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Effect of Gamma-Radiation on Hygienic Quality, Amino Acids and Antioxidant Eenzymes in Beef Meat and Liver

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Wafaa S. Mohamed[(1)], Dalia F. Khater[(2)], Fatma M. El-Demerdash[(3)], Madeha A. Ibrahim[(1)#]

[(1)]Health Radiation Research Department, National Centre for Radiation Research and Technology (NCRRT), Atomic Energy Authority, 11762 Cairo, Egypt; [(2)]Animal Research Institute, Kafr El- Sheikh, Kafrelsheikh, Egypt; [(3)]Department of Environmental Studies, Institute of Graduate Studies and Research, Alexandria University, Alexandria, Egypt.

IN THE PRESENT study, the effect of different doses of gamma irradiation (1, 3, 5 and 7kGy) on the hygienic quality (microbial and sensory properties) as well as antioxidant parameters in beef meat and liver were investigated. The microbial reduction increases as the dose level of irradiation increases. Sensory examination revealed that there were no significant changes between irradiated and non-irradiated groups in color, odor and texture. Results showed that the changes in protein profile depended on radiation dose while the total protein content was stable. In addition, irradiation treatment reduced the activity of the antioxidant enzymes as well as glutathione content.

It could be concluded that the use of gamma irradiation in low doses improves the hygienic quality of beef meat and liver without changing its chemical parameters while oxidative stress and enzymatic and non-enzymatic antioxidants are affected in a dose-dependent manner.

It is highly recommended that gamma irradiation (3kGy) in low doses could be used to improve the hygienic quality of liver and meat.

Keywords: Beef-meat, Beef-liver, γ-rays, Sensory-evaluation, Amino-acids, Oxidative-stress, Antioxidant-enzymes.

Introduction

Irradiation has been widely used in food industry as preservation technology, and irradiated foodstuffs are approved in many countries. Nutritive values and physiochemical properties of irradiated foodstuffs could be preserved much longer than those of non-irradiated foodstuffs. Meat irradiation is recognized as a safe and effective method to attain meat preservation. The use of high-energy gamma rays or accelerated electrons to irradiate fresh meat may extend shelf-life and inhibit proliferation of pathogenic bacteria. Therefore, there have been attempts to utilize irradiation not only for food safety, but also for technological purposes. Consumers demand high quality, nutritious, fresh appearance and convenient meat with natural flavor and taste. The alteration in composition as a result of irradiation depends on the dose of irradiation, storage temperature and packaging conditions (Galati et al., 2019). Although, irradiation can provide pathogen-free raw materials, its application in meat production may be hindered by its known adverse effects on quality characteristics of fresh or processed meats resulting in the possibility of color changes, lipid oxidation and off-odor generation (Derakhshan et al., 2018).

Irradiation is known to produce a characteristic

#Corresponding author email: madyhamoda@yahoo.com
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aroma as well as alters meat flavor, changes color, and increase oxidative changes that significantly affect consumer acceptance, but when irradiation is used in combination with freezing, the irradiation doses can be reduced through synergistic action without affecting the product quality. It has been pointed out that irradiation doses ranging from 5 to 10kGy would control the growth of pathogenic and spoilage bacteria on meat and meat products (Kawasaki et al., 2019).

Antioxidant enzymes; glutathione peroxidase (GPx), superoxide dismutase (SOD), catalase (CAT) as well as numerous non-enzymatic molecules reduce glutathione (GSH), albumin, uric acid, vitamins (E, A and C) participate in protecting muscle cells of live animals and meat (Brewer, 2009). Therefore, the objective of the present study is to determine the effects of different doses of γ-rays on microbial quality, sensory characteristics, chemical composition, amino acid analysis, lipid peroxidation and enzymatic and non-enzymatic antioxidants of beef meat and liver.

Materials and Methods

Sample preparation, storage and irradiation

Beef liver and meat slices were purchased from retail markets at Cairo Governorate. Meat and liver slices were divided into 5 groups. The 1st group served as control. The other 4 groups were irradiated at 1, 3, 5 and 7kGy. Each group was packaged individually in a polyethylene bag and put in the refrigerator (5±1°C) until analysis. 5 packages for each treatment were analyzed. The irradiation process was carried out using the Russian Medical Sterilizing CM-20 Gamma cell located at the NCRRT, Nasr City, Cairo, Egypt. The source was giving a dose rate of 2.4kGy/ hour at the time of the experiment. Samples were kept cold during irradiation.

Microbiological evaluation

Ten grams of each sample were homogenized with 90ml of 1% sterile buffered peptone water for 1min using stomacher (Lab-blender 400Seward. Serial No. 30469 type BA 7021, UK) to provide dilution 10^{-1}, then tenfold decimal serial dilutions up to 10^{7} were prepared. Aerobic bacterial count was carried out on a standard plate count agar at 35°C for 48h according to Çakıcıa et al. (2015).

Amino acids determination

Dried and defatted samples were weighed in screw-capped tubes (50- 100mg) and 5ml of 6.0N HCL were added. The hydrolysis tubes were attached to a system, which allows the connection of nitrogen and vacuum lines without disturbing the sample. The tubes were placed in an oven at 110°C for 24h (Cambero et al., 2012). The tubes were then opened and the contents of each tube were filtered and evaporated until dryness in a rotary evaporator. A suitable volume of sodium citrate buffer pH 2.2 was added to dissolve the contents of each dried film of the hydrolyzed sample followed by ultrafiltration using 0.2µm membrane filter (Cheng et al., 2011). All analyses were performed using a high performance amino acid analyzer Biochrom 20 (Auto sample version) Pharmacia Biotch at the NCRRT. The data of each chromatogram was analyzed utilizing EZ Chrom™ chromatography data system tutorial and user´s Guide-version 6.7.

Sensory examination

The test was conducted to detect whether the radiation-induced changes in odor, color and texture of the irradiated samples immediately after irradiation. Non-irradiated samples were used as control. Nine panelists conducted the 5-points hedonic scale: 1= Very poor, 2= Poor, 3= Common, 4= Good, 5= Very good (Descalzo et al., 2005).

Biochemical analysis

Samples preparation for biochemical analysis

The irradiated beef meat and liver tissues and the control samples were weighed, minced and homogenized (10% w/v) separately in ice-cold 1.15% KCl-0.01mol/l sodium, potassium phosphate buffer (pH 7.4) in a Homogenizer type MNW-302, Poland. The homogenate was centrifuged at 18,000xg for 20 minutes at 4°C, and the resultant supernatants were stored at -80°C for different enzyme assays.

Enzymatic and non-enzymatic assays

Thiobarbituric acid-reactive substances (TBARS) and reduced glutathione (GSH) contents were measured in Beef meat and liver homogenate using the method of Ohkawa et al. (1979) and Ellman (1959), respectively. The glutathione peroxidase (GPx), superoxide dismutase (SOD) and catalase (CAT) activities were analyzed according to the methods described by Hafeman et al. (1974), Misra & Fridovich (1972), Sinha (1972) and Habig et al. (1974), respectively. The protein content of the liver was determined by following the method described by Lowry et al. (1951).

Statistical analysis

Whole experiment was conducted 5-times and data were analyzed according to Snecdecor & Cochran (1989). Statistical significance of the difference in values of control and treated samples was calculated by (F) test at 5% significance level. Data of the present study were statistically analyzed using Duncan's Multiple Range Test (SAS, 1986).

Results

Microbiological evaluation

The results of microbiological analysis showed that log the mean of Total Aerobic Bacterial Count (TBC) of irradiated samples at 1, 3, 5 and 7kGy were gradually decreasing with the irradiation dose (Fig. 1). At an irradiation dose of 3kGy, the colonies were not detected and all samples were maintained acceptable microbiologically.

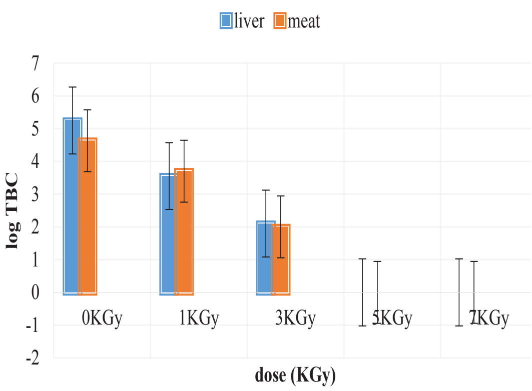

Fig. 1. Effect of irradiation dose on log mean total bacterial count in beef meat and liver.

Protein breakdown was irradiation dose-dependent. Tables 1 and 2 showed the changes in the different amino acids. The mean value of some amino acids increased with increasing the dose of irradiation e.g. Methionine and Cystine in beef meat slices and Isoleucine and Methionine in liver slices. While others decrease e.g. Proline, Alanine, Histidine and Lysine in beef meat slices and Cysteine and Leucine in liver slices, but still the content of the total amino acids was not affected by irradiation.

Sensory evaluation

Irradiation of liver and meat slices showed no significant change in color and all samples were accepted by the panelists (Fig. 2, 3 and 4).

Lipid Peroxidation and Glutathione Content

Data of TBARS measured in beef meat and liver are presented in Fig. 5. A significant increase ($P< 0.05$) in TBARS concentrations was observed in beef meat and liver exposed to different irradiation doses (0, 1, 3, 5 and 7kGy). The content of TBARS increased from an initial value of 0.57 to 0.83µg MDA /g meat and 0.83 to 1.19µg MDA /g liver after irradiation at a dose of 7kGy, respectively.

In the present study, a significant dose-dependent decrease ($P< 0.05$) was observed in GSH-content of beef meat and liver exposed to irradiation doses as compared to the control tissues (Fig. 6). The percentage of the decrease in GSH-content were 16.5, 26, 28 and 34% in beef meet and 10, 21, 27, 38% in beef liver, respectively.

Antioxidant enzyme activities

Data concerning the antioxidant enzyme activities in beef meat and liver are presented in Fig. 7-10. A significant reduction ($P< 0.05$) in the activity of the measured antioxidant enzymes (SOD, CAT, GPx and GST) associated with the increase in irradiation dose was observed.

Discussion

Microbiological evaluation

The results of microbiological analysis showed that log the mean TBC of irradiated samples at 1, 3, 5 and 7kGy were gradually decreased with the irradiation dose and were lower than the controls (Fig. 1). After irradiation at 3 kGy, all samples maintained acceptable total bacterial count. Similar findings were also reported by Park & Ha (2019). The irradiated groups remained within the permissible limits ($\geq 10^6$) approved by the Egyptian Organization for Standardization (EOS-1972/2005, 2005).

Amino acid determination

The change in the content of different amino acids could be overcome by decreasing the temperature of the product during irradiation. Most chemical changes in irradiated meat are associated with free radical reactions, and the resultant sulfur compounds could be controlled by using appropriate packaging methods (Derakhshan et al., 2018).

TABLE 1. The changes in the different amino acids of irradiated beef meat slices

Peak No.	Amino acid	Concentration (mg/g)				
		Control	1kGy	3kGy	5kGy	7kGy
1	Aspartic	5.6 ± 1.1a	5.9 ± 1.2a	5.5 ± 1.1a	5.6 ± 1.1a	5.5 ± 0.9a
2	Threonine	5.6 ± 0.6a	5.8 ± 0.7a	5.3 ± 0.4a	5.8 ± 0.5a	5.6 ± 0.6a
3	Serine	4.6 ± 1.2a	4.6 ± 1.1a	5.3 ± 1.8a	4.6 ± 0.8a	4.5 ± 0.9a
4	Glutamic	6.7 ± 1.1a	6.4 ± 1.2a	8.7 ± 2.1a	6.9 ± 0.8a	6.3 ± 0.7a
5	Proline	1.2 ± 0.4a	1.5 ± 0.8b	1.0 ± 0.1b	0.2 ± 0.05b	0.3 ± 0.04b
6	Glycine	4.1 ± 0.8a	4.2 ± 0.9a	4.8 ± 1.1a	4.1 ± 0.8a	4.4 ± 1.2a
7	Alanine	4.4 ± 0.8a	3.5 ± 0.8a	3.0 ± 0.2a	3.5 ± 0.7a	3.7 ± 0.1a
8	Cystine	1.4 ± 0.4a	2.0 ± 0.3b	6.7 ± 2.5b	3.4 ± 1.3b	2.6 ±1.1b
9	Valine	5.1 ± 0.4a	5.1 ± 0.3a	5.3 ± 0.5a	4.9 ± 0.1a	5.2 ± 0.4a
10	Methionine	3.3 ± 0.5a	4.9 ± 0.2b	4.1 ± 0.2b	4.0 ± 0.2b	3.5 ± 0.1b
11	Isoleucine	6.0 ± 0.5a	6.1 ± 0.6a	6.6 ± 1.1a	6.4 ± 0.9a	6.5 ± 1.0a
12	Leucine	20.9 ± 1.9a	20.5± 1.5a	18.9 ± 0.5a	19.4 ± 0.6a	20.6 ± 1.5a
13	Tyrosine	4.9 ± 0.2a	5.0 ± 03a	5.3 ± 0.6a	5.1 ± 0.5a	5.2 ± 0.4a
14	Phenylalanine	5.8 ± 0.6a	5.7 ± 0.5a	5.9 ± 0.8a	6.0 ± 0.7a	6.4 ± 1.1a
15	Histidine	6.6 ± 0.3a	4.2 ± 0.2b	3.4 ± 0.1b	3.3 ± 0.1b	3.0 ± 0.1b
16	Lysine	11.1 ± 0.1b	9.7 ± 0.2b	9.4 ± 0.1b	9.1 ± 0.2b	9.0 ± 0.2b
17	Arginine	5.9 ± 0.3a	6.1 ± 0.5a	6.2 ± 0.6a	6.3 ± 0.7a	6.2 ± 0.8a

Means ± S.D.

a,b Different superscript letters indicate significant differences between control and irradiated samples at P<0.05.

TABLE 2. The changes in the different amino acids of irradiated beef liver slices

Peak No.	Amino acid	Concentration (mg/g)				
		Control	1kGy	3kGy	5kGy	7kGy
1	Aspartic	5.1 ± 0.1a	5.2 ± 0.2a	5.3 ± 0.1a	4.9 ± 0.1a	5.3 ± 0.2a
2	Threonine	5.2 ± 0.2a	4.8 ± 0.1a	4.9 ± 0.3a	4.8 ± 0.2a	4.8 ± 0.1a
3	Serine	5.4 ± 0.2a	5.4 ± 0.2a	5.0 ± 0.1a	5.6 ± 0.4a	5.3 ± 0.2a
4	Glutamic	6.7 ± 1.2a	6.7 ± 1.2a	6.4 ± 0.9a	6.3 ± 0.8a	6.4 ± 0.9a
5	Proline	1.1 ± 0.1a	1.2 ± 0.2a	1.3 ± 0.3a	1.2 ± 0.2a	0.9 ± 0.1a
6	Glycine	3.9 ± 0.2a	3.8 ± 0.1a	4.0 ± 0.3a	3.9 ± 0.2a	3.8 ± 0.1a
7	Alanine	4.7 ± 0.1a	4.8 ± 0.2a	4.9 ± 0.3a	4.9 ± 0.3a	4.7 ± 0.1a
8	Cystine	7.9 ± 0.1a	5.5 ± 0.1b	5.4 ± 0.2b	5.3 ± 0.2b	5.1± 0.3b
9	Valine	5. 2 ± 0.6a	4.8 ± 0.3a	5.2 ± 0.5a	5.4 ± 0.9a	4.8 ± 0.4a
10	Methionine	1.3 ± 0.2a	2.2 ± 0.1b	3.5 ± 0.2b	4.1 ± 0.3b	6.2 ± 1.1b
11	Isoleucine	3.5 ± 0.1a	4.6 ± 0.2b	5.3 ± 0.4b	6.2 ± 0.8b	8.4 ± 1.3b
12	Leucine	26.1 ± 0.3a	22.6 ± 0.5b	20.1 ±0.2b	19.4 ± 0.1b	16.6 ± 0.1b
13	Tyrosine	2.3 ± 0.3a	2.9 ± 0.6a	3.0 ± 0.8a	2.6 ± 0.5a	3.3 ± 1.1a
14	Phenylalanine	4.6 ± 0.2a	5.3 ± 0.9a	6.3 ± 1.6a	5.0 ± 0.7a	5.9 ± 1.4a
15	Histidine	9.4 ± 0.6a	9.3 ± 0.4a	8.7 ± 0.1a	8.8 ± 0.1a	9.1 ± 0.4a
16	Lysine	9.6 ± 1.1a	10.8 ± 2.3a	8.6 ± 0.1a	9.5 ± 0.9a	8.5 ± 0.1a
17	Arginine	4.8 ± 0.1a	4.6 ± 0.8a	4.2 ± 0.4a	4.9 ± 1.1a	5.0 ± 1.4a

- Means ± S.D.
- a,b Different superscript letters indicate significant differences between control and irradiated samples at P<0.05.

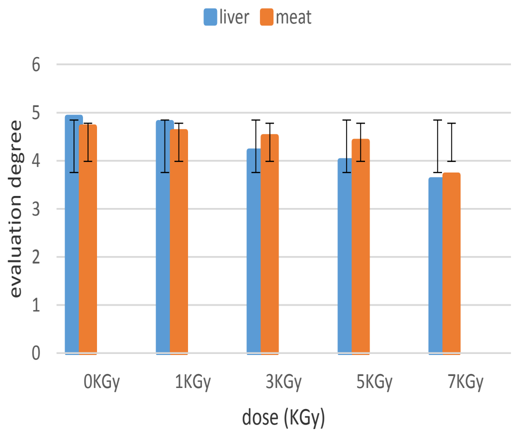

Fig. 2. Effect of irradiation dose on the texture of beef liver and meat [1= Very poor, 2= Poor, 3= Common. 4= Good and 5= Very good].

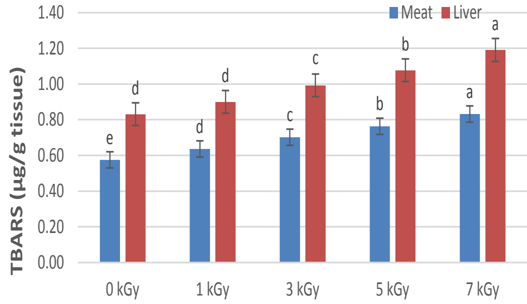

Fig. 5. Effect of different gamma irradiation doses on the level of thiobarbituric acid reactive substances (TBARS) in beef meat and liver [Values are expressed as means ± S.E.M.; n= 5 for each treatment group. Mean values not sharing common letters (a, b, c, d) were significantly different (P<0.05)].

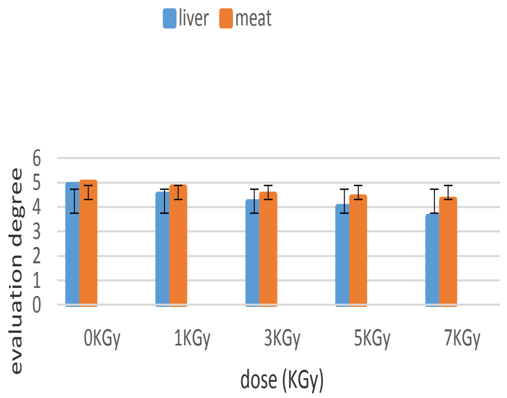

Fig. 3. Effect of irradiation dose on the color of beef liver and meat [1= Very poor, 2= Poor, 3= Common. 4= Good and 5= Very good].

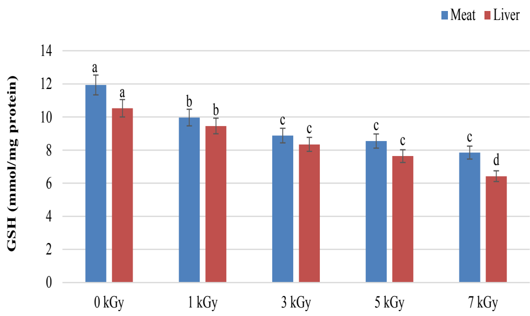

Fig. 6. Effect of different gamma irradiation doses on reduced glutathione content (GSH) in beef meat and liver [Values are expressed as means ± S.E.M.; n= 5 for each treatment group. Mean values not sharing common letters (a, b, c, d) were significantly different (P<0.05)].

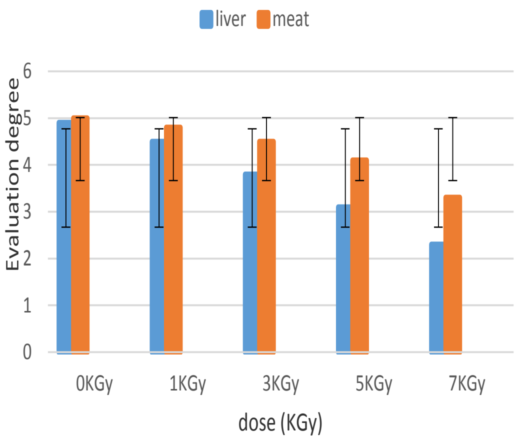

Fig. 4. Effect of irradiation dose on the odor of beef liver and meat [1= Very poor, 2= Poor, 3= Common. 4= Good and 5= Very good].

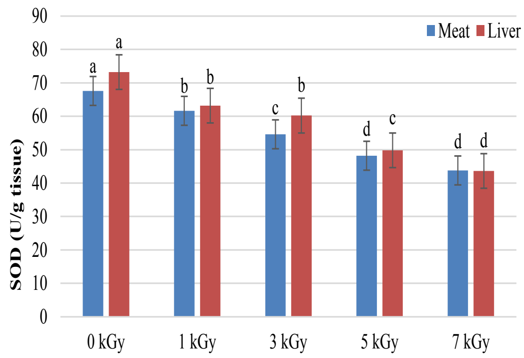

Fig. 7. Effect of different gamma irradiation doses on superoxide dismutase (SOD) activity in beef meat and liver[Values are expressed as means ± S.E.M.; n= 5 for each treatment group. Mean values not sharing common letters (a, b, c, d) were significantly different (P<0.05)].

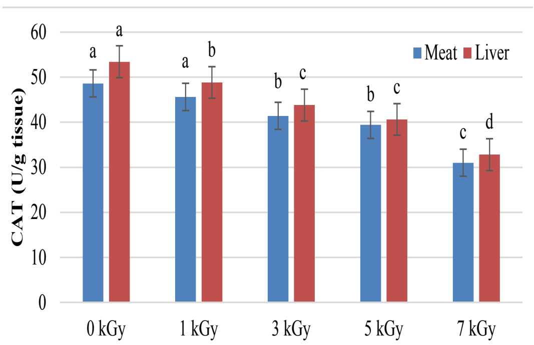

Fig. 8. Effect of different gamma irradiation doses on catalase (CAT) activity in beef meat and liver [Values are expressed as means ± S.E.M.; n= 5 for each treatment group. Mean values not sharing common letters (a, b, c, d) were significantly different (P<0.05)].

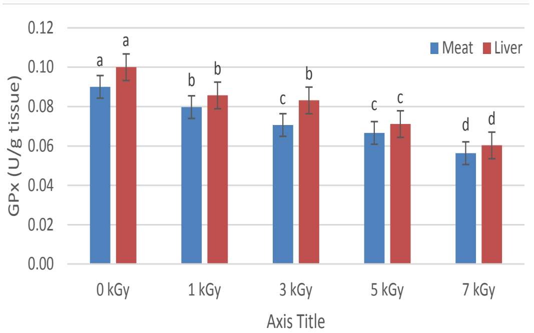

Fig. 9. Effect of different gamma irradiation doses on glutathione peroxidase (GPx) activity in beef meat and liver [Values are expressed as means ± S.E.M.; n= 5 for each treatment group. Mean values not sharing common letters (a, b, c, d) were significantly different (P<0.05)].

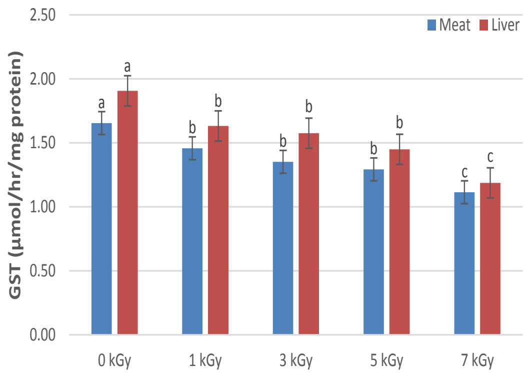

Fig. 10. Effect of different gamma irradiation doses on glutathione S-transferase (GST) activity beef meat and liver [Values are expressed as means ± S.E.M.; n= 5 for each treatment group. Mean values not sharing common letters (a, b, c, d) were significantly different (P<0.05)].

Tables 1 and 2 show that the mean of some amino acid increased, e.g. Methionine and Cystine in beef meat slices and Isoleucine and Methionine in liver slices. While others decrease, e.g. Proline, Alanine, Histidine and Lysine in beef meat slices and Cystine and Leucine in liver slices, but still the content of total amino acids was not affected by irradiation. It was found that irradiated liposomes containing “sulfur amino acids” produced similar odor characteristics to the irradiated meat, indicating that sulfur amino acids are mainly responsible for irradiation odor and that side chains of amino acids were susceptible to radiolysis degradation (de Souza et al., 2019). Also, Kim et al. (2011) showed that the odor characteristic of the irradiated sulfur-containing amino acid have similar odor characteristics to those of the irradiated meat. Methionine and cysteine were the major sulfur-containing amino acids among meat components, but methionine was responsible for more than 99% of the total sulfur compounds produced by irradiation (Park et al., 2010). Furthermore, Kumar et al., (2012) indicated that the side chain of methionine was highly susceptible to radiolysis degradation. The increase of sulfur amino acids in the irradiated beef is one of the important factors that can be considered in the irradiation process.

Free radicals generated from the radiolysis of water, such as hydroxyl radicals, hydrated electrons and hydrogen ion (Maleknia & Downard, 2019), attack food components (proteins, amino acids, lipids, etc.), and lead to an increased rate of lipid oxidation. These free radicals appear in aqueous systems and also in meat because over 75% of muscle cells are composed of water and surrounded by lipid bilayers (Wang et al., 2019).

Sensory evaluation

Irradiation of liver and meat slices showed no significant change in color and all samples were accepted by the panelists (Fig. 2, 3, 4). Derakhshan et al. (2018) reported that irradiation doses up to 3 kGy had no significant effect on the sensory properties of meat. Also, irradiation at 1 and 3kGy had negligible effects on sensory attributes of ready-to-eat meats (Cambero et al., 2012). Furthermore, the results of An et al. (2017) showed that irradiation up to 1-4.5kGy was useful in reducing bacterial populations without affecting the sensory characteristics of smoked duck meat.

Meat color is distinguished by consumers as indicative of freshness against meat that turned to brown in color (Dutra et al., 2017). Sensory panelists confirmed that the odor intensity of sulfur-compounds was much stronger and stringent than that of other compounds; also volatiles from lipids accounted for only a small part of the irradiation odor and the contents of sulfur compounds and its specific odor intensity were irradiation dose-dependent (Nam et al., 2011).

Lipid peroxidation and glutathione content

Data of the TBARS measured in beef meat and liver are presented in Fig. 5. A significant increase (P< 0.05) in TBARS concentrations was observed in beef meat and liver exposed to different irradiation doses (0, 1, 3, 5 and 7kGy). Irradiated samples had relatively higher TBARS values than the control. In agreement with Li et al. (2017), irradiation and refrigeration storage at 4°C of the fresh pork significantly increased TBARS with increasing the dose of irradiation. This increase could be attributed to the direct effect of gamma radiation on amino acids leading to the formation of small amount of amines (Al-Bachir, 2016) and/or on the volatile sulphur compounds, which produced from the radiolytic degradation of the side chains of sulphur-containing amino acids (Colovic et al., 2018). Also, ipid oxidation was promoted by irradiation and the oxidative stability of meat depends on the balance between antioxidants and pro-oxidants and the content of oxidation substrates including polyunsaturated fatty acids, cholesterol, proteins and pigments (Li et al., 2017).

In the present study, a significant dose-dependent decrease (P< 0.05) was observed in GSH content of beef meat and liver exposed to irradiation doses as compared to control tissues (Fig. 6). GSH redox cycles serve as a crucial component of cellular antioxidant defenses and they are essential for the tissues to protect themselves against the reactive oxygen species (ROS) damage. They participate in the elimination of ROS, acting both as a non-enzymatic oxygen radical scavenger and as a substrate for various enzymes such as GPx (Tsukamoto et al., 2002). Several studies have demonstrated that a shortage of sulfhydryl groups brings about the cells/tissues at risk of oxidative damage (Nasr et al., 2016). The antioxidant property of GSH is due to the thiol group of cysteine. The observed decrease in GSH-content and GPx activity in irradiated meat and liver may be due to enhanced free radical production as evidenced by increased TBARS (Cardenia et al., 2015).

Antioxidant enzyme activities

Data concerning the antioxidant enzyme activities in beef meat and liver are presented in Fig. 7-10. A significant reduction (P< 0.05) in the activity of the measured antioxidant enzymes (GPx, GST, SOD and CAT) associated with the increase in the irradiation dose was observed.

Oxidative stress resulting from increased production of free radicals and ROS, and/or a decrease in antioxidant defense, leads to damage of biological macromolecules and disruption of normal metabolism and physiology (El-Demerdash et al., 2016). In the current study, the significant decrease in the antioxidant enzyme activities of beef meat and liver proved the failure of antioxidant defense system to overcome the influx of ROS generated by irradiation.

As a result of this work, it is recommended that the application of gamma radiation to beef meat and liver induced significant reduction in TBC in a dose-dependent manner; irradiation at 3kGy was sufficient to reduce TBC to non-detectable levels. The results indicated that treatment with gamma radiation 1, 3, 5 and 7kGy had no adverse effect on its chemical composition; the total amino acids content of the non-irradiated beef was similar to the irradiated samples. On the other hand, gamma-radiation induced oxidative damage and caused a disturbance in antioxidant defense system in a dose-dependent manner.

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تأثير أشعة جاما على الجودة الصحية والأحماض الأمينية والإنزيمات المضادة للأكسدة في لحم وكبد البقر

وفاء سيد محمد[1]، ودالیا خاطر[2]، فاطمة الدمرداش[3]، مدیحه نجیب ابراهيم[1]

[1]قسم البحوث الصحیة الإشعاعیة - المركز القومي لبحوث وتكنولوجیا الإشعاع - ھیئة الطاقة الذریة المصریة- ص.ب. 29 مدینة نصر- القاھرة- مصر، [2]معھد بحوث صحة الحیوان- كفر الشیخ- مصر، [3]قسم الدراسات البیئیة- معھد الدراسات العلیا و البحوث- جامعة الأسكندریة- الأسكندریة- مصر.

في هذه الدراسة، تم دراسة تأثير جرعات مختلفة من أشعة جاما (1، 3، 5، 7 كيلوجري) على الجودة الصحية (الخصائص الميكروبية والحسية) وكذلك قياس معايير الأنزيمات المضادة للأكسدة في مفروم اللحم والكبد البقري.

أظهر الفحص الميكروبي أن عدد الميكروات يقل كلما زادت جرعة أشعة جاما المستخدمة. وأظهر الفحص الحسي عدم وجود فروق احصائية في لون وملمس العينات المعرضة وغير المعرضة لأشعة جاما.

أظهرت النتائج أن التغير في تحليل مكونات البروتينات يرتبط بالتغيير في مقدار جرعة أشعة جاما، بينما محتوي البروتين الكلي لم يتغير. بالأضافة إلي أن المجموعة المعاملة بأشعة جاما خفضت نشاط الأنزيمات المضادة للأكسدة و كذلك الجلوتاثيون المختزل.

الخلاصة: استخدام جرعات منخفضة من أشعة جاما يحسن من الجودة الصحية لمفروم اللحم والكبد البقري دون حدوث تغيير في قياسات المعايير الكيميائية، بينما كانت قياسات ضغوط الأكسدة والمضادات للأكسدة الانزيمية والغير انزيمية تتأثر بالتغيير في مقدار جرعة أشعة جاما.

التوصية: استخدام جرعات منخفضة من أشعة جاما يحسن الجودة الصحية للحوم وأكباد البقر.