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Machinery for Fresh Cut Watermelon and Melon

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Marketing of ready to eat fresh produce has an increasing share of supermarket shelves around the world. Most products are prepared manually or partially mechanized. Mechanization of fruit peeling and cutting is a known procedure mainly in canned fruits and vegetables production. As an exception, an automatized technology and mechanization for production of fresh produce was developed by the Institute of Agricultural Engineering for extracting pomegranate arils, now it is manufactured and distributed by Juran Ltd (Israel). The present study is designed to develop a technology and machinery for production of fresh cut, ready to eat watermelons and cantaloupes. It aims to mechanically cut, peel and pack the watermelons and cantaloupes. As part of this study we examined several alternatives to perform the whole process, ranging from laser-cut to high-pressure water using artificial vision systems as utilized in sorting processes in the production industry. The study evaluated, analyzed and developed a number of special puncturing tools: fixed, rotating, solid and perforated. As part of these experiments the shelf life of the fruit was tested. It was found that a round, disk shape slice as final fine product is achievable and maintains quality requirements more than a week in cooled and hermetically closed package.
The results of these trials have led to the design of the semiautomatic system which requires at this stage a manual feed of the fruit. The main parts of the machinery have been built and tested successfully.

1. Introduction

Marketing of certain agricultural crops are limited because of their excessive weight or size. Such produces are watermelon, pumpkin, cantaloupe, etc. Additionally these fruits and vegetables as a whole are too much for a consumption of one or two person. Moreover the above mentioned produces need an extensive preparation before consumption. These motivate the suppliers to introduce ready to eat fresh cut small portion products. Generally the marketing of ready to eat fresh produce has an increasing share of supermarket shelves around the world. Only in the canned fruit industry there is mechanized cutting technology. The ready to eat products are prepared mainly manually. The only exception, an automatized technology and mechanization for production of fresh produce was developed by the Institute of Agricultural Engineering for extracting pomegranate arils (Schmilovitch et al, 2004, 2011), not it is manufactured and distributed by Juran Ltd (Israel), (Schmilovitch et al 2011). Keeping the freshness of the fresh cut products is a challenge. Quality of these products has been improved using modified atmosphere packaging or postharvest treatments such as calcium chloride to prevent softening or ascorbic acid to prevent browning (Guzmán, 1997).
The objective of the present study is to design and develop a technology and machinery for production of fresh cut, ready to eat watermelons and cantaloupes.

2. Instrument development process

The whole process from the opening, through cutting, removing seed and slicing of the water melon and cantaloupe was examined. Several alternatives were evaluated to perform the whole process. In the first stage different cutting methods were studied, employing laser or high pressure water and using artificial vision systems like in sorting processes in the production industry. Additionally several mechanical cutting were tested, including punctures based on smooth and perforated steel tubes as shown in Figure 1, which are short cylinders suitable to cut 50 mm slice. A full size (300 mm long and 120 mm in diameter) of puncture cutter was tested, mounted in a construction allowing vertical operation as presented in Figure 2. In the next stage the option of using part of a tube to create a scoop cutter was tested with rotation as well as operation in horizontal mode (Figure. 3). Slices of 50 mm were cut from the separated fruit flesh cylinder. All samples of cut disks were tested for storage and shelf life (Fig 1c.). The samples (cubes, disk, and slice) were packed in sterile conditions in plastic boxes and without any treatment they were kept in 8°C for 15 days. During the storage the quality of the samples were evaluated and grades from 1 (not acceptable) to 5 (great) were given.

<u>Shelf life evaluation</u>

The shelf life of mechanically cut fruit flesh disks was tested in comparison with slices of similar size and shape excised manually with a sharp knife, either left as one piece or further diced into cubes of approx. 2.5 x 2.5 cm. The products were prepared at pilot fresh-cut facility at the ARO Department of Postharvest Science and further stored at cold storage facility of the same department. All samples were packaged under sterile conditions in plastic clamshell containers without any additional treatment, and kept at 8°C for 15 days. During the storage the visual quality of the samples was evaluated weekly based on pre-defined criteria, such as juice leakage, tissue translucency, piece shape and cut straightness, off-odor, and decay signs. Each parameter was evaluated according to the visual scale from 5 (excellent) to 1 (extremely poor). The overall quality score was determined by the lowest score obtained by the sample in any of the listed categories. The score 2.5 was considered a marketability threshold, i.e. the samples that received a score below 2.5 in any category were considered unmarketable. The firmness of fresh-cut melon pieces was evaluated penetrometrically with a Chatillion force gauge using a flat probe of 1 cm in diameter. The tests were performed at least on three independent packages serving as replications and the results were evaluated statistically by calculation of standard deviations and confidence intervals.

In order to design the full prototype additional subsystems were required and evaluated. The ability to align the fruits with their elongated axis was tested by grommets system as shown in Figure 5 and demonstrated in the scheme design in Figure 4. In order to enable the scoop system to operate, meaning cutting directly into fruit flesh and cutting out the cylindrical fresh cut form, the edges of the water melon and the cantaloupe needed to be removed. For this operation a sub system with a guillotine knife shape was constructed and tested (Fig. 5).



Figure 1. Mechanical cutting and puncture tests based on smooth and perforated steel tubes.

Figure 2. Full size (300 mm long and 120 mm in diameter) of puncture cutter test in construction in vertical operation.

Figure 3. Test of scoop in horizontal mode.

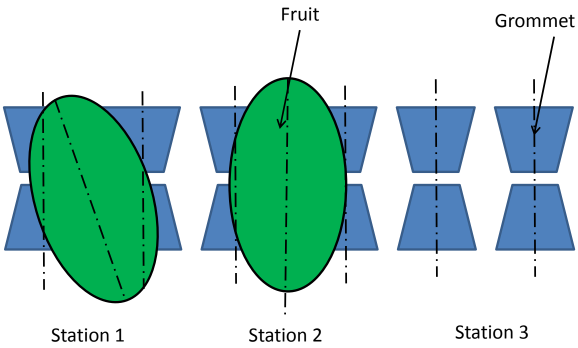

Figure 4.The design of the step grommets' conveyor

Figure 5.Prototype of edge cutting blades system.

3. Results

Storage tests

Figures 6-8 present typical results of a storage test of mechanically excised disc-shape slices of watermelon in comparison with similar slices excised manually with a knife and either kept as one piece or further manually diced into 2.5 cm – side cubes. Figure 6 shows that the profound tissue wounding in course of dicing resulted in the enhancement of juice leakage from the fresh-cut watermelon. Keeping the product as a single slice greatly reduced the juice leakage irrespectively of the cutting method (manual or mechanical). Mechanical excision did not cause accelerated softening of the fresh-cut watermelons (Figure 7). Furthermore, after 7 days of storage the mechanically excised slices demonstrated slightly higher firmness than the manually cut ones.

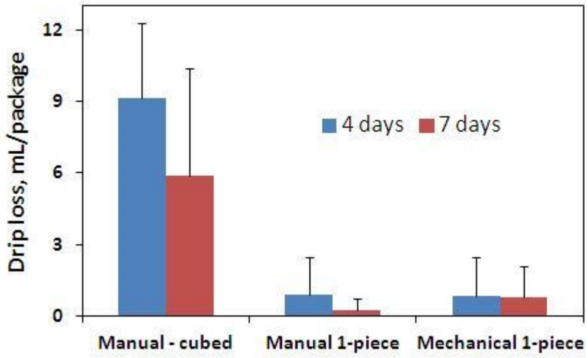

Figure 6. Effect of cutting method on the juice leakage from fresh-cut watermelons stored at 8°C for 4 and 7 days.

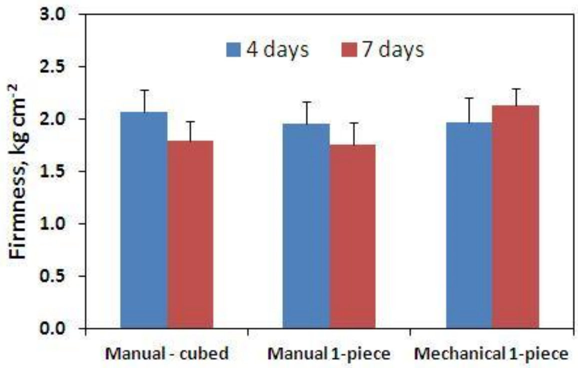

Figure 7. Effect of cutting method on the firmness of fresh-cut watermelons stored at 8°C for 4 and 7 days.

Figure 8 demonstrates that up to 7 days of cold storage the products showed a good quality with a score around 4 and stayed fairly marketable until day 10. Beyond the day 10, the products passed the marketability threshold. Although the difference in quality scores between the three cutting methods was not statistically significant, at the end of storage the cubed product (the method used by the industry today) showed the fastest degradation and the lowest quality scores than one-piece packages. The mechanically cut slices showed no inferior quality compared to the manually excised samples throughout the storage trial.

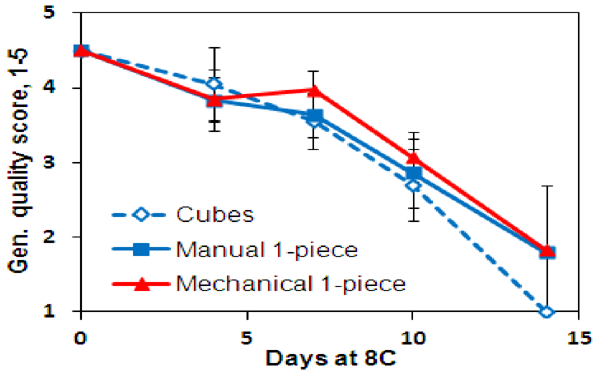

Figure 8: Effect of cutting method on quality degradation of fresh-cut watermelons during typical storage test at 8°C. The quality scale is from 5 (excellent) to 1 (extremely poor).

We found complicated and expensive the use of laser-cut and high-pressure water together with artificial vision systems as utilized in sorting processes in the production industry. The smooth and perforated steel tubes created pressure on the cut fruit flesh. Therefore, as described above the next stage of cutter, a scoop shape was developed and tested. The cuts of the scoop shown smooth and continues cut and caused almost no pressure on the flesh.

For melon it was found that two scoops are needed. The first one was a 65 mm in diameter for removing internal seed part and the second one is 120 mm in diameter, which is suitable to cut hollowed cylinder of fresh cut flesh as shown in Figure 9.

The design of the semiautomatic system which requires at this stage a manual feed of the fruit was conducted and its concept is presented in Figure 10. The system is based on step apparatus conveyor. Each cell contains four conical drums (grommets) which enables in the first station to be loaded and (Fig. 4) in the second station to rotate the fruit in order to set it elongated with its concentric axe (Fig. 5). In the second station guillotine blades moving down and up remove the edges of the fruit (Fig. 5). In the third station and forth the apparatus is using special scope knife which is rotating and progressing to the extract flesh of the fruit. The first one is in small diameter in order to remove the inner part of melons with the core of its seeds. The second scope is larger and close in dimensions to the peel diameter of the fruit. The scope shape allows conducting an easy and clean cut with small pressure on the yet attached part of the fruit flesh. As well as releasing the cut part later on easily with minimum friction by rotating it to upright position allowing down release of the flesh from the scope for further slicing.

Figure 9a. The first melon scoop operation for removing internal seed part.

Figure 9 b. The second melon for removing out hollowed cylinder of fresh cut flesh.

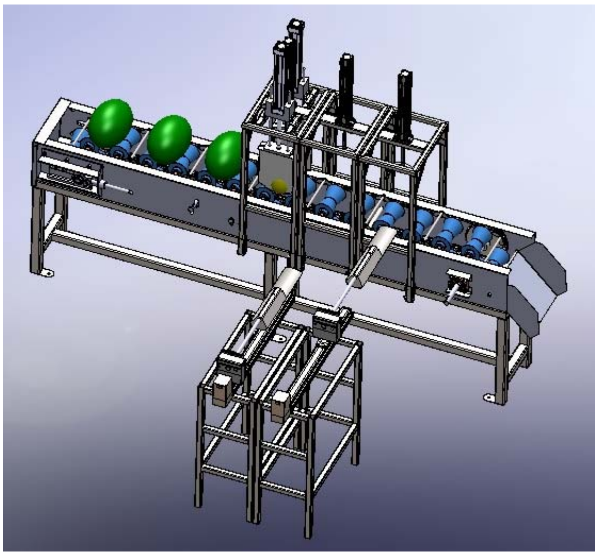

Figure 10. The full system design.

4. Conclusions

The full system was designed and it is under construction. The new ideas developed and tested are under patent pending. The analysis of efficiency of cutting out cylindrical flesh from an intact fruit stress out the need to use elongated varieties' and such were chosen for future operation. The success of this system will be evaluated in commercial use in the close future and we believe this product has potential of success as fresh cut melons as such are being introduce to the consumers already(Lima R. 2014).

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