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Shelf stable intermediate moisture pineapple (*Ananas comosus*) slices using hurdle technology

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ABSTRACT

A process has been developed to prepare shelf stable ready-to-eat (RTE) intermediate moisture pineapple (*Ananas comosus*) slices using hurdle technology. The combination of hurdles including osmotic dehydration, infrared drying, and gamma radiation dose of 1 kGy successfully reduced the microbial load to below detectable limit. The shelf life of the intermediate moisture pineapple slices was found to be 40 days at ambient temperature (26 ± 2 °C). The untreated control samples spoiled within 6 days. The RTE intermediate moisture pineapple slices were found to have good texture, colour and sensory acceptability during this 40 days storage.

1. Introduction

Pineapple (*Ananas comosus*) is one of the most popular tropical fruits. The fruit is known for its nutritive and health promoting properties (Mortan, 1987). It is commonly used as table fruit or in desserts. The shelf life of ripe pineapple is short and limited to 4–6 days (Hajare et al., 2006). Fresh pineapple contains thick, thorny inedible peel and a large crown which consumes storage space and also results in higher transportation costs (Fernandes, Rodrigues, Gaspareto, & Oliveira, 2006). Therefore, value addition by processing to a RTE product is an attractive alternative. Pineapple slices dipped in sugar syrup and canned are normally used around the world (Mortan, 1987). The canned pineapple is shelf stable but it is not liked by some consumers due to its high sweetness.

The shelf life of peeled, sliced and polyethylene packed pineapple sold in market is 4–6 days when stored at room temperature, whereas, pineapple slices when kept at 8–10 °C, do not stay more than 8–10 days. Therefore, many alternate approaches were followed for pineapple preservation. The blanching treatment for microbial reduction and browning inhibition affects freshness and taste. Cut pineapple undergoes enzymatic browning which can be inhibited by dipping in potassium metabisulfite solution (Adams & Moss, 2000). In osmotic dehydration water is partially removed from the product by dipping in hypertonic sugar syrup (Corzo & Gomes, 2004; Fito, 1994; Pokharkar, Prasad, & Das, 1997; Raoult-Wack, 1994; Raoult-Wack, Lafont, Rios, & Guilbert, 1989; Rastogi, Eshtisghi, & Knorr, 1999; Simal, Benedito, Sánchez, & Rosello, 1998; Torreggiani, 1993). The dipping in sugar solution reduces water activity (a_w) to about 0.9 which is not enough for preventing bacterial, yeast and moulds growth, being these involved in spoilage. Infrared drying offers a number of advantages including drying uniformity, reduced drying time, energy efficiency, and high quality finished products (Abe & Afzal, 1997; Afzal & Abe, 1998, 2000; Hebbar & Rostagi, 2001; Zhu, Zou, Chu, & Li, 2002). Due to limitations of individual preservation methods, a combination of these hurdles was used for maximizing pineapple shelf life. The intermediate moisture pineapple products are becoming popular because these are shelf stable, retains nutritional value, convenient to use, incur in less transportation and storage costs (Leistner, 1992; Thakur & Singh, 1995). Radiation processing, a cold process, is being used as a preservation method for food commodities and is increasingly attaining new applications (Diehl, 1990; Urbain, 1986). This is one of the very effective alternatives for ensuring microbial quality and safety of minimally processed fruits and vegetables and is also recommended for processed pineapple (Shashidhar, Dhokane, Hajare, Sharma, & Bandekar, 2007).

The objective of the present study was to prepare shelf stable, ready-to-eat and safe intermediate moisture pineapple slices using combination of different hurdles.

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2. Materials and methods

2.1. Chemicals

Luria-Bertani agar (LBA), potato dextrose agar (PDA), Baird-Parker agar (BPA), violet red bile agar (VRBA), and egg-yolk tellurite emulsion were purchased from Himedia Laboratories, Mumbai, Maharashtra, India. High density polyethylene packages (HDPE) of film thickness, 500 gauge and sucrose were obtained from local market. Potassium metabisulfite and sodium chloride (NaCl) were purchased from S. D. Fine-Chem. Ltd., Mumbai, India.

2.2. Gamma radiation treatment

Gamma radiation treatment was carried out in a cobalt-60 Gamma Chamber-5000 (GC-5000, BRIT, Mumbai, Maharashtra, India; dose rate 7.65 kGy/h) at Food Technology Division, Bhabha Atomic Research Centre, Mumbai, India. The packed samples were treated at different doses of gamma radiation (250 Gy, 500 Gy and 1 kGy) at ambient temperature. Non-irradiated samples were used as control. After radiation treatment, the samples were stored at ambient temperature (26 ± 2 °C) and relative humidity ($56 \pm 3\%$ RH). The radiation dosimetry was carried out by placing Fricke dosimeters (Super Fricke for the dose range: 400–1000 Gy) among samples, where conversion of ferrous to ferric was spectrophotometrically measured at 304 nm (Sehsted, 1970).

2.3. Pineapple processing

The pineapples (6 nos.) procured from a local market were cleaned in water, crowns removed and peeled manually. The fruits were then transversely cut into 8 slices, each of approximately 1 cm thickness. The slices were dipped in potassium metabisulfite water solution (0.25%) for 2 h followed by immersion in sugar (sucrose) water solution (70%, 16 h). The slices were taken out of the sugar solution, drained on a two layered muslin cloth and dried in infrared (IR) dryer (Sakav, Shirsat Electronics, Mumbai, Maharashtra, India) at 80 °C/1 h to bring the a_w to 0.82. The slices were then packed in high density polyethylene bags, sealed, radiation treated, and stored at ambient temperature (26 ± 2 °C). Such processed pineapple named in this paper as intermediate moisture (IM) pineapple slices were periodically examined and subjected to following analyses up to a period of 40 days of storage.

2.4. Microbiological analysis

The every microbiological load analyzed in this work: total bacterial count (TBC), yeast and mould count (YMC), coliform counts and *Staphylococcus* spp. was determined as described by ICMSF (2002). Individual pineapple slices (25 g) were aseptically homogenized for 2 min in stomacher bags with 75 ml sterile saline water solution (0.85% NaCl) using Stomacher Blender (Stomacher Lab Blender, model 400, Seward, U.K.). Serial dilutions were made in sterile saline and spread plated in duplicate. Media employed were plate count agar, potato dextrose agar, violet red bile agar, and Baird-Parker agar for determination of TBC, YMC, coliform counts, and *Staphylococcus* spp., respectively. The microbial analyses of pineapple slices were undertaken periodically during storage. All the media were procured from Himedia Laboratories, Mumbai, Maharashtra, India.

2.5. Water activity (a_w) measurement

A small piece of pineapple slice weighing approximately 2 g was used for determination of water activity using a water activity meter (AqualabCX2T, Decagon Devices, USA). The measurement was taken with samples drawn from four slices and the average value was expressed as water activity of the product.

2.6. Moisture content

To determine the moisture content, weighed pineapple slices were kept in a hot air oven (Metlab Scientific Instruments, Mumbai, India) at 100 °C till the weight remained constant. The percentage decrease in weight was expressed as moisture content (AOAC, 1995). The measurement was replicated with the samples drawn from four different slices and the average was taken as moisture content of the product.

2.7. Colour measurement

Colour of the central region of pineapple samples was measured by reflectance measurement using a Minolta CM-3600D Spectrophotometer (Konica Minolta Sensing, Inc., Osaka, Japan). The reflectance of whole visible spectrum (360–780 nm) was recorded at wave length intervals of 10 nm. D_{65} lamp was used as reference light source and the detector was fixed at an angle of 10° with respect to the light source (Hajare et al., 2006). The colour parameters L^* (Lightness), a^* (Redness), b^* (Yellowness), C^* (Chroma), and H^* (Hue) were analyzed with using JAYPAK 4808 software (Quality Control System, Version1.2).

2.8. Texture analysis

Texture was analyzed using a Texture Analyser (TA.HD plus, Stable MicroSystems, Godalming, Surrey, UK) with a P/2N needle probe. The probe speed and penetration depth were 0.5 mm/s and 5 mm, respectively. The hold time was 0.01 s and the trigger force was set at 10 g force. The probe travel distance was optimised for 5 mm. Texture was expressed in the unit of gram resistance force (g) measuring resistance offered by the sample to the penetrating needle probe (Hajare, Saroj, Dhokane, Shashidhar, & Bandekar, 2007). The instrument was calibrated before each use. In sliced pineapple, tissue firmness varies from centre to periphery and hence, texture was measured at various points starting from the central pith region to the peripheral region of the edible portion. Different zones in pineapple slice were classified on the basis of difference in texture and are shown in the Fig. 1. Zone 1 was the innermost central portion followed by zone 2 that surrounded the central pith region. Zone 3 was the portion surrounding zone 2.

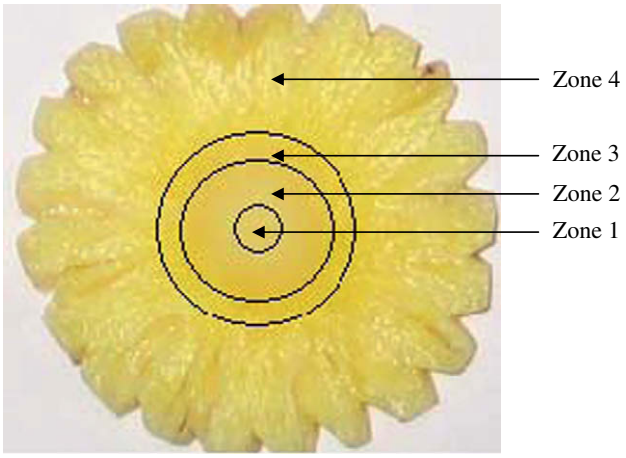

Fig. 1. A sketch of pineapple slice depicting the portions selected for texture analysis.