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СРАВНЕНИЕ МЕТОДОВ ОЦЕНКИ ТЕХНОЛОГИЧЕСКОГО КАЧЕСТВА ЛЬНОВОЛОКНИСТОЙ ПРОДУКЦИИ

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Представлены результаты сравнительного анализа оценки технологического качества льнотресты по основным признакам: выходу и номеру длинного и короткого волокна, содержанию и общему выходу волокна, определенных различными методами по нормативной документации. Исследования проведены в 2001–2021 гг. в льносеющих регионах России: Тверской, Смоленской, Вологодской, Костромской областях. Установлено, что от выбранного метода оценки зависит информационная ценность полученных результатов. Абсолютные отклонения среднего уровня значений признаков, определенных различными методами, составляют для выхода длинного волокна 3,55–9,05%, его номера – 0,00–1,64 N, выхода короткого волокна – 0,20–11,60%, его номера – 0,40–2,75 N, содержания и общего выхода волокна 0,40–10,80%. Относительные отклонения для тех же признаков соответственно равны 24,0–44,5%; 0,00–13,60; 1,80–51,60; 1,30–44,40; 1,00–32,00%. На приведенном примере показан возможный разброс в оценке интегрального технологического качества льнотресты (от номера 1,25 до 2,00 N) и стоимости (19%) произведенной из нее продукции (длинного и короткого волокна) при условии определения по двум вариантам. Первый вариант предусматривал определение выхода длинного волокна на лабораторном мяльно-трепальном станке СМТ-200М, номера длинного волокна – по изменению № 4 ГОСТ 10330–76, выхода короткого волокна – по методике технологической оценки качества льнотресты на мяльно-трепальной машине ТЛ-40, номера короткого волокна – по ГОСТ 9394–76. Второй вариант заключался в нахождении выхода длинного и короткого волокна в производственных условиях на мяльно-трепальном агрегате, органолептической оценке номера длинного волокна и определении номера короткого волокна расчетным путем. Сделано заключение о необходимости приведения уровня значений указанных признаков, определенных различными методами к единому уровню с целью повышения информационной ценности оценки технологического качества льносырья.

Ключевые слова: технологическое качество, выход и номер длинного и короткого льноволокна, общий выход и содержание льноволокна, методы оценки, уровень значений, информационная ценность

COMPARISON OF METHODS FOR ASSESSING THE TECHNOLOGICAL QUALITY OF FLAX FIBER PRODUCTS

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The paper presents the results of a comparative analysis of technological quality assessment of flax fiber by the main features: the yield and number of long and short fiber, the content and total fiber yield, determined by different methods of regulatory documentation. The research took place in 2001–2021 in the flax–growing regions of Russia: Tver, Smolensk, Vologda, Kostroma regions. It is established that the information value of the obtained results depends on the chosen evaluation method. The absolute deviations of the average level of the values of the signs determined by various methods are 3.55 - 9.05% for the output of a long fiber, its numbers are 0.00 - 1.64 N, the output of a short fiber is 0.20 - 11.60%, its numbers are 0.40 - 2.75 N, the content and total fiber output are 0.40–10,8%; relative deviations are for the same signs, respectively equal, 24,0–44,5%, 0,00–13,60%, 1,80–51,60,%, 1,30–44,40%, 1,00–32,00%. The given example shows a possible variation in the assessment of the integral technological quality of flax (from number 1.25 to number 2.00) and the cost of the products produced from it (long and short fiber) (19%), subject to determination by the following two options. The first option provided for the determination of the output of a long fiber on a laboratory ribboner CMT-200M, the numbers of a long fiber - according to the change N4 GOST 10330–76, the output of a short fiber according to the method of technological evaluation of the quality of flax on the ribboner TL-40, the numbers of a short fiber according to GOST 9394-76. The second option was to find the output of long and short fibers in production conditions on a ribboner, organoleptic evaluation of the number of the long fiber and determination of the number of the short fiber by calculation. It is concluded that it is necessary to bring the level of values of these signs determined by various methods to a single level in order to increase the informational value of assessing the technological quality of flax raw materials.

Keywords: technological quality, yield and number of long and short flax fiber, total yield and content of flax fiber, evaluation methods, value level, information value

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INTRODUCTION

Timely and reliable information about the quality of flax fiber production along the whole technological line from variety breeding to processing at flax processing plants is one of the components of increasing efficiency of flax fiber production[1] [1, 2]. The problem of improving the quality of flax products is inextricably linked to the assessment of the level of its integral quality, as well as the main attributes that condition it, the objective features that are observed during the creation, consumption and operation. Planning, attestation, control, variety creation, selection of the best product variant, analysis of changes in individual quality parameters are the links of technological cycle, each of which requires assessment of product quality level with sufficient accuracy according to the current regulatory documentation [3].

Technological quality of fiber raw material of fiber flax varieties depends on a combination of the following features: yield and quality of long and short fiber to obtain the maximum total yield, produced from flax straw of different quality by traditional processing technology in production conditions [4, 5]. These basic characteristics ensure the level of processing and use of raw materials as intended. However, at present different methods are used to determine the characteristics of flax raw material, the implementation of which leads to different levels of values of the same indicator[2] [6, 7]. One of

[1]Trukhachev V.I., Belopukhov S.L., Dmitrievskaya I.I., Baybekov R.F., Zharkikh O.A. Quality and Safety Indicators of Flax fiber // Database Registration Certificate 2021621161. 01. 06. 2021. Application № 2021620776 dated 22.04.2021.

[2]Romanov V.A., Rozhmina T.A., Kovalev M.M., Belopukhov S.S. Method of the technological value evaluation of fiber flax stems // Patent for invention RU 259755 C1, 10.09.2016. Application № 2015108332/12 dated 10.03.2015.

the important signs of technological quality - the yield of long fiber from flax straw of different quality - can be determined by the following methods currently used [8-12].

– after processing flax straw on the CMT 200M laboratory ribboner according to GOST 24383-89 Flax straw.

Requirements for harvesting:

– on methods of technological evaluation of flax raw material quality after processing on flax pulling machine TL-40;

– after processing on a flax pulling machine under production conditions.

Six methods can be used to estimate the long fiber number.

To ensure that the information obtained in the course of evaluation, relating to the determination of one or another quality trait, has the necessary value, it must be timely, reliable and comparable [13, 14]. Comparability of evaluation results is one of the significant factors influencing the correctness of breeders' conclusions about the advantages of a new variety in fiber yield and quality over varieties created earlier, provided that these traits are determined by different methods.

In addition, the correct orientation of producer and consumer products also depends on timely, reliable and comparable information about its level of quality. Such information will also make it possible to make informed decisions aimed at improving the production activities of agricultural enterprises.

The aim of the research is to analyze the information value of assessing the technological quality of flax fiber products using the existing methods, to develop proposals for improving metrological expertise in determining the main quality attributes using different methods.

MATERIAL AND METHODS

The studies were conducted at the All-Russian Flax Research Institute (a separate subdivision of the Research Institute of Flax of the Federal Scientific Center of Bast Crops) and flax-growing regions of Russia in 2000-2021 according to the scheme shown in Fig. 1.

The formation of flax straw batches of different quality of 30 fiber flax varieties of domestic and foreign selection was carried out in the period of harvesting in the conditions of flax-growing farms and flax-processing enterprises of Smolensk, Tver, Kostroma, Pskov and Vologda regions. When carrying out these works, a special methodological program[3] [1, 15] was used, which provided for control developments in accordance with the Rules of technical operation of flax-processing plants. At optimal modes of production equipment operation, depending on the quality of initial flax raw material, flax straw was processed according to the traditional technology with obtaining long and short fiber. The evaluation of features determining the quality of flax fiber products was carried out according to the current normative documentation[4-8].

The following laboratory and production equipment was used: ribboner CMT-200M, decorticator LM-3, motorized decorticator ML-5, shive separation unit PC-2M, tensile testing machine RMP-1, dynamometer DKV-60, electronic scales VLKT-500, flexometer GV-3, quadrant Po-2, moisture meter VLS, desiccators SSh-2, US-4, standard samples of fiber color, OBA device to determine separability, drier for flax straw SKP-10LU, ribboner MTA, flax

[3]The Decree of the Ministry of Agriculture of the Russian Federation № 23 - p of March 10, 2016. "Procedure for determining the norms of conversion of flax and hemp trusts into fiber" (As amended by the Russian Federation Government Decree No. 450 of 12.06.2008). 7 p.

[4]GOST 24383-89 Retted straw. Conservation requirements. Official edition. Moscow: Publishing house of standards. 1990. 17 p.

[5]GOST 10330-76 Scutched flax. Technical conditions. Official edition. Moscow: Publishing house of standards. 1982. 11 p.

[6]Amendment № 4 GOST 10330-76 Scutched flax. Technical conditions. Moscow: Approved and put into effect by the Decree of the USSR State Standards Committee of 28.06.88 № 2441 1989. 11p.

[7]GOST 9394-76 Short flax fiber. Technical conditions. Official edition. Moscow: Publishing house of standards. 1981. 7 p.

[8]Methodical guidelines for technological assessment of flax straw and experiments on primary flax processing. Torzhok: VNIIL. 1972. 58 p.

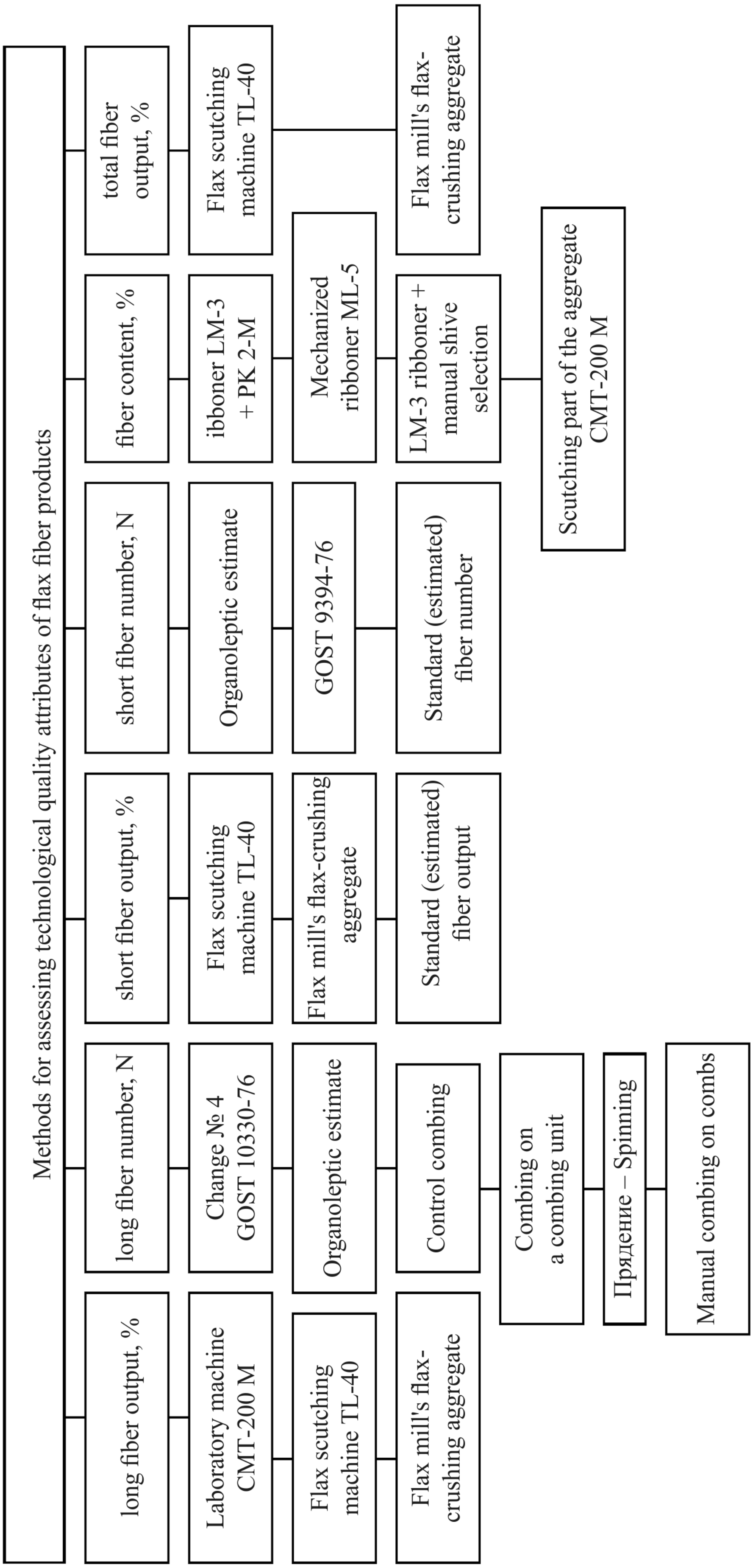

Рис.1. Схема определения признаков технологического качества льноволокнистой продукции
Fig.1. Scheme for determining the signs of technological quality of flax fiber products

scutching machine TL-40 and TL-4-2, dryer for short fiber SKP-10KU, tow opener KPAL, carding machine Ch-302-L, spinning machines.

The obtained results were processed using methods of mathematical statistics. The distribution of the trait values was checked for compliance with the law of normal distribution using the "plus-minus three sigmas" rule and taking into account the excesses. Significance of differences was determined by pairwise comparisons in equal and unequal samples using Student's test [13, 14, 16].

RESULTS AND DISCUSSION

A comparative assessment of the level of values of the main attributes of technological quality of flax straw by the currently used methods was carried out for 20 different samples consisting of different numbers of batches - from 15 to 256.

Fig. 2 shows the level of long fiber yields determined by the different methods. The average yield of long fiber from grass-retting flax straw established by the three methods differs by 3.55-9.05% absolute or 24.00-44.50% relative units.

Statistical processing by the method of pairwise comparisons of data of equal samples confirmed the significance of differences between the average values of long fiber yield found by different methods at 95% probability (see Table 1).

In order to determine the reliability and comparability of the results of estimation of the average level of values of long fiber number, fiber content, total fiber yield, yield and number of the short fiber by existing methods, a comparative analysis of 15 samples consisting of different number of batches was conducted. Earlier studies [3, 6, 9, 10, 11, 15] proved that the experimental values of characteristics in random samples are distributed according to the normal law, since randomly selected samples do not deviate from the general average by a value exceeding the standard deviation by 3 times. Due to the fact that in most cases the number of pairs of compared values did not exceed 30, we used the parametric Student's test to deter-

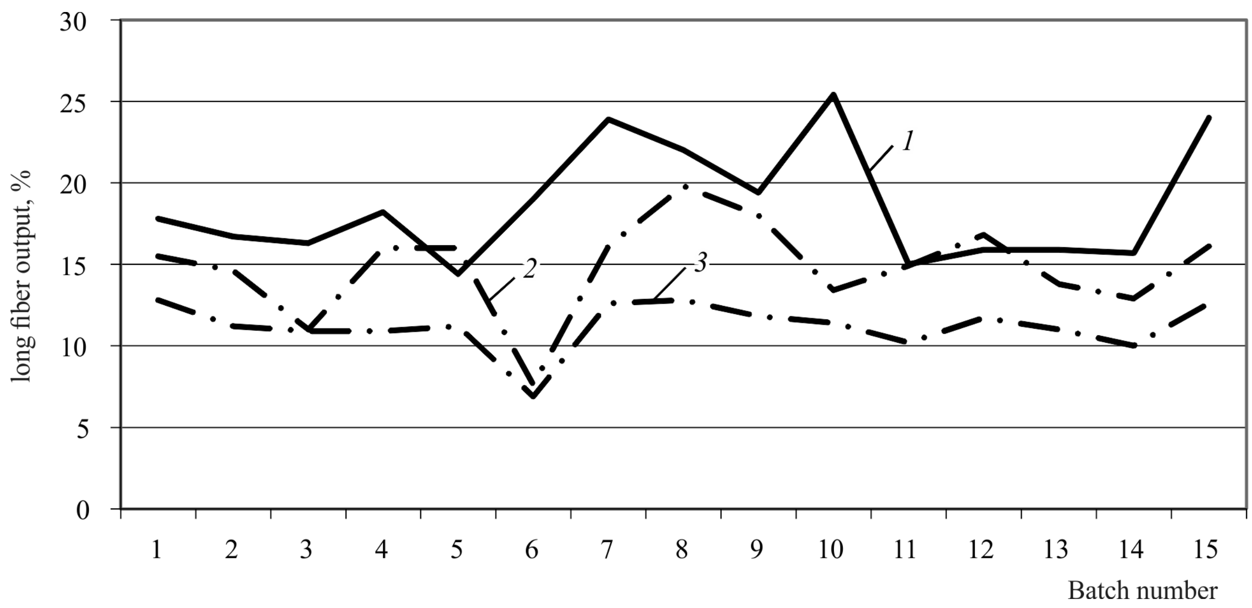

Рис. 2. Уровень значений выхода длинного волокна при определении по различным методам:
1 – выход длинного волокна на лабораторном мяльно-трепальном станке СМТ-200М;
2 – выход длинного волокна по методике технологической оценки (трепальная машина ТЛ-40);
3 – выход длинного волокна на мяльно-трепальном агрегате (МТА) льнозавода
Fig. 2. The level of long fiber output values when determined by various methods
1 – the output of a long fiber on a laboratory ribboner CMT-200M;
2 – the output of a long fiber according to the method of technological evaluation (ribboner TL-40);
3 – the output of a long fiber on a ribboner (MTA) of a flax plant

Табл. 1. Определение значимости различий между средними значениями выхода длинного волокна
Table 1. Determination of the significance of differences between the average values of the long fiber output

Test method	Average value of the long fiber yield, %	Differences between average values *d*, %	Error of difference of the averages S_d, %	Student's coefficient *t*		Conclusion on the significance of differences
				factual $t_ф$	tabular t_T	
CMT-200M machine	20,30	5,50	1,49	3,07	2,05	Significant
TL-40 machine	14,80					
CMT-200M machine	20,30	9,05	1,12	8,08	2,05	»
MTU	11,25					
TL-40 machine	14,80	3,55	0,87	4,08	2,05	»
MTU	11,25					

mine the significance of differences between the mean values.

The data of pairwise comparison of the values of the above attributes are shown in Tables 2-4.

Six methods currently used to estimate the quality of long fiber, four methods for fiber content, two for total yield, three for yield and short fiber number were considered. It has been found that the average level of long fiber number values determined by various methods varies considerably: absolute deviations range from 0.00 to 1.64 N, and relative deviations range from 0.00 to 13.60% (see Tables 2-4). Fiber content and total fiber yield of absolute units vary by 0.4-10.8%, relative by 1.0-32.0%, short fiber yield by 0.2-11.6%, 1.8-51.6% respectively; short fiber number by 0.40-2.75 N, 1.3-44.4% of relative units. The results of determining the technological quality of flax straw are largely due to the chosen method of evaluation and can lead to erroneous conclusions in breeding and production activities in the field of flax fiber production and processing.

Estimation by different methods of values of yield and number of long and short fiber affects the integral parameter of fiber production quality - fiber percent number (%N), on which technical and economic indicators of flax processing enterprises depend and, in particular, adequacy of determination of quality of harvested flax raw material (see Fig. 3). Two options are presented for comparison. The first one consisted in evaluating the yield of long fiber when using a ribboner CMT-200M (20,3%), the number of long fiber - according to the modification № 4 of the State Standard 10330-76 (10,73), the yield of short fiber - according to the technique of technological evaluation of quality of flax raw materials on flax scutching machine TL-40 (9,4%), the number of short fiber - according to the State Standard 9394-76 (2,38).

According to the second variant, the same features were determined on a turbine scutching machine (TSM) under production conditions (11.25%), by organoleptic evaluation (10.56 N), on the TSM (12.6%), by calculation (3.03 N), respectively. Technological quality in the first variant was 240% N, in the second - 157% N (see Fig. 3). According to the norms of fiber yield and quality[9] from grass-retting flax straw in the first variant the flax straw should be estimated by the number 2.00, in the second - 1.25. The cost of production was calculated at average prices established in recent years for long and short fiber. The following prices were adopted for 1 kg of long fiber N 10 - 131,35 rubles, short fiber - N 2 - 42,6, N 3 - 49,7 rubles, with the difference in price of 1 kg of fiber between the neighboring numbers of 7,1 p. The total cost of the manufactured goods produced from one ton of flax straw in the first version was equal to 31 994 rubles, in the second - 25 726 rubles. That is, the cost of production in the second option was 81% of the production in the first option experiment (see Figure 3).

Табл. 2. Различия среднего уровня значений номера длинного волокна при определении по существующим методам

Table. 2. Differences in the average level of long fiber number values when determined by existing methods

№ i/n	Method for determining the long fiber number	Average long fiber number, N	Differences	
			$\Delta_{абс.}$	%
1	Change № 4 GOST 10330-76 Scutched flax	10,01	page 1 – page 2 –0,55	5,2
2	Organoleptic evaluation	10,56		
Student's coefficient	$T_ф$ = 3,11	$T_т$ = 2,05	Significant	
3	Control combing technique GOST 10330-76 Scutched flax	11,11	page 3 – page 4 –0,45	4,3
4	Organoleptic evaluation	10,56		
Student's coefficient	$T_ф$ = 3,01	$T_т$ = 2,05	Significant	
5	Change № 4 GOST 10330-76 Scutched flax	10,73	page 5 – page 6 –0,26	2,4
6	Combing on the carding machine	10,99		
Student's coefficient	$T_ф$ = 2,90	$T_т$ = 2,12	Significant	
7	Change № 4 GOST 10330-76 Scutched flax	10,79	page 7 – page 8 +0,52	4,8
8	Spinning	10,27		
Student's coefficient	$T_ф$ = 4,01	$T_т$ = 2,05	Significant	
9	Control combing technique GOST 10330-76 Scutched flax	10,45	Page 9 – page 10 –1,64	13,6
10	Combing on the carding machine	12,09		
Student's coefficient	$T_ф$ = 7,03	$T_т$ = 2,07	Significant	
11	Control combing technique GOST 10330-76 Scutched flax	10,38	page 11 – page 12 0	0
12	Technological evaluation of raw flax quality (manual combing)	10,38		
The average values are the same				
13	Control combing technique GOST 10330-76 Scutched flax	10,48	page 13 – page 14 +0,23	2,2
14	Spinning	10,25		
Student's coefficient	$T_ф$ = 2,73	$T_т$ = 2,07	Significant	
15	Control combing technique GOST 10330-76 Scutched flax	10,79	page 15 – page 16 +0,23	1,1
16	Change № 4 GOST 10330-76 Scutched flax	10,91		
Student's coefficient	$T_ф$ = 2,40	$T_т$ = 2,07	Significant	

Табл. 3. Различия среднего уровня значений выхода и номера короткого волокна при определении по существующим методам

Table. 3. Differences in the average level of the output values and the short fiber number when determined by existing methods

№ i/n	Method for determining the output of short fiber	Average short fiber output, %	Differences	
			$\Delta_{абс.}$	%
	Short fiber output			
1	Short fiber output from dew-retted flax on an MTU, %	22,5	page 1 – page 2 11,4	50,7
2	Standard (estimated) short fiber output, %	11,1		
Student's coefficient	$T_{ф}$ = 18,30	$T_{т}$ = 2,05	Significant	
3	Short fiber output on the TL-40 machine	10,9	page 3 – page 4 –11,6	51,6
4	Short fiber output from dew-retted flax on an MTU, %	22,5		
Student's coefficient	$T_{ф}$ = 16,80	$T_{т}$ = 2,06	Significant	
5	Short fiber output on the TL-40 machine	10,9	page 5 – page 6 –0,2	1,8
6	Standard (estimated) short fiber output, %	11,1		
Student's coefficient	$T_{ф}$ = 1,91	$T_{т}$ = 2,05	Not significant	
	Short fiber number			
№ i/n	Method for determining the number of short fiber	Average short fiber number, N	Differences	
			$\Delta_{абс.}$	%
1	Short fiber number using the organoleptic evaluation, N	5,13	page 1 – page 2 2,75	44,4
2	Short fiber number GOST 9394–76 Flax fiber short, N	2,38		
Student's coefficient	$T_{ф}$ = 15,70	$T_{т}$ = 2,05	Significant	
3	Short fiber number GOST 9394–76 Flax fiber short, N	3,12	page 3 – page 4 0,4	1,3
4	Short fiber standard number (estimated), N	3,08		
Student's coefficient	$T_{ф}$ = 18,40	$T_{т}$ = 2,05	Significant	
5	Short fiber number using the organoleptic evaluation, N	5,13	page 5 – page 6 2,1	40,9
6	Short fiber number GOST 9394–76 Flax fiber short, N	3,12		
Student's coefficient	$T_{ф}$ = 16,80	$T_{т}$ = 2,06	Significant	

Табл. 4. Различия среднего уровня значений содержания и общего выхода волокна при определении по существующим методам

Table. 4. Differences in the average level of the content and total fiber yield values when determined by existing methods

№ i/n	Method for determining the content and total fiber output	Average fiber content and total fiber output, %	Differences	
			$\Delta_{абс.}$	%
1	Fiber content (LM-3 + manual shive selection), %	30,3	page 1 – page 2 5,6	19,9
2	Total fiber output (MTU), %	24,7		
Student's coefficient	$T_ф$ = 25,30	$T_т$ = 2,07	Significant	
3	Fiber content (LM-3 + manual shive selection), %	35,0	page 3 – page 4 2,0	5,7
4	Fiber content (LM-3 + PK-2M), %	33,0		
Student's coefficient	$T_ф$ = 2,08	$T_т$ = 2,05	Significant	
5	Fiber content (LM-3 + manual shive selection), %	29,9	page 5 – page 6 6,9	23,1
6	Total fiber output (TL-40), %	23,0		
Student's coefficient	$T_ф$ = 19,10	$T_т$ = 2,06	Significant	
7	Fiber content (LM-3 + manual shive selection), %	35,0	page 7 – page 8 –0,4	1,0
8	Fiber content (ML-5), %	35,4		
Student's coefficient	$T_ф$ =1,12	$T_т$ = 2,05	Not significant	
9	Fiber content (LM-3 + manual shive selection), %	35,0	page 9 – page 10 0,5	1,4
10	Fiber content (CMT-200M), %	34,5		
Student's coefficient	$T_ф$ = 1,93	$T_т$ = 2,05	Not significant	
11	Fiber content (ML-5), %	35,4	page 11 – page 12 0,9	2,5
12	Fiber content (CMT-200M), %	34,5		
Student's coefficient	$T_ф$ = 2,06	$T_т$ = 2,05	Significant	
13	Fiber content (CMT-200M), %	33,93	page 13 – page 14 10,88	32,0
14	Total fiber output (TL-40), %	23,05		
Student's coefficient	$T_ф$ = 18,20	$T_т$ = 2,05	Significant	

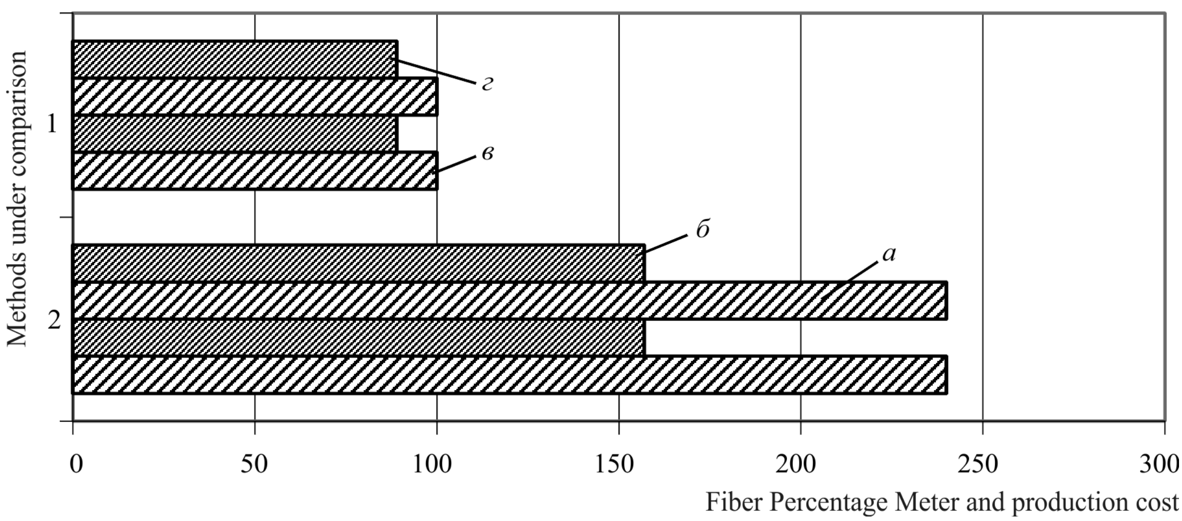

Рис. 3. Технологическое качество льнотресты и стоимость произведенной из нее продукции в зависимости от метода оценки:
а – процентономера волокна (1); *б* – процентономера волокна (2);
в – стоимость продукции в процентах (1); *г* – стоимость продукции в процентах (2)
Fig. 3. Technological quality of flax straw and the cost of its products depending on the method of evaluation:
а - fiber percentage (1); *б* - fiber percentage (2);
в - product value in percents (1); *г* - product value in percents (2)

The analysis of assessing the technological quality of flax straw fiber, formed depending on the combination of basic attributes: yield and quality of long and short fiber, fiber content and total fiber yield, revealed the obvious need to bring the level of these attributes defined by different methods to a single level, so as to increase the information value of the assessment.

CONCLUSIONS

1. A comparative analysis of assessing the level of values of the main attributes of technological quality of flax raw material, determined by different existing methods, was carried out. It has been established that deviations by the yield of long fiber of absolute units are 3,55-9,05%, relative - 24,0-44,50%; by the yield of short fiber - 0,20-11,60%, 1,80-51,6.0%; by the number of long fiber - 0,00-1,64 N, 0,00-13,60%; by quality of short fiber - 0,40-2,75 N, 1,30-44,40%; by content and total fiber yield - 0,40-10,80, 1,00-32,00% respectively.

2. In order to increase the informational value of determining technological quality of flax straw, which depends on timeliness, reliability and comparability of the results of evaluation of the main features found by different methods, it is necessary to bring them to a unified level. This will allow to make reasonable decisions when creating new fiber flax varieties in breeding work, in management of production processes in production and processing of flax fiber products.

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