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Evaluation of Potential Use of a Compact Sorter Equipment for Small Vegetables Growers

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Tomato classification can bring advantages to farmers and consumers. However, classification is usually done in packinghouses of difficult access for small farmers, which in most cases have little access to technology, and need solutions adapted to their conditions. The development of a compact mobile sorting unit can combine the advantages of this process and therefore be used in field conditions, providing fruits with a better classification and giving benefits to the whole production chain. This study aimed to evaluate injury incidence and postharvest quality changes of tomato fruits subjected to cleaning without water and classification in a mobile sorting unit that applies a three way compact brush system – two brushes in down position and one up, comparing them to those of a traditional, static unit. Tomato fruits (cv. Pizzadoro) were harvested at breaker and turning stage and separated into three groups. The first group was subjected to sorting in a traditional, static unit; the second group was submitted in a mobile compact unit; the third group was used as a control. Fruits were stored in a cold room (21±2°C) for 14 days and subjected to the following quality analyzes: mechanical injury incidence, weight loss, pH, soluble solids, firmness, lightness, chroma, hue angle, maturation index and CO_2 production. The traditional static unit sorting resulted in the highest total number of injured fruits, about 2.5 times more than the mobile fruit sorting unit. The average quality analyses results obtained over the 14 days of storage indicate no significant difference among treatments for all attributes except firmness and color components (lightness, chroma and hue angle). Based on the found results, there is a great potential for use of the mobile unit by small farmers, with a possibility of bringing benefits to the entire chain.

1. Introduction

Sorting of fresh market tomatoes is usually done in large packinghouse, where they are graded, packed and shipped (Sargent et al., 1989). One of the main problems in tomatoes classified in packing machines is the incidence of mechanical damage to the fruit (Sargent et al., 1992). Although physical injuries are not always perceived externally (Van Linden et al., 2006), they can cause metabolic, physiological and flavor changes (Lee et al., 2007), and result in significant quantitative and qualitative losses (Desmet et al., 2004). The development of sorting units that can reduce the occurrence of these injuries is desirable (Kitinoja and Kader, 2002), and it can aggregate value to fruits without reducing quality. Sorting and classifying can bring several advantages for small farmers, such as time reduction reaching consumers and quality improvements that can influence profit earnings and reducing post-harvest losses (Londhe et al., 2013). Although there is already a number of small-scale equipment for small producers (Kitinoja and Kader, 2002), in many undeveloped countries grading is still done by hand (Londhe et al., 2013).
The main goal of this work was to evaluate the incidence of injury and fruit quality changes in fresh market tomatoes subjected to sorting in a compact mobile unit, compared to sorting in a traditional static unit,

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evaluating the possibility of use of this machine in field conditions for small scale farmers and the decrease in postharvest steps.

2. Material and Methods

Tomato fruits (cv. Pizzadoro) were harvested on a farm located in São Carlos, São Paulo, Brazil, and carefully transported to the laboratory, and selected for uniformity, size and color, for breaker and turning stage, based on the United States Standards for Grades of Fresh Tomatoes (USDA, 1991). Then fruits were submitted to two different sorting systems, and one part was set aside as a control, as follows: Treatment 1, tomato fruits were subjected to a horizontal conventional sorting unit, which simulates a commercial packing line, that was composed of the respective steps: Part A, washing under sprinkler spray (6 pieces), nylon and foam brushes (15 pieces); drying with conventional fan and nylon brushes (5 pieces) and Part B grading by rollers (2 pieces). This machine was 1.00 m wide and 4.40 m long (Figure 1). The parameters used for this treatment were: flow rate of each washer spray nozzle: ~ 450 mL/h; brush rotation: 120 rpm; grading roller rotation: 90 rpm. For Treatment 2, the tomato fruits were submitted to a vertical mobile unit prototype, which is comprised of the following respective steps: Part A, cleaning by using three sets of a three way compact brush (nylon bristles) system – two brushes (length: 1.00 m) in down position and one up (length: 0.82 m) - and Part B, grading with one set of two plastic rollers (length: 1.00 m). This machine is 2.20 m high and 1.60 m wide (Figure 2). Rotation for brush and roller grading was 90 rpm. The parameters applied for Treatments 1 and 2 were those considered most effective in tests carried out previously (data not shown). Treatment 3 (control), fruits not subject to any machine grading.

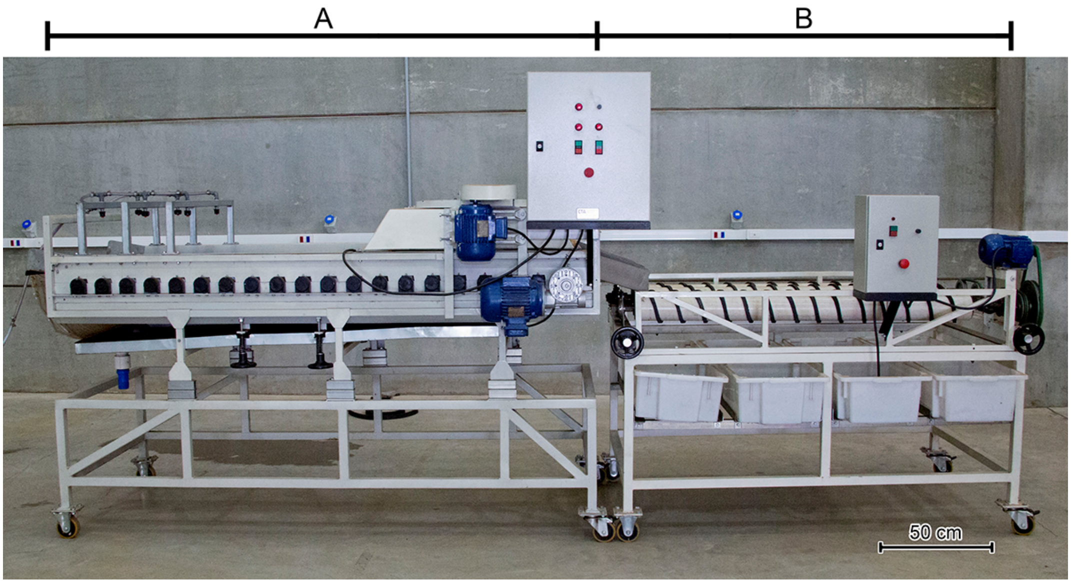

Figure 1: Conventional sorting unit. Part A. Cleaning with sprinkler spray and drying with conventional fan. Part B. Classification with plastic rollers. Machine 4.40 m long and average high 2.10 m

For each machine treatment, 100 tomatoes fruits uniformly selected for similar grading size were submitted to sorting, and fruits were stored at 21±2 °C for 14 days. Injury incidence analysis was performed only once, independently of the other analyzes. Non-destructive analyses (weight loss, firmness, maturity index, lightness, chroma, hue angle and CO_2 production) and destructive analyses (pH and soluble solids) were performed every two days during storage. All analyzes are described as follow:

2.1 Injury Incidence and Severity

Fruits were evaluated for physical damage incidence according to the methodology described by Ferreira et al. (2013), which consists of the detection of mechanical injuries in fruits using a technique of coloring skin surface by applying gentian violet. After staining, the fruits were classified according to the intensity (number of regions that remained stained) and severity (low, medium, high or very high) of the detected injuries. This technique is useful to show mechanical damage differences among fruits (Ferreira et al., 2013).

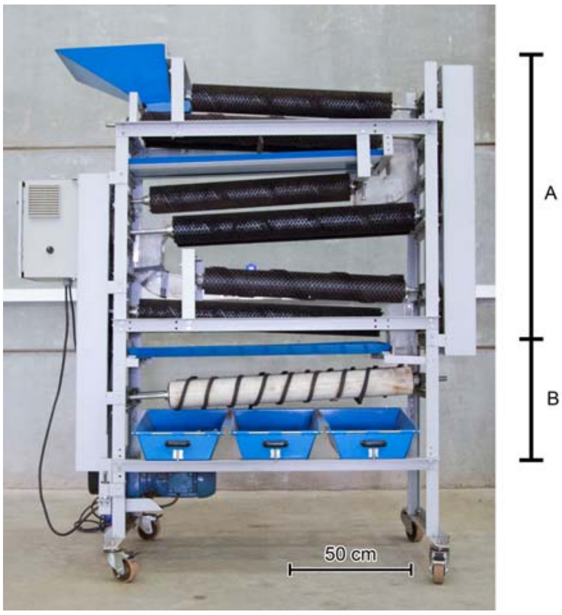

Figure 2: Vertical compact unit. Part A. three sets of a three way compact brush system – two brushes in down position and one up. Part B. one set of two plastic rollers used for classification

2.2 Quality analysis

Weight loss. Tomatoes were weighed individually on a Marte® AS1000C scale with 0.01 g accuracy. Weight loss was expressed as percentage, calculated from the ratio of the initial mass of each fruit and the mass obtained on each day of analysis.

pH. This was determined using a PHS-3B pH meter in homogenate juice according to AOAC method No. 981.12 (AOAC, 1997).

Soluble solids. Soluble solids content was measured in juice drops extracted and quantified in a Atago RX-5000cx digital refractometer, expressing the results in ºBrix (AOAC, 1997 method 932.12).

Firmness. The cell turgor pressure dependent firmness of each tomato fruit was obtained by the flattening method (Calbo and Nery, 1995), using the ratio of the fruit surface area (cm2) flattened by the weight of the probe (0.914 kgf). The result in kgf/cm2 was converted to kPa by using the conversion value 98.07.

Color Analyses. Lightness, chroma and hue angle. Tomato fruit color was evaluated by using a Hunter Lab Reflectometer, Model 45/0-L, which gives the values of L*, a* and b*. The color parameters analyzed were: lightness (L*), chroma ($C=\sqrt{(a^2+b^2)}$) and hue angle (tan-1 = (b*/a*)

Maturity index. Ripening rate was obtained visually according to the scale of the United States Standards for Grades of Fresh Tomatoes (USDA, 1991), described as: "green" (completely green), "breaker" (less than 10 % red), "turning" (between 10 % and 30 % red), "pink" (between 30 % and 60 % red), "light red" (between 60 % and 90 % red) and "red" (fully red). Fruit received scores from 0 to 5, where 0 represents the entirely green fruit.

CO_2 Production. For CO_2 production, fruits were stored in a 9 L hermetically sealed chamber (12 fruits per chamber) with 3 replicates per treatment in a total of nine chambers. Each chamber has a gas inlet and outlet with continuous air flow (~5 L/h) supplied by a flow board equipment described by Carmelo et al. (2010). 1 mL gas sample from each chamber were collected and analyzed on a Varian CP-3800 gas chromatograph, equipped with a thermal conductivity detector (TCD) and N HayeSep packed column (80/100; 6 'x 1/8 "SS). Using argon as carrier gas, the temperatures used in the gun, oven, DCT and filament were 150; 50; 150 to 280 °C, respectively.

2.3 Statistical Analysis

The experiment was conducted in a completely randomized experimental design in a factorial consisting of two factors: treatments (3) and laboratory analyses dates (8). Data were subjected to analysis of variance by the F test, and means compared over the days of storage, using the Tukey test at a 5 % significance level.

3. Results and discussion

3.1 Injury Incidence and Severity

A previous article (Ferreira et al., 2013) had indicated the application of this method to detect physical injury incidence, when comparing Treatment 1 and 3. In this work, all treatments showed some type of physical injuries on tomato fruits. Treatment 1 showed the highest injury intensity (81 in total), distributed in low and medium injury intensities (86 and 14 %, respectively). Treatments 2 and 3 had lower injury incidence, with a total of 23 and 34 injuries detected, respectively. Treatment 2, mobile unit, showed the lowest injury incidence, however injuries were detected with low (83 %), medium (4 %), high (9 %) and very high (4 %) severity (Figure 3). As expected, Treatment 3 (control), showed only low injury severity. The low severity injuries found in Treatment 3 originated in the field. The injuries detected in this treatment had the shape of a small dry point, and it is believed that these were present in the fruit prior to harvest, since the injuries caused at harvest or during post-harvest handling showed different standard features (such as "scratches" or "tears"). Therefore, the average intensity of injuries, high and very high found in Treatments 1 and 2 originated mostly from fruit sorting.

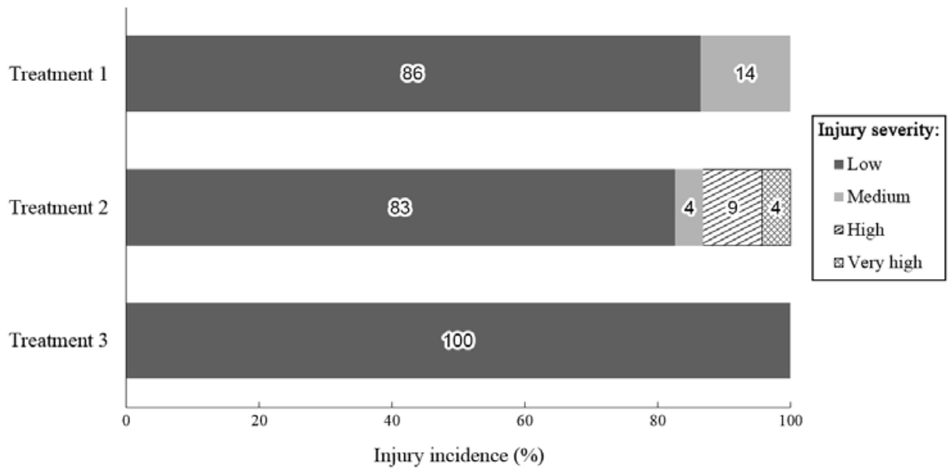

Figure 3: Intensity and severity of injuries detected in treatments

3.2 Quality analysis

No significant statistical differences were observed after storage among treatments for weight loss, pH, soluble solids content, maturity index and CO_2 production (Table 1). The values for lightness, chroma and hue angle, although significantly different, remained fairly similar among treatments, making the qualitative differentiation in fruits that possess these attributes impossible.

The average firmness values observed for Treatments 2 and 3 were significantly different from Treatment 1. For the latter treatment, from the second day of analysis, the average fruit firmness always remained below the average of the other treatments (Figure 4). After 14 days of storage, fruits from Treatment 1, showed average firmness of 26.6 kPa, while Treatments 2 and 3 showed average values in the range of 34.0 kPa.

Lee et al. (2007) described the relationship between mechanical stress incidence and qualitative losses in tomato fruits. The high injury intensity detected in Treatment 1 suggests a relationship with a decrease in firmness found in this treatment compared to the others, that can be related to a decrease in physiological capacity of the fruit in the maintenance of osmotic balance that ensures the conservation of its initial cell turgor pressure. At the same time, a higher incidence of injuries in this treatment did not seem to be enough to cause a significant increase in weight loss and CO_2 production. Although Moretti et al. (1998) have observed an increased respiratory rate in fruits due to the incidence of injuries and impacts, their results are similar to those found by Buccheri and Cantwell (2014), who also observed no increase in respiration rate of injured tomato fruit.

The absence of significant differences in most of the quality attributes and low firmness loss of the Treatment 2 fruits when compared to Treatment 1, associated with a lower injury percentage, indicates that sorting in this new prototype does not negatively affect fruit quality when compared to the traditional unit. Therefore, this compact unit has potential for use.

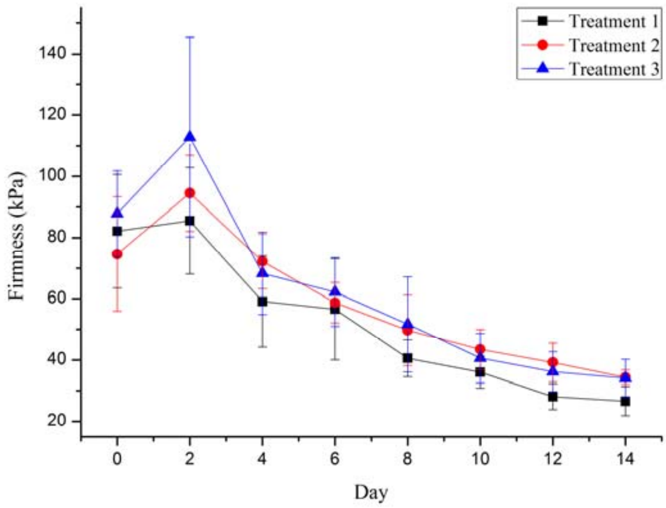

Figure 4: Tomato firmness (kPa) during storage at 21±2 °C

Table 1: Mean values of attributes measured over 14 days of analysis of tomato fruits. For each column, values followed by the same letter do not differ by the Tukey test ($p \leq 0.05$)

	Treatment 1	Treatment 2	Treatment 3
Weight Loss (%)	4.86 a	4.77 a	4.29 a
pH	4.33 a	4.35 a	4.34 a
Soluble Solids	4.55 a	4.55 a	4.45 a
Firmness (kPa)	51.82 b	58.34 a	61.72 a
Lightness	47.95 a	46.50 b	47.0 ab
Chroma	43.34 b	44.32 a	44.26 a
Hue Angle	50.53 a	49.34 ab	48.61 b
Maturity Index	3.83 a	3.95 a	3.87 a
CO_2 (%)	0.45 a	0.45 a	0.43 a

4. Conclusions

Sorting tomato fruits in a compact unit did not significantly affected fruit quality when compared to fruits subjected in a conventional static unit. This new system shows a potential for application by small growers, since it is mobile and does not require the use of water. Further studies are necessary to evaluate grading and cleaning efficiency and other machine parameters.

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