Study on the effect of low energy electron beam irradiation on the quality and shelf life of beef

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Introduction: Beef is one of the main meat foods consumed by Chinese people, which is rich in protein, lipids and various vitamins. However, the short shelf life has become a major factor hindering its development (Park et al., 2010). Electron beam irradiation can make use of the interaction between ionizing radiation and matter, so as to achieve the effect of sterilization and preservation. The application of electron beam irradiation in meat preservation has been studied for many years, but most of them are irradiated by 5 - 10 MeV at high energy, which will have a significant impact on the sensory quality and nutritional value of meat.

In this study, the low energy electron beam irradiation technology with 0.2MeV energy combined with vacuum packaging is used to process the beef steak. Through the simulation calculation of MCNP program, it was determined that the irradiation only penetrated 277μm of beef after passing through 10 mm air and 55 μm PVDC film. While killing microorganisms, it ensured that the sensory quality and nutritional value of beef would not be significantly affected, so as to solve the problem of short shelf life of beef. The purpose of this study is to provide technical guidance for the application of electron beam irradiation in beef preservation and storage.

Materials and methods: Six Simmental crossbred cattle aged 18-24 months, with similar body weight and growth environment were selected and slaughtered in commercial abattoir. The longissimus dorsi muscle of cattle was taken and their pH value between 5.4 - 5.7, then the surface fat and connective tissue were removed, and the steak with 1.5cm thickness was divided. After vacuum packaging, the steak was stored at 4 ℃. E-beam irradiation was conducted using an electron accelerator (Low Energy Linear Accelerator, 0.2 MeV) to ensure five different absorbed doses (0, 4, 8, 12 and 16 kGy). Because the irradiation dose only acts on the surface of beef, the higher dose has little effect on the overall sensory and nutritional value of beef, which is worth exploring. After irradiation, it was stored at 0-4 ℃ for 21 days. Each cow is a parallel repeat. Total viable count (TVC), meat color, pH value and lipid oxidation (TBA) were measured at each time point (0, 7, 14 and 21 days), and sensory evaluation was performed. The effect of irradiation doses and storage intervals were determined by two-way analysis of variance (ANOVA) test using SPSS 16.0 software (IBM, Armonk, NY, USA)(Jo, An, Arshad, & Kwon, 2018).

Results: Storage time and irradiation dose had significant effects on total viable count, pH value and sensory evaluation ($P < 0.05$), but there was no interaction between them ($P > 0.05$). Total viable count in all samples increased with the extension of storage time. The total bacterial count in the control group was 5.99 log CFU/g after 21d storage, which was close to the national microbiological safety standard 6.0 log CFU/g for meat products, while that in the 4 kGy treatment group was 4.02 log CFU/g. The pH value increased with the prolongation of storage time, but had no significant change with the increase of irradiation dose. During the whole storage time, the acceptability scores of 4kGy, 8kGy and the control group were higher.

There was a significant interaction between storage time and radiation dose in meat color ($P < 0.05$). The values of L*, a * and b * in the control group decreased with the extension of storage time, while those in the radiation group increased with the extension of storage time. In the early stage of storage, the values of a * and b * in the radiation group were significantly lower than those in the control group, but improved with the extension of storage time. Irradiation treatment accelerated lipid oxidation in the early stage of storage, but the oxidation rate in the later stage of storage was slower than that in the untreated group.

Conclusions: In this study, the total number of bacteria in chilled beef decreased significantly after low energy electron beam irradiation, and the higher the radiation dose, the better the germicidal efficacy. The increase of irradiation dose had no significant effect on pH value. Low dose (≤ 8kGy) treatment had no significant effect on sensory quality and fat oxidation of beef after 14 days. The use of ≤ 8kGy in low energy electron beam irradiation can effectively inhibit bacteria and does not affect its physical and chemical properties.

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