# Effects of Low-Level of Electron Beam Irradiation on the Characteristics of Pork Fermented Sausage During Storage

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***Abstract*— The effect of low levels of electron beam (EB)-irradiation (1, 2, and 4 kGy) on the quality of vacuum package pork fermented sausage during storage at 4 °C was evaluated (1st, 30th, 60th and 90th days). Significant differences were observed in the values of pH, meat color (CIE L*, a*, b, c*, and hue), microbial viability (Total plate counts and lactic acid bacteria), TBARS, and VBN within the samples of fermented sausage treated with EB-irradiation during storage.**

***Index Terms* — fermented sausage, electron beam irradiation, storage, color, microbial, TBARS**

***Index Terms*—about four key words or phrases in alphabetical order, separated by commas.**

## I. INTRODUCTION

Fermented sausages are characterized at the end of the ripening by accentuated acidity, slight sourness, elastic, and semi-hard consistency (Comi et al., 2005). They are produced by lactic acid bacteria (LAB), which reduce the pH of the sausage within a few days (Houben and Hooft, 2005). Fermented sausages are produced as a result of the lactic fermentation of a mixture of comminuted lean meat (pork and/or beef), pork back fat, sugars, salt, curing agents (nitrate and/or nitrite) and spices (Caplice and Fitzgerald, 1999). Considering a series of recent outbreaks of pathogenic bacteria in meat, the expanded application of irradiation technology in meat and meat products becomes especially important to improve safety and public confidence. It is well known to be able to reduce pathogenic microorganisms thus increasing meat safety and controlling food borne diseases (Ahn et al., 2006). Ionizing radiation includes gamma rays, electron beams, and X-rays. Electron beam (Ebeam) irradiation uses a stream of high-energy electrons, known as beta rays, which can penetrate only approximately 5 cm. In generally, X-Irradiation penetrates foods more shallowly than gamma irradiation but much more deeply than electron beams (Aymerich et al., 2008). FDA regulations state the maximum irradiation dose for refrigerated red meat is 4.5 kGy and frozen meat is 7.0 kGy(21CFR 179.26). The aim of the present work is to study the effect of low level of EB-treatment (1, 2, and 4 kGy) and vacuum packaging on the characteristics of fermented sausages during refrigerator storage.

## II. MATERIALS AND METHODS

### *A. Pork salami preparation and packaging*

Fresh boneless pork cuts from loin and back fat were processed in a mincer (Model 5K5SS, USA) equipped with an adjustable plate set at a hole diameter of 5 mm, and then, inoculated with the starter culture. Used seasonings and additives were obtained from MSC Co., Ltd. (Seongnam, Korea). All the sausages were manufactured on the same day, using the same technology, ingredients and formulation, which were: (a) raw material (% w/w): pork meat (86), pork backfat (9), NaCl (2.5), $NaNO_3$ (0.012), $NaNO_2$ (0.008), sodium ascorbate (0.25), glucose (0.3), sucrose (0.4), powdered black pepper (0.2), red pepper (0.2), garlic (0.5), commercial seasoning (0.58); and a microbial starter (0.05%) of *Lactobacillus pentosus and Staphylococcus carnosus* in the same proportions. The final mixture was stuffed into synthetic casings (4.5 mm diameter) and left to ripen in a ripening cabinet. The sausages were fermented at 25 °C and 90% relative humidity (RH) for 24 h. Then, the temperature and RH were slowly reduced to reach 10 °C and 70% RH, respectively, after 30 days. At that time, the final products were vacuum-packed and irradiated and stored at 4 °C.

*B. Irradiation and storage conditions*

Both side of vacuum-packaged salami were irradiated at 0 (control), 1, 2, and 4 kGy by EB. EB irradiation was performed with an ELV-4 Electron-Beam-Accelerator (2.5 MeV) at the EB-Tech (EB-Tech Co., Daejeon, Korea). After irradiation, the patties were stored at 40 °C for 90 days.

*C. Quality Evaluation of fermented sausage*

The pH values were determined by homogenizing (T25B, IKA Sdn. Bhd., Malaysia) 10 g of a ground sample with 90 mL distilled water, and then measuring it with a pH meter (Model 8603, Metrohm, Swiss). Color was measured instrumentally using a spectrocolorimeter (CR 400, Minolta Co., Japan) (λ: 400–700 nm, Δλ: 10 nm, D65, 10°) calibrated with a white plate and light trap supplied by the manufacturer. Color was expressed using the CIE $L^*a^*b^*$ color system (CIE, 1976). The VBN was determined according to using the Conway micropipette diffusion method (Pearson, 1968) and was expressed as mg VBN 100 $g^{-1}$ of the sample. The 2-thiobarbituric acid reactive substances (TBARS) test according to Tarladgis et al. (1960) was used to determine the extent of oxidative rancidity. Total plate counts were measured on the plate count agar (PCA; Difco Lab) at 37°C for 2 days. Lactic acid bacteria were incubated anaerobically on Lactobacilli MRS Agar (Difco, Detroit, MI, USA) at 32°C for 2 days. Enterobacteriaceae and *E. coli* were incubated on *E.coli*/Coliform count plate petrifilm (3M Health care, USA) at 30°C for 2 days under same aerobic conditions.

## III. RESULTS AND DISCUSSION

Fermented sausages are characterized by low acidity and the final pH is of about below 5.5 (Aymerich et al., 2003). As shown in Table 1, initial pH (day 1) of non-irradiated samples were 4.90 and those of irradiated samples at 1, 2, and 4 kGy were 4.97, 4.95 and 4.96, respectively. The pH values of treated samples were significantly higher than those of control during storage ($p < 0.05$). ANOVA results for lipid oxidation (TBARS) indicated that TBARS values were significantly affected by irradiation dose (Fig. 1). Changes in TBARS of fermented sausages are shown in Fig. 1. TBARS values increased after irradiation (2 and 4 kGy), except 1 kGy treated samples. In this way, sausage treated at 2 kGy and 4 kGy had higher TBARS numbers (mg MDA/kg) than non-treated samples. Results are in agreement with several studies that reported an increase in TBARS numbers in meat and meat products irradiated at different dose levels (Akamittath et al., 1990). Additionally, regression analysis indicated that increases in the amounts of thiobarbituric acid-reactive substances did linearly with the irradiation dose ($R^2$=0.70, $p$<0.01) at 1 day of storage, being in agreement with previously works in which a dose-dependent relationship has been described (Ahn et al., 1998).

ANOVA results for CIE color coordinates indicated a significant effect of irradiation dose for b, chroma, and hue angle was found at initial day of storage between EB-irradiated sample and control (Fig. 1). The values of $L^*$and $a^*$ were not affected ($p > 0.05$) by the irradiation treatment, however, the higher dosage of EB-irradiate samples were slightly higher in CIE $L^*$ and lower in CIE $a^*$ values comparing the control at 1 day of storage. Several authors have found that irradiation reduced the redness ($a^*$ value) of ground beef significantly (Nam and Ahn, 2003). Previous research has reported that the complex of heme pigments with carbon monoxide produced by irradiation was responsible for the colour changes in irradiated meat (Nam and Ahn, 2002). Giroux et al. (2001) speculated that free binding sites of myoglobin can react with free radicals such as hydroxyl or sulfuryl produced by irradiation to form metmyoglobin and sulfmyoglobin. However, there is scarce information on the pigments responsible for producing the off-colour in irradiated fermented sausages. On day 1, total aerobic bacterial populations in fermented sausages (untreated) were about 5.09 log CFU/g.. After irradiation, TPC of 4 kGy irradiated samples were slightly lower than those of others, however, there were no significant difference among the samples. At 30 day of storage, TPC of 4 kGy irradiated samples (1.00 log CFU/g) were significantly lower than the others (5.07-5.25 log CFU/g). In addition, until 60 day of storage, TPCs of 0, 1, and 2 kGy treated samples were not changed, however, after 60 days, untreated samples became increased, 1 and 2 kGy treated samples became decreased.TPC of 2 KGy treated samples were dramatically decreased after 30 days of storage and maintained low values of bacteria untill the last day of storage. (0.73-1.17 log CFU/g). This result was also found in studies by Chung et al., 2000).

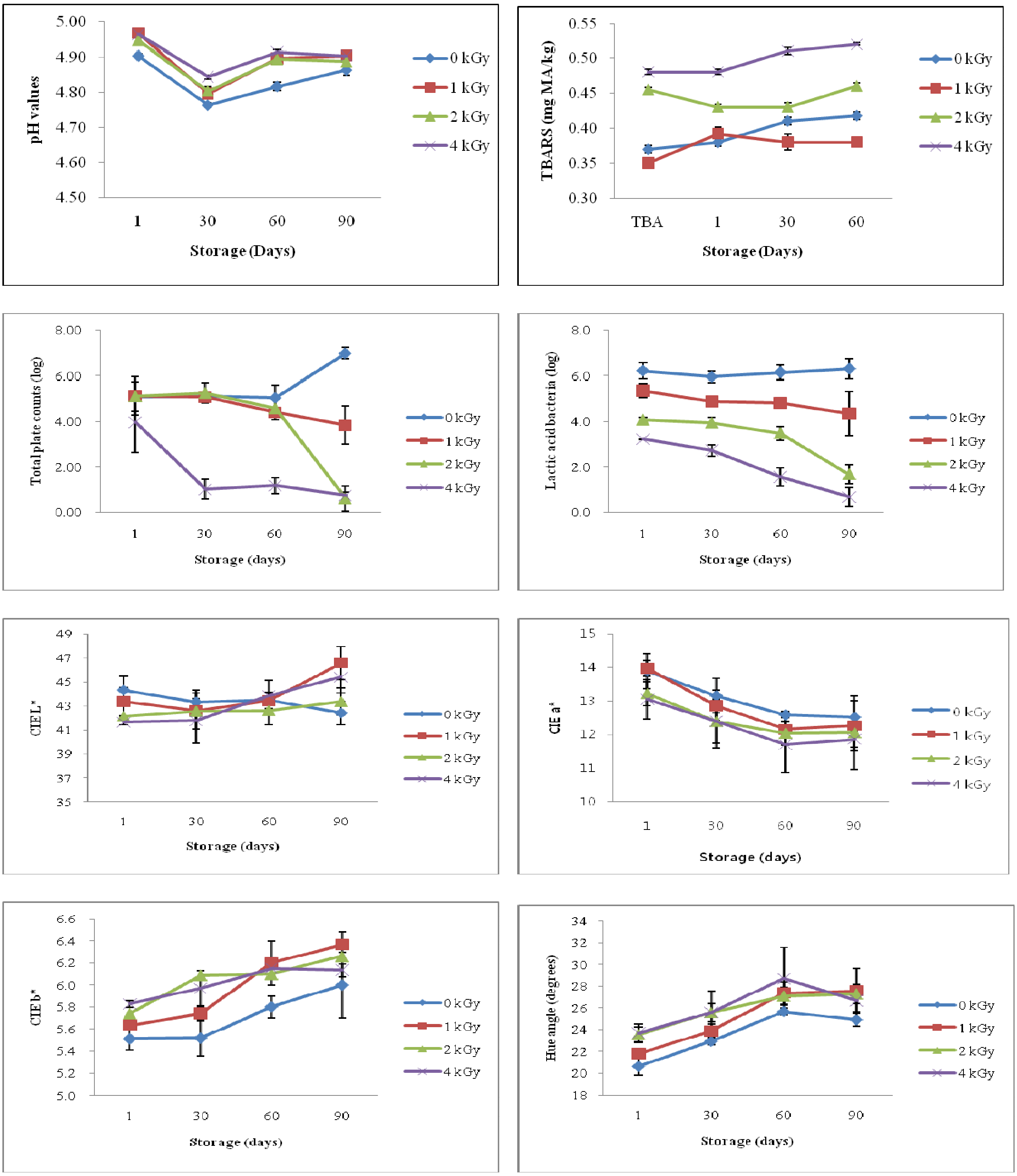


Fig. 1. Effects of electron beam irradiation on the pH, TBARS, total plate counts (TPC), lactic acid bacteria (LAB) and color parameters (CIE L*, a*, b*, hue angle) of fermented sausage during storage.

## IV. CONCLUSION

Resuts suggest that 2 kGy irradiation change the values of TBARS, total microbial counts, lactic acid bacteria of fermented sausage dramatically. However, in the aspect of the survival of LAB during storage, irradiation of 1 kGy was more effective in storaging fermented sausages than higher dose (2, 4 kGy).

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