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Development of shelf-stable, ready-to-eat (RTE) shrimps (*Penaeus indicus*) using γ-radiation as one of the hurdles

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Abstract

A process has been developed for the preparation of shelf-stable, ready-to-eat (RTE) shrimps using a combination of hurdles. The hurdles employed to cooked marinated shrimps included reduced water activity (0.85 ± 0.02), packaging and γ-irradiation (2.5 kGy). Microbiological analysis revealed a dose dependent reduction in total viable count and *Staphylococcus* species. In nonirradiated samples a visible mold growth was seen within 15 days of storage at ambient temperature (25 ± 3 °C). No significant changes in textural properties and sensory qualities of the product were observed on radiation treatment. These RTE shrimps were microbiologically safe and sensorially acceptable even after 2 months of storage at ambient temperature.

Keywords: Shelf-stable; Hurdle technology; Radiation processing; Water activity; Mold growth

1. Introduction

Shrimp is a highly perishable commodity and its post-harvest handling and processing being labor intensive, result in increased microbial contamination. In recent years there is increase in the demand for convenience, ready-to-cook/eat, shrimps. Individually quick frozen (IQF) breaded shrimps are available in the market. Freezing facilities are expensive and inadequate in developing countries and thus there is only a very small market for these products. Freezing being bacteriostatic is not effective in eliminating pathogenic microbes, thus posing a potential health hazard to the consumer (Geraldine, 1992). Therefore, there is a need to develop a technology, which can give shelf-stable and microbiologically safe products that will be of great economic and health significance.

In India, shrimps are traditionally sun dried and/or heavily salted to preserve them at ambient temperature. Such products are however susceptible to spoilage by mold and are inferior in quality due to loss of color, texture and flavor. Investigations were carried out to prepare shelf-stable and microbiologically safe ready-to-eat (RTE) shrimps using combination of various hurdles such as reduced water activity (a_w), packaging and γ-irradiation. Reduction of water activity is an effective preservation method of perishable material as growth of many of the spoilage bacteria is retarded due to low water activity. There are a number of reports on the development of intermediate moisture (IM) products having reduced water activity (Wang & Leistner, 1993, 1994; Kanatt, Chawla, Chander, & Bongirwar, 2002). At water activities of less than 0.85, growth of most of the spoilage bacteria will be arrested but many types of yeasts, molds and a few kinds of bacteria may continue to grow. Among bacteria of public health significance *S. aureus* is known to grow and produce enterotoxin at a_w values of 0.86 or higher (Jay, 1991). Radiation processing is a useful technique to improve microbiological quality and enhance safety of several food commodities (Farkas, 1998). More than 26 countries throughout the world use irradiation on a commercial scale (Lacroix &

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Ouattara, 2000). However, because of misunderstandings about the technology itself and misguided association with the nuclear establishment, food irradiation has often been set aside for use only when everything else fails. Further, irradiation of fish and meat may be the key to a wider adoption of the technology the world over because of its unique potential as a control measure of diseases well known and feared by the public. In the present study we report the feasibility of preparing shelf-stable and microbiologically safe, convenience shrimps using γ-radiation as one of the hurdles.

2. Materials and methods

2.1. Preparation of shrimps

RTE shrimps were prepared by marinating deveined shrimps. Marinade consisted of soy sauce (Sams Foods Products, Mumbai, India) (40 ml), ginger–garlic paste (Dabur Foods Ltd., New Delhi, India) (40 g), chilli powder (S. Narendra Kumar & Co., Mumbai, India) (4 g) and salt (Tata Chemicals Ltd., Mumbai, India) (12 g) per kg of deveined shrimps. The product was then steamed for 10 min in a perforated steel container. Partial dehydration of the product was carried out in a hot air oven (60 °C) for 3 h to obtain $a_w \leqslant 0.85$. The product was packed after cooling in low-density polyethylene bags (LDPE) (700 gauge; water vapor transmission rate (WVTR) 0.4 g/m^2/day; oxygen transmission rate (OTR) 1800 ml/m^2/day).

2.2. Irradiation

The packed samples were irradiated at ambient temperature at a dose rate of 1.8 kGy/h in a Food Package Irradiator (Nordion Intl. Inc., Canada) with a ^{60}Co source. The samples received minimal doses of 1, 2.5 and 5 kGy. Dosimetry was performed as per described in Kanatt et al. (2002). Nonirradiated lot served as control. All samples were stored at ambient temperature (25 ± 3 °C). Samples from both irradiated and nonirradiated lots were analysed immediately after irradiation and subsequently at regular intervals of 2 weeks during storage.

2.3. Measurement of water activity

The water activity of the samples was measured using Aqua Lab CX2 T water activity meter (Decagon Devices, Inc., USA).

2.4. Microbiological analyses

Samples (20 g) in duplicate from the irradiated as well as the nonirradiated batches were aseptically homogenized for 2 min in sterile stomacher bags containing 180 ml of sterile saline using Stomacher 400 Lab Blender (Seward Medical, UK). Serial dilutions were made in sterile saline and appropriate dilutions were plated in duplicate. All microbiological media were procured from HiMedia Laboratories, India. Media employed were plate count agar, Baird–Parker agar, violet red bile agar and potato dextrose agar for determination of total viable counts (TVC), *Staphylococcus* spp., coliforms and mold counts, respectively. For aerobic spore counts homogenate was heated in a water-bath at 80 °C for 15 min, cooled and plated on plate count agar.

2.5. Measurement of lipid peroxidation

Oxidative rancidity was measured by estimating thiobarbituric acid reactive substances (TBARS) by the method of Alasnier, Meynier, Viau, and Gandmer (2000). To 4 g of shrimp samples, 16 ml of trichloroacetic acid (TCA) (5 g per 100 ml) was added, followed by 10 µl of butylated hydroxy toluene (BHT) in ethanol (1 g per 100 ml). Samples were homogenized in a polytron homogenizer and filtered through Whatman filter paper (No. 4). Two milliliters of 0.02 mol/l thiobarbituric acid (TBA) was added to 2 ml of the above filtrate and heated in a boiling water-bath for 30 min. The samples were cooled and the pink colored complex with absorption maxima at 532 nm was measured. The intensity of the colored complex is a measure of the malonaldehyde concentration. The TBARS content was expressed as mg malonaldehyde per kg of sample.

2.6. Mechanical properties

Method described by Bhushan and Thomas (1998) was modified to determine the cutting force required for nonirradiated and irradiated IM shrimps using Instron Universal Testing Machine. A blade probe was used instead of a cylindrical one.

2.7. Sensory analysis

Acceptability of products at different storage points was determined as described in Kanatt et al. (2002). Briefly, convenience shrimp product was presented to a panel of 12 trained panelists for sensory evaluation. The panelists were familiar with the characteristics of shrimps. Panelists were asked to rate samples as 'acceptable' or 'nonacceptable' on the basis of appearance, odor, flavor and taste using a 10-point scale, where 10 corresponds to a product of highest quality and 0 corresponds to a poor quality of product. Scores of 6 and above were considered acceptable.