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THE INFLUENCE OF MATURITY DEGREE OF VEGETABLES ON THEIR CUTTING RESISTANCE FORCE

CIULICĂ LAURA GEORGIANA[1], RUS FLOREAN[2]
[1] Transilvania University, Braşov, laura_georgiana1@yahoo.com
[2] Transilvania University, Braşov, florus@yahoo.com

Abstract: *This paper presents the influence of root vegetables maturity degree in their cutting process. The role of this paper is to highlight that maturity degree of vegetable products is important for their further processing, causing the variation of cutting force and thus the energy consumption for their processing. In the industrial processing of vegetables and fruit their texture is an important factor for determining the technological parameters of process (temperature, pressure, time).*
Keywords: *maturity degree, vegetables, cutting force.*

1. INTRODUCTION

Fresh-cut fruits and vegetables are a relatively new and rapidly developing segment of the fresh produce industry. Fresh-cut products have been freshly cut, washed, packaged, and maintained with refrigeration. They are in a raw state and even though minimally processed, they remain in a fresh state, ready to eat or cook. [1]

The production and consumption of fresh-cut commodities is not new. However, the fresh-cut industry was first developed to supply hotels, restaurants, catering services, and other institutions. For the food service industry and restaurants, fresh-cut produce presents a series of advantages, including a reduction in the need of manpower for food preparation, reduced need of special systems to handle waste, and the possibility to deliver in a short time, specific forms of fresh-cut products. Yet it has not been until the past two decades that fresh-cut fruit and vegetable products have gained popularity and penetration in the produce business as a result of a general trend to increase fresh fruit and vegetable consumption. [2]

In terms of use and acceptability requirements for fresh consumption or diverse processed, vegetables and fruit maturity may be commercial (technical or industrial), harvest (the orchard or garden), for consumer and physiological. The commercial, harvest and industrial maturity refers to fruits and vegetables that have just begun to define up to and including termination of growth and development. The orchard maturity is defined by shape, size, pigmentation, namely properties characteristic of the species, variety and agropedoclimatic conditions. If the commercial and orchard maturity is performed before the vegetables or fruits to be detached from mother plants, on the contrary processes leading consumer maturity occur after harvest. This kind of maturity is characterized and defined by firmness and harmonic relation between the dry components, that give fruits and vegetables that taste, smell, flavor and physical characteristics of the species and variety and they are to be accepted and consumed with pleasure, especially fresh. The industrial maturity represents the optimal stage of processing fruits and vegetables and, in general, must coincide with the maturity of the consumer, taking account of its characteristics at this stage.

The maturity stage is characterized through many changes taking place in the structure of vegetables, the green color turns in specific colors due to plant pigments, flavors arise as a result of training essential oils, and the taste becomes nice.

Measurement consistency is achieved with different devices called penetrometer which is based on determining the force needed to pierce plant tissue, and the results are expressed in Pa.

Both the maturity at harvest and the ripeness stage at cutting will affect the postcutting quality and shelf life of fresh-cut fruit products. Because many fruit are picked before they are fully ripe, the question arises as to what maturity should climacteric fruit be used for fresh-cut processing to optimize product shelf life and eating quality? In order to withstand mechanical damage during postharvest handling and deliver excellent visual quality and acceptance by retailers and consumers, fresh-cuts may be produced with firm fruit that was harvested slightly immature. Consumer preferences within a single fruit type are often cultivar dependent and often defined by the stage of ripeness. Firmer fruit tends to be less ripe and thus tastes more acidic or “sour” and has a volatile profile rich in aldehydes delivering green grassy aroma and flavor notes. On the other hand, softer fruit is generally much riper, has a lower acidity, and has a volatile profile dominated by esters that deliver typical fruity aroma and flavor notes. [2]

2. MATERIALS AND METHODS

Structo-textural firmness of fruits and vegetables influence the choice of technological parameters necessary for their further processing required (temperature, pressure, time). Vegetables and fruits cutting represent a basic operation for their processing. For the operation of cutting vegetables and fruits to achieve the optimum in terms of energy consumption is important to take into account all factors affecting the operation (factors relating to the product entered for processing, general factors related to the cutting operation, factors relating to machinery used in processing, etc).

For the determination of cutting resistance is used a special stand created by Zwik / Roell which is presented in figure 1. This equipment works whit software called Test Expert, which stores data in its Windows operating system for acquisition, visualization and data analysis. One of its most important ability is to store one of the measures procedures and have immediate access to it. A determination can be defined by two windows: one by imposing the parameters, and the other one by defining the way to view the results (graphs, tables). The equipment is composed from the frame 1 in which is mounted the drive mechanism of the knife holder, a control panel 2 and a device for vegetables application 4. The knife 3 is presented in figure 2 and is of edged right type.

For experimental measurements were used vegetables such as carrots. Each one of this vegetable was subjected to the determination of cutting resistance in three different areas on the vegetable length, varying this way the cutting diameter.

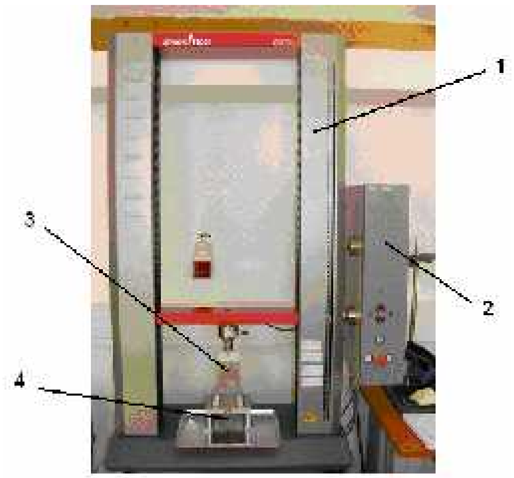


Figure 1: Zwick /Roell stand for cutting resistance determination

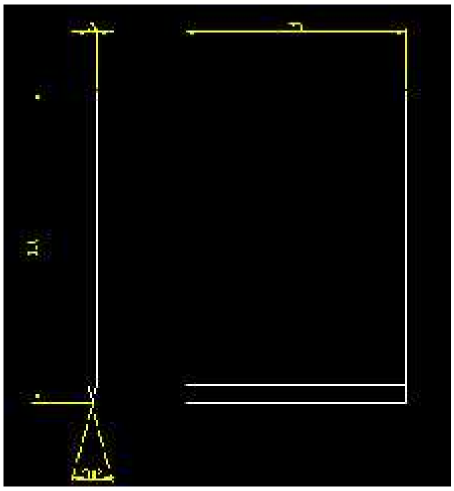


Figure 2: The cutting knife of edged right type

Electronic device for measuring firmness of vegetables and fruits shows optimum time for harvesting agricultural products while indicating the optimal maturity during their storage. The results obtained with the help of this device can be read on the electronic display device. On the top line of the display it can be read the maturity in grams.

Figure 3: Maturity meter device 200

Measurements are made in opposite points on fruit. Using two points to determine press the device portion of fruit (vegetables) being tested; the machine device enters in the analyzed product, gradually up to a sign, indicated by the device. The device transmits on the screen the hardness and resistance probe introduction which is directly related to degree of ripeness of the fruit, expressed in g / kg.

3. RESULTS AND DISCUSSION

The experimental research results for those vegetables used in the experimental researches were displayed in table 1.

Table 1: Values registered with Maturity meter 200

Probe number	1			2			3			4		
Diameter of tested probe [mm]	25	20	21	30.4	26.28	22.6	45	40	32.16	49.02	41	28.4
Probe weight [g]	66.64			85.05			240.19			199.5		
Maturity degree	17.8	17.8	17.8	17.8	17.8	17.8	17.6	17.6	17.6	17.6	17.6	17.6

After processing the data from table 1, it can observe that the maturity of the products tested is almost the same and does not depending on the diameter of the testing area for each root vegetables used in the research. The maturity degree of tested products is optimal, because the recorded values are between 16 and 18, interval corresponding to an optimum degree of maturity for consumption.

For determining the cutting resistance, the products were tested with a special stand created by Zwick / Roell. The results obtained in this way are presented in table 2.

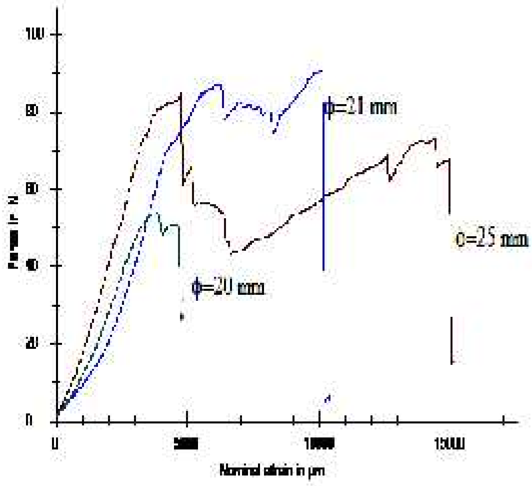
Table 2: Values registered at the cutting tests

Probe number	1			2			3			4		
Material	Carrot			Carrot			Carrot			Carrot		
Diameter in cutting area, [mm]	25	20	21	30.4	26.28	22.6	45	40	32.16	49.02	41	28.4
Maximum cutting strain,[N]	84.62	90.89	53.80	130.28	137.55	94.31	210.4	240.3	128.2	206.62	193.7	156.9

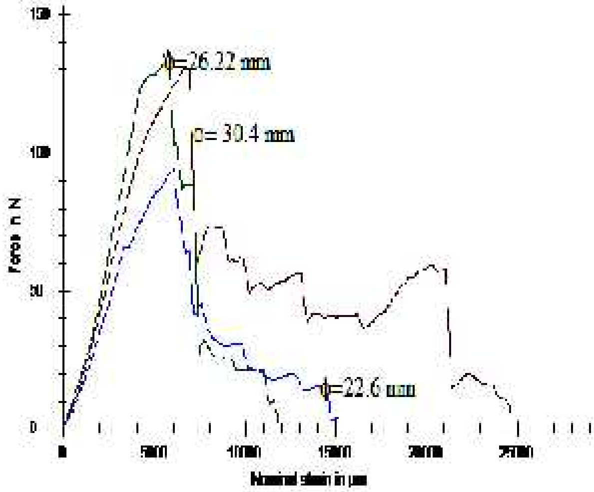
After measurements, the experimental research equipment displays the results in the form of graphs representing the variation of cutting resistance depending on the diameter in the cutting area.

For each of the four samples that were subjected to cutting operations in three different areas, largest diameter corresponds to the upper area of the carrot, middle diameter corresponds to the middle area, and the minimum corresponds to lower part of the carrot.

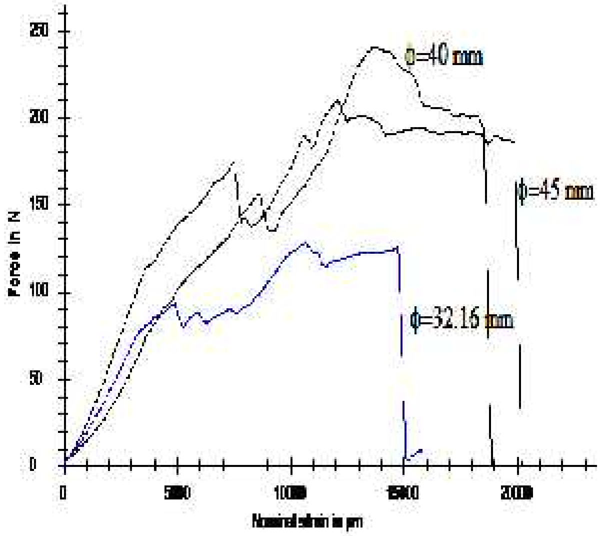
Analyzing the graphs from figure 4, it can be observed the mechanism of cutting operation, characterized by the existence of two stages. By applying shear force on one axis (transverse), on this direction the material will be required to compression. In the first step under cutting blade action, in the mass of sample material develops a state of efforts, its cellular tissue will be elastic deformed. In the second stage, characterized by reaching a critical value (on the chart the maximum variation curve), causing cracks, which quickly spreads and branches, phenomenon that is evidenced by low levels of effort, after which the process is repeated until the total separation of slice. Action the knife in material is accompanied by plastic deformations of cellular tissues, which is destroyed and produce a certain amount of release cellular juice, which will have lubricating qualities. Complete separation of the splinter material, is characterized by a sudden decrease of the values force that drives the knife.



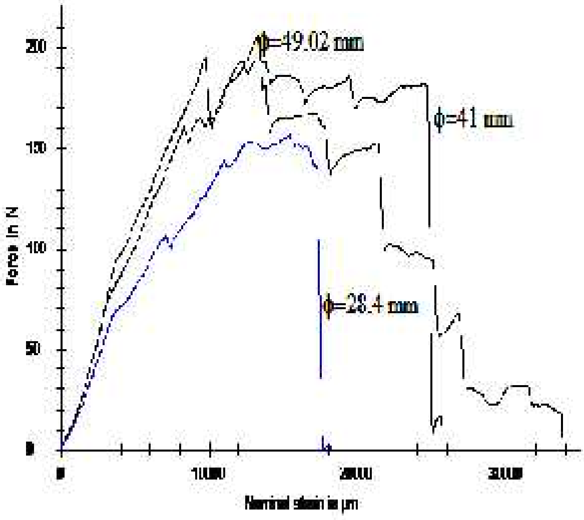
a.



b.



c.



d.

Figure 4: Variation of cutting resistance:
a. - chart for sample no. 1; b. – chart for sample no. 2; c. – chart for sample no. 3; d. – chart for sample no. 4

Following the evolution of curves results from cutting samples it can see that the highest resistance force was recorded in the middle area of carrots subjected to cutting operations (fig. 4,*a*, *b*, *c*), this shows that their internal structure is stronger in this area. Analyzing the top area of the carrots, which, although carrying a larger diameter has a lower value of resistance to cutting force, because this area is exposed to external environment, the tissue has lower humidity (partially dehydrated), which gives the material a higher elasticity. Also, resistance to cutting force is lower and at the bottom of carrots, where the section cutting area is smaller.

At the sample number 4 (fig. 4, d), the situation is slightly different from previous, in this case the value of the resistance force is greater in the upper area. By analyzing the curves of this graph it can see that the cutting in this area occurs in steps, until complete rupture occurs. This is possible because of large diameter (ϕ = 49.2 mm for superior area and ϕ = 41 mm for middle area) of cutting section and hence the internal structure of wood. This structure gives it greater resistance, so the break does not occur progressively throughout the mass of material, but occurs gradually, separated splinters of material are smaller and more numerous.

This can be observed in figure 5, where the sample number 4 is subject to the cutting operation.

Figure 5: View of the cutting surface

The results obtained from experimental measurements were processed as a graph (figure 6).

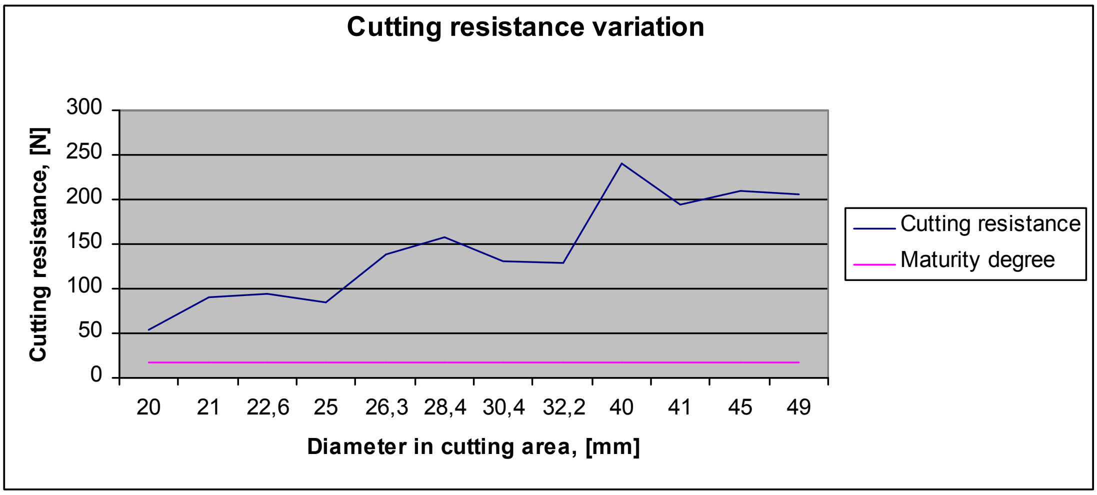


Figure 6: Cutting resistance variation at a constant level of maturity degree

5. CONCLUSIONS

Following the experimental measurements can be seen that to an optimum degree of maturity for consumption, carrots cutting operation is influenced by cutting their sectional area, so that with increasing cutting section, increase their resistance to cutting.

Value of effort invested in the first phase depends on the initial state of material (number and size of existing cracks in the material), and for the second phase depends on the native structure of the material. Cracks in the native structure of the material is due to discontinuities in the material structure, which is stress concentrators and breaking primers, that favors breaking and the splinters formation results.

If the material has non-homogeneous structure slip can lead to development of local unit stretching efforts that triggers brittle fracture.

The more splinters that fall are greater and their size is increasingly reduced, the energy invested in the process of cutting is higher. Energy usage would be maxim if the breaking material would produce at the amount of force applied at the start of fracture.

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