

INFLUENCE OF LINEAR DIMENSIONS AND TECHNOLOGICAL PREPARATION PARAMETERS OF COTTON SEEDS ON HULLING EFFICIENCY AND REDUCTION OF OIL LOSSES

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ABSTRACT

The article presents the results of a study on the influence of linear dimensions, lint content, and moisture of technical cotton seeds on the efficiency of hulling and subsequent separation processes. It was established that the optimal kernel moisture content is 8.5–9.5% for seeds of grades I–III and 9.5–10.5% for grade IV, which ensures minimal oil losses with the hulls. It was shown that when the lint content of seeds is below 8%, hulling equipment operates at 100% of its rated capacity, whereas

when this value exceeds 8%, a reduction in operational load to 80–85% is technologically justified to maintain process efficiency.

Keywords: cotton seeds; hulling; separation; linear dimensions; kernel moisture; lint content; residual hull; oil losses; technological optimization.

INTRODUCTION

Processing of cotton seeds is one of the key sectors of the oil and fat industry of the Republic of Uzbekistan, ensuring the production of edible and technical oils, as well as high-quality oil cake for the feed industry. In recent decades, the growing global demand for vegetable oils and related products has necessitated improvements in the efficiency of processing technologies, reduction of oilseed losses, and optimization of the quality of final products [1].

One of the critical stages of processing is seed dehulling, which ensures the separation of the hull from the kernel [2]. The efficiency of dehulling determines the degree of kernel preservation, reduction of fine fractions, and optimization of subsequent separation processes [3]. Insufficient removal of the hull increases the husk content in the kernel and reduces oil yield, whereas excessive mechanical impact leads to the formation of oil dust and increased technological losses [4, 5].

Modern cotton varieties are characterized by significant diversity in morphometric and physicomachanical parameters, including linear dimensions, fuzziness, and seed moisture content [6]. These characteristics significantly influence the selection of dehulling equipment design and its operating modes. The use of conventional disc or drum machines without considering the morphometric features of seeds may lead to reduced productivity, increased residual husk content in the kernel, and higher oil losses, which remains one of the unresolved problems in cottonseed processing technology [7].

The scientific challenge also lies in the need for a quantitative assessment of the influence of these parameters on oil yield and kernel quality. Despite the existence of studies on dehulling and separation, most research focuses on standard varieties and does not account for the variability of imported raw materials, their linear

dimensions, and degree of fuzziness [8]. This creates technological uncertainty in the large-scale processing of new cotton varieties.

In addition, an important aspect is the optimization of multistage separation, including the selection of sieve diameters and their arrangement sequence. Scientifically grounded regulation of these parameters makes it possible to minimize losses of oil-bearing raw materials and improve kernel quality, which directly affects the economic efficiency of production [9].

Thus, an urgent task is a comprehensive study of the relationship between morphometric characteristics of seeds, moisture content, fuzziness, and parameters of technological preparation with the efficiency indicators of dehulling and separation. Solving this problem will allow the development of scientifically grounded recommendations for optimizing the technological process, increasing oil yield, and reducing production losses in the processing of cotton seeds of various varieties.

MATERIALS AND METHODS

The analysis of cottonseed hull mixture (rushanka) was carried out according to the method specified in GOST 5947-68 [10]. The sample of rushanka is collected either automatically or manually by intercepting the material stream. The composite sample is thoroughly mixed and reduced to 25 g using the quartering (diagonal division) method. The selected sample is weighed on technical scales and then sieved through a 1 mm sieve. The oil dust is separated, and the remaining material is manually sorted on a glass surface using a feather into whole seeds, broken particles (particles of the kernel smaller than half its size), and kernels. Whole seeds, broken particles, and oil dust are weighed separately. The mass of each fraction is multiplied by 100 and divided by the sample weight, yielding the percentage content of broken particles, oil dust, and whole seeds in the rushanka.

The analysis of cottonseed kernels was carried out according to the method described in “Technochemical Control and Production Accounting ...” [11]. For the analysis, approximately 25 g of kernels is taken, and the sample is sieved through a 1 mm sieve. From the fraction remaining on the sieve, free hulls and whole seeds are

separated. From the fraction passing through the sieve, visible hull particles are isolated manually.

To determine the percentage content of total hulls in the kernels, free hulls, hull particles, and whole seeds are weighed together. Whole seeds are determined by dehulling them after separating the sample. The total hull content is expressed as a percentage of the initial sample weight.

RESULTS AND DISCUSSIONS

The obtained results confirm that the moisture content of cottonseed kernels is one of the key factors determining the efficiency of the dehulling process and the level of oil losses with the hulls. It was established that for cotton seeds of grades I–III, the optimal kernel moisture range is 8.5–9.5%, whereas for grade IV seeds, this value should be within 9.5–10.5%. Maintaining these values ensures a reduction in the oil content of the hulls and, consequently, minimizes oil losses at the dehulling stage.

Deviation of seed moisture from the optimal range leads to deterioration in the conditions for separating the kernel from the hull. At low moisture levels, the shell becomes more brittle, resulting in increased kernel fragmentation and a higher content of oil dust in the hull fraction. Conversely, under high moisture conditions, a decrease in seed opening efficiency and an increase in partially dehulled fractions are observed, which negatively affect kernel quality and complicate subsequent processing stages.

The conducted studies showed that moisture conditioning of seeds using saturated steam or a steam-water mixture ensures uniform moistening of the shell without significant overmoistening of the kernel. At the same time, the residence time of seeds in the conditioning chamber should not exceed 30 minutes, and the treatment temperature should be maintained within the range of 65–80°C. Exceeding these parameters leads to the accumulation of surface moisture and increases the risk of thermal damage to the seeds, which in turn reduces dehulling efficiency.

The subsequent cooling stage of seeds in a vibrating chute using an aspiration system to a temperature not exceeding 45°C plays an important role in stabilizing their physicomachanical properties. The removal of surface moisture before feeding

the seeds into the dehulling unit reduces particle adhesion and improves separation conditions.

Special attention in this study was given to the selection of dehulling equipment. It was shown that the disc dehullers traditionally used in oil-processing enterprises do not provide the required efficiency for dehulling imported cottonseed varieties that are widely cultivated today. This is due to differences in their linear dimensions and geometric characteristics, which lead to increased residual hull content in the kernel and higher oil content in the waste.

A comparative analysis of different types of dehulling equipment demonstrated that the design features of the machinery significantly affect the degree of hull separation and the level of oil losses. The data presented in Table 1 indicate the possibility of reducing residual hull content in the kernel and the oil content of the hulls when using alternative dehulling devices (drum-type dehullers), which are better adapted for processing seeds with modified linear dimensions.

This confirms the necessity of revising traditional technological solutions in the preparatory sections of oil-processing plants, taking into account the varietal characteristics of the processed raw materials.

According to the data presented in Table 1, both disc and drum dehulling machines were used for processing cotton seeds of grades I–III and IV, which differ in linear dimensions. It was found that when using a disc dehuller, the residual hull content in cottonseed kernels exceeds the corresponding value obtained with a drum dehuller by 3.8% for grades I–III and by 3.3% for grade IV seeds.

Table 1

Effect of Cottonseed Dehulling Method on Residual Hull Content in Kernels and Hull Oil Content

Linear dimensions of cotton seeds (length/width/thickness), mm	Cottonseed varieties	Residual hull content in the kernel, %	Oil content of hulls, %
With a disc dehuller			

8,1/4,9/4,4	I-III	10,5	1,16
7,8/4,7/4,3	IV	11,6	1,08
With a drum dehuller			
8,1/4,9/4,4	I-III	6,7	0,81
7,8/4,7/4,3	IV	8,3	0,74

A similar trend was observed for the oil dust content in the hull fraction. The difference in oil dust content between disc and drum dehulling methods amounted to 0.35% for seeds of grades I–III and 0.34% for grade IV seeds, indicating higher oil losses when using disc dehulling equipment.

The analysis of the obtained data allows us to conclude that the use of drum dehulling machines is preferable to traditional disc dehullers in the preparation of technical cotton seeds derived from imported varieties that differ in linear dimensions from local varieties. The application of drum dehulling ensures a significant reduction in residual hull content in the kernel, as well as a decrease in the amount of oil dust in the hull fraction, which ultimately contributes to an increase in cotton oil yield at subsequent processing stages.

The productivity of dehulling machines is directly dependent on the degree of fuzziness of technical cotton seeds. It was established that when seed fuzziness is below 8%, the equipment can operate within the specified nominal capacity, achieving maximum load. When the fuzziness exceeds 8%, it is technologically advisable to reduce the load to 80–85% of the nominal capacity due to the deterioration of separation conditions between the hull and kernel, as well as increased material resistance during processing.

After the dehulling stage, the separation of the resulting mixture (rushanka) is carried out during the separation process. At oil-processing enterprises, this process is implemented using bitter-separator units. Structurally, the equipment provides two-stage separation, where at each stage the mixture is sequentially divided into hull (shell) and kernel fractions.

The bitter-separator is equipped with two drum sieves, each divided into five sections with hole diameters ranging from 4 to 8 mm. The efficiency of separation is determined by the correspondence between sieve hole sizes and the linear dimensions of the processed seeds, as well as the ratio of kernel to hull. Therefore, the correct selection and arrangement sequence of sieves with different hole diameters is of particular importance to ensure optimal fractionation of the material.

Table 2 presents the recommended parameters for sieve arrangement in the bitter-separator. It was found that at the first stage of separation, it is advisable to use a sequence of sieves with hole diameters ranging from 4 to 8 mm, which ensures effective primary separation of the mixture. At the second stage, it is rational to use sieves with hole diameters from 4 to 6 mm, allowing for improved kernel purification and reduced content of hull impurities in the final fraction.

Table 2

Parameters of Mixture Fractionation during Two-Stage Separation in a Bitter Separator

Sieve sheet number along the product flow	Sieve aperture diameter, mm	
	first dehulling	second dehulling
1	4	4
2	5	4
3	6	5
4	7	5
5	8	6

The data presented in Table 2 confirm that proper adjustment of separation parameters, taking into account the linear dimensions of technical cotton seeds, is an important factor in improving the efficiency of the technological process and reducing losses of oil-bearing raw materials.

CONCLUSION

The conducted studies confirmed that the efficiency of cottonseed dehulling and subsequent separation is largely determined by seed linear dimensions, moisture content, and degree of fuzziness, as well as by the design features of the equipment used. It was established that the use of drum dehulling machines provides more effective hull removal compared to disc dehullers, which is reflected in a reduction of residual hull content in the kernel by 3.3–3.8% and a decrease in oil losses with the hull due to a reduction in oil dust by 0.34–0.35%. An additional technological effect is achieved through optimal adjustment of the two-stage separation process with a rational selection of sieve diameters. The combination of the proposed solutions makes it possible to increase kernel purity, reduce technological losses, and ensure a higher yield of cottonseed oil during the processing of seeds of different varieties.

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