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Formation of Technological Properties of the Cotton Fiber in the Process of Its Development

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Abstract: ***The data given in the article showed that the growth of the fiber strength and the decrease of the metric number in the studied forms of cotton went in strict accordance with the biosynthetic processes of accumulation of fatty substances. The varieties and forms of cotton were clearly visible, the biological feature of the mature fiber had a low strength index where there was a significant (5-12%) amount of fatty substances. The level of cellulose in these samples was reduced by 10-12%.***

Keywords: cotton, fiber, strength, toning, fat, fat-and-wax substances, fatty acid composition

1. Introduction

Cotton fiber is from 30 to 40% of the weight of raw materials, gaskets (linter) -0.2-1.5%. Each cotton seed fiber is a giant elongated skin cell of the rind with a thickness to length ratio of 1: 1500 to 2000). The shape of the filament is somewhat rounded, looks like a very elongated ribbon, curved and slightly twisted. Inside the fiberthere is the deposited cellulose with a noticeable stratification in the cross section. In the center of the filament there is a cavity, outside it is covered with a thin layer of wax coating, which imparts gloss to the fiber [1, 2].

The amount of pure fiber, expressed as a percentage of the dry weight of the raw material, is called fiber yield. The yield of fiber depends on the characteristics of the variety, agrotechnics and soil-climatic conditions. One of the most important indicators of the quality of cotton fiber is its length. The longer the fiber, the more valuable it is, since it allows you to get thinner yarn. The length of cotton fiber, depending on the variety and the conditions of cultivation, ranges from 10 to 50 mm (more often from 25 to 40 mm).

The physical and mechanical properties of fiber - strength, toning (metric number or tex.), tensile length, extensibility, etc., along with length are the main components of a complex set of indicators in assessing the technological and operational properties of the fiber [4]. The physical and mechanical properties of the fiber are determined by its chemical composition, the structure of the secondary wall and the amount of cellulose contained in it. These indicators in turn depend on the variety of cotton, the age of the fiber, the location of the boll on the bush and the fiber on the seed, and also the environmental conditions in which cotton is grown. Therefore, we studied the properties of the developing fiber taking into account these factors.

2. Material and methods

The seeds of the genetic lines of the mutant ML-180, *G.hirsutum* L. served as the starting material for the studies. Three different groups participated in the experiment:

- Genetic line, the seeds are absolutely bare without fiber,
- Genetic line, absolutely naked seeds with fiber,
- Genetic line, seeds are pubescent.

The analysis of the signs - the weight of the capsules, the weight of the seeds, the yield and length of the fiber, was carried out on trial samples of the boxes, collected in all variants of the experiment in three, four times of repetition.

Samples of seeds for various chemical analyzes and determinations consisted of a harvest of test bolls collected from the first places of 2-3 sympodial branches of plants of each repetition.

To determine the total amount of carbohydrates, fats, fat-and-wax substances, fatty acid composition of the oil in the dynamics of seed ripening, the average sample for each sample consisted of seeds 15-20 capsules-15, 20, 23, 25, 28, 30, 36, 40, 50, 60 days of age and mature. The material was collected differentially, purified and fixedseed kernels with dry heat. After fixation, the samples were subjected to freeze drying.

3. Results

Physical and mechanical properties of fiber - strength, toning (metric number or tex), discontinuous length, extensibility, etc., along with length are the main components of a complex set of indicators in assessing the technological and operational qualities of the fiber. The physical and mechanical properties of the fiber are determined by its chemical composition, the structure of the secondary wall and the amount of cellulose contained in it. These indicators in turn depend on the variety of cotton, the age of the fiber, the location of the boll on the bush and the fiber on the seed, and also the environmental conditions in which cotton is grown [5]. Therefore, we studied the properties of the developing fiber taking into account these factors. Plants were grown in equalizing planting, with a randomized block in 4-fold replication. Fiber for analysis was taken in all variants of the experiment strictly from the same place on the bush.

Table 1 presents data on the dynamics of the development of mechanical properties of fiber (strength, toning). The formation of physical and mechanical properties of the fiber proceeded according to the scheme inherent in the general development of fiber. All the parameters of the fiber, except toning, increase with the age of the capsules, the metric

number characterizing the tonus decreases. The maximum in increase of the strength index was observed in the 36-50 days of age. According to our data, the increase in the strength of the fiber and the decrease in the metric number of the studied forms of cotton went in strict accordance with the biosynthetic processes, the accumulation of fatty substances and the synthesis of cellulose.

The rate of fiber formation in all the samples studied remained approximately at the same level. The potential maximum development of fiber in the gymnosperm, with the yield of fiber 1-5% of the form L-180, is more extended in time and significantly shifted to a later age.

Fatty substances are responsible forlubricants and stretching of cotton fiber. The presence of wax together with fat-like substances makes the fiber more flexible and elastic partially protects it from clipping and damage. Wax also has a great importance in the processes of bleaching and refinement. On the other hand, the absence of wax causes the fiber to adhere to the rollers, creating great difficulties in the production of fine yarn [3, 6].

Wax as a percentage of the samples we studied comprised from 1.5 to 12.5%.

Studies have established that cotton fiber wax consists of esters, mainly saturated high-molecular fatty acids and non-saponifiable substances, consisting essentially of alcohols.

Fatty acids in wax about 48%, not saponifiable substances up to 55%. The non-saponifiable fraction is mainly represented by monohydric primary saturated alcohols having a normal structure. In all the forms of cotton we studied, the content of free fatty acids and alcohols is quite constant.

In addition to fatty substances, the physical, mechanical, chemical and technological properties of cotton fiber are determined by the chemical composition, structure and amount of cellulose deposited in the fiber walls.

The process of fiber formation, just like the synthesis of fatty substances, lasts for 50-75 days, depending on the variety of cotton.

Table 1: Dynamics of formation of physico-mechanical properties of cotton fiber ML-180 (*G.hirsutum* L.)

№	Age of the capsules In days	Grade of cotton				
		Technological Indications of variety	L-180 is pubescent in. at. 40-42%	L-180 is pubescent in. at. 40-42%	L-180 is pubescent in. at. 32-34%	L-180 is pubescent in. at. 1-5%
1	30	Metric Fiber Number	16300	15800	14700	10600
2		Fortress in gs (Gauss)	1,4	1,3	1,7	1,9
3		Discontinuous length in km	22,8	20,5	24,9	20,1
4	40	Metric Fiber Number	91000	11000	9300	8250
5		Fortress in gs (Gauss)	2,0	1,9	2,4	2,2
6		Discontinuous length in km	18,2	20,9	22,4	18,2
7	50	Metric Fiber Number	9000	12200	9100	8400
8		Fortress in gs (Gauss)	2,0	1,8	2,3	2,0
9		Discontinuous length in km	18,0	21,9	20,9	16,8
10	60	Metric Fiber Number	9100	11400	11145	9000
11		Fortress in gs (Gauss)	2,0	2,0	2,2	1,8
12		Discontinuous length in km	18,2	22,8	24,5	16,2
13	70	Metric Fiber Number	5600	5200	6200	8400
14		Fortress in gs (Gauss)	4,3	4,3	4,0	3,3
15		Discontinuous length in km	27,0	22,3	24,8	27,7

A study of the dynamics of cellulose accumulation during the development of the fiber of the studied biotypes has shown that in samples belonging to the same botanical species (*G.hirsutum* L.), the character of cellulose formation in the developing fiber is not the same. A common regularity for all varieties is the weak synthesis of cellulose in the fiber to 10 days of age. Its content in such a fiber does not exceed 5-8% of its total weight.

Between the 10^{th} and 20^{th} days after flowering, the cellulose formation in the fiber increased about 2-2.5 times. Between the 20^{th} and the 30^{th} days after flowering, the rates of biological synthesis of cellulose in fiber are the highest. The growth of cellulose over this period was expressed in 52-57%. The level of cellulose content in the 30-day fiber in different species and varieties was leveled, although in the gymnosperm low-yield form of L-180 the growth of cellulose in this interval was lower. In the next 10 days there was a significant decrease in the rate of cellulose deposition. In the interval between 40-50 days the rate of cellulose accumulation in all biotypes was almost the same as in the previous 10 days. In the next 20 days, the growth of cellulose was 3 to 7%, depending on the biotype (table 2).

Table 2: The content of cellulose in the fiber, depending on the age of the capsules, %

№	Grade of cotton	Age of the capsules in days						
		10	20	30	40	50	60	70
1	L-180 is pubescent. With an output of -40.42%	12,34	36,43	70,34	72,81	90,60	94,27	96,18
2	L-180 is pubescent. With an output of -34-36%	11,79	34,27	70,11	70,89	90,73	91,17	96,87
3	L-180 is pubescent. With an output of -32-34%	11,51	33,48	68,49	70,31	89,50	91,97	94,34
4	L-180 is pubescent. With an output of -5%	9,80	15,23	61,64	81,98	83,23	94,71	97,27

Thus, the synthesis of cellulose in a fiber in different equal conditions is determined by the physiological-biochemical characteristics of the variety and, mainly, by the fiber yield and precocity.

According to our data, the increase in the strength of the fiber and the decrease in the metric number in the studied forms of cotton went in strict accordance with the biosynthetic processes of accumulation of fatty substances. In the varieties and forms of cotton, a biological feature clearly emerged: the mature fiber had a low strength index where there was a significant (5-12%) amount of fatty substances. In these samples, the level of cellulose was reduced by 10-12%.

The rate of fiber formation in all the samples studied remained approximately at the same level. The potential maximum development of fiber in the gymnosperm, with a fiber yield of 1-5%, forms L-180 over time is more extended and significantly shifted to a later age.

4. Discussion and Conclusion

The data given in the article showed that the growth of the fiber strength and the decrease of the metric number in the studied forms of cotton went in strict accordance with the biosynthetic processes of accumulation of fatty substances. The varieties and forms of cotton were clearly visible, the biological feature of the mature fiber had a low strength index where there was a significant (5-12%) amount of fatty substances. The level of cellulose in these samples was reduced by 10-12%.

The formation of physical and mechanical properties of the fiber proceeded according to the inherentscheme of fiber development. The rate of fiber formation in all the studied samples remained approximately at the same level. The potential maximum development of fiber in the gymnosperm, with a fiber yield of 1-5% of the shape of the ML-180 line, is longer in time and significantly shifted to a later age.

All the parameters of the fiber, except tonin, increase with the age of the capsules, the metric number characterizing the tonus decreases. The maximum in increase of the index of the fortress was observed in 35-50 days of age. According to our data, the increase in the strength of the fiber and the decrease in the metric number of the studied forms of cotton went in strict accordance with the biosynthetic processes, the accumulation of fatty substances and the synthesis of cellulose.

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