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Storage ability and differences of carrot varieties defined by firmness changes measured with new non-destructive acoustic method

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Summary Carrot production in Hungary is getting more important these days. The condition of the quality insurance is to choose the proper variety of carrot and store on optimal conditions therefore measuring firmness and matter parameters are very important. Four varieties of carrots were measured (Bangor, Olympus, Napa and Bolero). The roots were stored in unsealed polyethylene bags at 4–10 degrees Celsius and 95% relative humidity. The vegetables were measured three times: at harvest, after 1.5 months of storage and after four months of storage. The samples were tested by non-destructive acoustic stiffness measuring method during the 112 days experiment for firmness. In laboratory were measured weight loss, dry material -NO_3 and sugar content as an important matter parameters.
The firmness change as a function of storage time are the following: First part of the storage (after 60 days), the Napa variety changed least in the case of acoustical parameter, at the same time its weight loss and dry material content were not rise significantly, while its sugar content increased with 50%. The Bolero variety had the highest changes of sugar content during storage. During the second storage period, the softening speed of all samples was increased. The Bolero had the highest average mass loss (32,7%) and NO_3 content changes as well. All measurements showed the largest changes for the Bolero variety. The highest percentage of dry material content was found by the Bolero and Napa varieties (18–20%).
In this experiment, we found that the Bolero variety showed the greatest loss in compressibility during storage. If both firmness and weight loss results are considered, the Napa variety is found to be the most storable variety in sort period. The Bangor variety was found to be the best for long-term storage.

Key words: carrot, storage ability, quality defining, firmness, acoustic stiffness, non-destructive

Introduction

Carrot had a secondary place in our eating habit but these days ambition of the reform kitchen and to be in the EU had been proved the importance of carrots. Today customers are not only looking for the price also looking for quality as well. The market's expectation has been grown, therefore is very important looking for measuring quality parameters (*Balázs* et al., 2003). One of those quality parameters is the firmness of the product for self-life or storage ability, meanwhile measuring for in components are the nitrate, dry matter sugar and carotene contents.

Major in results, that those quality parameters can be measured by quick and non-destructive methods. The fully non- destructive and quick acoustic method comprehensive applied for measuring texture changes. As an example Potassium content of vegetables is defines the products firmness and texture changes (*Terbe*, 2001).

Chiefly used measuring globe objects however according to pre experiments and deep tests for methodic and the property of vibrancy relate to methodic parameters can be capable to measure long shape objects too (*Istella & Felföldi*, 2003).

Aim of our experiment was finding results for changes in carrot firmness and in component values during storage. Also we wanted to show it can be used showing the difference between varieties in storage ability too.

Material and method

The carrot varieties were grown by Carota BT at Soponya, in 2003. Through the growing period carrot had been irrigated continuously until the harvesting time (*Némethy & Fehér*, 2002). Carrots were processed for baby food, therefore in the growing period were used a minimal chemical against pests and disease and given minimal fertilization. At harvest 90% of the carrots had less then 300 ppm of nitrate content. That parameter shows a good quality, and ability for storing carrots (*Némethy & Fehér*, 2002).

In our experiment were used four varieties of carrots, mainly Nanty type: Bangor, Olympos, Napa and Bolero.

The samples were not washed. The roots were stored in unsealed polyethylene bags at 4–10 degrees Celsius and 85–90% relative humidity. The vegetables were measured three times: at harvest, after 1.5 months of storage and after four months of storage. The samples were tested by non-destructive acoustic stiffness method during the 112 days experiment for firmness. In laboratory were measured weight loss, dry material, NO_3 and sugar content as the important matter parameters.

Acoustic method

The carrot was tapped lightly with a wooden stick and a microphone located under the cushioning sample holder sensed the carrot's acoustic response (*Figure 1*). The soft support found to be the best between the carrot samples and the microphone (*Felföldi & Ignát*, 1999).

The microphone's output was recorded by the sound card in a PC-compatible computer. Custom fast Fourier transform software was used to analyze the recorded acoustic response. There is significant connection between the peak (characteristic) frequency of the acoustic signal and the sample's firmness (*Felföldi*, 1996). The characteristic frequency and the sample mass were used to calculate the firmness coefficient:

$$S = f^2 * m \text{ [N/mm]},$$

where S – acoustic firmness coefficient, f – characteristic frequency of the sample, m – sample mass.

In previous experiment we proved acoustic method can be useable for measuring carrot firmness, following firmness changes and making difference between carrot varieties.

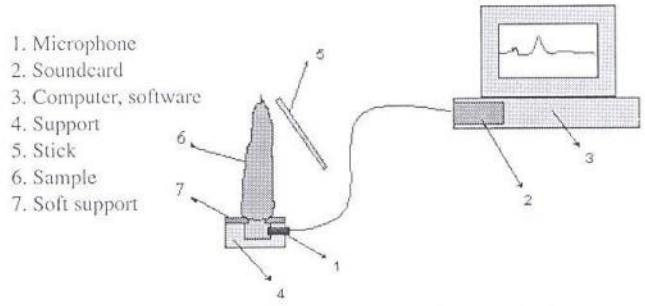


Fig. 1. Arrangement of the acoustic stiffness method

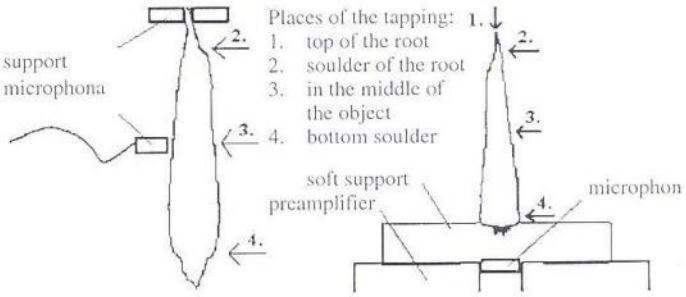
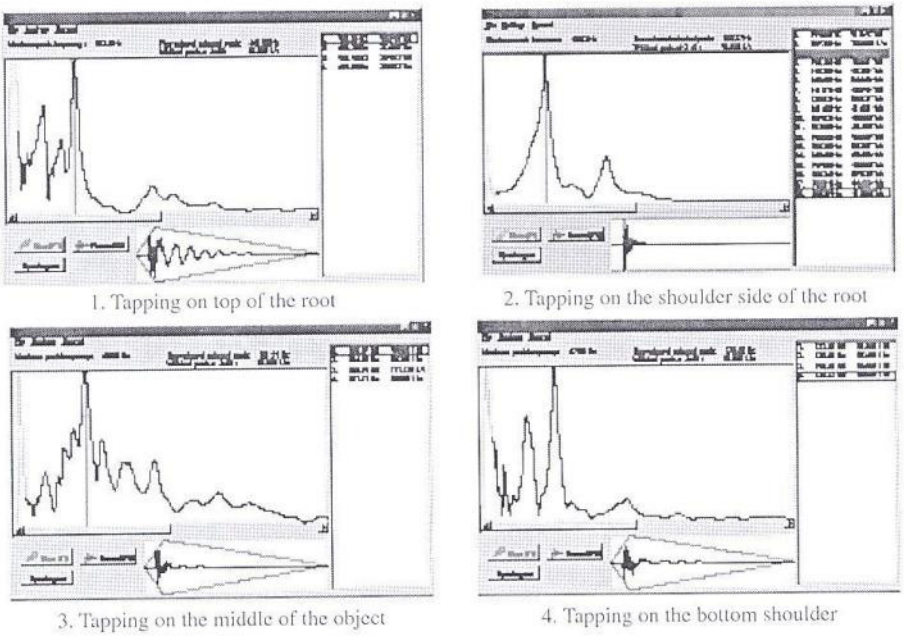


Fig. 2. Different supporting systems with the different tapping places

In our pre-experiment 5 progressing Flakker type carrot varieties were measured. Two different holding systems were used for carrot: holding by the root and soft support (*Figure 2*). Four different places were found to excite the object: top of the root neck, shoulder of the root growing centre, in the middle of the object and on the top of the object (*Figure 3*).

According to the results to support the long object were found soft supporting system the best. Shoulder of the root side was found the best tapping and to excite sound easily and reproducibly (*Istella & Felföldi*, 2003).



1. Tapping on top of the root
2. Tapping on the shoulder side of the root
3. Tapping on the middle of the object
4. Tapping on the bottom shoulder

Fig. 3. Carrot spectrums of frequencies on four different tapping places

Results and discussions

Changes of the acoustic stiffness coefficient

In *Figure 4*, it can be seen at the first part of the storage time (after 60 days) the Napa variety has the least firmness changes but at the 2nd period of the storage its firmness was decreased dramatically. At the first storage period Bangor F1 and Olympus F1 varieties were found about the same softening degree. During the second storage period (60–112 days) the firmness of the Bangor and Olympos varieties were decreased less than after the first storage period, meanwhile the firmness of the Napa and the Bolero varieties were decreased under 20% of the original (after harvest) firmness. The acoustic method showed that the Napa and Bolero varieties could be stored for short term. The Bangor and Olympus varieties used for processing and can be stored for long-term.

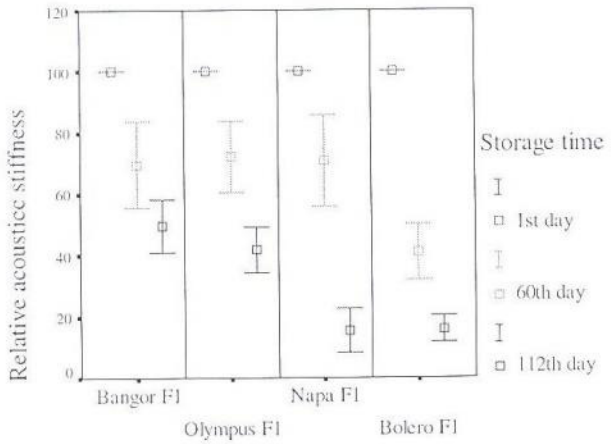


Fig. 4. Changes of acoustic stiffness coefficient of carrot varieties during storage

Changes of the relative mass loss

Figure 5 shows the relative mass loss of the carrot varieties during storage. During the first period the Bangor and the Olympos varieties were lost about 10 % from their mass and the Napa F1 15% and the Bolero 20%. During the whole storage period the Bolero F1 was lost the most (36%) from their mass. The Olympos F1 variety has the least changes of mass during storage. After the 112 days storage the mass loss of the Bangor F1 and Olympos F1 varieties was leas than after 60 days storage the mass loss of the Boloero F1 and Napa F1 varieties. The Napa and the Bolero variety were lost the most from their mass and those varieties were found the softest varieties.

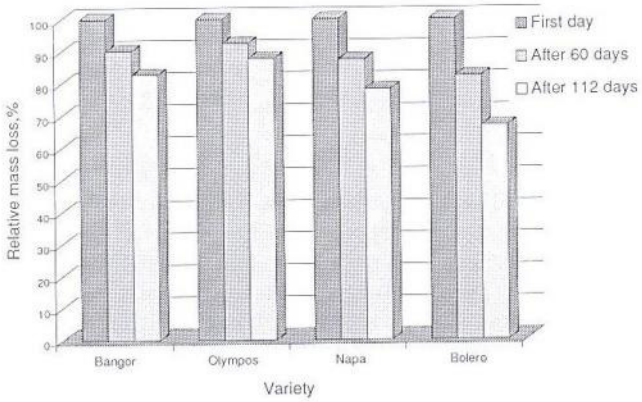


Fig. 5. Relative mass loss of carrot varieties during storage

Changes of dry matter content

Figure 6 shows the changes of the content of dry matter of the samples. During the storage period the content of dry matter was increase in case of all varieties. The Bangor F1 and Olympos F1 varieties had lower initial dry matter content than the Napa F1 and Bolero F1.

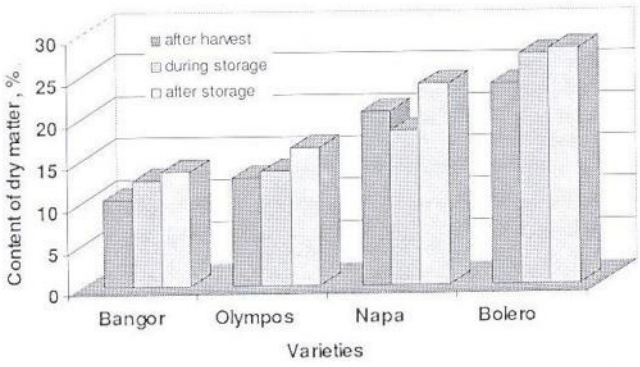


Fig. 6. Changes of dry matter content of different carrot varieties during storage

Changes of nitrate content

In the *Figure 7* can be seen the initial nitrate content was almost the same in case of all variety (580-610 mg/kg). During the storage period this value was decreased. The decreasing of the nitrate content was low in case of Napa F1 and Bolero F1 varieties (less than 100 mg/kg) meanwhile the NO_3 content of Bangor 210 mg/kg and Olympos F1 300 mg/kg were changed after 112 days storage.

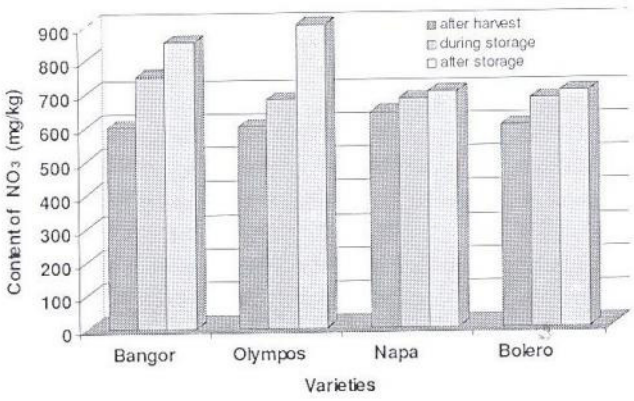


Fig. 7. Changes of nitrate content of carrot varieties during storage

Changes of sugar content

Figure 8 shows the changes of the sugar content of carrots. The sugar content was increased in case of all variety during storage period. The initial sugar content was found the highest in case of Bolero (9%) and the lowest was the Bangor (5%). The sugar content of Bolero was almost doubled during the 112 days storage meanwhile its mass loss was decreased more than 30%.

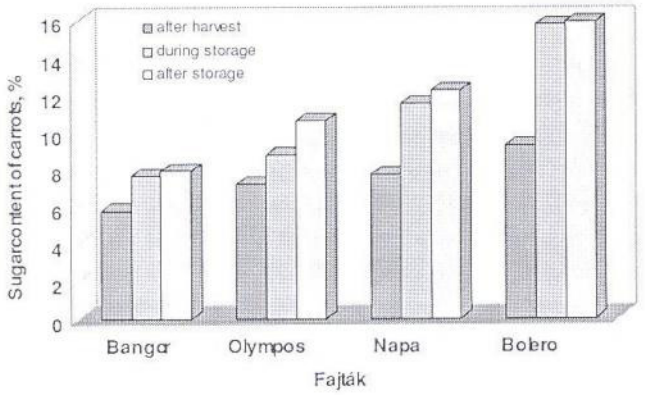


Fig. 8. Changes of sugar content of carrot varieties during storage

Conclusion

In our experiment Napa and Bolero varieties were Nanty types, therefore they haven't got real storage ability. For proof, the firmness results showed the same. Our results of the in components proved these varieties have the best contents out of all varieties.

In this experiment, we found that the Bolero variety showed the greatest loss in compressibility during storage. If both firmness weight loss dry matter and NO_3 content results are considered, the Napa variety is found to be the most storable variety in short period. However, the Bangor variety's change of NO_3 content was found to be the highest, still this variety was the best for long term storage.

References

Balázs, S., Kristóf, L., Terbe, I., & Zatykó, F. (2003.): Legfontosabb zöldségnövények mint hungarikumok. Kertgazdaság. 35 (2): 75–83.

Terbe, I., Slezák, K., Némethyné, U. H. & Kappel, N. (2001): Crop quality and yield of vegetable as affected by potassium supply. Bulletin of the Szent István University. 17: 29–38.

Felföldi, J. (1996): Firmness assessment of fruits and vegetables based on acoustic parameters. Journal of Food Physics. 58:39–47.

Felföldi, J & Ignát, T. (1999): Dynamic method for quick and non-destructive measurement of the surface firmness of fruits and vegetables. Hungarian Agricultural Engineering. 12: 29–30.

Némethy, H. & Fehér, M. (2002): Changes in dry matter and sugar content of Nantes type carrots during storage. International Journal of Horticultural Science. 8 (2): 67–72.

Istella, S. & Felföldi, J. (2003): Measurement of carrot varieties firmness chanches with non-destructive acoustic method. Hajtatás korai termesztés. 4: 24–26.