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# Residual Nitrite in Some Egyptian Meat Products and the Reduction Effect of Electron Beam Irradiation

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**Abstract:** Nitrite, a curing agent of meat products, is a precursor of carcinogenic N-nitrosamines during processing of meat products or under human stomach conditions, as well as having its own toxicity. To investigate the residual nitrite level in meat products marketed in Egyptian markets, 160 samples of cured cooked (luncheon and frankfurter) and cured raw (oriental sausages and pastirma) meat products (40 sample each) were analyzed for residual nitrite by a spectrophotometric method. Samples were subjected to irradiation (3.0 and 5.0 kGy) by electron beam accelerator to evaluate its effect on the residual nitrite level in the examined cured meat products. For statistical analysis, means and standard errors of residual nitrite level were determined and analyzed by one-way analysis of variance. The results revealed that the residual nitrite level was ranging between 10.45-251.6 ppm in the examined meat products and that pastirma had the highest residual level ($p<0.05$) while luncheon showed the least level. Residual nitrite level was significantly reduced ($p<0.05$) by electron beam irradiation (5.0 kGy) and the reduction was dose dependent. This demonstrated that it would still be important to strengthen on control of residual nitrite level in Egyptian meat products and food safety education for public people.

**Key words:** Cooked, irradiation, meat products nitrite

## INTRODUCTION

Nitrate and nitrite as sodium and potassium are used in processed meat products specially cured products because they stabilize red meat color, inhibit some spoilage and food poisoning anaerobic microorganisms such as *Clostridium botulinum*, delay the development of oxidative rancidity and contribute to flavour development (Pierson and Smoot, 1982; Skibsted, 1992; Kanner, 1994; Cassens, 1995; Rahman, 2007). At the commercial level, nitrate is used as reservoir to nitrite in meat products because it is more stable than nitrite (Daniel and Alan, 1998). Nitrates are reduced to nitrites in meats by naturally occurring bacteria and nitrites are reduced to Nitric Oxide (NO), the compound that reacts with myoglobin to produce the typical color of cured meat. Cassens *et al*. (1976) reported that most of the added nitrite is present in meat as NO bound with myoglobin (5-15%), sulphydryl groups (5-15%), lipids (1-5%) and proteins (20-30%), partially is present as nitrate (<10%) and as nitrite (10-15%). However, nitrite can react with secondary amines to form carcinogenic compounds called nitrosoamines, in food products or in the digestive system. Which constitute the major adverse effect of nitrites because of its possible cancer induction. Another well-known effect of nitrite is the lowering of oxygen transport by the bloodstream through the mechanism of oxidizing hemoglobin to methemoglobin especially in infants (Newberne, 1979; Pierson and Smoot, 1982). Exposure to preformed nitrosamines in food should be minimized by appropriate technological practices such as lowering the levels of nitrate and nitrite salts added to foods to the minimum required to achieve the necessary preservative effect and to ensure microbiological safety (EFSA, 2010) or by adding ascorbates or erythorbates to accelerates the depletion of nitrite and reduce nitrosamine formation (Giese, 1994). Concentration of nitrite added to a meat product is affected by several factors including: cooking process, water activity, salt concentration, pH storage time and temperature. Hence, the lowest level of nitrite to have a protective effect against microbiological risks, such as *C. botulinum*, will differ in different products (Rahman, 2007).

Permissible limits for residual nitrites in meat products have been established Worldwide, according to the processing condition of the meat product ranged from40-100ppm (ESS/3597, 2005; ESS/3598, 2005; Shemshadi *et al*., 2006 and Bao-jin *et al*., 2007).

Ionizing radiation is known to be the best method to destroy pathogenic and spoilage microorganisms without compromising the nutritional properties and sensory quality of food (WHO, 1999) and its use is gradually

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increasing worldwide. The U.S. Food and Drug Administration has approved the use of ionizing radiation in fresh and frozen beef at levels of 4.5 and<7.0 kGy, respectively (Olson, 1998). Moreover, WHO (1999) concluded that food irradiated to any dose appropriate to achieve the intended technological objective is both safe to consume and nutritionally adequate. In addition, the application of irradiation for reducing the toxic or undesirable compounds such as volatile N-nitrosamines (Ahn *et al*., 2002), food allergy (Lee *et al*., 2001) and production of low salted fermented foods. (Byun *et al*., 2000) has been reported besides the sanitary purpose of the technology. Ahn *et al*. (2004a) introduces the irradiation technology for the application of reducing the residual nitrite and nitrosamine contents in meat products.

This study was conducted to estimate the level of residual nitrite in cured raw (pastirma and oriental sausage) and cooked (luncheon and frankfurter) meat products, and evaluate the effect of electron beam irradiation on the residual nitrite level in the examined products.

## MATERIALS AND METHODS

In this study, 160 sample of cured cooked (luncheon and frankfurter) and cured raw (Pastirma and oriental sausages) meat products (40 sample each) were collected during second half of 2010 from local supermarkets in Egypt and transferred directly to laboratory of National Center for Radiation Research and Technology (NCRRT), Cairo Egypt. Each sample was divided into 3 parts, the first was left unirradiated and served as control, the second and third part were subjected to 3.0 and 5.0 kGy, irradiation dose respectively. The irradiation process was carried out using electron beam accelerator with energy 1.5 Mev and current 0.9 mA. The samples were then transferred to the lab again to be analyzed for residual nitrite level using the technique recommended by AOAC (2000).

Five grams (5 g) of each sample were mixed thoroughly with 40 mL of hot water (80ºC) in a 50 mL beaker and transferred to 500 mL volumetric flask and thoroughly wash beaker with successive portions of hot water adding all washings to flask. Enough hot water was added to bring volume to about 300 mL, and transferred to steam bath for 2 h with occasional shaking, then cool, filtrate and centrifuge if necessary. Sulphanilamide solution was added to the filtrate in 50 mL flask and leave for 5 min followed by addition of N-1 Naphtyl Ethylendiamine Dehydrochloride (NED), mix and wait for 15 min to develop colour. Absorbance of the developed colour was measured spectrophotomter at 540 nm wave length, against blank of 45 mL water and 2.5 mL of sulphanilamide reagent and 2.5 mL of NED reagent. Residual nitrite level was determined by comparison with the prepared standard curve.

**Statistical analysis:** The values given in each product were the mean value of three replicates. All data were analyzed using one-way ANOVA (SAS, 1985). Comparisons between means were tested. Significance was determined by the F-test and least square means procedure. Main effects were considered significance at $p<0.05$.

## RESULTS AND DISCUSSION

Mean values of residual nitrite (ppm) of non-irradiated and electron beam irradiated (3.0 and 5.0 kGy) cured cooked and cured raw meat products (40 samples each) are shown in Fig. 1 and Table 1 and 2. The results revealed that residual nitrite in the four meat products was between 10.45 to 251.6 ppm. Pastirma samples showed the highest ($p<0.05$) residual nitrite level followed by frankfurter and oriental sausage while luncheon was the lowest ($p<0.05$) level. High residual nitrite in producing pastirma could be attributed to many factors; the product is marketed as raw salt dry product without any type of heat treatment also salt used during curing process of the product may be contaminated with nitrate and nitrite salts. The high level nitrate and nitrite salts used in curing process for protection against anaerobes growth due to product nature-made from whole muscle and covered with spices past then stored in room temp-and to fulfill consumers' desire of pastirma with attractive pink colour. Similar results of high residual nitrite level were recorded by Aiedia (1995) and Attall (1997). Regarding the lower residual nitrite level in oriental sausage, it could be refer to reduced amount of nitrate and nitrite salts used in sausage production because it is consumed fresh –within couple of days after production- and other colouing matters may be used to produce the required product colour. The results obtained in this study are in harmony with that recorded by Aiedia (1995), Kamkar *et al*. (2003), Shemshadi *et al*. (2006). Residual nitrite in luncheon and frankfurter samples was lower than that of pastirma due to effect of heat treatment (Jantawat *et al*., 1993; Khaksar *et al*., 2007). In this regard Cassens *et al*. (1979); Cassens (1995) stated that nitrite is a reactive molecule and less than 50% of the amount added can be chemically analyzed after completion of processing.

Although luncheon and frankfurter samples were within permissible limit, Frankfurter samples showed higher level than that of luncheon and oriental sausage which could be explained as a result of higher amount of nitrate and nitrite salts added to the product during processing aiming to obtain attractive pink colour.

Based on Egyptian specification for residual nitrite in meat products, all examined luncheon and frankfurter samples had acceptable level ranging from 11.59 to 36.71 ppm and 32.25 to 60.37 ppm, respectively. On the other hand, only 22.5% of pastirma and 90% of oriental sausage samples had acceptable residual nitrite level ranging from

Table 1: Mean values of residual nitrite (expressed as ppm of $NaNO_2$) of control and irradiated cured raw meat products. (Samples no. 40 for each product)

| | Pastirma | | | | | Oriental Sausage | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | % of samples | | | | | % of samples | |
| | Min | Max | Mean ±ES | Acceptable | Unacceptable | Min | Max | Mean±ES | Acceptable | Unacceptable |
| Control (0.0 Kgy) | 51.99 | 251.60 | 151.88±8.28$^{aA}$ | 22.5 | 77.5 | 10.45 | 117.0 | 36.47±4.61$^{aB}$ | 90 | 10 |
| 3.0 Kgy | 51.99 | 249.01 | 49.91±8.18$^{aA}$ | 22.5 | 77.5 | 9.95 | 115.38 | 35.59±4.512$^{aB}$ | 90 | 10 |
| 5.0 Kgy | 32.98 | 183.40 | 93.04±5.11$^{bA}$ | 50 | 50 | 5.33 | 77.92 | 25.019±3.21$^{bB}$ | 100 | 0 |

Means with different small letters in the same column are different significantly at the 0.05 level; Means with different capital letters in the same raw are different significantly at the 0.05 level

Table 2: Mean values of residual nitrite (expressed as ppm of NaNO2) of control and irradiated cured cooked meat products. (40 samples for each product)

| | Luncheon | | | | | Frankfurter | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | % of samples | | | | | % of samples | |
| | Min | Max | Mean±ES | Acceptable | Unacceptable | Min | Max | Mean±ES | Acceptable | Unacceptable |
| Control (0.0 KGy) | 11.59 | 36.71 | 24.31±1.18$^{aA}$ | 100% | 0% | 32.25 | 60.37 | 44.87± 1.4$^{aB}$ | 100% | 0% |
| 3.0 Kgy | 11.11 | 36.61 | 24.06±1.17$^{aA}$ | 100% | 0% | 32.05 | 60.00 | 44.50±1.4$^{aB}$ | 100% | 0% |
| 5.0 Kgy | 7.77 | 24.85 | 15.56± 0 .66$^{bA}$ | 100% | 0% | 22.71 | 43.16 | 31.29±1.00$^{bB}$ | 100% | 0% |

Means with different small letters in the same column are different significantly at the 0.05 level; Means with different capital letters in the same raw are different significantly at the 0.05 level

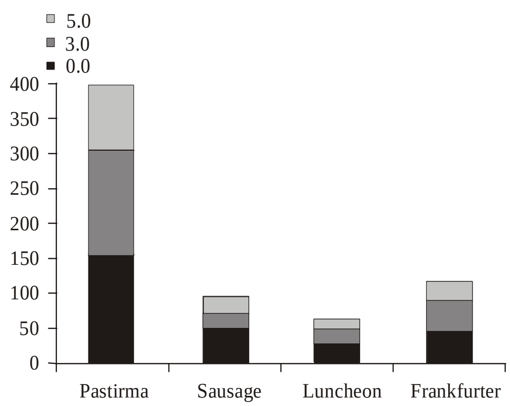


Fig. 1: Residual nitrite in different meat products

51.99 to 97.37 ppm and 10.45 to 100.36 ppm, respectively. It is worth to mention that, EES stated 100 ppm as the maximum permissible limit for residual nitrite in cured meat products and didn't differentiate between cooked, raw meat products, salted and dry products in their residual nitrite. Concerning the effect of electron beam irradiation of meat products, no significant ($p<0.05$) difference in the residual nitrite among irradiated samples compared by non irradiated samples by the application of 3.0 kGy irradiation doses as provided in Fig. 1 and Table 1 and 2. While application of 5.0 kGy significantly ($p<0.05$) reduced residual nitrite in all irradiated samples compared with the non irradiated and 3.0 kGy irradiated samples. This finding was corresponding to those reported by many authors (Ahn *et al*., 2002; Ahn *et al*., 2004a; Ahn *et al*., 2004b; Wei *et al*., 2009). It was observed that pastirma samples provided the highest reduction percent in their residual nitrite content by application of 5.0 kGy while the residual nitrite reduction percent in fresh sausage, luncheon and frankfurter samples was nearly the same as recorded in Table 1 and 2 and Fig. 1.

Furthermore, application of electron beam irradiation on meat products at 5.0 kGy irradiation doses, increase the acceptable sample percentage of examined pastirma from 22.5 to 50% while all fresh sausage, examined samples were within the acceptable limit as stated by the Egyptian standard.

## CONCLUSION

The result obtained in this study clearly indicated that pastirma-popular dry cured meat product- contain high level of residual nitrites which constitute a public health hazard. While residual nitrite in oriental sausage, luncheon and frankfurter were within permissible limit. This demonstrated that nitrate and nitrite salts added to dry cured meat products should be minimized to the minimum requirement that achieve the necessary preservative effect and to ensure microbiological safety. In addition strengthen the food safety education for public people. Moreover, electron beam irradiation at 5.0 kGy may be used to reduce the residual nitrite level in meat products.

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