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Short communication

The effect of electron beam on dates infestation

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ABSTRACT

This is a commercial scale study to assess the effect of electron beam (EB) treatment on pest load, microbial load, antioxidant and free radical content of dates using different doses; 0.5, 1.0, 2.0 kGy. EB efficiency was assessed by measuring *Oryzaephilus surinamensis* mortality, total viable count (TVC), yeast and mold count (YMC), total antioxidants and free radicals. All doses used in EB treatment successfully eliminated all stages of *O. surinamensis* in dates. EB dose of 2.0 kGy had the greatest reduction in TVC to 4.35 log CFU/g in Khalas and 4.75 log CFU/g in Lulu dates. YMC was low in samples treated by EB compared with control sample. There were no significant differences in total antioxidants between treatments, except reduced antioxidants for samples treated with 2.0 kGy. The free radical content of samples treated by 2 kGy decreased by 65% after 25 days of storage. These results support the applicability of using 1.0 kGy to ensure and enhance the safety of dates.

1. Introduction

The world production of dates has increased from 3.4 million tons in 1990 to 7.9 million tons in 2010 (FAO, 2012). Of this date production, 60–70% is dried and stored for later consumption. These stored dates face a critical problem of infestation by Surinam beetle (*Oryzaephilus surinamensis*) and other spoilage organisms, which leads to a reduction in the quality of dates. Insects within stored food cause numerous quality damages affecting consumer health. According to Gulf Cooperation Standards for pre-packaged whole dates standards (GSO 656, 2011), dates should be free from living insects, their eggs, larvae and excreta. Dirty dates and dates with insects and mites residues should not exceed 8%. The presence of insects and insect fragments above specified tolerances make the product legally unsuitable for human consumption.

Contamination of stored fruits with insects, insect fragments, fungi, and mycotoxins is a major concern of the food industry. Methyl bromide is the only fumigant accepted by most countries as a quarantine treatment for plants and to control insects in buildings and food commodities (Taylor, 1994). Recently methyl bromide was banned from use as a fumigant due to depleting substance of ozone layer (Hansen & Jensen, 2002). Successful marketing for expending larger volume of dates will depend greatly on the development of viable control treatments which could replace methyl bromide. Therefore, alternative, preferably non-residual methods of effective pest control are needed for the post-harvest handling and storage of dates.

Intense radiant energy, known as electron beam (EB), is a non-thermal technology which produces ionizing radiation to destroy insects and microorganisms. The ionizing radiation produces free radicals which cause inhibition by eliciting structural damage (membrane breakdown, DNA change, protein aggregation) within microorganisms and insects (Scott & Suresh, 2004). The effect of these reactions in the molecules of plant material also brings beneficial effects such as the inhibition of sprouting and the retardation of ripening. This technology has advantages of being a continuous process, does not cause pollution of the environment and leaves no residues (Stewart, 2001). Also the production of radiation by accelerators uses electricity instead of radioactive isotopes, allowing it to be turned on and off as needed (Stewart, 2001). In the Gulf Cooperation Council (GCC) countries, food irradiation treatment was approved by the Standardization Organization for the GCC countries at 10 kGy or less (UAE.S GSO 1814, 2007).

Several studies have reported the effective mortality of EB on common pests in foods (Cleghorn, Nablo, Ferro, & Hagstrum, 2001; Salimov, Cherepkov, Kuksanov, & Kuznetzov, 2000; Todoriki, Hasan, Miyanoshita, Imamura, & Hayashi, 2006). Ic, Kottapalli, Maxim, and Pillai (2007) found 1.09–1.59 kGy was required to eliminate 90% of the yeast and mold on dried fruits. The effect of EB on food quality has been reported in different studies; Egea, Murcia, Sánchez-Bel, Romojaro, and Martínez-Madrid (2005) found no significant difference on physico-chemical and nutritional properties of apricots treated with 0.5 and 1 kGy. Also Girennavar et al. (2008) concluded

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that low dose EB (1 kGy) has very little effect on bioactive compounds of grapefruits. Moreno, Gomes, Da Silva, Castell-Perez, and Moreira (2005) found a significant increase (10–20%) in total phenolics and tannins in blueberries treated with 1.1, 1.6 and 3.2 kGy. Few studies on the irradiation of dates use gamma ray; Al-Kahtani, Abu-Tarboush, Al-Dryhim, Adnan, and El-Mojaddidi (1998) used Co^{60} to irradiate dates; they found 0.9 kGy sufficient to eliminate insect infestation. Emam, Farag, and Hammad (1994) and Ihsanullah, Iqbal, and Khattak (2005) found 3 kGy irradiation more effective than methyl bromide for the disinfestation of dates and reported small decrease in date's nutrients after irradiation.

The aims of this study were to evaluate the optimum EB dose to control the pest and microbial load of dates and to assess the effects of these doses on antioxidant and free radical content of dates using a commercial EB line. This study has an advantage of using a commercial EB line to study the effect of this technology on dates' infestation, and used large dates sample (300 kg) to give more representative results.

2. Materials and methods

2.1. Plant materials

Un-fumigated dried dates (Fard, Khalas and Lulu 100 kg from each variety) obtained from Al Foah Company, UAE, were used in this study. The dates were infested with the insect *O. surinamensis*, which collected from stored dates, and incubated at 30–40 °C for 3 months to increase the insect population. Date samples (10 kg) were packaged in cardboard boxes (depth 20 cm, width 30 cm and length 40 cm), sealed, and stored at room temperature (25 °C) for EB treatment and analysis.

2.2. EB treatment

Date samples were irradiated by 0.5, 1.0 and 2.0 kGy at room temperature (25 °C) using a commercial 10 MeV electron beam system based in SureBeam Middle East Company, Riyadh, Kingdom of Saudi Arabia. This system employs two accelerators for double-sided processing with a roller conveyor. Non-treated dates served as the control (0 kGy). The details of EB parameters employed during irradiation are given in Table 1.

2.3. Mortality of insects

To measure the mortality effect of EB doses on dates insects, samples each containing 100 fruits were used to count the live and dead insects visually. The number of dead insects was reported as percentage of mortality for each dose. To determine the effect of EB on other stages of insect such as egg, larva and pupa, the same samples used for insect mortality (after removing live and dead insects) were incubated at 30–40 °C for a further 60 days, then counting the adult insect.

Table 1
Operating parameters of the electron beam system.

Parameter	Tower	Pit
Beam energy (MeV)	10	10
Average beam current (mA)	1.43	1.6
Average beam power (kW)	14.3	16
Scan magnet current (A)	233	200
Scan width (cm)	120	120
Pulse per scan	64	64
Scan frequency (Hz)	5.05	5.26
Pulse repetition rate (Hz)	288	302
Distance between scanner and product surface (cm)	33	33
Processing time (s)	>2	

Source: SureBeam Middle East in Riyadh, Kingdom of Saudi Arabia.

2.4. Microbial analysis

Total viable count (TVC) was carried out according to AOAC Official method 986.33 (2002). Each sampling box was opened aseptically using 70% ethanol. Random samples were taken and homogenized by sterilized mortar. A 10 g homogenized date sample was placed in a sterilized blender with 90 ml Ringer solution (1/4 strength). The mixture was blended for 10 min at high speed. Serial dilutions were made from this homogenate and inoculated to Aerobic Count Petrifilm (3M, St. Paul, USA). The petrifilm was incubated at 32 °C for 48 h and the developing colonies were reported as log colony forming units per gram of sample (log CFU/g). Yeast and mold count (YMC) was carried out according to AOAC Official method 997.02 (2002) using Yeast and Mold Petrifilm (3M, St. Paul, USA).

2.5. Total antioxidant analysis

Total antioxidants in dates were determined using Antioxidants Assay Kit (CS0790, Sigma, St. Louis, USA). Briefly, date samples were extracted three times by phosphate buffer (pH 7.4). In 96 well plates, 10 µl of standard (trolox acid) or sample extract and 20 µl of myoglobin were added followed by 150 µl of ABTS (2,2′-azino-bis [3-ethylbenzothiazoline-6-sulphonic acid]). After incubating the plate for 5 min at room temperature, 100 µl of stop solution was added to each well and absorbance measured at 405 nm. Measurements were calibrated to a standard curve of trolox acid ranging between 0.045 and 0.42 mM. Total antioxidant activity was expressed as mM of trolox equivalents per 100 g of sample on a wet weight basis.

2.6. Free radical analysis

Samples were prepared according to the method described by Bhushan, Bhat, Rao, Ahmad, and Bongirwar (2003) using Electron Paramagnetic Resonance (EPR) spectrometer (Miniscope MS100, Magenettech, Berlin, Germany). The EPR-measurements done for Khalas dates sample in comparison with alanine dosimeters, both were treated with 2 kGy.

2.7. Statistical analysis

Samples containing 100 fruits were used to count the live and dead insects visually. Other analysis was preformed in triplicate and reported as mean values ± standard deviation on a wet weight basis. Statistical significance (*t*-test: two-sample equal variance, using two-tailed distribution) was determined using the Microsoft Excel Statistical Data Analysis Program. Differences at $p > 0.05$ were considered to be not significant.

3. Results and discussion

3.1. Mortality of insect

The insect count and percentage mortality of date samples treated by EB doses 0.5, 1.0, 2.0 kGy are presented in Table 2. Control samples (0 kGy) show the natural death of insects which ranged between 10% for Lulu and 19% for Fard varieties. The treated samples show no live insects and mortality was 100% for all doses. Al-Kahtani et al. (1998) supported our results as they found 0.9 kGy of Co^{60} irradiation was sufficient to eliminate insect infestation. This proved a direct effect of these treatments on dates' infestation of