

## COMPARATIVE INVESTIGATIONS OF THE PHYSICO-MECHANICAL PROPERTIES OF CHOSEN VARIETIES OF APPLES FROM THE POINT OF THEIR APPLICABILITY FOR MECHANIZED HARVESTING

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The aim of the work was to compare the physico-mechanical properties of chosen varieties of apples from the point of introductory evaluation of their applicability for mechanized harvesting. Measurements of the force necessary to break apple off from short stem and investigations of the resistance of apples to dynamic damage were carried out.

### CONDITIONS OF INVESTIGATIONS

The experiment was carried out in 1975. The orchard was on podsolic soils derived from loamy and weakly loamy sands. Four varieties of apples were investigated: McIntosh, Bankroft, Boiken, Starking. The apple trees were planted at the distances 6 by 4 m. McIntosh, Bankroft and Starking were planted on black westeland and Boiken was planted on grassland. In order to protect the fruit from pests and illnesses a series of chemical measures were taken. Data about the blossoming and the age of trees are presented in Table 1. The vegetation period lasted from 201 to 206 days. Mean temperature of the vegetation period was

Table 1

Age of trees and time of blossoming

Variety	Blossoming	Age
McIntosh	15.05.	1964 — 1975 r.
Bankroft	18.05.	1964 — 1975 r.
Boiken	19.05.	1962 — 1975 r.
Starking	21.05.	1969 — 1975 r.

16.58. The first ground frosts were on 1st November and the last on 6th May. Fruits for investigations were chosen from the point of health and being characteristic for each variety in size and shape.

#### COURSE OF MEASUREMENTS AND DESCRIPTION OF MEASURING EQUIPMENT

Field investigations were utilized for the determination of force necessary to break apples off from the short stem. Too high force needed to pick an apple eliminates the possibility of applying mechanized harvesting, since the force causing the picking of fruits would give them too high an energy at the moment of their fall. The assumption of the investigations was the determination of an optimum term of harvest, i.e. the finding of such a moment when the application of mechanized harvesting would be the most advantageous. The terms of field investigations are presented in Table 2. For investigating the force of breaking

Table 2

Dates of Laboratory and field investigations

Variety	Date								
	7.09.	12.09.	17.09.	22.09.	27.09.	2.10.	8.10.	13.10.	18.10.
McIntosh	×	×	×	×					
Bankroft				×	×	×	×		
Boiken					×	×	×	×	
Starking						×	×	×	×

apples off from the short stem an apparatus was applied, the diagram of which is presented in Fig. 1. The apparatus consists of a hand operated dynamometric lever with a holder, tensometric force converter with a tensometric bridge and an indicator.

Investigations of the resistance to dynamic damage were carried out

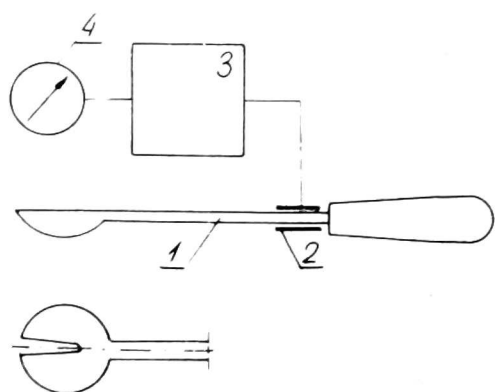


Fig. 1. Diagram of device for the determination of force of breaking apple off from short stem: 1 — dynamometric lever with holder, 2 — tensometer, 3 — tensometric bridge, 4 — probe

in the Institute of Mechanization of Agriculture in Lublin in terms enumerated in Table 2. The investigations were carried out on the red and green sides of fruit after removing the skin. Fig. 2 presents the diagram

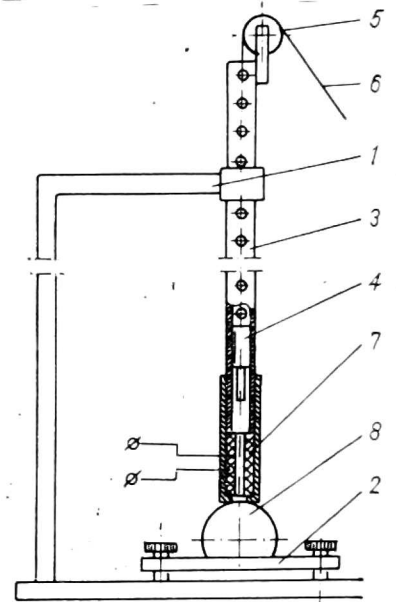


Fig. 2. Diagram of measuring device for the determination of the resistance of apples to mechanical damage: 1 — frame, 2 — measuring table, 3 — leading pipe, 4 — stamp with pin, 5 — tackle, 6 — flexible connector, 7 — core with coil, 8 — sample

of the apparatus for the determination of resistance to dynamic damage. The measuring apparatus consists of a shock device, and a recording system. The leading pipe contains the stamp falling down on to the apple with the speed of 3.22 m/s from the height of 530 mm. The speed was chosen experimentally so that the pin at the end of the stamp enters the pulp of the fruit but does not reach the seed nests. The depth of entrance was measured with the help of the differential transformer used as an index of the movement of the pin of the damaging stamp. 30 measurements were made for each term, variety, and the red and green sides of fruit.

#### ANALYSIS OF RESULTS OF THE INVESTIGATIONS

The measurement results from the dynamic investigations and the field investigations were subjected to statistical analysis and significant differences between the investigated values were found. In order to grasp the quantitative relationships further conclusions were worked out on the basis of Tukey's halfranges of credibility at the level of significance 0.05.

Table 3 compiles the mean values of the force necessary to break apple off from the short stem. On the basis of variance analysis (Table 4) significant differences between the mean values of force necessary to break apple off from the short stem in the particular varieties were found. To pick an apple of the Starking variety the greatest force is ne-

Table 3

Mean values of the force necessary to break apple off from short stem (kG)

Term	Variety				Mean value for term
	Boiken	Starking	Bankroft	McIntosh	
I	2.48	3.48	3.08	1.75	2.70
II	2.22	2.98	2.90	1.55	2.41
III	1.83	1.47	2.55	1.25	2.02
IV	1.56	1.88	1.85	0.63	1.48
Mean values for varieties	2.02	2.70	2.59	1.29	—
Half-range of credibility	L = 0.15				

Table 4

Variance analysis of the force necessary to break apple off from short stem

Source of variability	Freedom degree	Sum of the squares of deviation	Mean squares	Calculated function	Tabulated function
Among varieties	3	150.1182	50.0394	1073.60	2.62
Among terms	3	99.7640	33.2547	713.46	2.62
Interaction	9	5.5131	0.6125	13.14	1.96
Error	464	21.6300	0.0466	—	—
Total	479	277.0253	—	—	—

cessary. Apples of the McIntosh variety require the least force. The force necessary to pick an apple decreased with time. With all the varieties the force was the least in the IV term, and thus mechanized harvest should be done in this term.

Table 5 presents the variance analysis of the results obtained during dynamic measurements. Significant differences between the compared values were found. The tabulated functions in all cases are higher than the calculated function. Differences between the damage depth of peeled apples on the red and green sides are significant, which is presented in Table 6.

Differences between the mean values of damage for the different varieties are significant. Corresponding results are compiled in Table 7. The highest resistance to dynamic damage was found in the Boiken variety. The McIntosh variety turned out to be the least resistant. The Starking variety is characterized by a higher resistance than the Bankroft variety.

Table 5

Variance analysis of results obtained from dynamic experiments

Source of variability	Freedom degrees	Sums of the squares of deviation	Mean square	Calculated function	Tabulated function
Among varieties	3	9531.6203	3177.2067	6467.33	2.61
Among the sides	1	259.7921	259.7921	528.81	3.84
Among terms	3	2083.4477	694.1825	1413.65	2.71
Interaction:					
variety v. terms	9	152.3427	16.9269	34.46	1.89
variety v. side	3	13.8231	4.6077	8.26	2.61
terms v. side	3	0.3161	0.1160	3.23	2.61
variety v. term v. side	9	14.2847	1.5872	3.23	1.89
Error	928	445.9007	0.4913	—	—
Total	959	12511.5594	—	—	—

Table 6

Mean penetration of stamp on both sides of apple

Side	Green	Red
Mean penetration of stamp (mm)	17.55	16.51
Half-Range of credibility	$L = 0.10$	

Table 7

Mean penetration of stamp in particular terms of investigations

Variety	Bankroft	Boiken	McIntosh	Starking
Mean values	17.28	12.98	21.76	16.12
Half-range of credibility	$L = 0.25$			

Table 8

Mean penetration of the stamp in particular terms in investigations

Term	I	II	III	IV
Mean values	15.03	16.33	17.91	18.87
Half-Range of credibility	$L = 0.18$			

Table 8 presents the mean values of the penetration of the stamp in the particular terms of investigations. There are significant differences in the resistance to dynamic damage. A decrease of resistance with time is observed. In the IV term of investigations the resistance is the lowest for all the varieties.

### CONCLUSIONS

The value of force necessary to break apple off from the dwarf shoot depends on the variety and the maturity of the apple. The greatest force of picking was observed in term I of the investigations, then the force decreased during the two intermediate terms and reached the minimum in term IV. Apples of the Starking variety are bound the strongest to the dwarf shoot, and apples of the Bankroft, Boiken and McIntosh varieties are bound weaker.

The damage occurred during the dynamic investigations carried out on apples with the skin removed depend on the variety maturity and the side of the fruit. The highest resistance to dynamic damage is shown by the Boiken variety, and then come the Starking, Bankroft and McIntosh varieties. The resistance to dynamic loading decreased with the increase of maturity. The red side of fruit is more resistant to dynamic loading than the green side.

The above presented investigated may facilitate the evaluation of the resistance of a variety and the choice of the term of harvesting connected with the least risk of damage.

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#### BADANIA PORÓWNAWCZE WŁASNOŚCI FIZYKOMECHANICZNYCH WYBRANYCH ODMIAN JABŁEK POD KĄTEM ICH PRZYDATNOŚCI DO ZBIORU MECHANICZNEGO

#### Streszczenie

W celu uzyskania charakterystycznych dla odmiany wskaźników odporności na uszkodzenia mechaniczne przeprowadzono w IMR AR w Lublinie badania porównawcze czterech odmian jabłek. Badano siłę oderwania owoców od krótkopędów oraz odporności na uszkodzenia dynamiczne. Do badań użyte zostały urządzenia pomiarowe własnej konstrukcji.

Badania wykazały, że występują istotne różnice wartości badanych parametrów pomiędzy odmianami. Na wartość tych parametrów ma również wpływ stopień dojrzałości owoców i czas przechowywania.

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СРАВНИТЕЛЬНЫЕ ИССЛЕДОВАНИЯ ФИЗИКО-МЕХАНИЧЕСКИХ СВОЙСТВ  
ИЗБРАННЫХ СОРТОВ ЯБЛОК С ТОЧКИ ЗРЕНИЯ ИХ ПРИГОДНОСТИ  
К МЕХАНИЧЕСКОМУ СБОРУ

Резюме

Для получения характерных для сорта показателей устойчивости к механическим повреждениям провели в Институте механизации сельского хозяйства сельскохозяйственной академии в Люблине сравнительные исследования четырех сортов яблок. Исследовались сила отрыва фруктов от укороченных побегов и устойчивость к динамическим повреждениям. В исследованиях были применены измерительные приборы собственной конструкции.

Исследования показали, что появляются существенные различия между величинами исследуемых параметров отдельных сортов. На величину этих параметров имеет также влияние степень зрелости фруктов и время хранения.

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