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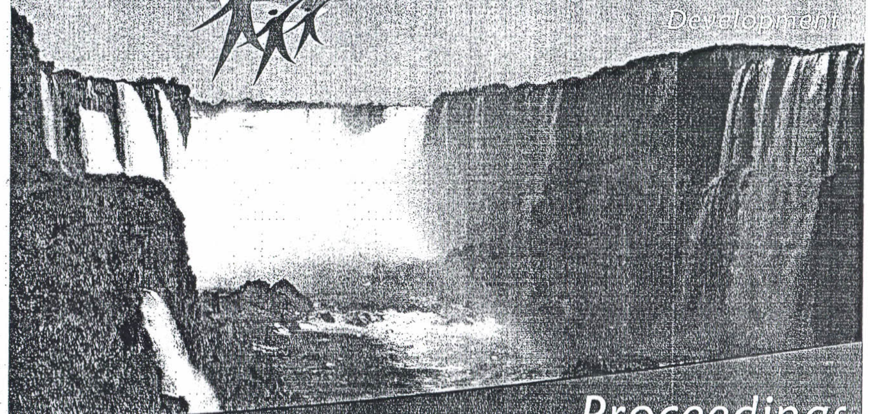

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# OPTIMIZING CLEANING EFFICIENCY AT A FRESH MARKET TOMATO PACKING LINE

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**ABSTRACT**: The post-harvesting cleaning process in fresh market tomatoes production is essential to the consumer acceptance, since the degree of dirtiness of the fruits is directly related to its quality. However, the washing stage of the cleaning process of commercial packinghouse demands an excessive water volume, bringing serious environmental concerns. The objective of this work was to compare the cleaning efficiency in two cleaning systems through the evaluation of different operational conditions of the cleaning process, related with the brush rotation, water flow and fruit standing time under the system. Therefore, it were compared the conventional system utilized in commercial equipment with a system using watering sprays. The results showed that the cleaning efficiency was not directly related to the water volume used, but to water pressure, standing time and brushes rotation. Therefore, the use of commercial sprays can bring benefits to the cleaning efficiency, increasing it up to 13%, and to the environmental, decreasing water consumption.
**KEYWORDS**: *Lycopersicum esculentum*, Cleaning systems, Water consumption.

**INTRODUCTION**: The production of tomatoes in Brazil is concentrated in the South, Northeast, and Center-West, and in 2005, was estimated at 3,155 tons, the lowest of the last four years (BRAZIL, 2007). Otherwise, in the State of Sao Paulo, it was estimated an increase of 7.5% in the production of fresh market tomatoes, in the 2005/2006 season (CASER et al., 2007). According CHITARRA & CHITARRA (2005), the main factors that cause losses of perishable products of plant origin, are inadequate procedures for handling, transport and storage. It is estimated that the losses in quality and quantity of production of tomatoes represents 5% of the post-harvest cost (AGRIANUAL, 2002). MARCOS (2001) stated that consumers relate the degree of dirt fruit with its quality, thus, the lower the dirt of products, greater acceptance of the consumer, which makes the step of cleaning essential in the packing line system. Another important factor to be taken into consideration in the washing tomato step is the use of water resources in view that the current system of cleaning consumes about 18m $^3$ of water daily (SILVA et al, 2006), and that global demand this natural resource has grown. This study aims to compare the efficiency of cleaning of two systems used in the process of washing fresh market tomatoes under different rotations of brushes, system flow and time of washing.

**METHODOLOGY:** The experiments were conducted at UNIMAC Laboratory, FEAGRI - Faculty of Agricultural Engineering – UNICAMP, Campinas-SP, in an installed prototype line, built by Barana Industry Ltda, which presents groups of brushes with different functions. The first group consists of brushes with bristles of synthetic origin, which combined with the system of spraying water, has the task of removing impurities surface of the fruit. The second group has specific brushes for the removal of excess water. In the last stage, the fruits go through brushes with bristles of animal origin, responsible for polishing. After polishing the fruits are sorted and packed.

Characterization of the conventional system: The original system of this equipment is composed of pipes, PVC-type land thickness of 1.7 mm, which has holes at the bottom with 2.21 mm in diameter spaced at 30.0 mm. The system has four valves that allow regulation of the flow of each tube independently. For evaluation of the efficiency of the conventional system, it was set up operational configurations of this equipment, varying brush rotation (low - 80 RPM and high - 160 rpm), flow of water (low -80 ml/s, average - 200 ml/s and high 400 ml/s), and time of washing (1 and 2 minutes).
Characterization of the proposed system: By replacing the conventional system, using a jet nozzle spray with cone full type manufactured by Spray Systems SA., Model Quick Full-Jet ProMax (QPHA-1.5), which according SILVA et al. (2006), meets the requirements of the fruit in question, mainly about the impact produced by the jet of water formed by the nozzle. For the use of this device was necessary to build a system of pumping in order to acquire the necessary pressure for the formation of the water jet. The proposed sprinkler system was evaluated, using as treatment combinations the following operating parameters: brushes rotation (low - 80 RPM and high - 160 RPM), time to wash (1 and 2 minutes) and water flow (low -500 ml/min, average-650 ml/min and high -800 ml/min). The values of flow adopted were significantly lower than those of the conventional system to fit the operating range of the spray. Determination of the effectiveness of cleaning: To evaluate the efficiency of cleaning it was used a methodology employed by FRANCO & FERREIRA (2005), which were used for rubber balls (diameter of 70 mm) to simulate the fruits of tomato in a packing line. The rubber balls received a layer of homogenous of artificial dirt on the external surface. The artificial dirt was applied to the surface of the ball and was obtained mixing a black ink gouache, with two parts of edible adhesive for waxes and more a part of charcoal ground and sieved (in sieve with Mesh 48). After uniform application the artificial dirt over the balls, they were dried at room temperature for 30 to 40 minutes.
The "dirt balls" were introduced to a prototype together with tomato fruits at the same time and exposed to cleaning for one or two minutes at the two systems on the proposed treatments. Therefore, it was increased the entry of fruit in the equipment, and the balls passed on the entire length of the equipment and reach a receiving box. The whole pad was finish in four minutes. This time was monitored using an accurate stopwatch. After passing through the prototype, the balls were cleaned using equipment with a sliding ring, developed to simulate the pressure constant cleaning. A sample of cut white Oxford tissue was fixed to the tip of the equipment, against which each sphere was rubbed in order to submitted the external surface. Thus, any remaining impurities on the surface of the ball, after cleaning the prototype, were retained in the tissue. In experimental trials, each treatment resulted in ten tissue samples obtained from the cleaning of the balls. These samples were taken for analysis in colorimeter MiniScan XE HUNTERLAB Plus, using the scale CIELAB (L *, a *, b *), aiming to assess the intensity of impurities present in the tissue after the cleaning process. The parameter L assessed for the samples is a parameter that indicates, on a scale of 0 to 100, the intensity of dark, and the value 0 refers to the black and white figure to 100. In determining the values of the efficiency of cleaning for each treatment, compared is the value of the parameter L of the tissue, before and after cleaning of the ball. Thus, the efficiency of cleaning (EL) was calculated as:

$$EL = \frac{L_{sample}}{L_{tissue}} \qquad \text{Equation 1}$$

In that $L_{sample}$ - L parameter of the sample; $L_{tissue}$ - L parameter of the fabric prior to sampling; EL - efficiency of cleaning.
The implementation of Equation 1 results in values of cleaning efficiency between 0 and 1, with 0 for lack of efficiency, and 1 for spheres thoroughly cleaned. For each sample of tissue, took place three readings in colorimeter, therefore gaining 30 L parameter values for each treatment. The results were evaluated using the analysis of variance and application of Tukey test of a 5% probability to compare averages.

**RESULTS AND DISCUSSION**: Table 1, are the results relating to statistical analysis of the values of efficiency obtained for the conventional system of cleaning

TABLE1: Statistical analysis for the parameter L evaluated at conventional system, at significance level of 5%

| Treatment | Rotation [RPM] | Water Flow [ml/s] | Period of exposure[min] | Consuption Volum [ml] | Efficiency | Coefficient of Variation [%] | Homogeneous Groups |
|---|---|---|---|---|---|---|---|
| A' | 80 | 80 | 1 | 4800 | 0,4 | 21,34 | X |
| H' | 160 | 80 | 2 | 9600 | 0,53 | 24,56 | O |
| E' | 80 | 400 | 1 | 24000 | 0,55 | 19,17 | O |
| D' | 80 | 200 | 2 | 24000 | 0,58 | 20,89 | Δ |
| K' | 160 | 400 | 1 | 24000 | 0,6 | 18,72 | Δ |
| B' | 80 | 80 | 2 | 9600 | 0,6 | 21,48 | Δ |
| G' | 160 | 80 | 1 | 4800 | 0,64 | 9,97 | ▼ |
| F' | 80 | 400 | 2 | 48000 | 0,64 | 17,32 | ▼ |
| L' | 160 | 400 | 2 | 48000 | 0,66 | 14,98 | ▼ |
| C' | 80 | 200 | 1 | 12000 | 0,68 | 17,27 | ▼ |
| I' | 160 | 200 | 1 | 12000 | 0,69 | 14,06 | ▼ |
| J' | 160 | 200 | 2 | 24000 | 0,76 | 8,36 | ■ |

Table 2 presents the results concerning the statistical analysis of the values of efficiency obtained for the alternative system of spraying for all treatments evaluated.

TABLE 2: Statistical analysis for the parameter L evaluated at alternative system, at significance level of 5%.

| Treatment | Rotation [RPM] | Water Flow [ml/min] | Period of exposure [min] | Consuption Volum [ml] | Efficiency | Coefficient of Variation [%] | Homogeneous Groups |
|---|---|---|---|---|---|---|---|
| G | 160 | 500 | 1 | 500 | 0,87 | 5 | X |
| H | 160 | 500 | 2 | 1000 | 0,9 | 4,9 | X 0 |
| C | 80 | 650 | 1 | 650 | 0,91 | 6,7 | 0 Δ |
| F | 80 | 800 | 2 | 1600 | 0,91 | 2,2 | 0 Δ |
| J | 160 | 650 | 2 | 1300 | 0,91 | 4,4 | 0 Δ |
| D | 80 | 650 | 2 | 1300 | 0,92 | 5 | 0 Δ ▼ |
| A | 80 | 500 | 1 | 500 | 0,93 | 5,6 | 0 Δ ▼ ■ |
| I | 160 | 650 | 1 | 650 | 0,93 | 3,4 | 0 Δ ▼ ■ |
| E | 80 | 800 | 1 | 800 | 0,94 | 3,2 | Δ ▼ ■ |
| L | 160 | 800 | 2 | 1600 | 0,94 | 2,9 | Δ ▼ ■ |
| K | 160 | 800 | 1 | 800 | 0,95 | 2,6 | ▼ ■ |
| B | 80 | 500 | 2 | 1000 | 0,95 | 2,1 | ■ |

By comparing the results obtained for the systems proposed and conventional, it was observed that the alternative system presented efficiency of cleaning above the conventional system for all treatments evaluated, with significant reduction of water consumption. It was observed that the lower efficiency for the alternative system is 13% higher than the greater efficiency obtained for the conventional system. These results show that the use of the spray nozzle tip provided better surface wetting, when compared to conventional system, in agreement with the results presented by SILVA et al., 2005. As for the consumption of water, the new system showed a reduction of 67 to 97% when compared to any of the conventional treatment. Comparing the highest values of efficiency of cleaning found for the two systems (76%-95%-conventional and alternative), there was difference of 19%, and among the lowest values (40%-conventional, 87%-alternate), the difference was 47%. The conventional system operates at a pressure of 0.96 kPa water flow from 200ml/s. By using the spray nozzle of Quick Full-Jet ProMax (QPHA-1.5), the pressure required for the formation of the jet for the flow of 500ml/min is 58kPa, and to 800ml/min is 164kPa. Thus, the proposed system will depend on the conditions available in packing-house units, and have a need of use of pumping systems, requiring greater consumption of electric energy. However, it appears that the work itself with high pressure, increases the efficiency of cleaning considerably. The ball used in the simulation of the product, as well as tomatoes, presents smooth surfaces, favoring the removal of dirts compared to other vegetables with rough surfaces, such as the potato. Therefore, there is an indication that the interaction rotation versus roughness of the surface can provide better or worse cleaning efficiency.

**CONCLUSION**: The introduction of commercial technologies into existing systems for cleaning fresh market tomatoes can provide the optimization of the sorting and packing process, with a significant reduction in water consumption and increase in the efficiency of cleaning, compared to the traditionally system used.

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