Quality Characteristics of Gamma Irradiation and Kale Leaf powder Treated Ostrich and Chicken Meat during Storage

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ABSTRACT
The current investigation was conducted to evaluate the result of gamma irradiation doses and kale leaf powder (KLP) on microbiological assay (total aerobic bacteria and coliforms), quality parameters (Hunter’s color [L*, a* and b*] and heme pigments [Mb and MetMb]) and stability modifiers (total volatile basic nitrogen [TVBN], thiobarbituric acid reactive substances [TBAR5s], and peroxide value [POV]) of ostrich and chicken meat under different storage intervals (0, 7 and 14d). Gamma irradiation dose (3kGy) with or without kale leaf powder (1% and 2%) was applied. The TPC and coliform outcome indicated that irradiation and storage caused significant changes in both meat patties while the microbial load was recorded zero at the treatment 3kGy. TVBN, TBARS and POV changed significantly in ostrich and chicken meat with different treatments and storage periods. TVBN value was observed high in ostrich meat at the treatment (3KGY) on the end of storage, whereas the higher values of POV and TBARS were evaluated in the chicken meat sample at 3kgy on 14th day of storage. The myoglobin, met-myoglobin, L*, a*, and b* showed significant changes with respect to different treatments and storage periods. The higher Mb value was seen at 2% KLP at day 0 of storage in ostrich meat and the extreme MetMb value was found at 3kGy at the end of storage. The L* and b* were observed high in chicken meat, whereas in ostrich meat, a* value was found high. In both types of meat, slight changes were observed in appearance, taste, texture, flavor and overall acceptability. However, it is concluded that both types of meat treated with 3kGy + KLP were examined better for quality, safety and stability during storage.

Introduction
Meat safety and quality are the current issues, for this purpose, there are different modern processing techniques used to produce safe meat. Gamma irradiation is one of the most important meat processing techniques in which meat is cooked with radiation. Irradiation improves the safety of meat and meat products by eliminating bacteria and prevent the growth of microbes. Gamma rays such as 137-Cesium or 60-Cobalt can kill foodborne pathogens and play a role in improving human health.

Food and Drug Administration–approved radiation technology like gamma ray is used in food processing to improve consumer preferences and nutrition, enhancing the storage life and quality of products. Gamma radiation acts at the cellular level because it contains high energy content and a wide range of penetration power. Meats treated with irradiation have more flavor compared to other

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cooked methodss. For chicken meat, recommended dose of gamma radiation is up to 7 kGy. These doses are suitable for increasing the shelf life of meat and meat products.\cite{5}

During the ionizing process, the radiolysis of water starts that creates some free radicals. These free radicals produce oxidation in meat and meat products.\cite{6} Some natural plant is used to control oxidation because it is a good source of bioactive compounds. Kale is known Brassica oleracea, commonly called Borecole and also belongs to the cabbage family.\cite{7} It is a rich source of bioactive compounds including antioxidants (e.g. beta carotene, ascorbic acid and tocopherol), phytochemicals (including Lutein, Zeaxanthin and Polyphenols), fiber and both macromineral and micromineral.\cite{8}

The trend of meat has been increasing because it is a rich source of nutrients which are composed in the form of protein, fat, vitamins and minerals. Globally, the meat consumption rate has been increasing due to two reasons: first is increased population and second is enhanced consumption because meat is a rich source of protein. The meat is of basically two types such as red and white; this division is due to color and nutrients variation. Animals and birds are two major sources of meat.\cite{9}

Worldwide with an increase in the consumption of meat, the production needs to be enhanced. For this purpose, chicken meat plays a vital role in distressed gap between consumption and production. Chicken meat is white meat that is attained from birds and has a high nutritional composition and cost-effective; it plays a particular role in improving the economy.\cite{10} The worldwide importance of chicken meat is due to its’ high nutritional composition; it contains amino acid, long-chain polyunsaturated fatty acids (PUFAs), vitamins and minerals.\cite{11}

Currently, new meat has been introduced in the world called ostrich meat, due to its high nutritional value. The worldwide consumption rate of ostrich meat has been increased day by day. It is a bird source and red in color, red meat lover, who was hunt any diseases (like heart diseases) due to red meat source especially beef, now ostrich meat can consume because it’s composed of low-fat content.\cite{12} The red color of ostrich meat is due to its high pigment that is 153 mg of Fe/g.\cite{13} Ostrich meat is a suitable choice to red meat because of its vital fatty acid contents and low intramuscular fat; it is also a source of good PUFA.\cite{14} Ostrich meat contains low cholesterol when compared to other meats like beef and poultry.\cite{15} Due to rich iron content, ostrich meat is recommended to anemic patients as well as pregnant women because it is necessary for hemoglobin formation and during hematopoiesis.\cite{16}

The current research was carried on a comparison between ostrich meat and chicken meat. Different combinations of kale leaf powder with and without gamma irradiation were used to evaluate the antimicrobial effects, antioxidants enhancement in meat and meat product for safety, influence the shelf life, physiochemical, stability and sensory parameters. These parameters were used on different storage intervals to compare ostrich and chicken meats.

Materials and methods

Procurement of raw material

The meat sample of ostrich procured from the Signature Meat Shop, Lahore, Pakistan, and chicken meat was collected from SB mart Faisalabad, Pakistan. The meat portions were treated with kale leaf powder and then irradiated with gamma irradiation. The samples were aerobically packed in oxygen impermeable plastic films. Then, the samples were irradiated with different doses (1% KLP+0kGy, 2% KLP+0kGy, 1% KLP+3kGy, 2%KLP+3kGy and 0%KLP+3kGy) from Nuclear Institute for Agriculture and Biology (NIAB), Faisalabad, Pakistan. After treatments, the ostrich and chicken meats were kept at 4°C. The storage time for the meat samples were 0, 7 and 14 days. The analyses were performed both at the Department of Food Science, Government College University, Faisalabad and at NIAB, Faisalabad. All reagents and chemicals used in the current research were attained from Sigma Aldrich (Tokyo, Japan).
**Gamma irradiation doses**

Gamma irradiation was performed at NIAB, Faisalabad, which is under the Pakistan Atomic Energy Commission. The 3 kGy gamma irradiation dose was used with kale leaf powder (KLP) with the control (0 kGy) and in contrast, without gamma irradiation, various combinations of 1% and 2% of KLP were also used for the analysis.

**Heme pigments**

The evaluation of heme pigments like myoglobin (Mb), metmyoglobin (MMb) from ostrich and chicken meat was determined according to the protocol of Krzywicki.\(^{[17]}\)

**Hunter color**

The surface color of both meat (ostrich and chicken) treated and untreated with ionization ray with and without KLP was measured by Hunter colorimeter. For standardized measurements, white calibration plate (\(L = 89.2\), \(a = 0.921\), and \(b = 0.783\)) was used. The color values (lightness (L), redness (a) and yellowness (b)) of each sample were made by the average of a three-random reading.

**Total volatile basic nitrogen (TVBN)**

The TVBN amounts were measured with irradiation treated and nonirradiation treated ostrich and chicken meat samples. Measurements of VBN were performed according to the Conway micro-diffusion method described by Pearson.\(^{[18]}\) Total volatile basic nitrogen value was determined using the following formula:

\[
N'\text{ mg/ml of extract } = 14 \times \text{normality of H}_2\text{SO}_4 \times b \times \text{volume of H}_2\text{SO}_4.
\]

\[
\text{TVBN value (mg/100 ml)} = 100 \times N.
\]

**TBARS value**

The extent of lipid oxidation was measured using the 2-thiobarbituric acid reactive substances (TBARS) method described by\(^{[19]}\) with a few modifications. The concentration of malonaldehyde was determined using utilizing the following formula, where the estimations of TBARS are evaluated as milligram (mg) malondialdehyde per kilogram (kg) meat:

\[
\text{mg malondialdehydes per kg meat} = (\text{Sample absorbance } - \text{ blank}) \times \text{Total sample vol.0.000156} \times 1000
\]

**Peroxide value**

The pov amounts were measured with 3 kGy and different concentrations of KLP in ostrich and chicken meat samples. The peroxide value was determined according to the method described by International Dairy Federation (IDF).\(^{[20]}\)

**Microbial assay**

The microbial assay was done immediately after irradiation. The total aerobic bacteria and coliform were determined according to the method described by Helrich,\(^{[21]}\) and indicated as log CFU/g. The ostrich meat and chicken meat were kept in enrichment broth, after that samples were incubated at the suitable condition.


**Sensory evaluation**

Meat patties sample of the ostrich and chicken were subjected to sensory evaluation. A panel of trained judges evaluated the sensory evaluation of meat patties by using 9-point hedonic scale (9 = extremely liked; 1 = extremely disliked) as a method narrated by Meilgaard.\[22\] At the sensory evaluation, the panelists used mineral water and expectorant cups for rinsing their taste receptors.

**Statistical analysis**

Data obtained from each parameter were analyzed statistically using Statistical Package, Statistic 8.1 (ANOVA) and CRD to check the level of significance at 5% alpha.\[23\] The least significant difference (LSD) was used to compare the mean values of ostrich and chicken meats. Besides of sensory and Hunter color, in all parameter three replicates were used.

**Results and discussion**

**Total volatile basic nitrogen (TVBN) value**

TVBN is composed of primary, secondary and tertiary amines and ammonia; TVBN value is formed by nonprotein nitrogenous compounds and the breakdown of protein.\[24\] During storage, TVBN value increased with storage time, that is in ostrich meat, TVBN was observed to be high while in chicken meat, TVBN was observed to be low. The TVBN ranged from 3.01 ± 0.10 to 7.34 ±0.08. TVBN in both types of meats varied significantly during storage, irradiation doses and kale leaf powder concentration. At the end of storage (14 day), higher outcome was observed in ostrich meat (7.34 ±0.08) on 0%KLP+3kGy, while the lower value of TBVN was observed in the control of chicken meat sample (3.01 ± 0.10) on 2%KLP+0kGy at day 0 of storage. During irradiation treatments, TVBN value was evaluated to be high in ostrich meat samples on 0%KLP+3kGy, whereas at 2%KLP+3kGy a decline was observed in chicken meat. TVBN value increased with increasing irradiation doses. The KLP effect in both types of meat is shown in Table 1. The current outcome has found that TBVN value is calculated to be high at 1%KLP and low at 2%KLP.

The current results were similar to Author\[25\] whose study was conducted on ostrich meat at storage (0, 5, 10, 15 day). That particular study showed TVBN value was increased by storage intervals. A previous study has been correlated with our finding in which chicken meat was used on different doses of irradiation with turmeric powder. The low dose of irradiation with turmeric powder has resulted in more TVBN, whereas by high dose of irradiation with turmeric powder, the TVBN value decreased.\[5\] Another study\[26\] was conducted on smoke duck in which different doses of e-beam were applied. The collected result confirmed that by enhancing the doses, TVBN value decreased. Our outcomes are in agreement with\[27\], whose research was conducted on chicken meat that was treated with different concentrations of Maringa leaf powder (MLF) and irradiation doses. In this study, enhancement of TBVN was observed on low MLF. Our finding is correlated with\[28\] who predicted

| Parameter | Treatment | 0th day Ostrich Chicken | 7th day Ostrich Chicken | 14 day Ostrich Chicken |
|-----------|------------|-------------------------|-------------------------|------------------------|
| TVBN (mg/100 mL) | Control 4.50 ± 0.35d | 3.55 ± 0.13d | 5.55 ± 0.37b | 4.76 ± 0.26ab | 6.75 ± 0.40b | 5.26 ± 0.24b |
| | 1%KLP+0kGy 4.37 ± 0.34e | 3.20 ± 0.03e | 5.25 ± 0.36 c | 4.23 ± 0.21d | 6.51 ± 0.39 c | 5.03 ± 0.23 c |
| | 2%KLP+0kGy 4.25 ± 0.32 f | 3.01 ± 0.10e | 4.75 ± 0.35e | 3.85 ± 0.07e | 6.07 ± 0.38d | 4.83 ± 0.19d |
| | 0%KLP+3kGy 5.27 ±0.10a | 4.75 ± 0.05a | 6.90 ±0.13a | 4.84 ±0.09a | 7.34 ±0.08a | 5.55 ±0.02a |
| | 1%KLP+3kGy 4.75 ±0.38b | 4.50 ±0.21b | 5.47 ±0.39b | 4.74 ±0.09b | 6.60 ±0.37 c | 5.25 ±0.29b |
| | 2%KLP+3kGy 4.62 ±0.35 c | 4.35 ±0.12 c | 4.89 ±0.35d | 4.54 ±0.15 c | 6.97 ±0.38b | 5.35 ±0.27b |

KLP: Kale leaf powder. The values are mean ±SD of three independent determinations, means carrying different letters in a columns differed significantly.
that volatile substances were increased by the ionization process in ready-to-eat chicken breast, whereas these compounds were formed slowly as compared to unirradiated meat at the time of storage. Moreover, another study reported that volatile compounds were seen in pork meat when subjected to a high dose of irradiation.\textsuperscript{[29]} The antioxidants play a vital role in repress volatile formation at the time of storage intervals and the irradiation process.\textsuperscript{[30]}

**Microbiological assay**

**Total aerobic bacteria (TAB)**

To check the total aerobic bacteria effect on ostrich and chicken meats, various treatments were used in which KLP and gamma irradiation were applied with different doses. The current results showed that there was a significant difference in all treatment and storage intervals. The outcomes of the TAB were found that all treatments reduced the pathogenic effect and elimination of the microbes from meat and meat products. Table 2 shows the results that were evaluated in TAB range from 4.01 ±0.01 log CFU/g to 10.53 ±0.06 log CFU/g. The higher finding of TAB was calculated in a control sample of chicken meat on 14 days of storage, whereas on 2%KLP+3KGY low value of TAB was found on day 0 of storage in ostrich meat. With passing of storage time, the TAB value had increased. In chicken meat, on 7th day, TAB value was 9.47 ±0.05 and it increased to 10.53 ±0.06 on 14th day of storage, whereas TAB in ostrich meat increased with storage time. The TAB decreased in both types of meat during the irradiation treatment.

Our result is similar to\textsuperscript{[27]} who worked on chicken meat treated with gamma radiation and MLP, whose results showed irradiation and antioxidants containing plant sources that reduce the TAB in meat and meat products. Our results found that ostrich meat has been kept at a low level of TAB as compared to chicken meat. In both types of meats, the level of TAB load was low with respect to all treatments. Our results are in agreement with the findings of Abou-Arab and Abu-Salem\textsuperscript{[31]} who reported that TAB of ostrich meat increased with the storage intervals. Similar research was conducted

| Parameter                  | Treatment | 0th day | 7th day | 14 day |
|----------------------------|-----------|---------|---------|--------|
| Total Aerobic Bacteria (log CFU/g) Control | 7.36 ± 0.01a | 8.43 ± 0.02a | 8.34 ± 0.03a | 9.47 ± 0.05a | 9.44 ± 0.15a | 10.53 ± 0.06a |
| 1%KLP +0kGy                | 6.38 ± 0.03b | 7.38 ± 0.04b | 7.36 ± 0.05b | 7.36 ± 0.06b | 8.35 ± 0.06b | 8.35 ± 0.02b |
| 2%KLP +0kGy                | 6.13 ± 0.04c | 6.24 ± 0.03c | 7.15 ± 0.02c | 6.33 ± 0.06c | 7.10 ± 0.04c | 7.77 ± 0.01c |
| 0%KLP +3kGy                | 4.12 ± 0.03e | 4.19 ± 0.04e | 5.07 ± 0.08e | 4.67 ± 0.01e | 5.82 ± 0.01e | 5.33 ± 0.01e |
| 1%KLP +3kGy                | 4.91 ± 0.02d | 5.05 ± 0.01d | 6.09 ± 0.01d | 5.55 ± 0.05d | 6.01 ± 0.03d | 6.62 ± 0.02d |
| 2%KLP +3kGy                | 4.01 ± 0.01e | 4.07 ± 0.03e | 4.99 ± 0.03e | 4.63 ± 0.04e | 5.78 ± 0.02e | 5.29 ± 0.04e |
| Coliform (log CFU/g)       | Control    | 3.30 ± 0.06a | 4.65 ± 0.06a | 4.20 ± 0.04a | 4.89 ± 0.07a | 5.39 ± 0.06a | 5.50 ± 0.06a |
| 1%KLP +0kGy                | 3.10 ± 0.05b | 3.87 ± 0.03b | 3.99 ± 0.05b | 4.31 ± 0.08b | 4.73 ± 0.02b | 4.96 ± 0.05b |
| 2%KLP +0kGy                | 2.95 ± 0.03c | 3.72 ± 0.04c | 3.89 ± 0.06b | 3.98 ± 0.06c | 4.07 ± 0.04c | 4.65 ± 0.07c |
| 0%KLP +3kGy                | ND         | ND       | ND       | ND       | ND       | ND       |
| 1%KLP +3kGy                | ND         | ND       | ND       | ND       | ND       | ND       |
| 2%KLP +3kGy                | ND         | ND       | ND       | ND       | ND       | ND       |

KLP: Kale leaf powder. The values are mean ±SD of three independent determinations, means carrying different letters in a columns differed significantly.
on chicken meat where chicken meat was fried and then irradiated with gamma rays. After irradiation treatment, the microbial load was reduced in all samples.\textsuperscript{32}

\textbf{Coliform bacteria}

Coliform bacteria are present in meat and meat products that are responsible to spoilage the meat. Different techniques are used to eliminate coliform from meat and meat products. In the current research, gamma radiation and KLP powder were used to eliminate coliform; various treatments with the different combinations had been used to reduce coliform. Table 2 shows that a higher value of coliform was observed in control sample of chicken meat on 14 days. The coliform range in ostrich meat was (2.95 ± 0.03 to 5.39 ± 0.06), whereas in chicken meat, it was (3.50 ± 0.07 to 5.50 ± 0.06). In ostrich meat, on treatment with (1%KLP+3kGy) at different storage periods (0, 7, and 14d), the coliform bacteria was not attained. The coliform was not seen in both types of meat during the combination of irradiation and KLP treatment (2%KLP+3kGy and 0%KLP+3kGy).

The results are in consistent with the outcomes of Arshad et al.\textsuperscript{5} who depicted that treatment of chicken meat with 1kGy+TP and 2kGy+TP observed no coliforms. Another study was correlated with our result in which duck meat was irradiated with various doses of e-beam. However, on a high dose of irradiation, coliform was not evaluated. Cap et al.\textsuperscript{33} predicted that gamma irradiation declined the microbial load. Different doses (1 kGy and 2.5 kGy) were applied to the ground beef. The results showed that a higher dose of irradiation declined the microbial load and also enhanced the shelf life of ground beef. Silva et al.\textsuperscript{34} evaluated the effects of gamma irradiation (1.5, 3.0 and 4.5 kGy) on meat (ham) who depicted that a significant dose reduced the microbial load.

\textbf{Physicochemical analysis}

\textbf{Myoglobin}

The color of meat is considered an important quality factor, for this purpose heme pigment like myoglobin test is performed. The myoglobin values of ostrich meat and chicken significantly changed with respect to storage interval on different doses of irradiation and different concentrations of KLP. The range of Mb was detected in both meats (12.65 ± 1.06 to 40.10 ± 1.97) as shown in Table 3. A higher value of myoglobin for both types of meats was detected on day 0 and lower on 14th day. So, the results have confirmed that myoglobin value decreases with storage. The range of the amount of Mb varied from 15.87 ± 1.12 to 40.10 ± 1.97 in ostrich meat and 12.65 ± 1.06 to 33.53 ± 1.30 in chicken meat. The higher amount was calculated in the ostrich meat sample on 2% KLP and the lower value in chicken meat on 0%KLP+3kGy. In calculated results, KLP has enhanced myoglobin because kale is a rich source of iron. Mb value result decreased when subjected to high doses of irradiation. During storage, the Mb value of both types of meats decreased with the passage of time intervals. At 0th day of storage, Mb vale was observed to be high in both types of meats, whereas the least value was attained in both types of meats at the end of storage (14th day).

The previous result was conducted on two different types of meats in which ostrich meat was compared with goat meat. These results showed that ostrich had high myoglobin contents than goat meat.\textsuperscript{35} Our Mb is similar to these results in which Mb value of ostrich meat was high as compared to chicken. Our result related to the research was conducted on chicken meat, treated with MLP and a combination of different doses of MLP with gamma irradiation. The result showed that myoglobin level was high in meat due to enhanced MLP amount.\textsuperscript{27} During storage (1, 5, 10, 15, 20, 25, 30, 35 day), the Mb value decreased in beef steaks with the passage of time intervals. On the first day, high value was recorded and at the end (35 day) of storage, low Mb value was recorded.\textsuperscript{36} In another research composed by\textsuperscript{37} beef was treated with different irradiation doses (1.25 or 2.50 kGy) and natural antioxidant sources. The antioxidants play a role to protect Mb by maintaining the iron in a reduced state.
Table 3. Myoglobin and Metmyoglobin of ostrich and chicken meat treated with Gamma irradiation and kale leaf powder at storage intervals.

| Parameter   | Treatment              | Storage Period (days) | Ostrich Chicken | Ostrich Chicken | Ostrich Chicken |
|-------------|------------------------|------------------------|-----------------|-----------------|-----------------|
| Myoglobin (%) | Control             | 0th day               | 7th day         | 14th day        |
|             | 0%KLP +0kGy         | 39.27 ±1.70ab         | 31.25 ±1.15b    | 19.07 ±1.02a    | 16.91 ±0.97b    |
|             | 2%KLP +0kGy         | 39.76 ±1.90ab         | 31.85 ±1.17b    | 19.56 ±1.03a    | 17.42 ±1.00a    |
|             | 1%KLP +3kGy         | 40.10 ±1.97a          | 32.03 ±1.20a    | 19.99 ±1.05a    | 17.98 ±1.01a    |
|             | 0%KLP +3kGy         | 35.10 ±0.11c          | 27.32 ±0.14d    | 15.87 ±1.12c    | 12.65 ±1.06d    |
|             | 1%KLP +3kGy         | 37.17 ±1.45b          | 29.35 ±1.8c     | 17.25 ±0.99b    | 15.01 ±0.88c    |
|             | 2%KLP +3kGy         | 37.63 ±1.60b          | 29.78 ±1.09c    | 17.78 ±1.01b    | 15.69 ±0.92c    |
| Met         | myoglobin            | 63.98 ±2.09c          | 45.34 ±1.65d    | 54.46 ±1.92d    | 50.24 ±1.80c    |
|            | Control              | 56.73 ±2.02c          | 41.12 ±1.53d    | 56.94 ±1.92d    | 50.24 ±1.80c    |
|            | 0%KLP +0kGy         | 45.80 ±1.67d          | 54.94 ±1.96c    | 63.76 ±2.07c    | 56.56 ±2.01c    |
|            | 2%KLP +0kGy         | 46.07 ±1.76c          | 55.14 ±1.88c    | 63.36 ±2.05d    | 56.20 ±2.00c    |
|            | 0%KLP +3kGy         | 47.90 ±2.70a          | 58.02 ±1.45a    | 66.98 ±1.87a    | 60.08 ±2.32a    |
|            | 1%KLP +3kGy         | 47.10 ±1.81ab         | 52.45 ±1.87ab   | 59.98 ±2.04ab   |                 |
|            | 2%KLP +3kGy         | 46.57 ±1.79b          | 56.34 ±2.03b    | 64.98 ±2.10b    | 57.11 ±2.03b    |

KLP: Kale leaf powder. The values are mean ±SD of three independent determinations, means carrying different letters in a columns differed significantly.

Metmyoglobin
In the current research, the metmyoglobin amount was seen to increase with the passage of time. The metmyoglobin value ranges in ostrich meat (45.34 ±1.65 to 66.98 ±1.87) and chicken meat (41.12 ± 1.53 to 60.08 ±2.32) were observed as shown in Table 3. The metmyoglobin was observed to be high in the ostrich meat on 14th day of storage, while a lower amount of metmyoglobin was found in chicken meat on 0th day. During the irradiation, the metmyoglobin amount was evaluated to be high in ostrich meat samples (66.98 ±1.87) on 0%KLP+3kGy, at 14 day of storage. At the time of irradiation, free radicals occurred that created oxidation in meat. By enhancing the amount of KLP (2%KLP+3kGy), the amount of oxidation was found to be minimum.

A research was conducted on mutton keema, which results that with the storage interval the value of metmyoglobin was observed high when meat was treated with radiation\textsuperscript{[38]}. The metmyoglobin value observed changed in both types of meat by the addition of KLP. Our result was the agreement of\textsuperscript{[26]} who predicted that irradiated meat with 4.5 kGy has a higher level of metmyoglobin on 40th day of storage. A similar study was practiced on beef patties in which four different antioxidants were added with different concentrations during storage. The metmyoglobin has decreased during storage, while metmyoglobin was recorded to be high by enhancing the concentration of the antioxidant.\textsuperscript{[39]}

Thiobarbituric acid reactive substances (TBARS) value
Quality is an important factor in meat, in processed meat and meat products, peroxide and TBARS are responsible for the degradation due to changes in fat. TBARS values enhance due to irradiation processing because oxidation is caused by radiation. During storage in both types of meats, the value of TBARS was recorded to enhance with the passage of time. The higher value of TBARS was observed in ostrich meat when compared to chicken meat on treatment (0%KLP+3kGy), at the end of storage. The current result evaluated that TBARS value was more in meat sample which is treated with high
irradiation dose, while by enhance the quantity of KLP (2% KLP), the TBARS value reduced. The ranges of both meats were seen from 0.26 ± 0.05 to 0.95 ± 0.07 that observed to be changing significantly. In ostrich and chicken meats, peak value was 0.95 ±0.07 and 0.59 ±0.05, respectively, while the lower TBARS of ostrich and chicken was recorded as0.60 ± 0.03 and 0.26 ± 0.05, respectively, as shown in Table 4.

Our results are related to previous research which had evaluated the effect of storage on ground beef. TBARS value had increased with the passage time. The higher value was observed at the end of storage and the low value was attained by 0th day of storage. A similar study was conducted on chicken meat in which turmeric powder was used with different doses of gamma irradiation, these results show that by enhancing the dose of irradiation, the TBARS value increased. Our results correlated with who research was conducted on shrimp patties in which guava leaf extract and papaya leaf extract were used. Results from this research had found that both leaf extracts decreased the TBARS value.

**Peroxide value**

The peroxide values of both types of meat were seen to change significantly. The POV ranges of both types of meat were seen from 0.26 ± 0.05 to 0.75 ± 0.09. The higher value of peroxide was indicated in ostrich meat on 0%KLP+3kGy at the end of the storage interval, whereas on 2%KLP+0kGy, chicken meat had decreased peroxide value at 0th day of storage. Table 4 showed the different non-irradiated and irradiated treatments on different storage intervals (0, 7 and 14), in which results of peroxide were found increased with storage time and irradiation, and these values were decreased with KLP. In the current indication, higher peroxide was detected in the ostrich meat sample on 1%KLP+3kGy, where enhancement showed that irradiation increases the peroxide concentration in meat and meat products. The lower value of peroxide was calculated in the chicken sample on 2% KLP, these results evidenced that KLP reduced the peroxide content in meat and meat products because it is a good source of natural antioxidants.

| Parameter | Treatment | 0th day | 7th day | 14 day |
|-----------|-----------|---------|---------|--------|
| TBARS (MDA/kg) | Control | 0.75 ± 0.03 c | 0.43 ± 0.04ab | 0.81 ± 0.05b | 0.48 ± 0.01 c | 0.90 ± 0.03b | 0.55 ± 0.04 c |
| | 1%KLP | 0.69 ± 0.02 c | 0.35 ± 0.03 c | 0.73 ± 0.01 c | 0.39 ± 0.03d | 0.83 ± 0.06 c | 0.42 ± 0.03d |
| | +0kGy | 0.60 ± 0.03d | 0.26 ± 0.05d | 0.64 ± 0.03d | 0.28 ± 0.03e | 0.75 ± 0.03d | 0.32 ± 0.05e |
| | 2%KLP | 0.81 ±0.05a | 0.47 ± 0.04a | 0.85 ±0.06a | 0.53 ±0.03a | 0.95 ±0.07a | 0.59 ±0.05a |
| | +0kGy | 0.79 ±0.04b | 0.46 ± 0.05b | 0.84 ±0.04a | 0.51 ±0.05b | 0.93 ±0.03b | 0.58 ±0.04a |
| | 0%KLP | 0.77 ±0.04b | 0.44 ± 0.05b | 0.82 ±0.05b | 0.50 ±0.05b | 0.91 ±0.02b | 0.56 ±0.04b |
| | +3kGy | 0.45 ± 0.01 c | 0.32 ± 0.03 c | 0.59 ± 0.03 c | 0.37 ± 0.01 c | 0.69 ± 0.04 c | 0.44 ± 0.01 c |
| | 1%KLP | 0.41 ±0.03d | 0.28 ± 0.04d | 0.55 ±0.03d | 0.34 ±0.04d | 0.63 ±0.05d | 0.39 ±0.03d |
| | +0kGy | 0.39 ±0.02d | 0.26 ± 0.05d | 0.47 ±0.02e | 0.30 ±0.02e | 0.56 ±0.03e | 0.35 ±0.04e |
| | 2%KLP | 0.53 ±0.10a | 0.44 ±0.08a | 0.64 ±0.21a | 0.46 ±0.05a | 0.75 ±0.09a | 0.51 ±0.08a |
| | +0kGy | 0.51 ±0.05b | 0.42 ±0.03ab | 0.62 ±0.04ab | 0.44 ±0.05ab | 0.72 ±0.04b | 0.49 ±0.01ab |
| | 0%KLP | 0.49 ±0.04ab | 0.39 ±0.01b | 0.60 ±0.05b | 0.42 ±0.03b | 0.71 ±0.05b | 0.46 ±0.04b |
| | +3kGy | 0.49 ±0.04ab | 0.39 ±0.01b | 0.60 ±0.05b | 0.42 ±0.03b | 0.71 ±0.05b | 0.46 ±0.04b |

KLP: Kale leaf powder. The values are mean ±SD of three independent determinations, means carrying different letters in a columns differed significantly.
Similar results were attained during storage by Khalid [42] who used wheat germ and bran fiber with different concentrations at different storage periods (0, 7, 14, 21 days) in raw and cooked chicken patties. In both patties, the peroxide value reduced by enhancing the concentration and increased with the passage of storage time. Arshad et al. [43] conducted a study on frozen duck meat that is treated (0, 3 and 7 kGy) at the storage period. The higher outcome of POV was observed at the end of storage, and the higher value of pov was observed at the high dose of E-bean. Another outcome is related to the current study in which fish was stored at different storage periods. Whereas plant extracts [green tea extract (GTE), grape seed extract (GSE), and pomegranate rind extract (PRE)] were added as an antioxidant with various concentrations. The POV value was found to be reduced when the plant extract concentration enhances, while POV value increased with storage interval. [44]

**Hunter color**

Color is the main sensory parameter of meat and meat products. At the time of storage, the color of irradiated or nonirradiated meat samples varied significantly. The lightness ranges of both types of meat were found from 37.11 ±2.01 to 59.02 ±1.48 as shown in Table 4. A higher value of L* was calculated in chicken meat, whereas lower L* observed in ostrich meat. Results showed that chicken meat was more white in color. During storage, the lightness of ostrich and chicken meat was recorded to increase, on 14th day, a higher L* value was observed in chicken meat while low lightness was found in ostrich meat samples on 0 day of storage. The ostrich meat and chicken meat samples were treated with different concentrations of KLP. The L* value of both types of meats was observed to increase with the excessive concentration of KLP. During KLP treatments, the peak value of L* was found to be high in chicken meat on 2% KLP while in ostrich meat, it was found to be low on 1% KLP. The results were calculated that when the irradiation dose increased then L* value was observed to be low in both meats.

Our result relates to [29] who detected that a minimum change has occurred in meat color during storage. The current results are related to the previous study who was conducted on chopped beef in which irradiation doses change the color of meat. [45] The current results were related to [46] who reported that during meat processing, antioxidants produce color, which transfers into the meat thus variation in color occur. The following a* value was observed in ostrich (114.67 ±0.71 to 19.89 ±0.87) and chicken meat (10.52 ±0.52 to 16.62 ±0.83). Our finding showed that ostrich meat color was reddish when compare to chicken. A higher value of a* was detected in the ostrich meat samples, while the least value was found in chicken meat. During storage, the a* value was predicted to decrease with increasing the day of storage interval. However, at 0th day, high value of a* was observed in both meats, and low at 14th day of storage. The ostrich meat and chicken meat samples were treated with different concentrations of KLP. The a* value of both types of meat was observed to increase with the excessive concentration of KLP. During KLP treatments, the peak value of a* was seen in ostrich meat on 2% KLP, while the lower finding had observed in chicken meat. The combined results of KLP and irradiation have recorded increase in both types of meats. Meanwhile, 0%KLP+3kGy was more a* value as compare to other treatments.

Our result was an agreement to [26] who was conducted research in duck meat treated with e-beam. These results predicted that when the irradiation dose was increased, the value of a* was calculated low. However, the turkey breast meat color change to pink after irradiation due to the formation of a CO-Mb complex. [47] A study was conducted by, [48] who predicted that during storage a* value was seen excessive by the passage of storage time. However, chicken meat was stored in modified atmosphere packaging and vacuum packaging at different storage intervals (0, 5, 10, 15). Another study was conducted on female roe deer meat in which a* value was evaluated decline during storage. [49]

A similar study conducted by, [50] who reported that plant-based antioxidant sources enhance the a* value during storage periods (1, 3, 5, 7) at different concentrations.

The b* value range was observed in ostrich meat from 7.27 ± 0.03 to 11.51 ± 0.33 and chicken meat from 10.05 ± 0.06 to 15.10 ± 0.80. Chicken meat had much yellow in color. The decline of b* was
observed when the storage time was increased. A higher result was calculated on 0 day of storage whereas, a lower result detected on 14 day of storage. The effective doses of irradiation with kale leaf powder were showed that \( b^* \) value in both types of meat observed increases. On 2%KLP+3kGY higher \( b^* \) value was observed in chicken meat and low \( b^* \) value was seen in ostrich meat in the control sample. The \( b^* \) value of both types of meat was observed to increase with the excessive concentration of KLP. During KLP treatments, the peak value of \( b^* \) was 15.10 ± 0.80 in chicken meat while the lower finding had 7.27 ± 0.03 observed in ostrich meat that is shown in Table 5.

A similar study by[51] who performed work on steaks of three different muscle of beef at different storage periods, in which \( b^* \) value was recorded to decrease with the passage of time intervals. Another study was compromised on ostrich meat at different storage intervals, yellowness value was observed low with the passage of time.[52] The current study was agreement to[53] who predicted that by addition of antioxidants rich shahpouri orange juice in raw stacked and ground meat the yellowness of meat seen enhance. In accordance with the outcomes in,[54] who depicted that incorporate treatment of meat with ionizing ray and citric acid increasingly affected the value of \( b^* \).

**Sensory evaluation**

The mean sensory parameters such as appearance, flavor, texture, taste, and overall acceptability of prepared pattie from ostrich and chicken meat are seen in Table 5. To check the effects of different treatments, patties were prepared from ostrich and chicken meat. Furthermore, for sensory comparison of ostrich meat and chicken meat, experience panelists were exam all samples, and panelists gave their results on the evaluation sheet. During storage, the range of appearances (5.80 ± 0.09 to 7.50 ± 0.29), texture (6.2 ± 0.17 to 8.29 ± 0.33), taste (6.1 ± 0.07 to 7.4 ± 0.24), flavor (6.1 ± 0.11 to 7.6 ± 0.25) and overall acceptability (6.02 ± 0.06 to 7.45 ± 0.24) was observed. Storage comparison results showed that appearance and texture were found high in ostrich meat while, the lower results had observed in chicken meat. Furthermore, the taste, flavor and OA were calculated more in chicken and least in ostrich meat. When the increase of storage interval the value of all sensory parameters was observed to decline. During irradiation treatment, the appearance, texture, taste, flavor and OA of ostrich meat and chicken meat were evaluated decline on different storage intervals. The current finding showed

![Table 5. Hunter’s color of ostrich and chicken meat treated with Gamma irradiation and kale leaf powder at storage intervals.](image-url)
Table 6. Sensory evaluation (appearance, texture, taste, flavor, and overall acceptability) of ostrich and chicken meat treated with Gamma irradiation and kale leaf powder at storage intervals.

| Parameter | Treatment | 0th day | 7th day | 14 day |
|-----------|-----------|---------|---------|--------|
| Appearance | Control   | 7.50 ± 0.29 | 7.4 ± 0.28 | 7.02 ± 0.25 | 6.50 ± 0.17 | 6.20 ± 0.15 |
|           | 1%KLP+0kGy| 7.44 ± 0.27 | 7.2 ± 0.25 | 7.03 ± 0.27 | 6.83 ± 0.18 | 6.60 ± 0.17 |
|           | 2%KLP+0kGy| 7.31 ± 0.25 | 7.0 ± 0.05 | 7.05 ± 0.02 | 6.89 ± 0.12 | 6.67 ± 0.10 |
|           | 0%KLP+3kGy| 7.45 ± 0.14 | 6.99 ± 0.16 | 6.96 ± 0.11 | 6.43 ± 0.09 | 6.16 ± 0.08 |
|           | 1%KLP+3kGy| 6.99 ± 0.19 | 6.8 ± 0.18 | 6.50 ± 0.14 | 6.22 ± 0.10 | 5.80 ± 0.09 |
|           | 2%KLP+3kGy| 6.66 ± 0.17 | 6.66 ± 0.16 | 6.65 ± 0.04 | 6.33 ± 0.11 | 5.93 ± 0.10 |
| Texture   | Control   | 8.29 ± 0.33 | 7.4 ± 0.23 | 7.0 ± 0.20 | 6.6 ± 0.12 | 6.5 ± 0.14 |
|           | 1%KLP+0kGy| 8.21 ± 0.62 | 7.2 ± 0.21 | 6.7 ± 0.18 | 6.5 ± 0.13 | 6.4 ± 0.15 |
|           | 2%KLP+0kGy| 8.01 ± 0.30 | 7.0 ± 0.20 | 6.6 ± 0.17 | 6.44 ± 0.15 | 6.37 ± 0.17 |
|           | 0%KLP+3kGy| 8.01 ± 0.21 | 6.90 ± 0.08 | 6.70 ± 0.09 | 6.49 ± 0.80 | 6.30 ± 0.07 |
|           | 1%KLP+3kGy| 7.75 ± 0.28 | 6.6 ± 0.18 | 6.5 ± 0.19 | 6.4 ± 0.14 | 6.30 ± 0.16 |
|           | 2%KLP+3kGy| 7.51 ± 0.25 | 6.4 ± 0.16 | 6.3 ± 0.18 | 6.3 ± 0.15 | 6.2 ± 0.17 |
| Taste     | Control   | 6.80 ± 0.19 | 7.4 ± 0.24 | 7.0 ± 0.20 | 6.6 ± 0.06 | 6.7 ± 0.07 |
|           | 1%KLP+0kGy| 6.66 ± 0.18 | 6.8 ± 0.16 | 6.5 ± 0.11 | 6.4 ± 0.07 | 6.5 ± 0.08 |
|           | 2%KLP+0kGy| 6.56 ± 0.15 | 6.7 ± 0.14 | 6.5 ± 0.14 | 6.3 ± 0.09 | 6.4 ± 0.10 |
|           | 0%KLP+3kGy| 6.77 ± 0.04 | 7.2 ± 0.06 | 6.5 ± 0.07 | 6.4 ± 0.03 | 6.5 ± 0.03 |
|           | 1%KLP+3kGy| 6.45 ± 0.13 | 6.6 ± 0.12 | 6.5 ± 0.11 | 6.2 ± 0.08 | 6.3 ± 0.09 |
|           | 2%KLP+3kGy| 6.38 ± 0.09 | 6.5 ± 0.11 | 6.2 ± 0.13 | 6.1 ± 0.07 | 6.2 ± 0.08 |
| Flavor    | Control   | 7.1 ± 0.21 | 7.6 ± 0.25 | 6.8 ± 0.16 | 6.4 ± 0.11 | 6.6 ± 0.12 |
|           | 1%KLP+0kGy| 6.9 ± 0.19 | 7.3 ± 0.02 | 6.7 ± 0.17 | 6.36 ± 0.12 | 6.56 ± 0.13 |
|           | 2%KLP+0kGy| 6.8 ± 0.08 | 6.9 ± 0.19 | 6.6 ± 0.18 | 6.3 ± 0.14 | 6.5 ± 0.15 |
|           | 0%KLP+3kGy| 7.0 ± 0.07 | 7.4 ± 0.09 | 6.66 ± 0.14 | 6.37 ± 0.11 | 6.2 ± 0.14 |
|           | 1%KLP+3kGy| 6.7 ± 0.07 | 6.8 ± 0.18 | 6.4 ± 0.14 | 6.2 ± 0.15 | 6.4 ± 0.14 |
|           | 2%KLP+3kGy| 6.6 ± 0.06 | 6.7 ± 0.17 | 6.3 ± 0.15 | 6.1 ± 0.14 | 6.3 ± 0.15 |
| OA        | Control   | 7.02 ± 0.21 | 7.45 ± 0.24 | 6.88 ± 0.16 | 6.32 ± 0.03 | 6.8 ± 0.13 |
|           | 1%KLP+0kGy| 6.91 ± 0.19 | 6.95 ± 0.19 | 6.73 ± 0.17 | 6.22 ± 0.12 | 6.40 ± 0.09 |
|           | 2%KLP+0kGy| 6.5 ± 0.15 | 6.45 ± 0.14 | 6.32 ± 0.13 | 6.18 ± 0.10 | 6.28 ± 0.21 |
|           | 0%KLP+3kGy| 7.00 ± 0.14 | 7.40 ± 0.14 | 6.60 ± 0.16 | 6.30 ± 0.16 | 6.29 ± 0.11 |
|           | 1%KLP+3kGy| 6.25 ± 0.15 | 6.3 ± 0.15 | 6.16 ± 0.10 | 6.14 ± 0.05 | 6.17 ± 0.07 |
|           | 2%KLP+3kGy| 6.12 ± 0.09 | 6.20 ± 0.10 | 6.08 ± 0.08 | 6.02 ± 0.06 | 6.10 ± 0.06 |

KLP: Kale leaf powder. The values are mean ±SD of three independent determinations, means carrying different letters in a columns differed significantly.

that irradiation changes the scenery score significantly when used KLP with different concentrations. Table 6 showed the effects of KLP in ostrich and chicken meats. The values of appearance, texture, taste, flavor and OA have seen a decline by increasing the concentration of KLP at different storage intervals.

The finding of the current study similar to [5] who predicted that with the increase of storage intervals, the appearance, texture, taste, flavor and OA were decreased in chicken meat. Our result relates to previous research conducted on ostrich meat that was irradiated (0, 1, 3kGY) at different storage intervals (0, 7, 14, 21 days). Its results showed that by increasing the irradiated dose, sensory parameters decreased. [55] Our results are correlated with [35] who conducted research on ostrich and goat meats. Sensory results were seen high in ostrich meat as compared to goat meat. Nisar et al. [27] predicted that by enhancing the MLP in chicken meat, the acceptance, texture, taste, flavor and OA had also increased on different storage intervals. Another study by [56] proved that texture parameters like gumminess, chewiness and hardness showed a decrease in the control sample at 0th day and high in the sample treated with irradiation.

**Conclusion**

This study evaluated that the nutritional, quality and sensory parameters improved in ostrich and chicken meat and meat product by gamma irradiation. KLP containing some antioxidants and phenolic compounds play a vital role in improving and protecting the fat, amino acid and some...
other functional nutrients of ostrich and chicken meat and meat products. The irradiation dose with or without different combinations minimized the load of total aerobic bacteria and complete decontamination of coliforms at the storage intervals in both types of meat and meat products. Uniformly, the TVB-N value was observed to be high in ostrich meat as compared to chicken meat, whereas a lower value of TBARS and POV was found in chicken meat that increased with storage periods. Conclusively, the 3kGy with or without KLP did not affect the sensory attributes but minimum changes were observed at the storage periods.

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