 2014)(Sarwar, 2014)(Sarwar, 2014)(Sarwar, 2014)(Sarwar, 2014)*. Meat preservation for future use is a basic need in meat processing. Among different methods, radiation processing is considered a safe and efficacious procedure for meat preservation (Al-Bachir and Zeinou, 2009). Food irradiation is the processing of food products by ionizing radiation in order to control foodborne pathogens, reduce microbial load and insect infestation, inhibits the germination of root crops, and extend the durable life of perishable produce. Cobalt-60 is the most extensively employed radioisotope for gamma irradiation of food (Sarwar, 2014; Stewart, 2001). Gamma rays pick electrons from the atoms of the material. Free electrons can take part in chemical reactions or destroy DNA molecules from the living organisms (Dasilva and Katia, 2012). Proximate composition of broiler chicken contains 75% moisture content, 22% protein content, 1.82% fats, and 0.1% ash content (Karakok *et al*., 2010). Hence the present study was focused to optimize such a dose for chicken meat which is safe for the consumption without harming the nutrient content.

Materials and methods

Sample collection and Irradiation

Sample was collected from retail markets and packed in Zip lock bags. They were then subjected to gamma radiations doses as 0.5kGy, 1kGy and 1.5kGy at Pakistan Radiation Services (PARAS). Periodic evaluations were carried out on day 1, 3, 6, 9 and 12 days with the intervals of 3 days in BS General Laboratory of Lahore College for Women University Lahore by placing in refrigerator.

Evaluation of sensory properties of chicken sample

Both the control and irradiated chicken samples were subjected to sensory evaluation periodically for 12 days using 9 point Hedonic scale. Color, texture, odor and taste of chicken were determined by using this scale. Following are the nine categories of the hedonic scale. 1. Like Extremely, 2. Like Very Much, 3. Like Moderately, 4. Like Slightly, 5. Neither Like nor Dislike, 6. Dislike Slightly, 7. Dislike Moderately, 8. Dislike Very Much, 9. Dislike Extremely (Silva *et al.*, 2010).

Proximate analysis

Determination of proximate composition was carried out in accordance with Association of official Analytical Chemists (AOAC) 2005 methods.

Determination of moisture content

Moisture content was determined by hot air oven at 180^{o}C for 1 hour. The % moisture content was calculated by using following formula:

% moisture = loss in weight (g) / weight of sample (g) × 100.

Determination of Ash

Ash content was determined by ignition in muffle furnace at 550^{o}C – 600^{o}C for 4 to 6 hours. The % ash content will be calculated by using following equation:

% Ash = Weight of ash (g) / weight of sample (g) × 100.

pH determination

pH was calculated by pH meter.

Determination of crude Fat

Fat content was determined by Soxhlet apparatus. The % fat will be calculated by using following equation:

% Fat = loss in weight (g)/wt. of sample (g) × 100.

Determination of protein content

The basic method used for protein determination was Kjeldahl method. % of protein was calculated by using following equations.

% protein = 0.4× titer used/ weight of sample (g) × 6.25 (nitrogen factor).

Statistical analysis

Standard deviation and mean square error of replicates from mean value were also calculated by Hashim *et al.* (1995).

Results and discussion

Sensory analysis

Both the control and irradiated chicken samples were assessed organoleptically for color odour and texture. The chicken meat sample irradiated at 1.5kGy was found more acceptable to the consumer because of its acceptable attributes till day12 as demonstrated in Table 1. Color was a sensory property attributed to the spectral distribution of light. With exposure to higher radiation doses slight change in the color of the chicken meat was observed. Gamma radiation produces free radicals and products of glycoside radiolysis were capable of condensing and thus producing colored products during and after the irradiation (James and James, 2002). Red color was a result of the formation of a carboxyhaem pigment; carboxy-myoglobin and/or carboxy-haemoglobin (Millar *et al.*, 1995). Nanke *et al.* (1998) found that with high radiation doses redness of meat decreases and yellowness increased. At higher radiation doses inconsiderable pink color and invidious odor was observed that vanishes after cooking (Prachasitthisak *et al.*, 1996). Color intensity related to the levels of myoglobin in meat which may alter by radiation (Monk *et al.*, 1995).

As this storage time increased off-odor seemed to be observed. These outcomes were agreed according to the findings of Sheridan and Lynch (1979). Off-odors were due to an accumulation of malodorous metabolic products, such as esters and thiols. The off-odors were identified as resulting from gamma ray treatment of packaging material (Chen *et al.*, 2007). Parachasitthisak *et al.* (1996) found that the shelf life of chicken meat can be extended to 6 or 10 days by a dose of 1kGy or 3kGy. However, a slight pinkish color and an unpleasant odor can be detected at a dose of 3kGy. This unpleasant odor should disappear after cooking.

Doses	Sensory analysis of irradiated and non-irradiated beef				
(kGy)	Day 1	Day 3	Day 6	Day 9	Day 12
Control				Spoiled	Spoiled
0.5 kGy					Spoiled
1 kGy					
1.5 kGy					

Meat texture was an imperative property. Meat storage was linked to its texture. Radiation doses did not influence the texture of the meat instantly after radiation. These findings were agreed with the specific conclusions of Chen *et al.* (2007) who reported that radiation with higher doses caused the lowest muscle texture. Yoon (2003) reported in his findings that low dose of gamma irradiation caused significant textural toughening of cooked chicken breast meat as well as the contraction of the sarcomere width and physical disruption in myofibril units of skeletal muscle.

Proximate analysis

The radiation doses from 0.5kGy to 1.5kGy did not show any significant effect on the proximate components of broiler chicken meat. The proximate composition of chicken meat was determined for both irradiated and non-irradiated samples, stored in refrigerator at day 1, day 3, day 6, day 9 and day 12 respectively.

Effect of Gamma radiation on moisture content

Moisture content of chicken meat was decreased as the radiation dose increased as shown in fig.2. The moisture content in non-irradiated chicken sample was found near to the findings of Qiao *et al.* (2002). However, decline in moisture content was observed with increase in radiation dosage as compared to non-irradiated chicken meat. The decline in the moisture content was due to reduction in metabolic activities. These results for irradiated chicken meat also agreed with the outcomes of Badr (2005).

Effect of Gamma radiation on ash content

Ash content was determined for radiated and non-radiated sample and dose dependent decrease was observed as shown in fig.3. The ash content of chicken meat was decreased with increase in storage period. The ash content had shown dose dependent non-significant decline with higher radiation doses.This study revealed the results according to the results of Badr (2005) that also demonstrated that ash content of meat decrease with increasing radiation doses.

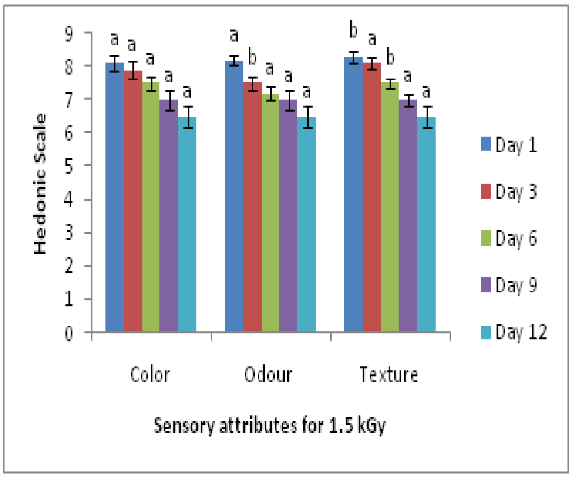

Fig. 1. Impact of gamma radiations on sensory attributes of broiler chicken stored at refrigerated temperature.

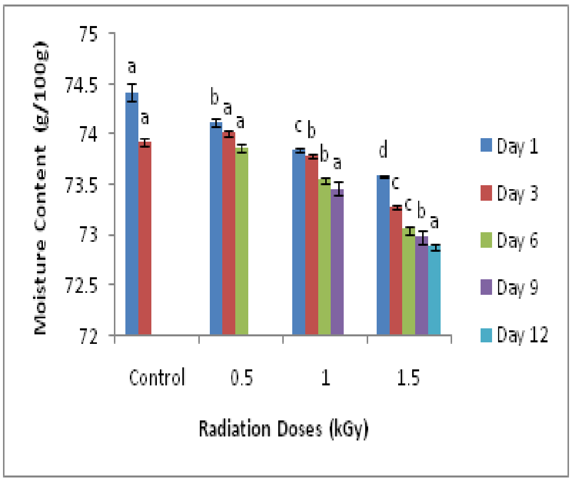

Fig. 2. Impact of gamma radiations on moisture content of broiler chicken stored at refrigerated temperature.

Effect of Gamma radiation on fat content

Fat content of radiated and non-radiated chicken meat was shown in fig.4. The increase in fat content might be due to degradation of large lipid molecules which ultimately adds to the fat content of our sample. This trend was similar to the study revealed by Al-Bachir and Zeinou (2014).For meat irradiated with 0.5kGy increase in fat content was detected. Fat content exhibited similar pattern for radiation doses 1kGy and 1.5kGy as these results were comparable with the outcomes of Yilmaz and Gecgel (2007).

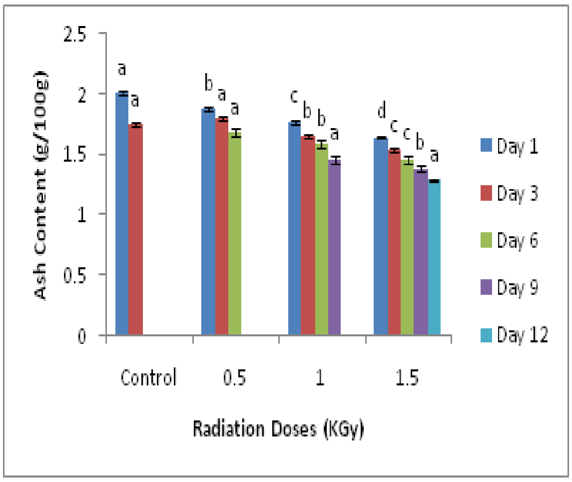

Fig. 3. Impact of gamma radiations on ash content of broiler chicken stored at refrigerated temperature.

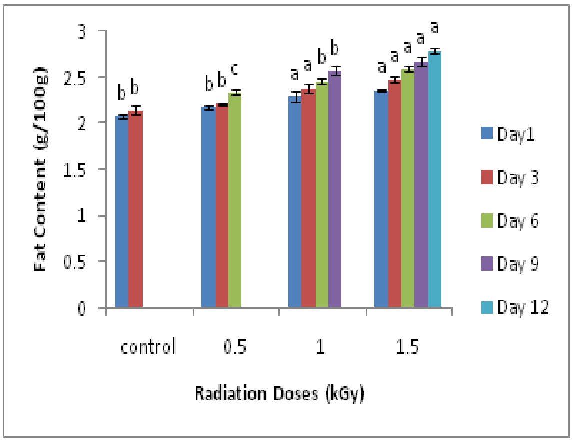

Fig. 4. Impact of gamma radiations on fat content of broiler chicken stored at refrigerated temperature.

Normal water losses, arising during irradiation, resulted in a higher dry matter content in irradiated meat than in non-irradiated control, which in turn increases the lipid content. In present experiment, contents of total intramuscular fat increased comparing with non-irradiated control, and, with irradiation dose increased, fat content increased correspondingly (Chen *et al.*, 2007; Kanatt *et al.*, 1997). According to Fallah *et al.* (2010) Presence of oxygen during or after irradiation accelerates lipid oxidation in irradiated meat. Free radicals generated during irradiation combine with oxygen to form hydroperoxides that breakdown into various decomposition products including aldehydes.

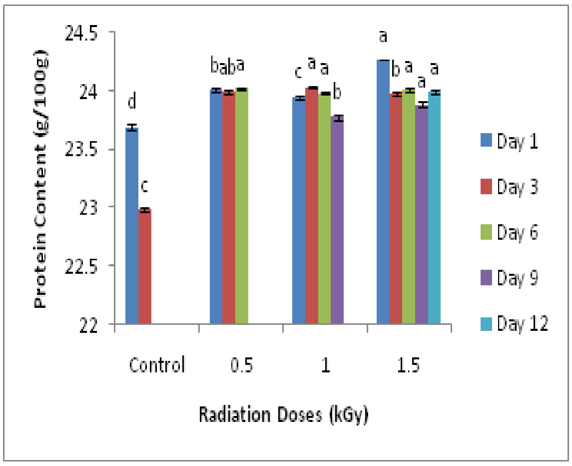

Fig. 5. Impact of gamma radiations on protein content of broiler chicken stored at refrigerated temperature.

Effect of Gamma radiation on protein content

There was no significant change in the protein content of chicken meat for both radiated and non-radiated sample as shown in fig.5.

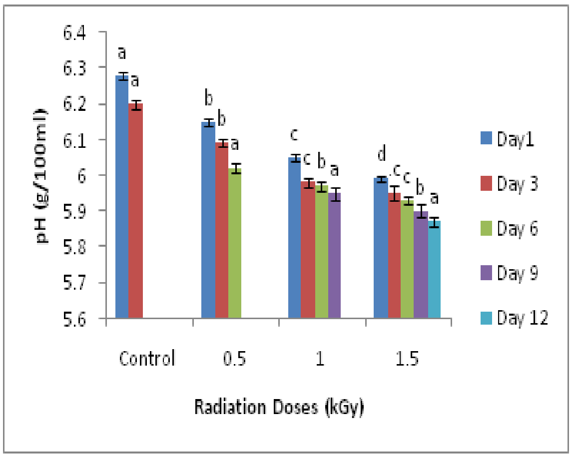

Fig. 6. Impact of gamma radiations on pH of broiler chicken stored at refrigerated temperature.

Effect of Gamma radiation on pH

The pH was slightly decreased as the dose increased as well as with the passage of time, stored in refrigerator as shown in fig.6. It had been noticed that by utilizing gamma radiation on meat pH of meat decreased non-considerably. Morales-delanuez *et al.* (2009) demonstrated in his outcomes that lack of change in pH reflects that there was not enough protein breakdown during these storage times to elicit increased pH typical of meat storage for longer periods. The increase in fat values in irradiated samples and during storage caused a slight decrease in pH values. Increase in fats produced mainly by hydrolysis was also observed by Modi *et al.* (2008) in broiler lipids.

Conclusion

Among all the radiation doses tested, 1.5 kGy proved to be the most efficient in extension of shelf life of broiler chicken at refrigerated temperature for 9 days as compared to non-iiradiated chicken meat hence increasing its export potential.

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