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Disinfestation of stored dates using microwave energy

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ABSTRACT

This study was conducted to determine the mortality of two common insect species in stored dates using a microwave oven operating at 2450 MHz. Adults of *Tribolium castaneum* (Herbst) and *Oryzaephilus surinamensis* (L.), and larvae of *T. castaneum* (15 days) were used to internally infest stored un-pitted dates and then subjected to microwave treatment at 180, 300, 600 or 800 W power for 20, 30 or 40 s. Complete mortality was achieved for adults of both insects and larvae of *T. castaneum* when the power was 800 W and the exposure time was 30 or 40 s. Mortality of *T. castaneum* larvae was also 100% when the power and exposure time were 600 W and 40 s, respectively. The quality attributes of the microwave-treated dates (in which 100% mortality was achieved) were compared with untreated dates. Instrumental evaluation of texture profiles revealed that microwave disinfestation did not affect hardness, adhesiveness, springiness, cohesiveness and chewiness. Microwave disinfestation did not affect the sensory attributes or the surface color of date fruits. The moisture loss during microwave treatment was between 1.0 and 1.5 percentage points. Further investigations are required to determine the capability of microwave disinfestation for packed dates and other stored product insects and life stages.

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1. Introduction

Date fruit is an essential component of the diet in many countries, especially in the Middle East and North Africa regions. It is a good source of rapid energy due to the high sugar content. It also contains dietary fiber, phenols, antioxidants and other bioactive compounds, and can be consumed on a daily basis (Ali et al., 2012). In Oman, the date palm trees represent about 82% of the total cultivated fruit crops, and occupy around 49% of the total agricultural land (Al-Yahyai and Al-Khanjari, 2008). The average annual national production is around 238,000 tonnes (Al-Yahyai and Al-Khanjari, 2008). Although the production in Oman is high, the annual export is less than 10,000 tonnes (Al-Rawahi et al., 2005) mainly due to the poor quality of the processed and packaged dates (Al-Marshudi, 2002). Date quality is determined based on color, size and absence of defects or damages (Ait-Oubahou and Yahia, 1999). In the international market, the standards for date qualities are: appropriate color, flavor, size, stage of ripeness, moisture content, freedom from insects, insect eggs, mites and absence of different types of defects (Kader and Hussein, 2009).

In general, the harvested dates are usually at 60–70% moisture content (MC), and then dried to 10–25% MC before storage. The insects find the dry dates with high sugar content (around 50–60%) as a good source of food, and if infested, disinfestation is a challenge due to the physical nature of the fruit and the rate at which the insects spread into stored dates. Like other date producing countries, in Oman the infestation of stored dates is a serious problem. Al-Zadjali et al. (2006) surveyed insect attacks in date palm fields and stored dates for seven years across the country, and reported that the extent of infestation was 6.7%, 12.3%, 18.4%, 21.8% and 22.7% in the Rustaq, Musan'a, Nizwa, Dhank, and Sohar regions, respectively. Methyl bromide (MB), which is being used by many countries, is very effective for controlling insects in stored dates (Al-Kahtani et al., 1998). However, it is an ozone depleting substance (ODS), and several environmental agencies have been developing strategies to phase out use of this chemical. According to the Montreal Protocol, developed countries were expected to phase-out MB by 2005 and developing countries should phase-out by 2015 (El-Mohandes, 2012). Hence there is an urgent need to look for effective alternatives for the MB application in date processing.

Microwave energy has been used for the disinfestation of several stored grains. Zouba et al. (2009) achieved 100% mortality

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in controlling the moth *Ectomyelois ceratoniae* in Tunisian dates. The disinfestation of stored wheat was accomplished by Vadivambal et al. (2007) without affecting milling and baking qualities. Vadivambal et al. (2007) also summarized other studies using microwave energy (Hurlock et al., 1979; Watters, 1976; Hamid et al., 1968). Microwave disinfestation has the advantage of selective heating in mixtures of different substances. This method does not leave any chemical residue in the food and does not have any adverse effect on the environment. Since microwave energy could penetrate into substances with water, sugar or fat molecules, there is a great potential in using microwaves to heat the inside of a date fruit more effectively than heating it from outside. The objectives of this study were: (1) to determine the effect of microwave treatment on the mortality of adults of *Tribolium castaneum* and *Oryzaephilus surinamensis*, and larvae of *T. castaneum* in date fruits, and (2) to determine the effect of microwave treatment on the fruit quality attributes (instrumental texture, surface color and sensory characteristics) of dates.

2. Materials and methods

2.1. Date samples and infestation

Fardh, one of the most susceptible varieties for insect infestation, was used in this study. Dried, fumigated and cleaned date samples were obtained from a processing factory (Bright Sun Dates, Seeb, Sultanate of Oman) to ensure that the fruits were of uniform maturity, drying stage, and were free from insects prior to testing. The adults and larvae of the insects were obtained from the Entomology Lab of College of Agricultural and Marine Sciences, Sultan Qaboos University. Each date was cut open with a dissecting blade and one live insect (adult or larvae) was inserted and closed by gentle pressing to prevent the escape of the insect.

2.2. Microwave treatment

A microwave oven operating at 2450 MHz (230 V, 50 Hz, Model MW83U, Samsung Electronics (UK) Ltd, Surrey, UK) with variable power levels and a turn table was used in this study. Twenty dates (10 infested and 10 un-infested) were uniformly arranged in mono layer on a circular paper plate and placed on the turn table for microwave treatment. The samples were exposed to microwave treatment at 4 power levels (180, 300, 600 or 800 W) for 3 exposure times (20, 30 or 40 s). Each treatment (power and exposure time combination) was replicated 3 times.

2.3. Mortality and quality measurement

2.3.1. Mortality

After exposure to microwave radiation, the number of dead and live insects in each sample tray was counted. The criterion explained by Vadivambal et al. (2007) to confirm the dead insects was followed. After microwave treatment, the mortality was determined by opening the dates along the cut side and inspecting the insect. The insects were considered dead if they failed to respond to gentle rubbing with a small brush. The insects were checked again for mortality after the sample was cooled for 15 min. During microwave treatment, insect remained inside the dates most of the time as it was closed. The insects came out of dates a few times, and those experiments were repeated with fresh dates and insects.

2.3.2. Texture

After microwave treatment, the samples were allowed to cool for 2 h at room temperature (22 °C), and the texture profiles were measured. A texture analyzer (Model TA XT2i, Stable Micro Systems, Surrey, England) was used to measure the force–time curve using two-cycle compression test as explained by Rahman and Al-Farsi (2004). A plate (diameter 7.5 cm) compressed the date sample (15 mm × 15 mm) placed on a fixed table. The load cell was calibrated with a 5 kg weight. The equipment was set to zero by automatically lowering the plate until the bottom surface of plate just contacted the table before each experiment. Then the crosshead was allowed to descend at the rate of 2 mm/s to a total deformation of 3 mm (70% compression). When the compression stroke was completed, plunger abruptly reversed its direction and started upward stroke at 5 mm/s. Then a second (down and up) cycle was run on the same sample. All operations were automatically controlled by the Texture Analyzer. The compression depth was held constant at 3 mm in all experiments. The instrument automatically recorded the force – displacement or force – time curve. The experiment was replicated 3 times. The following attributes were determined from the force – time curve as explained by Rahman and Al-Farsi (2004): hardness, cohesiveness, chewiness, springiness, gumminess and adhesiveness (hardness - force to attain a given deformation; cohesiveness – degree to which sample deforms (rather than ruptures); chewiness – number of chews required masticate before swallowing; springiness – rate of return to original shape after some deformation; gumminess – being sticky and cohesive; adhesiveness – force required to remove sample from a given surface) (Prasert and Suwannaporn, 2009; Meilgaard et al., 2007a). For texture analysis, each treatment (4 microwave power × 3 exposure times) was replicated 3 times. In each replication 3 dates were randomly taken for analysis. Therefore, in each treatment texture profiles of 9 dates were analyzed.

2.3.3. Temperature

The surface and internal temperatures of date fruits were measured after microwave treatment. As soon as the samples were taken out from the oven, the surface temperature was measured using an infrared thermometer (non-contact, digital type meter, Model 830-T1, Testo, Lenzkirch, Germany), and the internal temperature was measured using a thermocouple type digital food thermometer (Model HI 98501, Hanna Instruments, Bedfordshire, UK). While measuring the internal temperature, the thermocouple probe was touching the internal surface of the date's flesh (not air temperature).

2.3.4. Color

Color images of the date samples were acquired before and after microwave treatment using an RGB camera (Model DSC-W320, SONY Inc., Japan) under uniform diffused light produced by two fluorescent lamps (Model OSRAM DULUX L 36W/954, OSRAM GmbH, Munchen, Germany). Red (R), green (G) and blue (B) values of the date images were extracted after implementing region-based segmentation to eliminate the background using Matlab software (Version 7.1, The Mathworks Inc., Natick, MA).

2.3.5. Moisture loss

The moisture loss during microwave heating was measured for the treatments in which 100% mortality was obtained. Each treatment was replicated 3 times and from each replication 3 dates were randomly taken for moisture analysis. Therefore, 9 dates were analyzed in each treatment for moisture loss during microwave treatment. To measure the moisture content of the dates, the samples were dried in an oven (Brabender GmbH and Co, Duisburg, Germany) at 105 °C for 24 h (Rahman and Al-Farsi, 2004). The weight of individual date sample was measured before microwave treatment, after microwave treatment and after oven drying, and the moisture loss during the microwave treatment was calculated.

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