RESULTS OF STUDYING THE FRICTION COMPOSITION OF STRAW

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Introduction. To develop new designs of straw separators for livestock farms, as well as compact canonical and semi-conical straw shredders, it is necessary to take into account the physical and mechanical properties of the processed material - that is, the grain-free part of the ear crops, in other words, straw.

In previous research studies, straw has been studied primarily as a coarse feed for farm animals. However, its physico-mechanical properties, which are necessary for fractionation and subsequent grinding, have not been studied to date. In this regard, we conducted additional experiments to determine the size, mass, and physico-mechanical characteristics of straw. The obtained results were processed, after which their indicators (mean value, standard deviation, coefficient of variation, and others) were determined [1, 2].

Methods. In our country, straw is harvested both in pressed (baled) form and in bulk packages, after which it is crushed and used as coarse feed for farm animals.

Therefore, we conducted studies to determine the fractional composition, size and mass parameters, and physico-mechanical properties of straw for both pressed and bulk straw (Fig.1).

Experimental studies of the fractional composition, size and mass parameters and physico-mechanical properties of straw were carried out on the basis of the methods given in GOST 20915-2011 "Agricultural machinery. Methods for determining test conditions", as well as in the regulatory documents "Physical properties of plant and animal materials" [2].

To determine the fractional composition of pressed wheat, alfalfa and saxaul straw, they were divided into fractions by length: up to 30 mm, 30-50 mm and more than 50 mm, after which the fractional composition was determined by the ratio of the mass of each fraction to the total weight (Fig.1).

pressed straw

bulk straw

fractions up to 30 mm long

long fractions 30-50 mm

fractions over 50 mm long

Figure 1. The type of pressed wheat straw and its fractional composition

The fractional composition of wheat straw was calculated using the following formula

$$\Phi_i = \frac{M_i}{M_{total}} 100\% \qquad (2.1)$$

where Φ_i – is the fraction of fractions up to 30 mm long, 30-50 mm long, or more

than 50 mm long., %;

M_i – is the mass of the corresponding fractions with a length of up to 30 mm,

30-50 mm or more than 50 mm, kg;

M_{Total} – is the total mass of the sample, kg.

To determine the size and mass parameters and physico-mechanical properties of straw, a tape measure, ruler, caliper, electronic scales, a device for determining the angle of inclination, as well as a dynamometer DIGITAL FORCE GAUGE AMF-500 for measuring bending and fracture forces were

used as measuring instruments. The rupture force was determined on the UEIM20-300 installation (Fig.2) [3].

1 - installation of UEIM20300; 2 - scales; 3 - tape measure; 4 - calipers;

5 - ruler; 6 - dynamometer DIGITAL FORCE GAUGE AMF-500

Figure 2. Measuring instruments

Studies on the physical and mechanical properties of straw were conducted at the laboratory facilities of Karshi State Technical University, the Scientific Research Institute of Agricultural Mechanization and the Termez Institute of Engineering and Technology in accordance with generally accepted guidelines.

The research program, developed on the basis of the above-mentioned methodological documents, included the determination of the length, thickness, mass of straw, the ratio of its structural elements, density, angle and coefficient of friction, as well as tear and shear resistance forces for straw obtained from wheat, barley and rice stalks.

The experimental data obtained were processed by mathematical statistics methods, as a result of which their statistical characteristics were determined: the mean value of Mcp, the standard deviation σ, the coefficient of variation V and other indicators [4].

Taking into account the zootechnical requirements, according to which the length of crushed straw should be 3-5 cm, we analyzed the fractional composition of pre-pressed wheat straw. For this purpose, the straw was divided into fractions up to 30 mm long, 30-50 mm long and more than 50 mm long. The ratio of the mass of each isolated fraction to the total mass of the sample determined its fractional composition (Fig.1) [5].

When shredding straw, the methods of cutting, shearing, chopping and breaking are used. Despite the fact that hogy cutting and shearing methods are considered preferable for crushing dry straw, when processing dry, especially hard stems, the use of chopping or breaking methods can increase productivity and reduce the energy intensity of the process.

To this end, experiments were conducted using the DIGITAL FORCE GAUGE AMF-500 dynamometer to determine the bending and breaking forces of straw and stiff-stem impurities found among it.

The friction properties of shredded straw were determined based on the methods given in regulatory documents using an inclined plane device; this method is widely used in research practice [1, 3, 4].

In this case, the angle of inclination of the surface at which the straw moves relative to the horizontal surface was taken as the angle of friction. Knowing the angle of friction, the coefficient of static friction of straw was determined [160].

Results. An analysis of the size and mass parameters and fractional composition of pressed wheat straw showed that with an average bale weight of 13.3 kg: 10.42 kg or 78.2% are fractions longer than 50 mm, 2.34 kg or 17.6% are fractions 30-50 mm long, 0.56 kg or 4.2% are fractions up to 30 mm long.

Table 1

Fractional composition of pressed wheat straw

№	Naming of indicators	X_{min}	X_{max}	$M_{average}$	Share of the total weight, %
1	Total weight of pressed wheat straw, kg	9,75	16,89	13,32	100
2	More than 50 mm, kg	7,99	12,85	10,42	78,2
3	Up to 30-50 mm, kg	1,62	3,15	2,34	17,6
4	Up to 30 mm, kg	0,14	0,89	0,56	4,2

From the above data, it can be seen that 21.8% of the mass must be separated before crushing the pressed straw, while 78.2% of the mass must be crushed.

In studies on the fractional composition of straw collected in stacks, it was found that with a sample weight from 11.3 kg to 16.4 kg, the average straw density is 32.9 kg/m^3 (Table 2).

Table 2

Fractional composition of straw collected in stacks

№	Naming of indicators	X_{min}	X_{max}	$M_{average}$	Share of the total weight, %
1	Mass of straw samples collected in stacks, kg	11,3	16,4	14,4	100
2	More than 50 mm, kg	9,85	14,43	12,73	88,4
3	Up to 30-50 mm, kg	0,85	1,18	1,11	7,72
4	Up to 30 mm, kg	0,6	0,79	0,56	3,58

The average weight of the pressed wheat straw samples collected in stacks was 14.4 kg. At the same time, 88.4% of the mass was accounted for by fractions longer than 50 mm, 7.72% by fractions 30-50 mm long, and 3.58% by fractions up to 30 mm long.

It follows that the separable part of the stacked straw is 21.6%, and the shredded part is more than 88%.

In addition, the fractional composition of pressed wheat straw sown between cotton bushes was studied in experiments. According to the data obtained, the mass of pressed straw samples with cotton bush straw ranged from 13.8 kg to 19.14 kg, with an average density of 103.1 kg/m3.

The average weight of the studied samples was 16.47 kg. The fractional composition was distributed as follows: 71.8% of the mass accounted for fractions longer than 50 mm, 15.5% for fractions 30-50 mm long, 2.3% for fractions up to 30 mm long, and 10.1% of the mass accounted for cotton bush straw and other hard stems (Table 3).

Table 3

Fractional composition of pressed straw with cotton bush straw

№	Naming of indicators	X_{min}	X_{max}	$M_{average}$	Share of the total weight, %
1	Mass of straw samples collected in stacks, kg	14,1	19,4	16,7	100
2	More than 50 mm, kg	10,7	14,6	12,0	71,8
3	Up to 30-50 mm, kg	1,7	2,3	2,6	15,5
4	Up to 30 mm, kg	0,33	0,4	0,4	2,3
5	Cotton bush straw and	1,4	2,1	1,7	10,1

	other hard stems				

Discussion. It follows from this that among the fractions of straw with cotton bush straw, the crushed part is fractions with a length of more than 50 mm, which make up 71.8% of the mass, as well as cotton bush straw and other hard stems - 10.1%. The rest can be separated and used directly as feed.

Conclusions. According to the conducted studies, both in pressed and stacked form, about 80% of the mass of straw from the straw of a cotton bush falls into fractions with a length of more than 50 mm, and more than 20% of the mass falls into fractions with a length of less than 50 mm.

Therefore, a device designed for fractional straw sorting should separate about 20% of the mass of straw, and the shredding device should grind the rest according to zootechnical requirements.

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