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A Classification Study Of Biometric And Physico-Mechanical Properties Of Cobs Of Seed Corn.

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ABSTRACT

This article presents a classification system for the characteristics of cobs of seed corn for post-harvest processing. The systems of indicators for sorting operations, cleaning from wrapping leaves and threshing have been defined. Schemes of original instruments and results of investigation of biometric and physico-mechanical properties of cobs of some lines of maize hybrids are presented.

Keywords: corn cobs, biometric properties, physical and mechanical properties, classification, post-harvest operations.

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INTRODUCTION

The study of botanical, biometric and physico-mechanical features of cultivated plants is necessary for agrobiologists to produce new varieties and hybrids in order to increase their resistance to natural and mechanical influences for maximum harvest conservation.

Engineers study the same indicators for the opposite purpose - to find out the optimal parameters of the destruction of some parts of plants, while observing the integrity of others, which should occur during harvesting and post-harvest processing of cereals, including corn [4, 5, 6, 7, 8, 9, 12, 13, 14].

Thus, the properties of corn cobs are the main initial data for the development of structures and the determination of the parameters of the working organs of machines and machines for harvesting and post-harvest processing.

Of undoubted interest is the fact that the basic requirements for the anatomical and geometric parameters of the cobs of seed use, which are still in force, were formulated at the beginning of the 20th century [7].

In the process of harvesting and post-harvest processing in maize cobs, some changes in the anatomical structure, size-mass and physico-mechanical parameters occur. Therefore, the indicators need to be investigated in the dynamics of the corresponding process. Typically, such studies are associated with specific design solutions, and not all of them can be applied in a wide range.

In general, we can note the following:

- the corn cob is a complex biological structure with anisotropic properties of different layers;
- in the process of external influence in corn cobs changes occur in all biological layers;
- the method of studying the physical and mechanical properties of agricultural plants, and in particular corn was developed in the twentieth century, but it is constantly supplemented with new indicators;
- the accumulated statistical data on the size, mass and physicomechanical characteristics of the cobs often overlap or duplicate the results obtained earlier;
- there are no data on some morphological, biometric and physicomechanical indicators;
- a single and consistent, logically connected with the form of external influence, a scheme for studying the physico-mechanical properties of various cob structures has not been developed.

MATERIALS AND METHODS

Architectonics, biometric and physical and mechanical properties of corn cobs are the main initial data for the development of structures and the determination of the parameters of the working organs of machines and machines for harvesting and post-harvest processing.

Knowledge of these indicators allows us to develop the designs of working bodies and machines with optimal parameters that ensure the destruction of individual parts of plants while respecting the integrity or partial integrity of others, which is regulated by the corresponding initial requirements.

Thus, there is a need for a comprehensive, sound methodology for selecting indicators that will be sufficiently universal.

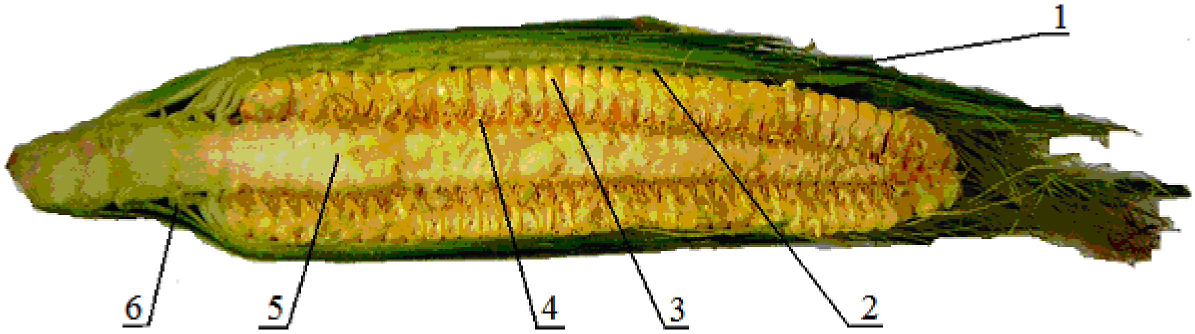
This method is based on the principle of consecutive interaction between the ear and the working parts in the process of processing.

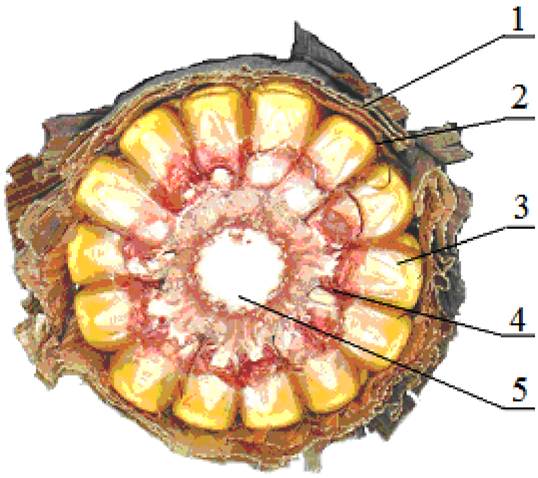
The proposed methodology for selecting the characteristics of corn cobs is based on the following provisions: 1) the ears are considered as a complex biological object, clearly divided into several dissimilar zones (Figure 1); 2) the physical and mechanical properties of cobs undergo significant changes during processing; 3) the properties of some working organs in the process of interaction with the cob vary.

The list of indicators for the study was carried out on the basis of an analysis of the designs of corn harvesters, sorters, cob cleansers, threshers and technological processes taken to mass production and original prototypes [4, 6, 7, 9, 12, 13, 14].

RESULTS AND DISCUSSION

The physical, mechanical and biometric properties of maize were studied by M.F. Burmistrova, A.I. Buyanov, N.I. Gurov, V.V. Derevenko, I.T. Os'mak, A.F. Sokolov, N.N. Shatilov, V.S. G.I. Kreymerman, M.G. Golik, V.S. Kravchenko, V.S. Kurasov, YU.I. Mozgovoy, G.A. Nikitina, A.I. P'yankov, A.I. Gokoyev, T.K. Togonbayev, V.F. Razdorskiy, N.N. Ul'rikh, V. G. Ivashkov, Ye. V. Truflyak, S. Vasilev, A. Mitkov, U.G. Anazodo, A. Brandolini, F. Hamid, R. Laubengayer, J. Mosz, A. Srivastava and other scientists [4, 5, 6, 7, 9, 12, 13, 14].





1 - wrapping-air layer; 2 - area of contact between wrappers and grains; 3 - layer of grain; 4 - zone of attachment of grain to the core; 5 - the rod; 6 - area of fastening of wrappers to a leg

Figure 1: Cob in a section

The technical realization of the processes of sorting, cleaning and threshing of the cobs of seed corn is optimal, if the following are taken into account:

1) properties of cultivated plant objects;
2) requirements for the technological state of maize cobs in general and their components;
3) the conformity of the parameters of technological processes to the change in the technological state of the corn cobs as a whole and their components.

Since all operations occurring in sorting, cleaning and threshing machines are dynamic, many parameters of the physical and mechanical properties of corn cobs have been studied by us in the process of their change.

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In substantiating and developing instruments for the study of biometric, physico-mechanical properties and architectonics of corn cobs, methods of classical mechanics were used, as well as special research methods developed by the authors.

The obtained indicators are presented in the form of a classification table and are selected depending on the cob zone and the nature of the impact on it by the working bodies or other cob zones (Table 1).

Table 1: Classification table for selecting the characteristics of the cob

Cob zone	The nature of the impact of the working organs or other areas of the cob	Indicator for research
Cob	Rolling, rotation, compression, bending	1. Weight 2. Scope 3. Length 4. Humidity 5. Bulk weight 6. Bulk density 7. * Length along the support surface 8. Center of gravity 9. * Diameter at the beginning of the bearing surface 10. * Diameter in the middle of the bearing surface 11. * Diameter at the end of the bearing surface 12. Density 13. The moment of inertia along 14. Moment of inertia across 15. Weight of the bulk product 16. Resistance to bending 17. Resistance to compression
I Wrapping-air layer	Compression, tension, rupture	1. Spectral properties of wrapper leaves 2. Number of wrapper leaves 3 *. The shape of the cob cover 4*. Corn cover angle of wrapper leaves 5. Length of wrapper leaves 6. Thickness of a layer of wrapping leaves 7. Distance between leaves (radial) 8*. Strain of the leaves 9*. Deformation when rolling a layer of leaves 10*. Change in sheet width during deformation with rental 11. Sheet break across 12. Sheet break along 13. Frictional properties of the leaves of the wrapper: 1) static 2) dynamic 14. Speed of rotation 15.Architectonics of leaves: 1) sheet shape in diameter 2) * the nature of the venation 3) * vein thickness 4) * thickness of connective tissue 5) * dimensional characteristics of unicellular hairs on wrapping sheets 6) * the principle of the arrangement of unicellular hairs 7) * density (number per unit area) of unicellular hairs

II The lower layer of the wrappers is the surface of the grains	Slipping, squeezing	1. Frictional properties of the wrapper-grains 2 *. Coefficient of sliding 3. Spectral properties of the grain surface
III Corn part of cob 1. The face surface of the grain (pericarp and pedicel)	Beat, stretch, squeeze	1. Sizes of grain 2 *. Size of the pedicel of the grain 3. Number of rows of grains 4*. The nature of the location of grains on the rod 5*. Coefficient of sliding 6. Shock recovery ratio 7. The angle of a natural slope 8. Speed of rotation 9. Strength 10. Strength of deformation 11.Roughness 12. The elastic modulus 13. Collapsing stress 14.Displacing load 15. Injuring load 16. Allowable load 17. Strength of breaking the connection with the pin by pulling 18 *. Strength of breaking the connection with the core with indentation 19. Violation force
2. The lateral surface of the grain (pericarp)	Shock, compression	1. Coefficient of sliding 2. Shock recovery ratio 3. The strain force 4. Rigidity 5. Modulus of elasticity 6. Stress of crushing
IV The area of attachment of grains to the stem (the zone of the pedicel	Bending, stretching	1. The pulling force of the grains from the stem 2 *. Effort of grain separation during pulling with bending 3 *. Effort to break the connection of the grains to the core with indentation
V Kernel	Blow, bend	1. Weight 2. Scope 3. Length 4. Humidity 5. Bulk weight 7. Center of gravity 8. Diameter at the beginning 9. Diameter in the middle 10.Diameter at the end 11. Density 14. Mass of the bulk product 15. Resistance to kinking 16. Resistance to compression
VI The area of fastening the wrappers to the foot	Stretching	1. The diameter of the foot 2. Length of the leg 3. Effort of detachment of leaves from the stem of the cob with longitudinal stretching and different angles relative to the surface of the cob 4*. The force of tearing off the leaves from the cob's foot with longitudinal stretching with torsion relative to the stalk and various angles relative to the surface of the cob

* Indicators are defined for the first time.

An investigation of the biometric and physico-mechanical properties of the ears, as well as the architectonics of the leaves of the wrapper, was performed on hybrids of the Krasnodar and Pioneer lines.

Selection of cobs was carried out in the field of 100 copies of each hybrid.

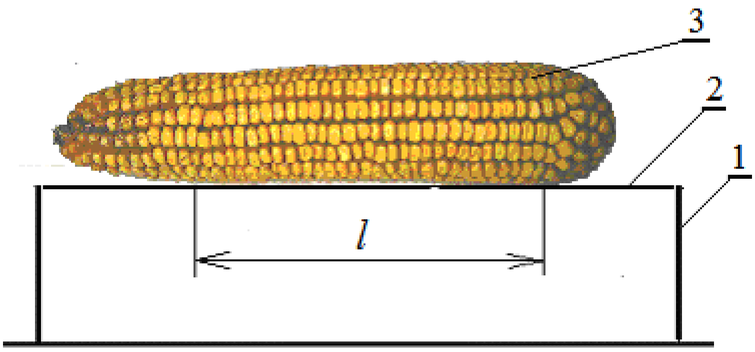
Each cob was labeled with a tag, the numerator of the fraction denoted the hybrid cipher, and in the denominator the cob number.

Humidity was measured by a high-speed electronic hygrometer, mass - by electronic scales, volume - by immersion in a measuring cylinder with water.

The total length of the cob is taken as the distance from the top to the bottom.

The length of the support surface l cob was measured on a plate of transparent plastic with a printed mesh. Determination of the length of the supporting surface was carried out as a result of rolling the cob over a transparent plate with fixation of four values of the reference length, every 90 degrees of rotation, with an average calculation (Figure 2).

The maximum and minimum diameters are taken at the ends of the contact line.



1 - stand; 2 - a plate with a marking; 3 - cob

Figure 2: Apparatus for determining the length of the supporting surface of the cob

The moments of inertia along and across the cob axis, as well as the location of the center of gravity, were determined by the method of a two-wire suspension.

As materials of frictional surfaces on which coefficients of friction of rest and motion were found, rubber, steel, leaves of wrappers, a surface of grains were accepted.

The number of leaves of the wrappers and the principle of their location were determined visually.

The angle of coverage of the cob with leaves of the wrappers and tear force was determined on a universal instrument (Figure 3).

The force of leaf separation was studied at different positions of the longitudinal axis of the cob with respect to the direction of the applied force, and also depending on the direction of rupture of the bonds of the leaves with the cob, ie, with the creation of only normal stress along the sheet or with tangential components.

In determining the tearing force of leaves with tangential components, i.e. with torsion, the cob was fixed in position when the upper cut of the leaf was rotated 90 degrees to the horizon and the wrapper sheet broke off, turning in relation to the base.

The rotation of the cob in the horizontal plane in determining the tear force was taken at 22.5

degrees from 0 to 90 degrees.

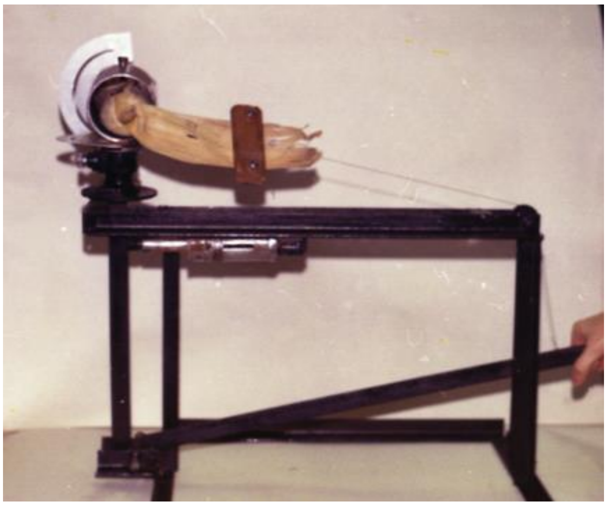


Figure 3: Universal device for assessing the ears

The change in the width of the wrapper leaves during rolling was investigated on the original instrument (Figure 4).

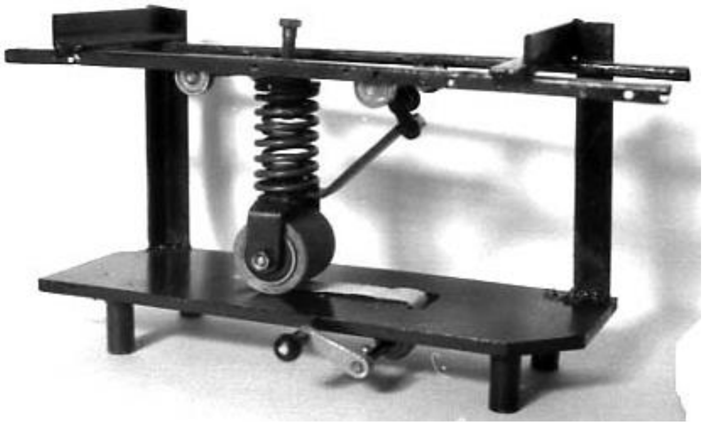


Figure 4: Apparatus for studying the variation of the width of the leaves of the wrappers

The study of the architectonics of wraps included a visual assessment of the leaves, and then an instrumental study, which was carried out using microscopes and macrophotography.

The nature of the venation and the shape of the transverse section of the leaves were studied with the help of macrophotography, for which the cob with the wrap was dissected transversely and the profile was fixed on the scale.

The color code and the percentage of filling the leaf and grain surfaces of the cob with red, green and blue colors according to the RGB method of color separation were performed in accordance with the developed theory for the software (Figure 5) [10, 11].

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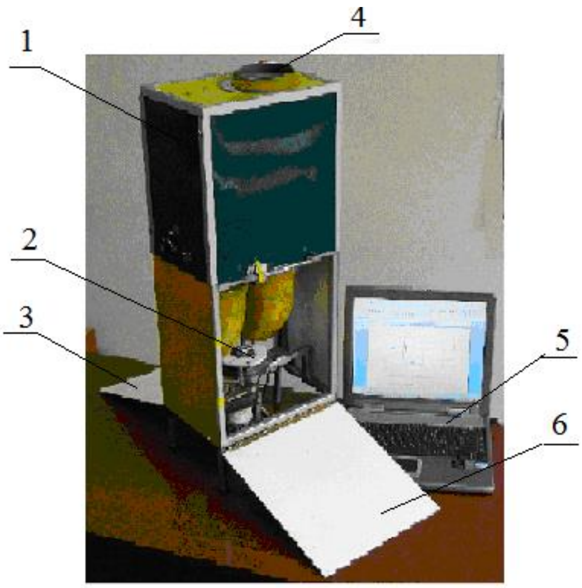

1-body, 2-actuator, 3-guide for untreated ears, 4-loading window, 5-control unit, 6-guide for cleaned ears

Figure 5: Setup for determining the color codes cobs

With a visual assessment of the nature of the clinging of the cobweb wrapping, the following was noticed: on the supporting surface, the leaves are changed in some cases by the straightness of the fit, despite the fact that they are attached to each other at the base of the cob.

Three characteristic variants of the wrapping of the surface wrappers were revealed (Figure 6): 1. The wrappers are arranged in pairs in opposition to each other. 2. The wrappers are offset relative to each other by an angle, the value of which can be 45, 90 and 120 degrees. 3. Wraps come one after another and twist around the grain surface in a fan-shaped manner.

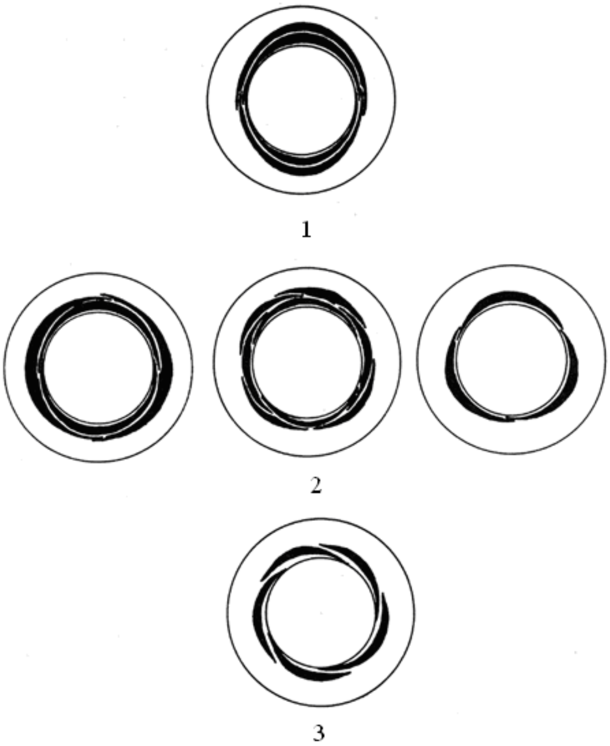

Figure 6: Schemes of arrangement of the leaves of the wrappers on the supporting surface of the cobs

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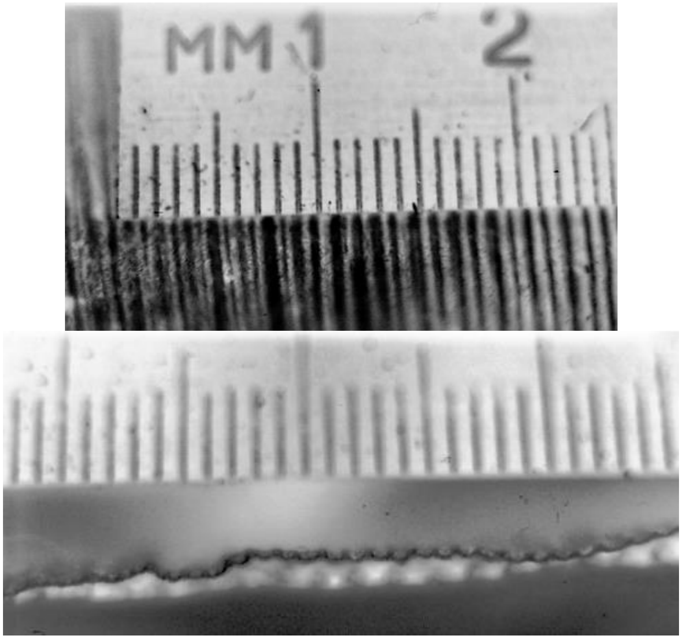
These features can not but affect, for example, the quality of cob cleaning. Obviously, in the first two cases, in the case of a polishing cleaning, the leaves of the wrappers can be tightened in rolls alternately, and this increases the cob path until completely freed from them. In the third case, if the direction of rotation of the rollers coincides with the direction of twisting of the leaves of the wrappers, the cob can remain uncleaned. In the opposite direction, several leaves of the wrapper can be drawn at once, which will speed up the cleaning.

We have established that the character of the covering of the wrapper of the cob bearing surface depends on the hybrid of maize. Thus, the Pioneer hybrids prevail in the first case for external (100%), and the second case for the middle and inner leaves (78%). For the hybrid is not typical wrapping wraps fan, which is obviously due to the stability of its dimensional characteristics. This is definitely related to genetic characteristics (similar to the spiral arrangement of the grain).

The nature of the venation of the leaves of the wrappers repeats the peculiarities of the venation of the stem leaves (anatomical sign). On the leaf surface alternate one to four small veins and one large. This feature gives the surface of the wrapper leaves a complex profile (Figure 7). On the cob, the wrappers are arranged in such a way that the veins of one sheet are located above or under the depressions of the other, which contributes to a dense and strong adhesion to each other.



a b

a - top view; b - is the cross section of the sheet

Figure 7: Wrap sheet profile

The surface of the leaves of the wrappers is covered with unicellular hairs (Figure 8). As a result of macro photography, the presence of such hairs on both the outer and inner side of the leaves of the wrap was determined, which was not previously noted in the literature.

We found that unicellular hairs growing on veins have a fairly strict order of location, direction of growth and angle of inclination.

On the inner side of the leaves of the wrappers the character of the arrangement of these hairs is similar.

Single-celled hairs of veins grow one by one or are assembled into bundles and differ by the presence of a folded end, which gives them the appearance of hooks. The direction of growth is to the base of the cob.

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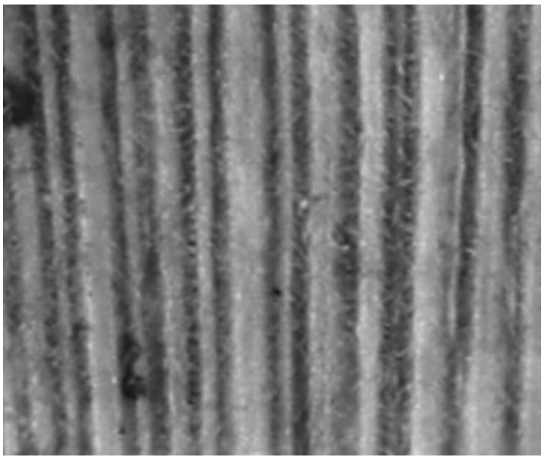


Figure 8: Surface of a wrapper sheet with unicellular hairs

On the inside of the leaf, unicellular hairs are not collected into bundles. The thickness of the hairs is on the average 2 µm with a length of 7-14 µm.

It was found that the hairs on the inside of the leaves are smaller in length.

The density of the hairs per 1000 μm^2 surface is 8-14 and decreases from the outer to the inner leaves of the wrappers.

The step between unicellular hairs on the outside of the leaves of the wrappers averages 7 µm, and on the inner side 12 µm. The angle of inclination to the surface of veins and the surface between veins varies from 45 to 75 degrees.

Thus, the presence of unicellular hairs, which have an increased adhesivity due to the presence of hooks, increases the surface roughness of the leaves of the cob-wraps and, in the final analysis, ensures a more tight fit of the latter to each other. It is these connections that have to be broken first of all in the process of cleaning the cobs of corn from the wrappers.

The measurement results obtained for a number of indicators are presented in Tables 2 and 3.

The average values of the weight of the hybrids studied varied from $2.1 \cdot 10^{-1}$ to $3.6 \cdot 10^{-1}$ kg. It is necessary to note significant fluctuations in mass among the cobs of one hybrid. The average volume of cobs also varied over a wide range - from $2.32 \cdot 10^{-4}$ to $3.9 \cdot 10^{-4}$ m^3 with a minimum value of $1.14 \cdot 10^{-4}$ m and a maximum of $6.31 \cdot 10^{-4}$ m.

Table 2: Indicators of biometric and physico-mechanical properties of cobs

Index	Hybrid		
	Krasnodarskiy 291AMB	Krasnodarskiy 385 MB	Pioner 39A50
Weight, M, g	224,5/35,7	232,4/46,9	246,1/25,1
Volume, V, cm^3	262,3/37,7	3043/52,1	281,2/19,6
Overall length, L, mm	182,4/21,04	179,1/19,6	203,6/9,2
Support length, L_{sp}, mm	114,1/17,5	108,9/19,5	131,4/8,9
Diameter on the supporting surface is maximal d_{max}, mm	49,7/3,1	52,4/3,2	51,2/2,1

Diameter of the supporting surface is minimum d_{min}, mm	42,2/2,7	48,3/3,1	45,1/1,8
Taper of the bearing surface α , град	1,1/0,5	1,3/0,5	0,89/0,33
Distance from the base of the cob to the center of gravity, mm	90,7/13,8	74.4/10,9	87,1/6,1
Distance from the top of the cob to the center of gravity, mm	87,4/13,2	98,8/11,4	107,6/6,8
Coefficient of center of gravity k_c	1,04/0,20	0,78/0,09	0,86/0,07
Moment of inertia longitudinal J_{prod}, 10^{-2} kgm^2	1,9/0,8	2,1/0,5	2,6/0,5
Moment of inertia is transverse J_{cr}, 10^{-3} kgm^2	2,3/0,8	3,3/0,1	2,3/0,5

The numerator is the average, the denominator is the standard deviation.

When assessing the total length of the cob, it was noted that the average values for the hybrids under analysis ranged from $1.54 \cdot 10^{-1}$ to $2.24 \cdot 10^{-1}$ m. The minimum and maximum dimensions in most hybrids are very close to each other, which indicates a sufficient equalization in this indicator for the same weather, soil and agro-technical conditions of cultivation.

For technological processes of sorting, cleaning and threshing an important factor is the length of that part of the cob that directly comes into contact with the working bodies - the supporting surface. Its average values varied from $1.1 \cdot 10^{-1}$ m to $1.43 \cdot 10^{-1}$ m, with oscillations from the smallest $6.5 \cdot 10^{-2}$ to the largest $1{,}19 \cdot 10^{-}1$ m.

As a result of the analysis of mean values of the lengths of the outer leaves, fluctuations from $2.1 \cdot 10^{-1}$ to $2.8 \cdot 10^{-1}$ m were established.

The middle leaves had average sizes that varied from $2.05 \cdot 10^{-1}$ to $2.62 \cdot 10^{-}1$ m, with a minimum value of $1.50 \cdot 10^{-1}$ m and a maximum value of $3.31 \cdot 10^{-1}$ m The dimensional characteristics of the middle leaves of the wrappers are fairly even, which is estimated by the coefficient of variation, varying from 6.43 to 12.11%.

The average lengths of the inner leaves of the wrappers ranged from 1.9 · 10 to 2.3 · 10 m with a minimum value of $1.3 \cdot 10^{-1}$ m and a maximum of $3.1 \cdot 10^{-1}$ m with a coefficient of variation of 6.69 to 11, 58%.

The average values of the maximum diameters of the reference surface varied from 4.7 · 10-2 to $5.5 \cdot 10^{-2}$ with a minimum of $3.9 \cdot 10^{-2}$ m and a maximum of $6.3 \cdot 10^{-2}$ m. Within each hybrid, the spread of the indices Insignificant - the coefficient of variation of 4.17-6.43%.

The average values of the minimum diameter of the supporting surface $4.3 \cdot 10^{-2}$ - $5.0 \cdot 10^{-2}$ m with a minimum of $3.7 \cdot 10^{-2}$ m and a maximum of $5.6 \cdot 10^{-2}$ m.

In the process of transportation and movement on the working surfaces, the cobs deviate from the straightness of the movement due to the non-cylindrical shape, i.e., the conicity of the support surface, which is determined by the angle of inclination.

The average tilt angle of the cob bearing surface for various hybrids ranged from 0.69 to 1.28 degrees.

The location of the center of gravity was estimated by the coefficient:

$$k_c = \frac{L_o}{L_B},$$

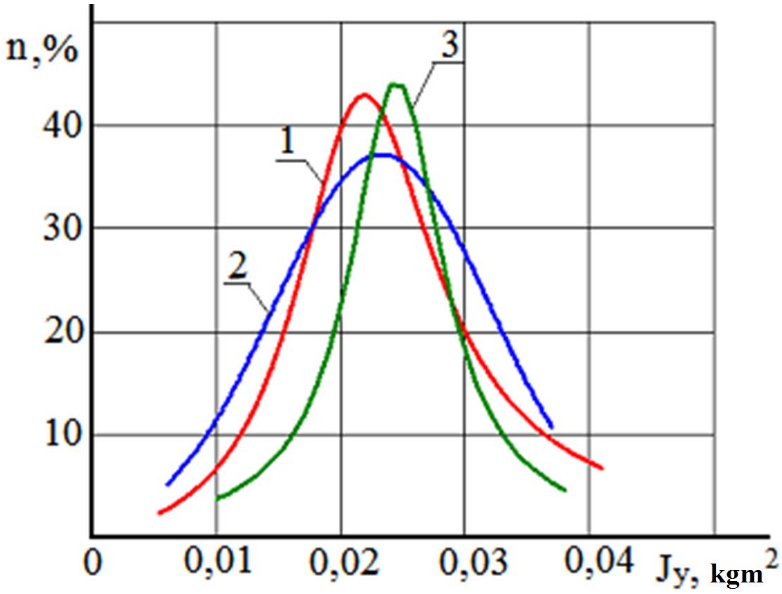
where L_0 – distance from the base of the cob to the enter of gravity;
L_B – distance from center of gravity to apex of cob.

Analysis of the average values of the L_0 lengths showed that they varied from $7.5 \cdot 10^{-2}$ to $9.9 \cdot 10^{-2}$ m with a minimum value of $5.0 \cdot 10^{-2}$ m and a maximum value of $1.25 \cdot 10^{-1}$ m. It is necessary to note a sufficient equalization along the length to the center of gravity of the cob from its base.

The values of the average lengths L_B had a wide spread and were in the range from $8.8 \cdot 10^{-2}$ to $1.24 \cdot 10^{-1}$ m. The minimum value was $5.5 \cdot 10^{-2}$ m, and the maximum value was l, $6 \cdot 10^{-1}$ m. In general, within each hybrid, the oscillations of the L_B lengths are insignificant - the coefficient of variation has values from 6 to 10%.

The minimum value of the average center factor was 0.77 and the maximum value was 1.06.

Analysis of the values of the moments of inertia of the cobs relative to the longitudinal axis showed that the average values have a wide spread from $1.92 \cdot 10^{-2}$ to 5.4 · 10-2 kg · m^2, with a minimum value of $6.11 \cdot 10^{-3}$ kg · m^2 and maximum - $8.93 \cdot 10^{-2}$ kg · m^2 with coefficients of variation from 18.02% to 42.64% (Figure 9).



1 - Krasnodar 291 AMB; 2 - Krasnodar 385 MB; 3 - Pioneer 39A50

Figure 9: Density of distribution of moments of inertia relative to the longitudinal axis of the cob

The average values of moments of inertia relative to the transverse axis of the cobs were from $1.75 \cdot 10^{-3}$ to $5.75 \cdot 10^{-3}$ kg · m^2 with a minimum of $5.17 \cdot 10^{-4}$ kg · m^2 and a maximum of $8.52 \cdot 10^{-3}$ kg · m^2 with coefficients of variation from 5.74 to 8.22%.

The working surfaces of the cleaning and threshing apparatus must have the values of the friction coefficients of the clamping and driving devices larger than the slave, the rupturing leaves of the wrappers or the wiping grains from the cob. The characteristics of the pitched parts of the cob-sorting devices must differ from the characteristics of the cob. Therefore, rubber, steel, the surface of the wrapping leaves and grains were taken as the working surfaces (Table 3) [1, 2, 3, 7].

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Table 3: Coefficients of friction of wrapping and grain layers

Type of friction surface	Coefficient of friction of rest of wrappers			Coefficients of friction of movement of wrappers		
	Minimal	average	maximum	minimal	average	maximum
Steel	0,34	0,47	0,56	0,24	0,33	0,56
Rubber	0,74	0,87	1,06	0,71	0,85	0,91
Wrapping layer	0,52	0,58	0,64	0,42	0,46	0,47
Cereal layer across cob	0,20	0,22	0,24	0,18	0,20	0,21
Grain layer along the cob	0,29	0,31	0,32	0,26	0,29	0,3

According to the results of investigations of the friction coefficients of rest and motion, it was established that for ripe corn the average values of the friction coefficients of rest for cobs in wrappers along the steel surface were 0.47, for rubber 0.87, for cobs 0.59. Coefficients of friction of movement along the steel surface were 0.33, for rubber - 0.85, on the ear - 0.47.

In the practice of removing the wrappers from the ears, the coefficients of friction of the wrappers along the grain, as well as the friction between the leaves in the position in which they are located on the cob, ie, the sliding of the inner side of the previous on the outside of the subsequent sheet, are of interest.

As a result of the studies carried out, it was found that the coefficients of friction of the grain wrappers, in the position as they are located on the cob, were on the average equal to 0.203 with a total interval from 0.186 to 0.212. For wrappers located across the cob, the value was on average 0.286 at an interval from 0.262 to 0.295. The coefficient of friction for the first internal pair of leaves of the wrappers was 0.42, with an interval for different hybrids ranging from 0.404 to 0.445; for the fifth and sixth internal leaves, the average value was 0.5 at the interval from 0.48 to 0.53; for the eighth and ninth leaves, the average value was 0.46 at a range from 0.445 to 0.486.

The patterns of variation in the friction coefficients of motion are the same as for the friction coefficients of rest, but their values are 1.05-1.26 times lower than the friction values of rest.

The energy values of the cleaning machines are influenced by the effort expended to separate the wrappers. Since in the process of removal the leaves are separated at different positions of the ears, it was assumed that the rolls act on them at different angles and in various combinations of tension and torsion. We have identified "clean" efforts. Analysis of the obtained data showed that as the effective force deviates from the cob axis, the leaf separation force decreases. The minimum value corresponds to the angles of 85-97 degrees. Further deviation from the axis leads to an increase in effort. Thus, when separating for an angle of 0 degrees to the surface due to rupture, the average force value for one sheet was 64.8 N, the maximum value was 191 N, and the minimum value was 10.2 N. When separating the leaves with torsion, the average value was 36.4 N, the maximum 98 N, and the minimum is 9.5 N.

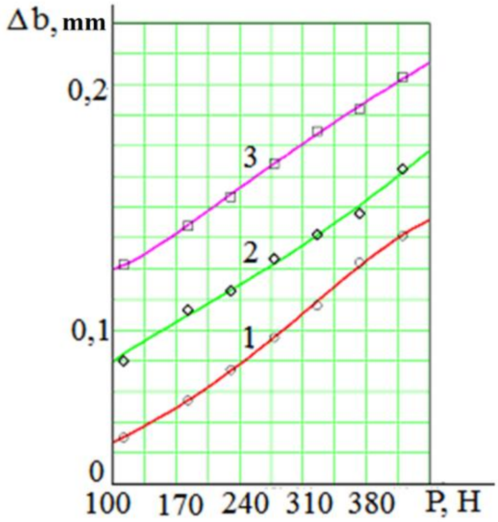
The minimum value of the average force for an angle of 90 degrees with separation with stretching was 44.9 N, and with twisting - 17.1 N.

Thus, during cleaning, a process of separating the wrappers is desirable, in which they would be removed from the cobs while torsion with displacement relative to the stem attachment socket at an angle close to 90 degrees.

Since the leaves of the wrappers have a complex geometric shape, when exposed to them when sorted or cleaned by working elements that can be represented as stamps, the sheet plates change their geometry and align. This leads to a change in the width of the sheet.

A change in the specific width of the sheet was compared, ie, the width of the sheet was one centimeter (Figure 10).

We have established that the nature of the deformation and the change in width in the zones of the beginning, middle and end of the sheet are identical, but the mean values of each part differ sufficiently between. A change in the pressing force from 110.6 to 420.0 N leads to an increase in the width of the sheet in the initial part of the supporting surface adjacent to the pedicel by $5.87 \cdot 10^{-4}$-$1.37 \cdot 10^{-3}$ m, in the middle by 7, $59 \cdot 10^{-4}$-$1.63 \cdot 10^{-3}$ m and at the end by $1.19 \cdot 10^{-3}$ -$1.93 \cdot 10^{-3}$ m.



1 - area of the sheet start; 2 - zone of the middle of the sheet; 3 - zone end of sheet

Figure 10: Changing the width of the cobweb sheet

The absolute values of the width change of the wrapper leaves in the beginning have values from $2.0 \cdot 10^{-4}$ to $3.1 \cdot 10^{-3}$ m, in the middle from $1.0 \cdot 10^{-4}$ to $3.1 \cdot 10^{-3}$ m and at the end The reference surface is from $1.8 \cdot 10^{-4}$ to $6.8 \cdot 10^{-3}$ m.

At present, sorting by means of photo and laser technologies is a priority for fruits, vegetables and seed products. It is used by almost all leading software companies.

We have developed a technology for sorting cobs of seed maize into peeled and unpeeled using the RGB method [10, 11].

For this purpose, the reflective properties of the surfaces of the leaves of the wrapper and grain were investigated. By results, blue was chosen from the three colors, since the cob of the wrapper, uncleaned from the leaves, has a degree of coverage in pixels of 1.3×10^4, and a purified one of 3.2×10^4. Thus, the intensity of the coating with blue color of the peeled cobs is 2.5 times higher than the untreated ones. The values of the code index of the density for the raw cob lie in the range from 51 to 160, and the cleaned cobs in the color range from 0 to 10^2. Here the average values of the density code for unclean cobs are 144, and for the purified cobs, 13, 11 times the value.

CONCLUSION

It is obvious that at the present stage the development of fundamentally new technical solutions that ensure the processes of sorting, cleaning and threshing cobs of seed maize should not only be justified theoretically, but also be based on a deeper and more comprehensive study of the technological properties of the processed plant material.

Such research should be carried out not only in a complex, but also taking into account the features of the proposed technologies.

Based on the results of the studies obtained by the authors, the parameters and modes of the plants for sorting, cleaning and threshing cobs of seed maize were calculated:

1. The length of the rollers is not less than 0.35 m (for the total and reference cob surface length), provided the cob rotation is parallel to the working bodies.

2. The maximum distance between the tangents to the surfaces of the working bodies is not more than $6.0 \cdot 10^{-2}$ m (according to the dimensions of the diameters along the reference surface).

3. The diameter of the rollers is not less than $2.8 \cdot 10^{-2}$ m (in terms of the diameter of the cobs).

4. Moments of inertia created by the working bodies - not less than $9.0 \cdot 10^{-2}$ kg $\cdot$ m^2 (by the moments of inertia of the cob).

5. Coefficients of friction of surfaces of working bodies on surfaces of cobs - not less than 0,55 (on friction coefficients of various pairs of surfaces of cobs and materials).

6. The force required to tear the pack of wrappers away from the cob is not less than 45 N (by the forces of detaching the leaves of the wrappers when they are stretched and twisted).

7. Profile of cleaning rolls (according to the structure of the leaves of the wrapper and the pitch of the venation).

8. Mode of operation of the sensor for recognition of cleaned and uncleared cobs (based on differences in the color code of grains and wrappers RGB-method).

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