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Development of a Device for Chopping Green Stem Feeds and Research of the Working Process

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ABSTRACT: The article presents the results of the development and study of the of a device for choping green stem feeds and research of the working process. According to theoretical research, a drum chopper designed to grind green stem nutrients was found to have an impact on the length of the drum and the rotational speed of the feeder jugs in the device and found its own proof in these experiments. It is preferable that the number of rotations of the chopper drum be 1500 rpm and the number of rotations of the stalks feeding roller 175 rpm for small-scale chopper of green stem feeds for fish and poultry.

KEY WORDS: green stem feeds, alfalfa, maize, chopper drum, feeding roller, knife.

I. INTRODUCTION

Uzbekistan pays special attention to the development of livestock, poultry and fish farming.

According to statistics, over the past 4 years in Uzbekistan, the number of fish and poultry in the regions has increased significantly. According to the data, the volume of fish farming in the Republic of Karakalpakstan, Andijan, Jizzakh, Navai, Syrdarya, Fergana and Khorezm regions exceeded 10,000 tons, and the number of poultry exceeded 4-6 million. In Samarkand and Tashkent regions, 12-15 mln. more than is formed.

When growing fish and poultry, it is important to feed them with nutritious and useful nutrients, strengthening their nutrient base.

When feeding fish and poultry, it is recommended to use mainly natural foods, complementary foods and normalized (balanced) foods. Supplements include a variety of plants, including alfalfa, alfalfa, maize stalks, legumes, reeds, and more. Supplements reduce the accumulation of fat in fish and poultry, along with their rapid growth and development. To rationally feed fish and poultry with additional nutrients, it is necessary to cut and grind the plants. It is recommended that the ration of fish and poultry should contain up to 20-25 percent, and ration of herbivorous fish and poultry should contain up to 45-50 percent of rations made of green grasses.

The emphasis is on the introduction of modern technology and innovative developments in industries. In the face of energy and resource shortages, it is important to create universal design of feed chopping machines that are resource-intensive, low-power, and reliably carry out technological processes and allow for the proper chopping of staple feeds. Therefore, research has been carried out on the development of choppers used in chopping of green stalk feeds in livestock, poultry and fisheries farms and cutting the feeds for each category of animal. As you know, feeding efficiency of livestock, poultry and fish farming depends on sorts of fodder and chopping them as well depending on the type and size of the creatures, it is necessary to trim the stalks from 5 to 100 mm [1, 2]. This is achieved by selecting the optimal type of chopping equipment, which is the main working part of the chopper. The results of the study of existing devices have shown that choppers with more blade drums meet this requirement [3-8].

Based on the above, it is important for fisheries to develop a small grinder that provides high-quality grinding of green fodder at the level of established requirements at low cost, as well as to justify its parameters and operating modes. Based on this, research has been conducted on the development of a grinder that can grind blue-stemmed feed to the required size, depending on the category of fish and poultry [9].

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II. MATERIALS AND METHODS

For defining the work-quality indexes of the cutting used methods in State Standard 11448-2002 «Powered shredders and chippers. Safety requirements and test procedures» and testing the fodder choppers and their work efficiencies were determined according to State Standard 20915-2011 «Testing of agricultural tractors and machines. Procedure for determination of test conditions».

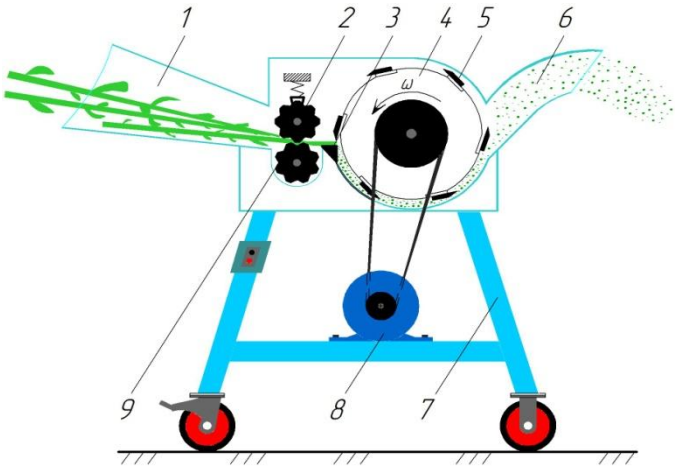
The technological scheme of the green stalk chopper was developed based on the analysis of existing equipment used for chopping and preparing feeds and the structure of their cutting apparatus.

The experiments were performed on the device's experimental sample. The experiments were carried out on chopping alfalfa.

In experiments to study the effect of the number of drum rotations on work quality indicators, the number of drum revolutions ranged from 750 rpm to 1750 rpm in 250 rpm steps, and the number of rotations per 100 rpm to 200 rpm ensured that the feed was evenly transferred to the shredder drum.

III. RESULT AND DISCUSSION

Devices for chopping and preparation of beetroot and other types of feeds, types of cutting machines used for chopping stalks and their cutting knives were studied [10-12]. Based on the research, a technological scheme of a compact lightweight device for chopping green staples for livestock, poultry and fish was developed (Fig. 1).



1-hopper; 2-top roller; 3- counter-cutting plate; 4-cutting drum; 5-cutting knife;
6-deflector; 7-frame; 8- electric motor; 9-bottom roller.

Fig. 1. Green stalk chopper machine

Chopping and feed cutting device consists of hopper 1, top and bottom roller 2 and 9, counter knife 3, cutting drum 4, cutting knife 5, deflector 6, frame 7 and motor 8. The operation of the equipment for coarse chopping unit is as follows (Fig.1). The coarse chopping unit is capable of chopping green stalk feeds, and the stalk feeder passes hopper 1 to the roller 2 and 9. Then, rollers deliver to the cutting drum 4 using a counter-cutting plate 3 and after completion of the chopping process, put in a special container. The movement is transmitted by the transmission of the motor 8. It is possible to trim the stalks to the required length by varying the number of rotating shafts and cutting drum rotations. The operation of this device has no negative impact on the environment and nature.

One of the most important indicators of stalks chopping is the cutting length [4,5,6,7,11]. When designing the chopper, a number of expressions are used to determine the cutting length depending on the type of chopping machine.

The cutting length of the trunks transmitted to the chopper is usually the following:

$$l_c = V_{tr} t_c, \quad (1)$$

where V_{tr} - the speed of the stalks transfer, m/s; t_c - the time the knives are placed in the cutting drum to cut the stalks, s.

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The time it takes to cut the stalk from the side blades can be calculated as follows

$$t_c = \frac{\pi D_d}{Z_k V_d} = \frac{2\pi}{Z_k \omega_d}, \quad (2)$$

where D_d - cutter drum diameter, m; V_d - drum rotation speed, m/s; Z_k - number of knives in the drum, m; ω_d - angular velocity of the drum, s^{-1}.

The speed of passing or transmitting the stalk between the rollers is as follows.

$$V_{tr} = \frac{2(R_r + r_s)\sin\alpha_0}{\frac{2\alpha_0}{\omega_r}} = (R_r + r_s)\omega_r \frac{\sin\alpha_0}{\alpha_0}. \quad (3)$$

where α_o - the angle of inclination of the stalk, degrees; ω_r - angular velocity of rollers, s^{-1}; R_r – radius of roller, m; r_s – radius of stalk, m.

In terms of the value of (3) and (6), the length of the stalk cutting in the cutter drum is:

$$l_c = \frac{2\pi}{Z_k \omega_d}(R_r + r_s)\omega_r \frac{\sin\alpha_0}{\alpha_0}. \quad (4)$$

In this expression, the value of all of the constituents in determining the length of the rods in the chopping process is unchanged, and only by adjusting the number of rotation cores and the transporter rotation can ensure the required cutting of the straps in the chopper. According to S.V.Melynikov's research, the speed of the feeder mounts should be higher than the transporter's velocity $V_r \succ V_{tr}$ and in this range, in order to better transfer the stalk to the cutting drum $V_r = (1{,}25 \div 1{,}35)V_{tr}$. According to N.E.Reznik there is a slip in the transmission of the stalk, and the rate of transmission of the stalks is always lower than the speed of the stalk $V_{tr} = (0{,}88 - 0{,}93)V_r$ and this is the ratio.

Taking this into account, the expression for determining the length of the straps on the drum chopper appears as follows.

$$l_c = \frac{2\pi}{Z_k \omega_d}(R_r + r_s)0{,}9\omega_r \frac{\sin\alpha_0}{\alpha_0}. \quad (5)$$

In this regard, the aim of the study was to develop an innovative small chopping machine that breaks down the green feed at the minimum requirements and justifies its parameters and operating modes.

From equation (5) it can be seen that the length of cutting of the stalks decreases with increasing frequency of rotation of the drum and the number of knives on the drum, and with increasing frequency of rotation and the diameter of the feed rolls, the length of cutting of stalks increases.

In order to determine the correctness of the obtained formula, experimental studies were conducted.

Studies to determine the cutting length were carried out on the stalks of alfalfa.

In experiments, with an increase in the number of drum rotations from 750 rpm to 1750 rpm, the amount of fractions up to 5 mm in the crushed feed ranged from 39.6% to 51.1%, the amount of fractions from 5-10 mm to 31.2% to 44.2%. The amount of fractions from 10 to 20 mm decreased from 22.9% to 4.2%, and the amount of fractions larger than 20 mm decreased from 5.9% to 0.5% (Table 1).

Table 1

Change in the degree of crushing of alfalfa bushes depending on the number of rotations of the chopper drum

№	Fractional composition of crushed feed	Number of drum rotations, rpm				
		750	1000	1250	1500	1750
1	Up to 5 mm, %	39,6	44,6	47,9	50,2	51,1
2	Up to 5-10 mm, %	31,6	36,2	38,5	42,5	44,2
3	Up to 10-20 mm , %	22,9	15,1	11,9	6,4	4,2
4	Older than 20 mm, %	5,9	4,1	1,7	0,9	0,5

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According to the results of the above experiments, the quality of crushing the alfalfa stem was determined when the rotation of the chopper drum was 1500 rpm and 1750 rpm.

In this case, the content of fractions up to 5 mm in the composition of the crushed mass is 50.2 and 51.1 percent, the amount of fractions up to 5-10 mm is 42.5 and 44.2 percent. Those larger than 10 mm, i.e. up to 20 mm and 20 mm the amount of large fractions was found to be at the level of the established requirements, ranging from 4.2-6.4% to 0.5-0.9%, respectively.

However, when the number of rotations of the drum was 1750 rpm, it was found acceptable that the number of rotations of the crusher drum should be 1500 rpm because of the high power required by the crusher.

The number of rotations of the transmission rollers in the device was varied from 100 rpm to 200 rpm at intervals of 25 rpm, and the amount of fractions up to 5 mm in the crushed mass during the experiments ranged from 54.2% to 44.8%, 5-10 mm. It was found that the amount of fractions decreased from 44.1% to 31.6%, the amount of fractions from 10 to 20 mm increased from 1.2% to 18.4%, the amount of fractions larger than 20 mm increased from 0.5% to 5.2% (Table 2).

Table 2

Variation in the degree of crushing of alfalfa stalks depending on the number of rotations of the supply stalks

№	Fractional composition of crushed feed	Number of rotations of the rollers, rpm				
		100	125	150	175	200
1	Up to 5 mm, %	54,2	52,9	52,4	50,2	44,8
2	Up to 5-10 mm, %	44,1	41,2	38,6	36,7	31,6
3	Up to 10-20 mm , %	10,2	40,8	70,4	10,7	18,4
4	Older than 20 mm, %	00,5	10,1	10,6	20,4	50,2

According to the results of the above experiments, the quality of crushing the beet stem in the blue state was determined to be at the level of demand when the rotations of the ground beef is from 100 rpm to 175 rpm. In this case, the content of fractions up to 5 mm in the crushed mass ranges from 50.2% to 54.2%, the amount of fractions from 5-10 mm to 36.7% to 44.1%, those larger than 10 mm, i.e. up to 20 mm and 20 mm. The largest fractions met the requirements, ranging from 1.2% to 10.7% and from 0.5% to 2.4% respectively.

When the number of rotations of the rollers is 200 rpm, the quality of grinding decreases and does not meet the required level.

The quality of crushing alfalfa stalks in the blue state meets the required level when the number of rotations of the rollers is from 100 rpm to 175 rpm, but the efficiency of the grinder when the number of rotations of the rollers is from 100 rpm to 150 rpm is 175 rpm was found to be 1.2–1.5 times lower than. For this reason, it was accepted that the number of rotations of feeder rollers is acceptable to be 175 rpm.

IV. CONCLUSION

According to theoretical research, a drum chopper designed to grind green stem nutrients was found to have an impact on the length of the drum and the rotational speed of the feeder jugs in the device and found its own proof in these experiments. It is preferable that the number of rotations of the chopper drum be 1500 rpm and the number of rotations of the stalks feeding roller 175 rpm for small-scale chopper of green stem feeds for fish and poultry.

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