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Radiosensitivities of bacterial isolates on minced chicken and poached chicken meal and their elimination following irradiation and chilled storage

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Abstract

The radiosensitivities of *Escherichia coli* and *Staphylococcus aureus* on poached chicken meal (PCM) and minced chicken substrate (MCS) were determined. Effect of irradiation (0, 1, 2 kGy) on total viable cells (TVC) of PCM components was determined under chilled (3–5 °C) storage (0, 9, 14, 21 days) and challenge testing of the bacterial isolates with irradiation (0, 2, 3 kGy) was also conducted on PCM under chilled storage (0,7, 14, 21, 28 days). Additionally, sensory evaluation of the PCM components was assessed with irradiation (0, 2, 3 kGy) during chilled storage (0, 7, 14, 21 days). D_{10} of *E. coli* on PCM and MCS were 0.18 and 0.25 kGy whiles those of *S. aureus* were 0.27 and 0.29 kGy, respectively. D_{10} values for PCM < MCS and values for *S. aureus* > *E. coli.* 2 kGy controlled TVC and extended the shelf life of meals to ⩾14 days but 3 kGy was required to eliminate *E. coli* and *S. aureus*. Sensory qualities of the meal were not affected by an irradiation dose of 3 kGy.

Keywords: Radiosensitivity; *Escherichia coli*; *Staphylococcus aureus*; Poached chicken meal; Shelf-life extension

1. Introduction

Ready meals have become a well-established sector of the food industry worldwide due to their convenience and nutritious nature. A large proportion of such meals is prepared and marketed under ambient tropical conditions in most developing countries. As such, they have limitations such as reduced shelf life and sensory quality (Zacharias, 1980; Bryan, 1990).

Studies have revealed high counts of 10^6–10^8 cfu/g for aerobic mesophiles and coliforms as well as the presence of potential pathogens such as *Klebsiella* sp., *Enterobacter* sp., *Staphylococcus aureus* and *Clostridium perfringens* in ready meals in Ghana (Nketsia-Tabiri et al., 2004; FAO/Ghana, 1997). Although a few caterers employ HACCP in the preparation of cook-chill meals, the method does not eliminate potential pathogens. Ready meals are not sterile hence inadequate temperature during storage could stimulate growth and proliferation of the residual pathogens.

It is in the light of the foregoing that treatments, such as irradiation should be considered. Studies have shown the use of irradiation and chilled storage could improve the microbiological quality and safety of ready meals (Patterson and Stewart, 2003; McAteer et al., 1995). The overall objective of this study is to determine the optimum radiation dose to enhance microbiological safety and extend the shelf life of cook-chill poached chicken meal (PCM) at storage temperatures of 3–5 °C without affecting the sensory qualities.

2. Experimental

2.1. Preparation of inocula, meal and substrate portions

Generic non-pathogenic *E. coli* and coagulase-positive *S. aureus* isolated from some local cook-chill meals were used for the study. Cultures were reactivated by incubation

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at 37 °C for 24 h and used for preparation of *inocula*, which were standardised to an approximate concentration of 10^8 cfu/ml by serial dilution and a haemocytometer.

Freshly prepared cook-chill PCM consisting of chicken, rice, boiled carrots, and gravy obtained from a local caterer was homogenized, respectively, in a ratio of 4.0:2.7:1:1 for 1 min using a stomacher homogeniser (Mix2, AES Laboratoire, France). Minced chicken substrate (MCS) was prepared by homogenizing poached chicken for 1 min.

2.2. Radiation sensitivity tests

A 5 ml suspension of each bacterial isolate was aseptically added to 25 g portions of the PCM and MCS in separate polyethylene pouches, sealed, stored at 3–5 °C for 24 h and then treated with doses of 0, 100, 300, 450, 600, 750, 850 Gy. All samples were analysed for surviving bacterial isolates.

2.3. Storage studies

2.3.1. Uninoculated pack experiments

Components of PCM were used for the experiment. The chicken and gravy were packaged together and irradiated at 2 kGy while the rice and boiled carrots were packaged individually and irradiated together at 1 kGy. Enumeration of total viable cells (TVC) was carried out at 0, 9, 14, 21 days of refrigerated storage (3–5 °C).

2.3.2. Challenge testing experiments

PCM (homogenised as above) was used for the experiment. A 5 ml suspension of each bacterial isolate was added to 25 g of the meal portions in polyethylene bags, sealed, stored at 3–5 °C for 24 h and treated with doses of 0, 2 and 3 kGy. Enumeration of surviving cells of *E. coli* and *S. aureus* was carried out at 0, 7, 14, 21, 28 days of refrigerated storage (3–5 °C).

2.4. Irradiation of samples

All samples were irradiated using a Co^{60}source (SLL-515, Hungary) at a dose rate of 2.65 kGy/h in air. The absorbed dose was confirmed by Fricke's dosimetry.

2.5. Microbiological analysis

Standard methods (APHA, 1976) were used to estimate TVC on Plate Count Agar (Merck, Germany), *E. coli* on Eosin Methylene Blue Agar (Difco, USA) and *S. aureus* on Baird Parker Agar (Difco, USA). Cultures were incubated at 37 °C for 48 h.

2.6. Sensory tests

Components of PCM (rice, carrots, chicken and gravy) irradiated at 0, 2,and 3 kGy and stored at 3–5 °C were analysed after 7, 14 and 21 days. After warming for 5 min using a microwave oven (600 W), 20 trained panelists subjected the components to sensory evaluation using a nine-point hedonic scale to determine whether irradiation significantly affected consumer preference in terms of taste, colour, aroma and texture.

2.7. Statistical analysis

Microbial counts (colony forming units, cfu/g) were transformed into logarithms ($\log_{10}$) and data subjected to regression analysis. The D_{10} values (the dose required to inactivate 90% of a population) were calculated by plotting $\log_{10}(N/N_0)$ against (D) according to the equation, $D_{10} = D/(\log N – \log N_0)$ where, N_0 is the initial viable count; N the viable count after radiation with dose D (Stumbo et al., 1950). Analysis of variance (ANOVA) was used to determine significant differences and least significant differences (LSD) for multiple comparisons in analysing the sensory attributes of the PCM components.

3. Results and discussion

3.1. Radiosensitivities of bacterial isolates

The D_{10} value provides information on the sensitivity of microbes to irradiation. The calculated D_{10} values of *E. coli* on PCM and MCS were 0.18 and 0.25 kGy, respectively (Figs. 1(a) and (b)). These compare well with the reported range of 0.16–0.39 kGy on beef and poultry meat (Thayer et al., 1995; Patterson, 1988). The D_{10} values of *S. aureus* were 0.27 and 0.29 kGy on PCM and MCS, respectively. These also compare well with the reported range of 0.22–0.58 kGy on meat and poultry (Grecz et al., 1983; Thayer and Boyd, 1992). The D_{10} values were lower on the PCM than the MCS and values for *S. aureus* were higher than *E. coli.* This observation could be due to the modifying role of higher content of proteins and probably lower water activity in the MCS compared to the PCM, which had a higher content of carbohydrates and possibly higher water activity (IAEA, 1982).

3.2. Effect of irradiation and storage time on total viable cells

As shown in Table 1, the initial count of TVC of the non-irradiated components of the PCM were low (1.68–2.53 $\log_{10}$ cfu/g). There was at least a 3 log cycles increase in TVC for the non-irradiated carrot and chicken/gravy by the 14th day compared to approximately a 1 log cycles increase for non-irradiated rice. Both non-irradiated carrot and chicken/gravy developed an offensive odour by the 21st day and were not analysed. However in the case of the irradiated components, the TVCs were all $<3.0\log_{10}$ cfu/g by the 14th day. Irradiation doses of 1 kGy for rice and 2 kGy for chicken/gravy were effective in reducing the TVC below 3.0 $\log_{10}$ cfu/g within 14 days of chilled storage. Although the TVC of irradiated carrots were lower after 9