J Bangladesh Agril Univ 17(4): 560–566, 2019 https://doi.org/10.3329/jbau.v17i4.44626

ISSN 1810-3030 (Print) 2408-8684 (Online)

Journal of Bangladesh Agricultural University

Journal home page: http://baures.bau.edu.bd/jbau, www.banglajol.info/index.php/JBAU

Effect of gamma irradiation on shelf life and quality of indigenous chicken meat

Anisul Islam, Md. Sadakuzzaman, Md. Anwar Hossain, Md. Mujaffar Hossain, Md. Abul Hashem✉

Department of Animal Science, Bangladesh Agricultural University, Mymensingh 2202, Bangladesh

ARTICLE INFO

Article history:
Received: 09 April 2019
Accepted: 10 September 2019
Published: 31 December 2019

Keywords:
Gamma Irradiation,
Indigenous chicken meat, kGy,
Safety, Quality

Correspondence:
Md. Abul Hashem
✉: hashem_as@bau.edu.bd

ABSTRACT

The experiment was conducted on fresh indigenous chicken meat treated with 0 (non-irradiated), 1, 2 and 3 kGy ^{60}Co gamma irradiation and stored for 0, 30 and 60 days at -20ºC to investigate the effects on proximate components, sensory attributes, and physicochemical, biochemical and microbial changes in meat quality. Data were analyzed under 4x3 factor CRD design of experiment in GLM procedure of SAS statistical package. The results showed that irradiation groups had significantly ($p<0.05$) higher color and tenderness of meat compared to that of non-irradiated group. The 2 kGy group showed significantly ($p<0.05$) higher Dry matter (DM) and Ether extract (EE) whereas the cooking loss, Free fatty acid (FFA), Peroxide value (PV), and Thiobarbituric acid reactive substances (TBARS) levels were higher in 3 kGy irradiated group. With the advancement of storage periods pH significantly ($p<0.05$) decreased. The 2 kGy irradiation group showed significantly ($p<0.05$) lower numbers of Total viable count (TVC), Total coliform count (TCC), Total yeast and mold count (TYMC) compared to non-irradiated group. From this study, it may be concluded that the 2 kGy irradiated group had positive effects on sensory evaluation, biochemical and microbial qualities of indigenous chicken meat to increase the shelf life and the quality of indigenous chicken meat.

Introduction

Now-a-days many preservation techniques have been developed which include cooking, freezing, fermenting, salting, drying and pickling (Choi *et al.* 2009; Kim *et al.* 2009). These methods have been used to reduce the number of microorganisms and increase the shelf-life and safety of meat (Farkas, 2004). Irradiation is one of the safest methods to maintain quality and safety of meat and meat products. Therefore, meat scientists have made an effort to develop new technologies that can be used not only to secure the safety issues but also to improve the quality of meat (Artes *et al.*, 2007). Irradiation is recognized as an effective, widely applicable food processing technique. Currently, several countries have permitted food irradiation and more than half a million tons of food are irradiated annually (Eustice and Bruhn, 2013). Gamma irradiation is a physical means of sterilization or decontamination where products are exposed to gamma rays.

It is well established that meat has several key nutritional factors, like lipids, proteins with high biological value, trace elements, and vitamins (Wyness *et al.*, 2013). Meat quality has intrinsic characteristics such as color, flavor, tenderness, texture, juiciness, and overall acceptability. The nutritional properties depend on animal genetics, feeding, and livestock practices and on the post-mortem processes that take place during the conversion of muscle into meat (Hocquette *et al.*, 2012).

The chemical and biochemical reactions with the free radicals produced by irradiation results in modification of the oxidation-reduction environment within meat products, and accelerates lipid oxidation, protein oxidation, off odor (Xiao *et al.*, 2011), and alters meat color (Nam and Ahn, 2002). With the approval of irradiation to improve the safety of poultry meat, concerns have been raised about the negative effects of irradiation on meat quality, which include lipid oxidation, protein oxidation, color, and odor. The negative effects of irradiation on indigenous chicken meat quality not yet been studied in our country. Lately Bangladesh is producing 72.60 Lakh metric ton of meat vis-à-vis demand of 72.14 Lakh MT (DLS, 2018) where chicken is contributing more share (around 50%). It indicates we are in surplus 0.46 Lakh MT meats production per year. As a result now we have opportunity to seek foreign markets to export our excess meats. To overcome the international trade barrier irradiation can be an effective way to increase the shelf life and safety of meats. To best of our knowledge our research team conducted first experiment in The Animal Science Laboratory of BAU on gamma irradiation of

Cite this article

Islam, A., Sadakuzzaman, M., Hossain, M.A., Hossain, M.M., Hashem, M.A. 2019. Effect of gamma irradiation on shelf life and quality of indigenous chicken meat. *Journal of Bangladesh Agricultural University*, 17(4): 560–566. https://doi.org/10.3329/jbau.v17i4.44626

different meats (chicken, beef, chevon and mutton) to evaluate the quality and shelf life in Bangladesh. Therefore, the study was carried out to determine the effect of gamma irradiation on sensory, proximate, biochemical and microbial qualities of chicken meat to increase the shelf life and the quality of indigenous chicken meat.

Materials and Methods

Sample collection and processing

The study was conducted in 2017 in the Department of Animal Science, Bangladesh Agricultural University, Mymensingh. About 3.5 kg of fresh indigenous chicken meat samples from four birds at the age of 12-18 month (on the basis of seller interview) were collected from local market of Mymensingh. The treatment time of sample was 24 hours after slaughtered.

The samples were divided into four treatment groups. Each group was exposed to the irradiation dose of 0 (T0), 1 (T1), 2 (T2) and 3 kGy (T3)) at the Bangladesh Institute of Nuclear Agriculture. Meat sample was irradiated at Cobalt 60 GC-5000 (BRIT, India) machine; whose central dose rate was 4.29 kGy /hr. Time had taken for each group of sample was 14 min, 28 min and 35 min 55sec which was treated with 1.00, 2.00, and 3.00 kGy, respectively.

Proximate components

Dry Matter (DM), Ash, Crude protein (CP), Ether extract (EE) was determined as per the standard procedures of Association of Official Analytical Chemists (AOAC, 1995). All determination was done in triplicate and the mean value was reported. The proximate determination was conducted to know the nutrient composition of chicken meat changed with irradiation.

Sensory evaluation

Sensory evaluation was executed by a trained 6-member panel (color, flavor, tenderness, juiciness and overall acceptability). Prior to sample evaluation, all panelists participated in orientation sessions to familiarize with the scale attributes (color, smell, juiciness, tenderness, and overall acceptability) of indigenous chicken meat using an intensity scale. Each sample was evaluated by using a 9-point hedonic scale (9 = like extremely, 8 = like very much, 7 = like moderately, 6 = like slightly, 5 = neither like nor dislike, 4 = dislike slightly, 3 = dislike moderately, 2 = dislike very much and 1 = dislike extremely) (Pena *et al*., 2016). Sensory evaluation was accomplished at 0 days and repeated at 30 and 60 days, respectively.

Physicochemical and bio-chemical assessment

pH value of raw meat and cooking loss was measured using pH meter (Hanna HI99163) from raw meat homogenate. The homogenate was prepared by blending 5 g of meat with 10 ml distilled water. FFA value, POV value and TBARS value were determined by (Sharma *et al*, 2012). All determination was done in triplicate and mean value was reported.

Microbial assessment

Ten grams of sample were aseptically homogenized after adding 90 ml of sterile solution in a sterile Stomacher bag for 2 min (BagMixer® 400, Interscience, France). Consequently the diluents were planted onto aerobic plated count agar (Difco Laboratories), incubated at 37^0c for 45 h. The total number of colonies observed on plate of each sample after incubation was counted and expressed as log of colony forming units per gram (Log CFU/g).

Statistical model and analysis

The proposed model for the planned experiment was a factorial experiment with two factors-A (Treatments) and B (Days of Intervals) is:

$yijk = \mu + Ai + Bj + (AB)ij + åijk$ i = 1,…,A; j = 1,…,B; k = 1,…,n

Where: yijk = observation k in level i of factor A and level j of factor B

μ = the overall mean

Ai = the effect of level i of factor A

Bj = the effect of level j of factor B

Data were statistically analyzed using SAS Statistical Discovery Software (2002-2003), NC, USA. DMRT test was used to determine the significance of differences among treatment means.

Results and Discussion

Sensory evaluation

Color, flavor, tenderness, juiciness and overall acceptability score at different treatment was 5.33 to 6.33, 6.33 to 5.44, 5.55 to 6.17, 5.88 to 6.22 and 4.55 to 5.16, respectively (Table 1). Color was significantly ($p<0.05$) increased with the increasing level of treatments but significantly decreased color of meat with longer storage time. The range values for three observations of different days of intervals for the color, flavor, tenderness, juiciness and overall acceptability score were 6.58 to 5.33, 6.33 to 5.16, 6.75 to 5.08, 6.66 to 5.16 and 5.50 to 4.33, respectively. Kim *et al*. (2002) also found that the development of red color in irradiated meat was due to the production of gas, especially CO. Contradictory reports were found by Souza *et al*. (2007) who investigated the influence of radiation on the levels of iron and color of pigments of thighs and chicken

breast meat irradiated at doses 0, 1 and 2.0 kGy and found that color was not influenced by those doses. The present findings also were not in agreement with Al-Bachir *et al*. (2010) who found that color of chicken kabab product were not influenced by the irradiation treatment. It may be due to species difference. Flavor, tenderness, juiciness and overall acceptability were significantly decreased with increasing days of interval. Kanatt *et al*. (2015) found that in chicken, lamb and buffalo meat tenderization is increased with dose-dependent manner. The lowest test score of juiciness was reduced to 5.16 in all treatments after 60 days of storage. Juiciness influenced by the cut of meat and how long the meat is cooked. Among all treatment groups except flavor higher dose 3 kGy showed higher value due to higher lipid oxidation of chicken meat. There was no interaction between treatment and days of interval among all treatments for all variables.

Table 1. Sensory-attributes (mean ± SE) in irradiated indigenous chicken meat samples compared at different storage period

Parameters	DI	Treatments (T)				Mean ± SE	Level of significance		
		T_0	T_1	T_2	T_3		T	DI	T*DI
Colour	0	6.33 ± 0.58	6.33 ± 0.33	6.67 ± 0.33	7.00 ± 0.00	6.58^{a} ± 0.31	0.0020	<.0001	0.4481
	30	5.33 ± 0.33	6.33 ± 0.33	6.67 ± 0.33	6.33 ± 0.33	6.17^{a} ± 0.33			
	60	4.33 ± 0.33	5.66 ± 0.33	5.67 ± 0.33	5.66 ± 0.33	5.33^{b} ± 0.33			
	Mean	5.33^{b} ± 0.41	6.11^{a} ± 0.33	6.33^{a} ± 0.33	6.33^{a} ± 0.22				
Flavour	0	6.66 ± 0.33	6.33 ± 0.33	6.33 ± 0.33	6.00 ± 0.57	6.33^{a} ± 0.39	0.1724	0.0125	0.9595
	30	6.33 ± 0.33	6.00 ± 0.57	5.33 ± 0.33	5.66 ± 0.67	5.83^{ab} ± 0.48			
	60	6.00 ± 0.58	5.00 ± 0.57	5.00 ± 0.57	4.67 ± 0.67	5.16^{b} ± 0.60			
	Mean	6.33^{a} ± 0.41	5.77^{a} ± 0.49	5.55^{a} ± 0.41	5.44^{a} ± 0.64				
Tenderness	0	6.67 ± 0.33	6.67 ± 0.33	6.66 ± 0.33	7.00 ± 0.00	6.75^{a} ± 0.25	0.1674	<.0001	0.9282
	30	5.33 ± 0.33	6.00 ± 0.00	6.00 ± 0.00	6.17 ± 0.44	5.87^{b} ± 0.19			
	60	4.66 ± 0.33	5.33 ± 0.33	5.00 ± 0.58	5.33 ± 0.33	5.08^{c} ± 0.39			
	Mean	5.55^{b} ± 0.33	6.00^{ab}±0.22	5.89^{ab} ± 0.30	6.17^{a} ± 0.26				
Juiciness	0	6.33 ± 0.33	6.67 ± 0.33	6.66 ± 0.33	7.00 ± 0.00	6.66^{a} ± 0.25	0.0656	<.0001	0.3564
	30	5.66 ± 0.67	5.33 ± 0.33	6.33 ± 0.33	6.33 ± 0.33	5.92^{b} ± 0.42			
	60	5.66 ± 0.33	4.33 ± 0.33	5.33 ± 0.33	5.33 ± 0.33	5.16^{c} ± 0.33			
	Mean	5.88^{ab}± 0.44	5.44^{b} ± 0.33	6.11^{a} ± 0.33	6.22^{a} ± 0.22				
Overall acceptability	0	5.33 ± 0.33	5.33 ± 0.67	5.66 ± 0.33	5.67 ± 0.33	5.50^{a} ± 0.42	0.2357	0.0018	0.9663
	30	4.33 ± 0.33	4.67 ± 0.33	5.33 ± 0.33	5.17 ± 0.44	4.87^{b} ± 0.36			
	60	4.00 ± 0.57	4.33 ± 0.33	4.33 ± 0.33	4.67 ± 0.33	4.33^{b} ± 0.39			
	Mean	4.55^{a} ± 0.41	4.77^{a} ±0.44	5.11^{a} ±0.33	5.16^{a} ±0.37				

Mean values with different superscript in same row for the treatment and in same column for the days interval varies significantly at $p < 0.05$. T_0=Control group, T_1= 1 KGy irradiated group, T_2= 2 KGy irradiated group T_3= 3 KGy irradiated group, DI=Days of Intervals, T= Treatment, T*DI=Interaction of Treatment and Days of Intervals.

Proximate analysis

From Table 2 DM, CP, EE and Ash content at different treatments were found 28.66 to 31.31, 22.84 to 22.90, 1.28 to 2.65 and 1.32 to 1.09 %, respectively. The range of different days of interval DM, CP, EE and Ash content were found 28.69 to 31.68, 24.41 to 21.09, 2.66 to 1.73 and 1.12 to 1.30, respectively. The result showed that increasing irradiation dose increased the DM content significantly ($p<0.05$) as a result the shelf life of meat increased. DM content also increased with storage time. Similar results also found by Al-Bachir and Zeinou (2014), Konieczny *et al*. (2007) and Fallah *et al*. (2010). Nitrogen content in turkey meat is significantly ($p<0.05$) increased with irradiation doses. Storage period also significantly ($p<0.05$) decreased of CP content. Irradiated treated samples had significantly ($p<0.05$) higher amounts of EE in comparable with the control group. This trend was similar to the study revealed by Al-Bachir and Zeinou (2014). EE was significantly increased with increasing level of treatment but decreased with storage time. Ash was significantly decreased with increasing level of treatment but increased with storage period. Similar results also found (Al-Bachir and Zeinou, 2014) that Ash content of meat decreased with increasing irradiation dose. There was positive and significant interaction between treatments and days of interval for DM and EE (Table 2).

Physicochemical and biochemical properties

Raw pH

From Table 3 shows the range of different treatments of pH and cooking loss score was 6.00 to 5.97 and, 20.07 to 24.98%. The rage of different days of interval pH and cooking loss score was 6.41 to 5.69 and 23.47 to 22.31%, respectively. The pH value slightly decreased with increasing irradiation doses. The effect of irradiation decreased raw pH values in the irradiated samples in comparable with controlled (Table 3). The data showed a slight decrease in the raw pH values and increased acidity values for all samples along with storage time during the 60 days of storage as a result of the increase of free fatty acids due to rancidity. A similar result also found by (Aftab *et al*., 2015) in irradiated broiler meat, pH was slightly decreased as the dose increased with the storage time. No statistically significant differences were found of pH in non-

irradiated and irradiated group. Only control group apparently showed slightly higher of pH level. The present findings were more similar with Kim *et al*. (2012) where they found that pH value of samples were not significantly influenced by irradiation. Modi *et al*. (2008) also found that the lack of change in pH reflects that there were not enough protein breakdowns by irradiation to elicit increased pH. There were statistically significant ($p<0.05$) differences of pH in storage periods. The results were in agreement with Morales-delanuez *et al*. (2009) findings who reported that the increase in fat values in irradiated samples and during storage decreased in pH values.

Table 2. Proximate composition (mean ± SE) in irradiated indigenous chicken meat samples compared at different storage period

Parameters	DI	Treatments (T)				Mean ± SE	Level of significance		
		T_0	T_1	T_2	T_3		T	DI	T*DI
DM (%)	0	27.39 ± 0.06	28.08 ± 0.06	29.16 ± 0.03	30.14 ± 0.05	28.69^{b} ± 0.05	<.0001	<.0001	0.0027
	30	28.28 ± 0.65	27.54 ± 0.19	28.60 ± 0.28	29.88 ± 0.11	28.57^{b} ± 0.30			
	60	30.32 ± 0.10	30.77 ± 0.12	31.75 ± 0.10	33.90 ± 0.12	31.68^{a} ± 0.11			
	Mean	28.66^{c} ± 0.27	28.79^{c} ± 0.12	29.84^{b} ± 0.14	31.31^{a} ± 0.09				
CP (%)	0	24.38 ± 0.11	24.41 ± 0.12	24.40 ± 0.13	24.46 ± 0.18	24.41^{a} ± 0.14	0.8540	<.0001	0.9935
	30	23.12 ± 0.02	23.10 ± 0.01	23.12 ± 0.02	23.12 ± 0.03	23.12^{b} ± 0.04			
	60	21.04 ± 0.01	21.14 ± 0.01	21.09 ± 0.05	21.13 ± 0.06	21.09^{c} ± 0.03			
	Mean	22.84^{a} ± 0.05	22.88^{a} ± 0.04	22.87^{a} ± 0.07	22.90^{a} ± 0.09				
EE (%)	0	1.09 ± 0.04	1.73 ± 0.10	1.97 ± 0.01	2.14 ± 0.05	2.66^{a} ± 0.05	<.0001	<.0001	<.0001
	30	1.27 ± 0.03	2.19 ± 0.09	2.45 ± 0.05	2.66 ± 0.08	2.14^{b} ± 0.06			
	60	1.49 ± 0.02	2.94 ± 0.04	3.07 ± 0.05	3.15 ± 0.02	1.73^{c} ± 0.03			
	Mean	1.28^{d} ± 0.03	2.29^{c} ± 0.08	2.49^{b} ± 0.04	2.65^{a} ± 0.05				
Ash (%)	0	1.23 ± 0.02	1.16 ± 0.01	1.03 ± 0.02	1.05 ± 0.02	1.12^{c} ± 0.02	<.0001	<.0001	0.1726
	30	1.31 ± 0.02	1.23 ± 0.02	1.12 ± 0.02	1.08 ± 0.03	1.18^{b} ± 0.02			
	60	1.42 ± 0.03	1.37 ± 0.01	1.26 ± 0.01	1.15 ± 0.02	1.30^{a} ± 0.01			
	Mean	1.32^{a} ± 0.02	1.25^{b} ± 0.01	1.14^{c} ± 0.02	1.09^{d} ± 0.02				

Mean values with different superscript in same row for the treatment and in same column for the days interval varies significantly at $p < 0.05$. T_0=Control group, T_1= 1 KGy irradiated group, T_2= 2 KGy irradiated group T_3= 3 KGy irradiated group, DI=Days of Intervals, T= Treatment, T*DI=Interaction of Treatment and Days of Intervals.

Table 3. Physicochemical and bio-chemical properties (mean ± SE) in irradiated indigenous chicken meat samples compared at different storage period

Parameters	DI	Treatments (T)				Mean ± SE	Level of significance		
		T_0	T_1	T_2	T_3		T	DI	T*DI
pH	0	6.26 ± 0.16	6.42 ± 0.01	6.46 ± 0.01	6.52 ± 0.02	6.41^{a} ± 0.05	0.8594	<.0001	0.0061
	30	5.97 ± 0.09	5.80 ± 0.01	5.79 ± 0.01	5.77 ± 0.01	5.83^{b} ± 0.03			
	60	5.78 ± 0.03	5.67 ± 0.01	5.67 ± 0.01	5.62 ± 0.01	5.69^{c} ± 0.01			
	Mean	6.00^{a} ± 0.18	5.97^{a} ± 0.01	5.97^{a} ± 0.01	5.97^{a} ± 0.01				
Cooking Loss (%)	0	21.16 ± 0.53	23.55 ± 0.02	24.32 ± 0.05	24.87 ± 0.04	23.47^{a} ± 0.16	<.0001	<.0001	0.0014
	30	20.16 ± 0.47	22.70 ± 0.13	23.54 ± 0.07	25.06 ± 0.05	22.86^{b} ± 0.18			
	60	18.90 ± 0.26	22.48 ± 0.05	22.84 ± 0.06	25.01 ± 0.02	22.31^{c} ± 0.10			
	Mean	20.07^{d} ± 0.42	22.91^{c} ± 0.07	23.57^{b} ± 0.06	24.98^{a} ± 0.04				
FFA (%)	0	0.33 ± 0.03	0.43 ± 0.03	0.49 ± 0.01	0.56 ± 0.02	0.45^{c} ± 0.03	<.0001	<.0001	<.0001
	30	0.79 ± 0.06	0.81 ± 0.01	0.87 ± 0.01	0.87 ± 0.02	0.84^{b} ± 0.03			
	60	0.87 ± 0.04	0.87 ± 0.02	1.51± 0.03	2.11 ± 0.02	1.34^{a} ± 0.03			
	Mean	0.67^{c} ± 0.04	0.70^{c} ± 0.02	0.96^{b} ± 0.02	1.18^{a} ± 0.02				
POV (meq/kg)	0	0.83 ± 0.02	0.83 ± 0.01	0.89 ± 0.02	1.30 ± 0.02	0.96^{c} ± 0.02	<.0001	<.0001	0.0347
	30	0.88 ± 0.01	1.01 ± 0.02	1.06 ± 0.01	1.50 ± 0.01	1.11^{b} ± 0.01			
	60	1.07 ± 0.08	1.04 ± 0.01	1.06 ± 0.01	1.52 ± 0.01	1.17^{a} ± 0.03			
	Mean	0.93^{c} ± 0.03	0.96^{bc} ± 0.01	1.01^{b} ± 0.01	1.44^{a} ± 0.01				
TBARS (mg-MDA/kg)	0	0.06 ± 0.01	0.16 ± 0.01	0.19 ± 0.01	0.26 ± 0.01	0.17^{c} ± 0.01	<.0001	<.0001	<.0001
	30	0.18 ± 0.01	0.41 ± 0.01	0.50 ± 0.02	0.62 ±0.02	0.43^{b} ± 0.02			
	60	0.21 ± 0.01	0.57 ± 0.01	0.86 ± 0.03	1.14 ± 0.02	0.69^{a} ± 0.02			
	Mean	0.15^{d} ± 0.01	0.38^{c} ± 0.01	0.52^{b} ± 0.02	0.67^{a} ± 0.02				

Mean values with different superscript in same row for the treatment and in same column for the days interval varies significantly at $p < 0.05$. T_0=Control group, T_1= 1 KGy irradiated group, T_2= 2 KGy irradiated group T_3= 3 KGy irradiated group, DI=Days of Intervals, T= Treatment, T*DI=Interaction of Treatment and Days of Intervals

Statistically significant ($p<0.05$) changes were found of cooking loss in non-irradiated and irradiated groups. Cooking loss was gradually increased with increasing irradiation dose. Irradiation, as well as storage time decreased muscle fiber that was the cause of increased cooking losses. Increase in cooking loss of irradiated meat samples could be due to the degradation of myofibrillar and structural proteins were found by

Sweetie *et al*. (2015) in irradiated meat samples which are similar with the present study.

Biochemical properties

Table 3 shows the range of different treatments for FFA, PV and TBARS were 0.67 to 1.18, 0.93 to 1.14, and 0.15 to 0.67%, respectively. The range values of different days of intervals for FFA, POV and TBARS were 0.45 to 0.1.34, 0.96 to 1.17 and 0.17 to 0.69%. FFA value was significantly ($p< 0.05$) increased with irradiation level as well as longer storage time. Similarly Quattara *et al*. (2002) showed that gamma irradiation increased lipid oxidation in ground beef samples. In general terms, irradiation accelerates the lipid oxidation process, which is highly significant in foods with a high content of fats and much unsaturated fatty acids, in which numerous free radicals are formed due to this oxidation (O'Bryan *et al*., 2008).

POV value was significantly ($p<0.05$) increased with irradiation level as well as with storage time. Chengliang *et al*. (2017) and Al-Bachir and Zeinou (2009) reported that an increase in oxidation activity and lipid per oxidation as a result of both radiation level of treatment and storage time on meat and meat products which was similar with the present findings. TBARS value was significantly ($p<0.05$) increased with irradiation level of as well as with storage time. Kim *et al*. (2012) found that TBARs increased significantly with storage time which is in agreement with the present study. There was positive and significant interaction between treatments and days of intervals among all treatments for all biochemical parameters (Table 3).

Microbiological assessment

From Table 4 shows the range of TVC, TCC and TYMC among different treatments was 4.81 to 3.22, 1.66 to 0.75 and1.75 to 0.74, respectively. The range of TVC, TCC and TYMC among different days interval was 3.81 to 4.26, 1.10 to 1.32 and 0.94 to 1.28, respectively. The results clearly showed that TVC was decreased significantly ($p<0.05$) with higher irradiation doses among all treatments group but decreased with storage period (Table 4). T_3 showed significantly lower bacteria than other treatments group. Similar results were found by Henriques *et al*. (2013). The low radiation doses can be efficiently used to control pathogens in chicken meat which is in accordance with Torgby *et al*. (2014). The present results clearly showed that TCC was decreased significantly ($p<0.05$) with higher irradiation doses among all treatments group and also increased with storage period. Similarly, Marta *et al*. (2016) found that cobalt-60 gamma irradiation process was effective in eliminating *E. coli* and found that lowest dose is enough to abolish this enter pathogen from the evaluated samples. Vereschako *et al*. (2016) proved that reduction in E. coli concentration has a linear relationship by the radiation doses. Non-irradiated group showed higher level of TYMC than irradiated groups.

The results clearly showed that TYMC was decreased significantly ($p<0.05$) with higher irradiation doses among all treatments group. During radiation, DNA molecules undergo swelling and break alongside the chain, preventing them from functioning normally. Fallah *et al*. (2010b) reported that the low doses irradiation reduced the initial counts of TYMC, while high doses were found below the detection levels of TYMC during 6 days of storage. There was positive and significant interaction between treatments and days of interval for TVC and TYMC (Table 4). Irradiation significantly improved the microbiological quality of aerobically packaged ready–to-cook (RTC). Iranian barbecued chicken by reducing the microbial floras without undesirable and detrimental effects on the sensory acceptability (Fallah *et al*., 2010b) which is in accordance with the present study except flavor.

Table 4. Effect of different doses of irradiation on microbial population (mean ± SE) of indigenous chicken meat samples compared at different storage period

Parameters	DI	Treatments (T)				Mean ± SE	Level of significance		
		T_0	T_1	T_2	T_3		T	DI	T*DI
TVC (log CFU/g)	0	4.61 ± 0.16	3.88 ± 0.02	3.68 ± 0.04	3.08 ± 0.05	3.81^{b} ± 0.07	<.0001	<.0001	<.0001
	30	4.78 ± 0.11	3.67 ± 0.06	3.02 ± 0.01	3.03 ± 0.01	3.62^{c} ± 0.05			
	60	5.02 ± 0.01	4.63 ± 0.03	3.83 ± 0.08	3.58 ± 0.04	4.26^{a} ± 0.04			
	Mean	4.81^{a} ± 0.09	4.06^{b} ± 0.04	3.51^{c} ± 0.04	3.22^{d} ± 0.03				
TCC (log CFU/g)	0	1.56 ± 0.05	0.99 ± 0.01	0.88 ± 0.02	0.58 ± 0.03	1.01^{c} ± 0.03	<.0001	<.0001	0.2241
	30	1.63 ± 0.04	1.07 ± 0.03	0.97 ± 0.01	0.71 ± 0.04	1.09^{b} ± 0.03			
	60	1.79 ± 0.03	1.27 ± 0.03	1.25 ± 0.01	0.97 ± 0.04	1.32^{a} ± 0.03			
	Mean	1.66^{a} ± 0.04	1.11^{b} ± 0.02	1.03^{c} ± 0.01	0.75^{d} ± 0.04				
TYMC (log CFU/g)	0	1.63 ± 0.03	0.91 ± 0.01	0.62 ± 0.04	0.60 ± 0.01	0.94^{c} ± 0.03	<.0001	<.0001	0.0153
	30	1.74 ± 0.03	0.97 ± 0.02	0.79 ± 0.01	0.68 ± 0.02	1.04^{b} ± 0.02			
	60	1.88 ± 0.02	1.27 ± 0.03	1.00 ± 0.01	0.95 ± 0.02	1.28^{a} ± 0.02			
	Mean	1.75^{a} ± 0.03	1.05^{b} ± 0.02	0.80^{c} ± 0.02	0.74^{d} ± 0.03				

Mean values with different superscript in same row for the treatment and in same column for the days interval varies significantly at $p < 0.05$.
T_0=Control group, T_1= 1 KGy irradiated group, T_2= 2 KGy irradiated group T_3= 3 KGy irradiated group, DI=Days of Intervals, T= Treatment, T*DI=Interaction of Treatment and Days of Intervals.

Conclusion

The study revealed that gamma irradiation had significant effect on indigenous chicken meat quality and safety. Among the treatments, irradiation dose 2.0 kGy showed the best results in terms of sensory evaluation, biochemical analysis and microbial assessment and the shelf life extension of indigenous chicken meat. It may be concluded that gamma irradiation will enable to deliver the larger amount of high quality indigenous chicken meat with extended shelf life.

References

AOAC. 1995. Official method of analysis. 16th Edition. Association of Official Analytical Chemists, Washington, D.C. USA.

Aftab, M., Rafaqat, I., Saleem, F., Aftab, B., Abdullah, R., Iqtedar, M., Kaleem, A., Iftikhar, T. and Naz, S. 2015. Enhancement of shelf life and wholesomeness of goat meat by gamma irradiation treatments. International Journal of Bioscience. 7(4): 177–185.

Al-Bachir, M. and Zeinou, R. 2009. Effect of gamma irradiation on microbial load and quality characteristics of minced camel meat. Meat Science. 82: 119–124. https://doi.org/10.1016/j.meatsci.2008.12.012

Al-Bachir, M., Farah, S. and Othman, Y. 2010. Influence of gamma irradiation and storage on the microbial load, chemical and sensory quality of chicken kabab. Radiation Physics and Chemistry. 79: 900–905. https://doi.org/10.1016/j.radphyschem.2010.02.010

Al-Bachir, M. and Zeinou, R. 2014. Effects of gamma irradiation on the microbial load, chemical and sensory properties of goat meat. Acta Alimentaria. 43(2): 264–272. https://doi.org/10.1556/AAlim.43.2014.2.10

Artes, F., Gomez, P. and Hernandez, F. 2007. Physiological and microbial deterioration of minimally fresh processed fruits and vegetables. International Food Science and Technology. 13: 177–188. https://doi.org/10.1177/1082013207079610

Choi, J.H., Kim, I., Jueong, J.Y., Lee, E.S., Choi, Y.S., Kim, C.J. 2009. Effect of carcass processing method and curing condition on quality characteristics of ground chicken breasts. Korean Journal of food science, 29: 356–363. https://doi.org/10.5851/kosfa.2009.29.3.356

Chengliang, L., Lichao, H., Guofeng, J., Sumin, M., Wenmin, W. and Lan, G. 2017. Effects of different irradiation doses treatment on the lipid oxidation, instrumental color and volatiles of fresh pork and their changes during storage. Meat Science. 43(3): 227–232. https://doi.org/10.1016/j.radphyschem.2010.04.015

DLS. 2018. Livestock Economy Report, Department of Livestock Services, Bangladesh.

Eustice, R. F. and Bruhn, C. M . 2013. Consumer acceptance and marketing of irradiated foods. Center for consumer's research, Department of Food Science and Technology. 173–195. https://doi.org/10.1002/9781118422557.ch10

Fallah, A. A., Tajik, H. and Farshid, A. A. 2010a. Chemical quality, sensory attributes and ultra structural changes of gamma irradiated camel meat. Journal of Muscle Foods. 21: 597–613. https://doi.org/10.1111/j.1745-4573.2009.00207.x

Fallah, A.A., Saei- Dehkordi,S.S. and Rahnama, M. 2010b. Enhancement of microbial quality and inactivation of pathogenic bacteria by gamma irradiation of ready-to-cook Iranian barbecued chicken. Radiation Physics and Chemistry. 79(10): 1073–1078. https://doi.org/10.1016/j.radphyschem.2010.04.015

Farkas, J. Mozumder, A. and Hatano, Y. 2004. Charged particle and photon interactions with matter, In: Food Irradiation, Marcel Dekker New York 785–812. https://doi.org/10.1201/9780203913284

Hocquette, J. F., Botreau, R., Picard, B., Jacquet, A., Pethick, D. W. and Scollan, N. D. 2012. Opportunities for predicting and manipulating beef quality. Meat Science. 92(3): 197–209. https://doi.org/10.1016/j.meatsci.2012.04.007

Henriques, L. S. V., Henry, .F. C., Laderia, S. A. and Antonio, I. M. S. 2013. Elimination of coliforms and Salmonella spp. in sheep meat by gamma irradiation treatment. *Brazilian Journal of Microbiology*. 44(4): 1147–1153. https://doi.org/10.1590/S1517-83822014005000003

Kanatt, S. R., Chawla, S.P., Sharma, Arun. 2015. Effects of radiation processing on meat tenderization. Radiation Physics and Chemistry. 111: 1-8. https://doi.org/10.1016/j.radphyschem.2015.02.004

Kim, Y. H., Nam, K. C. and Ahn, D. U. 2002. Color, Oxidation, Reduction Potential and Gas Production of Irradiated Meats from Different Animal Species. *Journal of Food Science*. 67 (5): 257–265. https://doi.org/10.1111/j.1365-2621.2002.tb08707.x

Kim, I.S., Jin, S.K., Kang, S.N., Hur, I.C., Choi, S.Y. 2009. Effects of olive-oil prepared tomato powder (OPTP) and refining lycopene on the physicochemical and sensory characteristics of seasoned raw pork during storage. *Korean Journal of Food Science*, 29: 329–334. https://doi.org/10.5851/kosfa.2009.29.3.334

Kim, I. S., Jo, C., Lee ,K. H., Lee, E.J., Ahn, D. U. and Kang, S. N. 2012. Effect of low level gamma irradiation on characteristics of fermented pork sausage during storage. Radiation Physics and Chemistry. 81: 466–472. https://doi.org/10.1016/j.radphyschem.2011.12.037

Konieczny, P., Stangierski, J. and Kijowski, J. 2007. Physical and chemical characteristics and acceptability of home style beef jerky. Meat Science. 76 (2): 253–257. https://doi.org/10.1016/j.meatsci.2006.11.006

Marta, M. X., Robson, M. F., Mauro, C. L. and Wagner, T. C. 2016. Effects of gamma irradiation (Co^{60}) in control of Enterococci spp. and Escherichia coli in chilled chicken (Gallus gallus) heart. *Journal of Bio-energy and Food Science*. 3(3): 124–129. https://doi.org/10.18067/jbfs.v3i3.116

Modi, V. K., Sakhare, P.Z., Sachindra, N. M. and Mahendrakar, N. S. 2008. Change in quality of minced meat from goat due to gamma irradiation. Journal of Muscle foods. 19: 430–442. https://doi.org/10.1111/j.1745-4573.2008.00128.x

Morales, D. A., Moreno-Indias, I., Falcon, A., Arguello, A., Sanchez-Macias, D., Capote, J. and Castro, N. 2009. Effect of various packaging systems on the quality characteristic of goat meat. *Asian-Australasian Journal of Animal Sciences*. 22(3): 428–432. https://doi.org/10.5713/ajas.2009.80488

Nam, K. C., and Ahn, D.U. 2002. Carbon monoxide-heme pigment is responsible for the pink color in irradiated raw turkey breast meat. Meat Science. 60:25–33. https://doi.org/10.1016/S0309-1740(01)00101-2

O'Bryan, C. A., Crandall, P. G., Ricke, S. C. and Olson, D. G. 2008. Impact of irradiation on the safety and quality of poultry and meat products: A review. Critical reviews in Food Science and Nutrition. 48: 442-457. https://doi.org/10.1080/10408390701425698

Pena, M. R. l., Nunez-Serrano, J. A., Torrion, J. and Velaquez, F. J. 2016. Are innovations relevant for consumers in the hospitality industry? A hedonic approach for Cuban hotels. *Tourism Management*. 55: 184–196. https://doi.org/10.1016/j.tourman.2016.02.009

Quattara, B., Giroux, G., Myefsah, R., Smoragiewicz, W., Saucier, L. and Borsa, J. 2002. Microbiological and biochemical characteristics of ground beef as affected by gamma irradiation, food additives and edible coating film. Radiation Physics and Chemistry. 63: 299–304. https://doi.org/10.1016/S0969-806X(01)00516-3

Souza, A. R. M., Arthur, V. and Canniatti-Brazaca, S. G. 2007. Alterações provocadas pela irradiação e armazenamento nos teores de ferro heme em carne de frango. Ciênc Tecnol

Aliment. 27 (2): 303–306. https://doi.org/10.1590/S0101-20612007000200016

Sharma, P., Jha, A.B., Dubey, R.S. and Pessarakli, M. 2012. Reactive oxygen species, oxidative damage ans antioxdative defense mechanism in plants under stressful conditions. *Journal of Botany*. 1–26. https://doi.org/10.1002/9781118482469.ch4

Sweeti, R., Kanattn , Chawla, S. P., Arun and Sharma. 2015. Effects of radiation processing on meat tenderization. *Radiation Physics and Chemistry*. 111: 1–8. https://doi.org/10.1016/j.radphyschem.2015.02.004

Torgby, T. W., Adu, G. A., Odai, B. T. and Appiah, V. 2014. Combined effect of irradiation and frozen storage on survival of viable bacteria and inoculated Escherichia coli in chicken. *Journal of Food and Nutrition Sciences*. 2(3): 53–57. https://doi.org/10.11648/j.jfns.20140203.11

Vereschako, G. G., Tshueshova, N. V., Gorokh, G. A., Kozlov, I. G. and Naumov, A. D. 2016. Effects of External Irradiation and Immobilization Stress on the Reproductive System of Male Rats. *Radiatsionnaia Biologiia, Radioecologiia*. 56: 56–63.

Wyness, L. 2013. "Nutritional aspects of red meat in the diet," in nutritional and climate Change: Major Issues confronting the Meat Industry, Wood, J. D. and Rowlings, C. Eds.,

Xiao, S., Zhang, W. G., Lee, E. J., Ma, C. W. and Ahn, D. U. 2011. Effects of diet, packaging, and irradiation on protein oxidation, lipid oxidation, and color of raw broiler thigh meat during refrigerated storage. *Poultry Science*. 90:1348–1357. https://doi.org/10.3382/ps.2010-01244