An experimental investigation on minimizing the damage inflicted on tomatoes due to post harvest handling and transport vibration

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Abstract

Post harvest handling and transport vibration inflicts a severe damage to tomato (*Lycopersicon esculentum*) which is a delicate horticultural crop grown in most areas of Sri Lanka. Damages inflicted by transport vibration may be invisible immediately after the journey, but develop rapidly to shorten their period of shelf-life. The Power Spectral Density (PSD or sometimes referred to as the acceleration spectral density ASD) of the vibration shows the variation of the energy or the vertical vibration acceleration as a function of the frequency. Vertical vibration acceleration levels experienced in actual road transportation by trucks were simulated in the laboratory using a Deca rotary electric vibrator (model DVP3.36.70) and a locally fabricated rotary electric vibrator. Computer interfaced tri-axial accelerometers (Steval LIS 320 DL) were used for the detection and recording of the vibration acceleration levels produced in actual and simulated vibration, in terms of PSD. An instrumented sphere (accelerometer embedded artificial tomato) was fabricated for the study of vibration environment around layered tomatoes in a box.

Present Serviceability Rating (PSR) was used to estimate the road quality in terms of International Roughness Index (IRI). On average, the road quality under this investigation could be rated between IRI values 2 to 4 mm/m. Two of the most commonly used truck models (Mitsubishi Canter model 535B6R and 635E6R) were employed in the investigation. At an average speed of 20 km/h on the above mentioned road, the rear end of the empty (unloaded) truck bed produces nearly 10 times higher vertical vibration acceleration level compared to the front end. The above factor was only 2 times higher when the truck was loaded approximately to its maximum payload capacity. Upon loading to the maximum payload capacity, the vertical vibration acceleration of the truck bed at the rear end drops down by 30 times. Tomato box at the rear top-most stack experiences the highest vertical vibration acceleration. An amplification of the vertical vibration acceleration was observed vertically across the stacked wooden tomato boxes (60 cm x 24 cm x 30 cm, and weighing 20 to 25 kg when filled with tomatoes).The amplification of vertical vibration acceleration level vertically across stacks approximates to a linear distribution. For the rear end, the amplification was about 0.0025 dB/Hz per stack and for the middle and front, it was as low as 0.0006 dB/Hz per stack. It implies 4 times higher amplification per stack at the rear end compared to the middle and front end of the fully loaded truck. However, an attenuation of vertical vibration acceleration was observed from bottom to top tomato layers within any given box. The energy dissipation occurred at each tomato layer interacts in-elastically on plant-cell and appears as the vibration-induced damage in tomatoes which are delicate biological living materials.

Equivalent Severe Bruise Rating Index (EBRI) method was found to be more reliable compared to Magness-Taylor (MT) firmness, Non-Destructive (ND) instrumental firmness and even Finger-Feel Firmness (FFF) in reporting the development of the damage level in tomatoes those have subjected to vibration effects. Since the vibration damage becomes visible only with time, the panel examination in EBRI method was proved to be a reliable method of unveiling the localized damage and its effect spread all over the fruit with time.

A colour index consisting of 10 colour ranks ranging from mature-green to table-ripe-red colour of tomatoes was derived from the colour chart of United States Department of Agriculture (USDA). This colour index was used to quantify the colour or the ripening of local tomato varieties. On the natural ripening process the ripe tomatoes (colour rank between 6 to 10)

registered an average time-rate of development of red colour of 0.5 rank per day. For the less-ripe tomatoes (colour rank between 1 to 5), the above mentioned time rate was approximately 1.7 rank per day. Red colour development in less-ripe tomatoes is nearly 3 times faster compared to that of ripe tomatoes.

In tomato handling, a gentle squeeze made on tomato by consumer for sorting at retail market induces only negligible loss of FFF ($\approx 1/15^{th}$) compared to the loss induced by natural ripening. Vertically dropping down of tomato through 50 cm height induces 5 times higher loss of FFF compared to that due to natural ripening.

The decreasing shelf life of tomatoes until the growth of damage level up to EBRI≈2 provides an indication of the increasing severity of vertical vibration acceleration levels effective at corresponding positions from the front to the middle and the rear end of the loaded truck. Tomatoes transported in the rear topmost stack-box suffer damage approximately twice as high as that taken place due to natural deterioration in the control sample. Also, the decreasing shelf life of tomatoes speaks for the increasing severity of vertical vibration acceleration effective at corresponding boxes stacked from the bottom to the top. Results of the actual road transportation have been reproduced at the laboratory with the vibration simulator under appropriate settings.

Using simulated vibration effects analogous to actual road transportation by truck, different vibration absorber materials have been tested for their suitability as a damping material. Coir rope has the best damping characteristics, as the time-rate of damage propagation in tomatoes was the lowest when coir rope was applied as the vibration absorber between wooden tomato boxes. Average EBRI results indicate that the damage observed on the 7^{th} shelf-day is more or less 5 times lesser when coir rope is used as the vibration absorber. Coir, in the form of long rope can manage easily and, a single pair of workers can lay parallel lines of rope on the truck bed or on the rows of stacking tomato boxes for damping the transport vibration.