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STRUCTURAL AND PERFORMANCE PROPERTIES OF NEW VARIETIES OF COTTON FIBER

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ABSTRACT

These studies are devoted to the study of the structural-sorption and operational properties of new varieties of cotton. A comparative analysis of new varieties of fine-staple cotton fiber Porlok-1 (P-1), Porlok-2 (P-2) with zoned fiber grade S-6524 was carried out. Using the methods of equilibrium sorption, X-ray diffraction analysis and obtaining an experimental batch of yarn from the studied fibrous raw material, it was found that the structure of the new breeding variety P-2 compared to P-1 has smaller pore sizes, is more densely packed and, accordingly, the strength is higher, and these indicators are confirmed by a relatively high degree of crystallinity. An assessment of the spinning and technological properties of the yarn showed that the yarn produced from the fiber of the experimental P-1, P-2 and control selection corresponded to the level of the I-grade, and C-6524 of the obtained data, the indicators of the II-grade.

KEYWORDS: *Gene Knockout, Quality, Cotton Fiber, Grade, Porlok, Current-Fiber Fiber, Pore Volume, Capillary Radius, X-Ray Analysis, Operational Properties, Deformation.*

1. INTRODUCTION

Cotton fiber is one of the most important raw materials in the textile industry. It is also a renewable natural resource, which is why cotton is widely grown in many regions of the world. In the Republic of Uzbekistan, cotton growing also occupies one of the most important places in the economy and the processing industry associated with it. As a result of large-scale economic reforms carried out by the government, including the modernization and technical re-equipment of industries, the approach to growing, processing raw cotton and producing fiber from it that meets high international standards has changed dramatically. To ensure the high competitiveness of cotton products, modern approaches are used in Uzbekistan to increase the yield and quality of cotton fiber.

Increasing global demand for cotton fiber and the demand of the textile industry and the market for finished products requires the development of better strategies to improve fiber quality while

maintaining yield levels is critical to the development of new varieties that are competitive in international markets.

The world's first gene-knockout technology has made it possible to create unique domestic varieties of genetically modified cotton of the Porlock series with improved characteristics both in terms of cultivation and vegetation, and in terms of fiber quality **[1-3].**

Modern trends in fiber quality requirements are such that the fiber must satisfy the consumer not only in terms of the main mandatory parameters used in the sale, but also in terms of textile and technological indicators...

2. THEORETICAL RESEARCH

The structural features of fiber-forming polymers affect not only the quality of the resulting product, but also the flow of technological processes of chemical finishing **[4, 5].**

The packing density of structural elements is one of the most important physical characteristics that determine the complex of structural-mechanical and sorption properties of a fibrous material, which change during deformation during the mechanical processing of technology: the density of the structure decreases or increases depending on the loading regime. In addition, in the coloring process, one of the significant factors that determine the value of dye sorption is the structure of the fiber, and any factors that affect the structure of the fibers predetermine the amount of sorbed dye.

Cotton fiber is a rather specific product that is subject to strong fluctuations due to many factors, from breeding varieties to weather changes in climate to economic policy. The formation of the supramolecular structure of cellulose-containing fibers in nature is a structurally organized matrix process **[6]** in which glucose units entering through the plasma membrane form macromolecular chains using covalent and hydrogen bonds. At the same time, the process of transverse aggregation of macromolecules in three-dimensional space takes place with the help of hydrogen bonds with the formation of micro fibrils. The length of micro fibrils reaches several micrometers. Such micro fibrils form the primary and secondary walls of plant cells. The primary wall is formed by micro fibrils with disordered mutual orientation. The secondary wall consists of three layers, which differ in the amount of cellulose and the direction of fibril twist along the fiber axis **[7].** The supramolecular structure of the fibrous raw material formed during its growth will undoubtedly have an impact on its further processing.

The genotype, growth environment, irrigation of cotton and textile technology of cotton fiber influences the structure formation of cellulose-containing fibers and, in the final stage, product quality. **[8-11].**

Long-term studies by scientists Delmer DP, Y. Amor., Yanjun Zhang, Addissu Ayele Eric Hequet, Farzad Hosseinali, J. Alex Thomasson are aimed at studying the influence of genotype, growth medium, method of irrigation of cotton, arrangement of bolls in plant stems on fiber maturity and further processing cotton fiber.

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The authors found that the maturity of the fiber affects the distribution of fiber length. Mature cotton fibers have higher strength and allow them to better withstand mechanical processing. This results in the stability of the average length of the fiber, which has not been greatly displaced due to breaks during machining. Consequently, immature fibers break more easily during processing,

causing an increase in the content of short fibers. A low level of fiber maturity leads to a higher degree of fiber breakage during machining and a high dispersion of the fibrous raw material along the length of the fiber. The maturity of cotton fiber affects not only the processing of raw materials, but also the formation of the surface-volume properties of the fiber.

Using the Uster Advanced Fiber Information System (AFIS) instrument, equipped with an electron-optical meter, Judith M. determined the chronology and physical maturity of cotton fibers. The study of quantitative changes in the quality of fibers associated with the genotype and growth medium found that immature fibers have relatively thin secondary cell walls that contain less cellulose than the cell walls of more mature fibers, while the required spinning properties can be maintained, but the number of dye defects in the yarn and tissue will increase significantly. The authors argue that the processing process can compensate for fiber variations resulting from differences in genotypes and yarn production methods. However, dyeing defects that occur during the coloring and printing process associated with the maturity of the fiber, i.e. shading, stripes and white spots, cannot be avoided or minimized without knowledge of the maturity characteristics of the fiber used to produce yarn or fabric. The data given in the source on the assessment of fiber quality indicate that the search for cotton producers to meet the demands of the industry for a stronger and thinner cotton fiber is also interconnected with the chemical finishing of textile materials from cotton fiber **[11].**

3. MATERIALS AND METHODS

Genetically improved, early ripening fine-staple cotton fiber Porlok-1 (P-1), Porlok-2 (P-2) cotton varieties were selected and, for comparison, the zoned variety S-6524. Determination of indicators: length, micronaire (thinness, maturity), strength, color and contamination were carried out on a USTER HVI-1000 type system in accordance with GOST Uz DSt 604:2016.

Sorption of water vapors was studied using spring tungsten Mc-Ben balances with a sensitivity of 1.5 mg/mm at 25+0.1 0C and a residual pressure of 10-5 mmHg. Conducted 5 parallel definitions. The relative measurement error was 1.5% **[12].**

X-ray studies of the samples were carried out on a DRON-3N X-ray diffractometer with monochromatized Cu K□ - radiation at voltage 22 kV and current strength 12 mA. Yarn samples were produced in the conditions of JSC "Scientific Center Uzpakhtasanoat" on the "Shirley" line. The composition of the laboratory installation: carding machine - LCH-246, draw frame: 1, transition LL-28, 2 transitions LL-28, and spinning machine LP-66.

RESULTS AND ITS DISCUSSION

For experiments, new breeding varieties of cotton fiber Porlok-1 (P-1), Porlok-2 (P-2), grown by scientists of the republic, which are distinguished by a short ripening period, relatively high physical and mechanical properties, were selected and compared with the indicators of the zoned variety S-6524 (Fig.1).

FIG.1. CHARACTERISTICS OF COTTON FIBER OF DIFFERENT BREEDING VARIETIES

Taking into account the peculiarities of the structure of the selected fibrous raw material, the sorption properties were studied and X-ray diffraction analysis was carried out. The sorption isotherm of water vapor samples of harsh fibrous raw materials, depending on the origin and breeding variety, have differences. Based on the results of the water vapor sorption isotherm, the surface and bulk properties of the feedstock were calculated.

Fig.2. Water vapor sorption isotherms at 25 ± 0.1°C of samples 1 - cotton fiber

C-6524; 2 - new breeding variety P-1; 3 - new breeding variety P-2;

TABLE 1 SURFACE AND BULK PROPERTIES OF COTTON FIBERS VARIOUS BREEDING VARIETIES

Cotton fiber grade	Quality indicators				
	Monolayer capacity, Xm, g/g	Specific surface area, S beats, m^2/g	Total pore volume, W0, cm^3/g	Radius of capillaries, Chk, A^0	Degree of crystallinity, %
P-1	0,0219	76,98	0,072	28,18	84
P-2	0,0118	41,52	0,058	18,71	86
S-6524	0,0105	36,75	0,048	26,12	84

The study of the surface and bulk properties of the harsh raw material shows that new varieties of cotton fiber have higher surface and bulk properties compared to the widely cultivated variety and are closer to natural silk. The specific surface area and the total pore volume of the P-1 grade are much higher than those of the protein fiber. New grades of cotton fiber also differ from each other in these indicators. The structure of the new grade of cotton fiber P-2, in comparison with P-1, has smaller pore sizes, is more densely packed and, accordingly, the strength is higher, and these indicators are confirmed by a relatively high degree of crystallinity.

Further, yarns were produced from breeding varieties P-1, P-2. An assessment of the spinning and technological properties of yarn from the selection cotton varieties P-1, P-2 was given, the tests were carried out in comparison with the zoned variety S-6524.

TABLE 2 PHYSICAL AND MECHANICAL PROPERTIES OF YARN FROM COTTON FIBERS OF VARIOUS BREEDING VARIETIES

Cotton fiber grade	Linear density, T tex	Coefficient of variation, CV %	Twist kr/m	Breaking load, cN	The coefficient of variation, %	Relative breaking load, cN/tex	Elongation at break, %
P-1	18,5	2,0	1049,2	252,4	12,3	13,64	6,3
P-2	18,6	1.8	748.00	258,7	12.66	13,97	6,98
S-6524	18,0	3,4	995,5	243,5	16,1	12,2	8,0

Physical and mechanical characteristics of the main yarn, linear density 18.5 tex, produced from the experimental cotton fiber P-1; P-2 with the value of the specific breaking load of a single thread of 13.5-13.97 cN/tex versus 12.2 cN/tex and the coefficient of variation in breaking load of 12.3-12.7% corresponded to the first grade. The yarn produced from the fiber of the experimental P-1, P-2 and control selection according to GOST 17-96-86 corresponded to the level of the I-grade, and C-6524 of the obtained data, the indicators of the II-grade.

When processing the experimental fiber P-1, P-2, the breaks on spinning machines amounted to 3-4 breaks per 8 spindles per hour against 4 breaks from the zoned selection S-6524.

In the process of mechanical technology under loading and deformation, changes in the initial structure of the material occur, at all levels, including both reversible and irreversible processes. In the process of coloring, one of the essential factors that determine the value of dye sorption is the structure of the fiber, and any factors that affect the structure of the fiber predetermine the amount of sorbed dye.

The cellulose of cotton fibers has an amorphous-crystalline structure. The degree of its crystallinity is 0.6-0.8, and the density of crystallites reaches 1.56-1.64 g/cm3. X-ray diffraction studies have shown that the degree of crystallinity of yarn obtained from fibrous raw materials with a higher order decreases during processing. At the same time, yarn made of cotton fiber grade C-6524 has a relatively dense structure.

TABLE 3 SORPTION CHARACTERISTICS OF YARN FROM VARIOUS BREEDING VARIETIES OF COTTON FIBERS

№	Yarn	Monolayer capacity Xm, g/g	Specific surface area. Ssp, m2/g	Total pore volume, W0, cm3/g	Radius of capillaries Rp ,A0	Degree of crystallinity
1	P-1	0,0119	42,07	0,088	41,87	57
2	P-2	0,0105	46,78	0,066	35,89	62
3	S-6524	0,0131	46,05	0,095	41,26	74

Compared to the cotton fiber yarn of the S-6524 breeding grade, the yarn from the P-1 breeding grade has a relatively low specific surface area, total pore volume, and degree of crystallinity. Analysis of the results on the study of the properties of yarns from cotton fiber of different breeding varieties shows that the structural and sorption properties of the yarn are significantly affected by technological processes accompanied by deformation effects during the formation of the yarn structure.

The operational properties of a fibrous material are determined by its elastic properties and are closely related to its molecular and especially supramolecular structure. Conditionally consisting of deformable (amorphous), non-deformable (crystalline) and transition regions, which determine the behavior of the fiber during deformations.

The study of single-cycle characteristics of textile materials from fibers of different nature is an indirect assessment of the structure formation of a fiber-forming polymer. In this regard, changes in the conditional values of the constituent parts of the deformation of the accumulated yarn samples were studied.

TABLE 4 COMPONENTS OF DEFORMATION OF YARN SAMPLES FROM VARIOUS BREEDING VARIETIES OF COTTON FIBERS

Components of deformation, %			
elastic	elastic	plastic	general
yarn from cotton fiber grade C-6524			
40	30	30	100
yarn from cotton fiber grade П-1			
60,9	21,7	17,4	100
yarn from cotton fiber grade П-2			
62	16	22	100

The components of the deformation of yarn from cotton fiber of different breeding grades differ significantly from each other. The new breeding varieties P-1 and P-2 have higher elastic properties compared to the cultivated variety S-6524. The results of studying the constituent parts of the deformation of new breeding varieties showed that in variety P-1, which has a relatively

low degree of crystallinity, the plastic component of deformation is respectively 5% lower than in variety P-2.

4. CONCLUSION

A comparative analysis of new varieties of fine-staple cotton fiber of the Porlok-1 (P-1), Porlok-2 (P-2) varieties with zoned fiber of the S-6524 variety was carried out. Using the methods of equilibrium sorption and X-ray diffraction analysis, it was found that the structure of the new breeding variety P-2 compared to P-1 has smaller pore sizes, is more densely packed, respectively, the strength is higher, these indicators are confirmed by a relatively high degree of crystallinity;

- Evaluation of the spinning and technological properties of the yarn showed that the yarn produced from the fiber of the experimental P-1, P-2 and control selection corresponded to the level of the I-grade, and C-6524 of the obtained data, the indicators of the II-grade;
- Based on the results obtained, it can be seen that in the process of creating a textile material, the structure of fibrous raw materials created by nature and in the processing processes contributes to the formation of quality indicators, as well as operational and commodity-consumer properties.

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