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Fruit Stress during Road Transport of Tomatoes in Loose Bulk

The mechanical harvest and transport of industrial tomatoes in Hungary cause considerable losses in quality and quantity. Tomatoes for industry are harvested with a complete harvester, similar to a potato harvester. The harvest is continuously loaded with a belt conveyor on parallel driving lorries, which transport it afterwards to the processing facility. Mechanical stress and damage on tomatoes were tested jointly by the Institute of Agricultural Engineering of Gödöllö and ATB in a Hungarian co-operative. Results of this investigation are presented here.

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Keywords
Tomato, mechanical load, fruit damage, transport

At the receiving point of a tomato processing plant, quality and mass losses of tomato fruit frequently exceeded 20%. These losses were mainly due to cracked fruit. Accordingly, the degree of damage was analysed on fruit samples taken on the one side from the conveyor belt of a combine harvester, and on the other side from the tomato stock during unloading of the truck in the processing plant. Visual inspection indicated appreciable lower degree of damage after harvest than after transport by truck. For this reason, the transport conditions were assumed to be the main source of tomato fruit damage.

Material and methods

The process of mechanical damage of fruit is very complex. Therefore, studies were carried out that cover both the visual inspection of the degree of damage of well defined fruit samples as well as measuring the truck motion and the pressure load on tomato fruit in a bulky load during transportation. For the samples, tomato fruits were carefully picked from the plants. One half of these intact fruits were subjected to a well-defined mechanical pre-load, simulating the effect of the mechanical harvest including loading onto the truck. Each of these fruits was dropped from 1 m height onto a wooden plate.

Every fruit with or without mechanical pre-load was numbered. Thereafter, equal numbers of fruits of each of both treatments were filled into test bags. These test bags were placed into the tomato bulk during the loading of the truck. For the tests with a common truck, one half of the test bags were placed in a height of 20 cm above the platform (bottom layer), the others were placed in a height of 60 cm (medium layer). Further tests were carried out simulating the truck by using a pick-up car. In this case, the tomatoes were filled into a container with appropriate loading height (test bags placed only in bottom layer).

In both tests, after loading onto common truck as well as onto pick up car, typical sapping of tomato juice was observed due to static load onto the lower fruit layers and cracking of fruit subjected to mechanical pre-load (*Fig. 1*).

The transportation tests were carried out under similar road and speed conditions. The trip with the truck to the processing plant took about 1 h, while the trips with the pick up car lasted 10 and 60 min on the road. Before each road trip, the pick up car covered about 1 km on a country lane.

Before and after the transportation test, visible fruit damage in the test bags was evaluated and classified into four levels (*Fig. 2*).

During transportation, the tri-axial accelerations of the vehicle platform and the pressure load onto the fruit in the bottom layer were recorded with sampling rates of 200 Hz. The pressure load data were acquired using a modified version of Pressure Measuring Sphere PMS-60 and transferred via cable to the PC, because the capacity of PMS-60 internal memory would not be sufficient for long term measurements.

Fruit damage due to transport

Visual inspection of fruit in test bags showed that the degree of fruit damage for fruit without mechanical pre-load was very low. However, mechanical harvest always caused me-

Fig. 1: Pick-up car with container half filled with tomatoes and above them with onions (16 bags each with 25 kg) to simulate the bulk height of a real truck

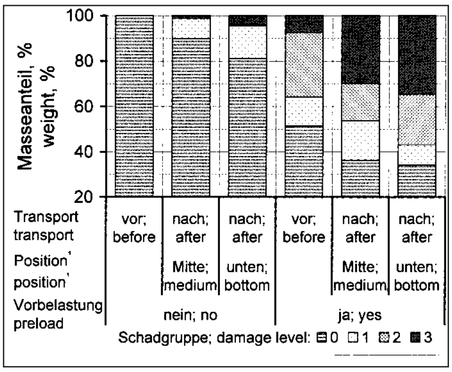

Fig. 2: Proportions of damaged tomatoes when transported by truck; variety Eskort; mean fruit mass 65 g; mean hardness 5.5 N; mechanical preload: drop from 1 m height onto a wooden plate; damage level: 0 undamaged; 1: skin cracks up to 5 mm, without juice loss; 2: skin cracks above 5 mm, with low juice loss; 3 shatter bruises, with high juice loss; 1) position of bags

chanical pre-load of tomato fruits and led to appreciable directly visible as well as invisible latent mechanical damage. The latter became visible only due to mechanical load during transportation. The length of the trip seemed to have a certain effect on the damage of tomato fruits without mechanical pre-load. However, this was negligible in comparison to the effect of the mechanical pre-load (*Fig. 3*). In this case, inconsistent damage results were obtained. After a 10 min trip, the degree of damage was higher than after 60 min. The reasons for that could be the relatively high variation of measured data and, additionally, the time interval between both tests.

After transportation, up to 30 % of fruit in the medium layer of the truck, and up to 22 % of fruit in the bottom layer of the pick up car showed damage level 3. These differences could be due to different composition of the test samples of both tests. In the average of the tests with the pick up car, smaller and more firm fruits were available than during the test with the truck. Accordingly, a relatively low degree of mechanical damage of fruit already was found after the mechanical pre-load. This behaviour was consistent with results of earlier studies on the influence of fruit size and firmness [1]. Additional effects could be due to differences in tomato varieties and in mechanical load conditions during transportation. All in all, there were homogeneous and comparatively similar results.

Accelerations and pressure loads during transportation

During transportation with the truck, acceleration maxima of up to 8.7 m/s^2 were measured in a single direction. But, the acceleration in positive z-direction that adds to gravity, did not exceed 5.4 m/s^2 [2]. Pressure loads in the tomato bulk consisted of a static load of about 44 N and dynamic loads with amplitudes up to ± 15 N depending on uneven road surface and on truck accelerations (changes in speed and driving direction). Violent accelerations, for example caused by uneven road surface, could also be detected in the course of pressure load (*Fig. 4*). However, in general, there was no significant correlation between acceleration and pressure load.

During transport with the pick up car, comparatively higher acceleration maxima were detected, particularly at high speed. Acceleration maxima of up to 10.8 m/s^2 were recorded in a single direction. However, the acceleration in positive z-direction did not exceed 6.1 m/s^2. In contrast, relatively lower static and dynamic pressure loads were recorded. The static load was about 30 N, and dynamic loads of up to ±6 N were measured.

Conclusions

The mechanical load before a transport leads to invisible latent tomato fruit damage and has crucial effect on tomato fruit damage after transportation. To reduce the currently high fruit losses, the mechanical load resulting from mechanical harvest has to be reduced urgently.

The truck and the pick up car differ in their road performance. However, both vehicles have widely the same damaging effect on tomato fruits. Therefore, the transportation tests with pick up car seem to be suitable to simulate the effect of mechanical load during transportation.

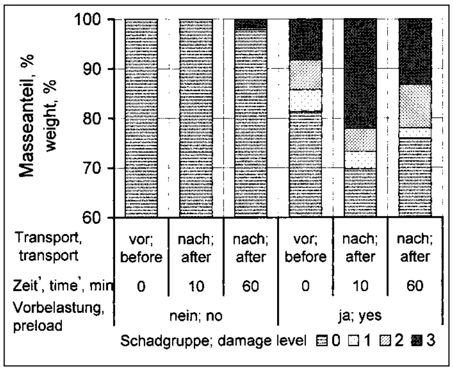

Fig. 3: Proportions of damaged tomatoes when transported by pick-up (1) : transport duration on road); variety Jovanna; mean fruit mass 50 g; mean hardness 6.5 N

Literature

[1] *Geyer, M., B. Herold, B. Oberbarnscheidt, B. Borsa, F. Jakovác and L. Kovács*: Minimized losses by mechanical tomato harvest in consideration of maturity and susceptibility. AGENG2002 Budapest, 2002, Paper No. 02-PH-037

[2] *Geyer, M., B. Herold, B. Oberbarnscheidt, B. Borsa, L. Kovács and F. Jakovác*: Detection of mechanical load and damage of industrial tomatoes. Postharvest Unlimited 2002, Leuven, Belgium, 2002, Book of Abstracts O24

Fig. 4: Vertical acceleration (z) and pressure force during driving on uneven road; example: transport by truck on road, speed 76 kph; correlation coefficients (r) between pressure force and accelerations: $r_x = 0.004$; $r_y = 0.230$; $r_z = 0.643$; $r_{res} = 0.644$