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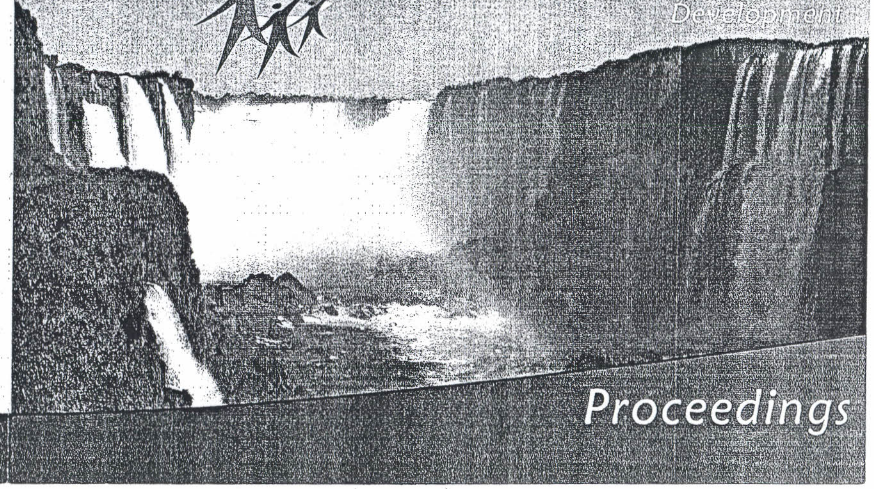

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EFFECTIVENESS OF CLEANING DURING POST HARVEST HANDLING OF FRESH MARKET TOMATOES

ANA MARIA DE MAGALHÃES[1]; MARCOS DAVID FERREIRA[2]

[1] Master of Science (M. Sc), FEAGRI/UNICAMP, Campinas, SP – Brazil.
[2] Researcher, PhD, Embrapa Instrumentação Agropecuária/São Carlos – Brazil. e-mail: marcosferreira@cnpdia.embrapa.br. Colaborator Professor, FEAGRI/UNICAMP, Campinas, SP – Brazil.

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ABSTRACT: This work evaluated the cleaning process of fresh market tomatoes Débora regards to efficiency cleaning and fruit quality. Initially, efficiency cleaning studies were carried with rubber spheres, changing the types of bristles (nylon, sisal fiber, PET and coconut fiber) and rotation (40, 80, 120 and 160 rpm) of rotary brushes. Afterwards, with the best results, the studies were carried out with fresh tomatoes for evaluating cleaning efficiency and fruit quality. In first case, the nylon and sisal fiber were more efficient at higher rotations. PET bristles and the rotation of 40 rpm were inefficient, presenting a cleaning index (CI) lower than 50%. For the fresh tomatoes, the nylon brush at 120 rpm treatment was the most efficient cleaning process (CI = 91%). However, nylon brushes at 160 rpm treatment showed the lowest CI (88%), these results were probably associated to the fact that, at higher speeds, fruits tended to jump, causing a poor contact between bristles and fruits. The lowest CI was observed on coconut fiber at 80 and 120 rpm treatments. In general, cleaned fruits with nylon and sisal fiber at 120 rpm demonstrated higher quality alterations when compared at cleaned fruits in these brushes at 160 rpm. It was also concluded that the cleaning process more effective may incremented fruit injury.

KEYWORDS: *Lycopersicon esculentum* Mill; post harvest; packing line; brushes; rotation

INTRODUCTION: In 2005, tomato world production was more than 122.5 million tones and Brazil was the ninth producer with around 3.4 million tones (FNP, 2006). However, there is a negative factor, the high rate of post-harvest vegetable losses, which reduce significantly the domestic availability of these products. In Brazil these losses ranges from 25 to 35%, and starts in the field during harvesting and preparation for marketing of the product; continuing in the central supply, wholesalers, retailers and consumers (VILELA et al., 2003). The main causes of post-harvest losses are mechanical injuries, which originate from outside forces, such as, vibration, compression and impact (KAYS, 1991; WILLS et al., 2004), which can cause different types of injuries such as abrasions, cuts, breaks, external and internal injury (SARGENT et al., 1989; CHITARRA & CHITARRA, 2005). During the cleaning process, in a packing line, fruits go through a series of rotating brushes that carry and rubbed the fruits, which are subjected to constant water sprays (MILLER et al., 2001; ARTÉS & ARTÉS-HERNANDEZ, 2004). Bristles from different sources, ie, synthetic material, plant or animal can be used in rotary brushes (PELEG, 1985). HYDE & ZHANG (1992) reports that brushes used in a packing line in accordance with its purpose have different speeds. However, the excessive speed of the brushes and / or excessive exposure to brushing can also cause damage and injury to fruit, especially if the brushes used have pointed rigid surfaces. According MILLER et al. (2001), the use of brushes with rigid bristles, submitted to excessive speed may results in an effective cleaning; however, can damage fruit more sensitive.

The objective of this study was to identify the parameters: bristles type and rotation of the brushes, which can make the process of cleaning more effective and less physical damage can cause to the fruit.

METHODOLOGY: The tests were performed in a laboratory at the Faculty of Agricultural Engineering, UNICAMP, using the prototype developed for testing cleaning efficiency. The equipment consists of two modules with 0.75 m long, 0.50 m wide and five transverse brushes of 0.11 m in diameter. The first module is a system of spraying water, which is formed by a jet nozzle spray cone filled type (Spray Systems SA, model Quick Full-Jet ProMax - QPHA-1.5). Initially, on the first trial were evaluated 4 types of bristles: nylon 0.15 mm, 0.10 mm sisal fiber, polyethylene terephthalate (PET) 0.15 mm and coconut fiber from 0.30 to 0.10 mm and at 4 rotations: 40, 80, 120 and 160 rpm. For this purpose, rubber balls with 70 mm diameter and 235 g mass, which simulated tomatoes fruits, in which it was applied a dirt artificial synthetic, prepared by homogenization of 20 ml of high density polyethylene with concentration 22.7% (Meghwax EPE 350N - Megh), 20 ml of black tempera gouache (Acrilex) and 6 g of charcoal ground and sieved, Tyler Mesh 48 (FRANCO et al., 2005).
For the characterization of material used in the brushes bristles, it was made up a test of flexibility of bristles, which was conducted based on studies of RAWL (1990, appud RODRIGUES, 2002). For this, each bristle, with standard length of 25 mm, was fixed at one end in a horizontal position and a force weight (P) vertical from 0.04 N was applied on the other end. The flexibility of each bristle was obtained by the flexibility index (FI), which is the relationship between the force (F) applied and flexion of bristle (f) obtained. To evaluate the effectiveness of cleaning, after passing by the prototype, balls were individually washed with 500 ml of distilled water, which withdrew samples for the analysis of turbidity. Analyses were performed in turbidimeter (MS Tecnopon Scientific Instrumentation, TB model 1000) with reads from 0 to 100 NTU (number of turbidity) and precision of 2%. The results were given on the basis of the index of cleaning, described in equation 1, which varies from 0% = dirty to 100% = clean.

$$CI_t = \left(\frac{NTU_{standard} - NTU_{sample}}{NTU_{standard}} \right) \times 100, \quad (1)$$

Where:
CI_t = cleaning index obtained with the turbidimeter, %;
$NTU_{standard}$ = average turbidity (NTU) to 100% balls soiled;
NTU_{sample} = value of turbidity of each sample (who passed balls by the process of cleaning).

After finish those trials, in a second step the tests were performed in fruits of tomato cultivar Débora, collected manually at mature green stage, in the region of Mogi Guaçu, state of Sao Paulo, in the months from June to August 2006. For evaluating the cleaning process using tomatoes, were applied the treatments that showed cleaning efficiency superior to 50% when washing rubber balls. It was applied the same procedure for evaluate cleaning efficiency, that was using the turbidimeter. The results were given on the basis of the index of cleaning, described in equation 1. Fruits quality, after cleaning, was evaluated by respiratory activity (RA) expressed as concentration of CO_2.
The experimental design was a completely randomized, factorial and with 3 replicates (n = 10). Analysis of variance and the comparison of means were performed by Tukey test ($p<0.05$) with the help of the program Statgraphics plus 4.1.

RESULTS AND DISCUSSION: In testing the flexibility of bristles observed that bristle nylon is more flexible, since showed the lowest flexibility index (FI = 68.34 $N.m^{-1}$) although this value did not differ significantly ($p>0,05$) of the value (70.27 $N.m^{-1}$) for sisal bristles. But these values differ statistically ($p<0.05$) of the values found for PET fiber bristles, and coconut, which also differ statistically ($p<0.05$) between them, with average values of 135.94 and 93.36 $N.m^{-1}$, respectively. In testing using the rubber ball, cleaning was more effective with the nylon bristles and rotation of 160 rpm, which showed an cleaning index (CI) statistically different ($p<0.05$), of all other treatments, exception of the values obtained for the treatments sisal 160 rpm, coconut fiber 160 and coconut fiber 120 rpm (Figure 1). The raise in rotations of 40 to 160 rpm increased the efficiency of cleaning for all brushes. According MILLER et al. (2001) it is because of excessive brushing or excessive speed resulting in a more effective cleaning. For PELEG (1985), the speed of rotation to be satisfactory varies from 150 to 200 rpm. In this work, rotations from 80 and 120 rpm, showed more efficient cleaning (CI over 50%), than rotation of 160 rpm, unlike the case for the rotation of 40 rpm that showed average values below 50% in all tests. In general, the CI obtained for PET brush bristles were very low with values ranging from 35 to 47% for rotations of 40 to 160 rpm, demonstrating that this type of bristles was inefficient in the process of cleaning. Therefore the use of bristles more flexible, than nylon bristles (FI of 68.34 $N.m^{-1}$), provided a better efficiency of cleaning, than compared to PET, which has greater rigidity (FI of 135.94 $N.m^{-1}$). BRECHT (2002) and ARTÉS & ARTÉS-HERNANDEZ (2004) agrees with this statement, indicating that for an effective cleaning bristles should be more soft and flexible.

For tomatoes fruits, cleaning with nylon bristles at 120 rpm rotation showed to be the most effective in the process of cleaning with CI average of 91%, which differed statistically ($p<0.05$) of the values obtained in the treatment nylon 80 rpm, coconut fiber 80 rpm and coconut fiber 120 rpm (Figure 2). In the process of cleaning with the bristles of the coconut fiber, CI increased with the increase in rotation, unlike the case of the fruits cleaned with nylon and sisal brushes, where the rotation of 120 rpm presented itself more efficient in the process of cleaning when compared to the rotation of 160 rpm. One explanation for this result is that at a high speed, rotation of 160 rpm, the fruits jumped among the brushes and were not rubbed by the bristles of high flexibility (nylon and sisal). These results differ from that indicates PELEG (1985), which suggests to better efficiency of the cleaning process the fruits using high rotation, between 150 and 200 rpm. However, these results are equal to those that suggest for MILLER & ISMAIL (2005), which recommend for cleaning citrus a maximum speed of 120 rpm and similar to those recommended by MILLER et al. (2001) and TAVERNER et al. (2005), that indicate for cleaning the rotation of 100 rpm. For coconut bristles fibers, due to high rigidity (93.36 $N.m^{-1}$), cleaning was performed by punctual contact, which tended to be more efficient with increasing speed of rotation.

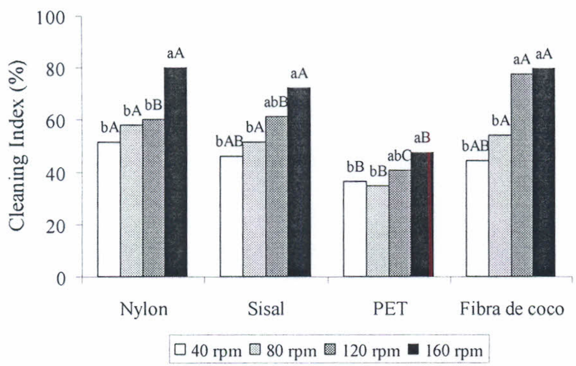

FIGURE 1. Cleaning index (%) obtained for rubber balls submitted for cleaning on nylon, sisal, PET, and coconut bristles, and the rotations of 40, 80, 120 and 160 rpm. Same letter there is no difference between rotations, same capital letters no difference between bristles, Tukey test, p> 0.05.

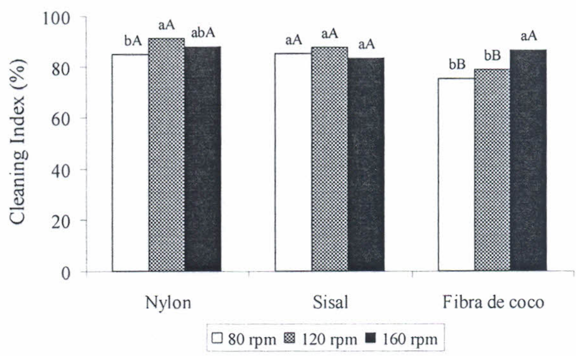

FIGURA 2. Index of cleaning (%) obtained for tomatoes submitted for cleaning on nylon, sisal, PET, and coconut bristles, at rotations of 40, 80, 120 and 160 rpm. Same minor letter there is no difference between rotations, same capital letters no difference between bristles, Tukey test, p> 0.05.

The respiratory activity (RA) decreased during storage time for almost all treatments, being different only in sisal treatment, 120 rpm, which incremented from 59.0 to 62.5 mg CO_2 kg^{-1} h^{-1} from the first to the second hour after cleaning. High values of RA initial indicate that the process of cleaning caused changes in the metabolism fruits, as well as observed CALEGARIO et al. (2001) that the post-harvest handling influence in increasing RA of tomatoes because the tomato fruits which were purchased on a wholesale presented a RA of 90 mg CO_2 kg^{-1} h^{-1}, whereas fruits harvested directly in the plant had a

RA of 60 mg CO_2 kg^{-1} h^{-1}. As for loss of mass (data not showed), it was observed that the fruits cleaned by nylon bristles and sisal, which are more flexible, combined to rotations of 80 and 120 rpm, showed higher RA values in the first hour after the procedure, compared to the fruits cleaned these bristles and the rotation of 160 rpm. In the case of the coconut bristles fiber, rotations of 80 and 160 rpm, it was observed high values of RA, indicating that bristles with greater rigidity influence the metabolism of fruits, regardless of the speed of operation applied.

CONCLUSION: The nylon bristles 0.15 mm, for being more flexible and involving both rubber balls and fruits, were more efficient in the process of cleaning, however major quality changes were observed in fruit submitted on those bristles at low rotations.

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