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HOMOGENEITY INVESTIGATION OF OIL FLAX PROCESSING PRODUCTS BY QUALITY INDEXES

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За результатами експериментальних досліджень проаналізована на однорідність стохастична структура вибірок волокон льону олійного української та польської селекції. Визначені закони розподілу волокон як сумішей нормального та логарифмічно нормального законів розподілу. Показана адекватність побудованих нелінійних моделей законів розподілу. Доведена суттєва розбіжність ймовірнісних розподілів довжин волокон льону олійного різної селекції на основі статистичного критерію Колмогорова-Смирнова

Ключові слова: льон олійний, показники якості, суміш законів розподілу, адекватність нелінійних моделей, критерій Колмогорова-Смирнова

По результатам экспериментальных исследований проанализирована на однородность стохастическая структура выборок волокон льна масличного украинской и польской селекции. Определены законы распределения волокон как смесей нормального и логарифмически нормального законов распределения. Показана адекватность построенных нелинейных моделей законов распределения. Доказано существенное расхождение вероятностных распределений длин волокон льна масличного различной селекции на основе статистического критерия Колмогорова-Смирнова

Ключевые слова: лен масличный, показатели качества, смесь законов распределения, адекватность нелинейных моделей, критерий Колмогорова-Смирнова

1. Introduction

In the conditions of development of innovative technologies, the index of successful work of industrial enterprises is the quality of products. One of the factors of products quality management is a reliable forecast of quantitative and quality descriptions of the properties of these products on the stage of planning. Despite the considerable number of standards and specifications that regulate methodologies of testing of raw materials, finished products and estimation of their consumer properties, the existent methods do not allow to carry out the prognosis of quality indexes of both unwoven materials in the conditions of their processing and finished goods in the process of exploitation [1]. Therefore, the necessity of a scientific approach for the analysis of raw materials becomes obvious, because the quality of the finished products depends on the initial indicators. The quality is also influenced by the competitiveness of products both on the Ukrainian and European markets, because in fact only 40 % of unwoven materials market of Ukraine are the products of own production [2]. That is why the improvement of quality descriptions of natural linens by the analysis of the initial indicators of oil flax for optimization of the processing modes is a key issue for modern producers.

2. Literature review and problem statement

At the moment, 60 % of Ukrainian market of unwoven materials consists of products of such producers as China, Korea, Turkey, Belarus, Germany, Italy, and France [2]. The basis for competitiveness of the Ukrainian goods is the proper quality of raw materials. At the moment, one of the basic sources of natural raw material for Ukraine is oil flax, which by this time has been considered as a low-suitable or even unsuitable raw material for the production of domestic textile goods. Because, in fact, there are mostly short fibres in the stems of oil flax. By this time these fibres have not been used effectively. However, by the conditions of breaking up into elementary fibres, i.e. its previous modification, the short fibre of oil flax, in mixture with other fibres, can be used not only for producing goods of industrial-use: unwoven materials, insulation materials, geotextile and agrotextile, but also in the production of textile goods [3]. Ukrainian scientists investigated the issue of quality providing of the unwoven textile materials [2, 4]. The researchers also pay attention to the requirements of forming the assortment and properties of ecologically safe types of the unwoven materials [5], as well as to the issues of quality providing of Ukrainian textile materials due to perfection of treatment and providing them with the best physicomechanical and technical characteristics [6, 7].

The necessity of composition estimation of fibres by length depending on a sort and climatic conditions of growing by using modern technical equipment arises for expansion of application of linen raw material. Foreign scientists conducted experimental researches regarding the properties of flax fibres of different selection [8] and to fibres distribution by length [9]. The various parameters of quality of both straw and processed products of oil flax were analysed in details [10]. The suitability of the above-mentioned fibres for producing goods for various purposes was considered [11, 12]. Properties of different variants of fibres mixtures were also compared [13, 14] and the influence of growing conditions on the quality indexes of straw was investigated [15, 16]. However, the mentioned researches do not contain the comparison of raw material of the Ukrainian selection to the sorts of oil flax of the Polish selection. In addition, as usual, the issue of the adequacy of the built models remains undefined. So, the authenticity of the results for the formulation of scientifically reasonable conclusions and recommendations to the production remains an additional point for further researches.

3. Aims and research tasks

The performed researches set the goal of conducting an analysis of series of stochastic structure for homogeneity of oil flax fibres Ukrainian and Polish selection.

For the achievement of the stated purpose, the following tasks are solved:

– to find out the structure of distribution laws of oil flax fibres of different selection by length as a mixture of normal and logarithmic normal laws of distribution;

– to define the adequacy of the built models of mixtures of density functions of probability distribution by the determination index value;

– to carry out the comparative analysis of probabilistic distributions of oil flax fibres length of the Ukrainian and Polish selection by the Kolmogorov-Smirnov criterion;

– to justify the distribution into factions by length of oil flax fibres of different selection.

4. Materials and research methods

For the research of selections of stochastic structure for homogeneity the method of separation of probabilistic distributions from their mixtures will be used, that is included into the total of cluster analysis methods [17]. It is reasonable to use this method when the number of informing indexes (in this case we have two parameters of normal or logarithmic normal distribution) is small and the type of distribution for a homogeneous group is known (in this case the normal and logarithmic normal laws of distribution are selected). It allows to get important information about the structure of the general totality even for the groups of objects, which are substantially recovered in a feature space. In addition, it allows, during interpretation of results of classifications, to use the traditional determined rules of decision-making, as well as the rules that are based on the theory of fuzzy sets.

The chosen approach for the application is based on a hypothesis that a stochastic model of general totality, from which a sample is derived, is a superposition of the known unimodal probabilistic distributions (which are mentioned above). The parameters of the obtained mixture of distributions characterize the stochastic structure of general totality, and in this case it is the distribution by length of oil flax fibres of the investigated sorts.

Considering that the general totality is a mixture of a few subtotalities, which have a unimodal law of distribution and differ in at least the vector of values of one distribution parameter, it is needed to distinguish these subtotalities by selective data in some forecasts about the number of classes, the matrix of covariance and others.

The central limiting theorem of probability theory allows to approximate the result of the experiment by normal or logarithmic normal law of distribution, when plenty of independently operating casual factors influence its result, each of which insignificantly influences the final result.

Let us build the self-reactance model of distribution of oil flax fibres length. Let us present the law of distribution of the investigated sign in general f (x) totality as the weighted sum of **k** laws of distribution $f_j(x;\theta_j)$, each of which describes distribution of the homogeneous j group of objects, part of which in the general totality is determined by the weighting coefficient π_j. The density function of probability distribution of the investigated sign has the form of a mixture of density functions:

$$f(x)=\sum_{j=1}^{k}\pi_j\cdot f_j\left(x;\theta_j\right), \qquad (1)$$

where π_j – specific weight (a priori probability) of j component in the mixture;

$$\pi_j \geq 0,\quad j=\overline{1;k};\quad \sum_{j=1}^{k}\pi_j=1.$$

Thus, the task of breaking up of a mixture is, having a selection of casual and independent supervisions from f(x) mixture and knowing the number of homogeneous **k** groups and criterion of proximity, to estimate the vector of parameters:

$$\Theta=\left(\pi_1,\pi_2,...,\pi_k;\theta_1,\theta_2,...,\theta_k\right). \qquad (2)$$

The task of authentication is to evaluate the unknown values of parameters $\pi_1,\pi_2,...,\pi_k$ and vectors $\theta_1,\theta_2,...,\theta_k$ according to selection $X=\left\{x_1,x_2,...,x_n\right\}$.

For normal or logarithmic normal laws of distribution every vector is determined by the parameters of distribution:

$$\theta_j=\left(\mu_j;\sigma_j\right), \qquad (3)$$

where μ_j – a mathematical expectation; σ_j – mean square deviation.

In the chart of automatic classification, the unknown π_j and Θ_j parameters and the number of homogeneous **k** groups can be estimated by the selective supervisions with the help of many methods. In the researches let us stop at the least-squares method. We will search for a minimum of the functional:

$$I=\sum_{i=1}^{n}\left(w_i-\sum_{j=1}^{k}\pi_j\cdot g_j\left(x;\theta_j\right)\right)^2\rightarrow \min, \qquad (4)$$

where n – sample volume; w_i – empiric relative frequencies;

$$g_j\left(x;\theta_j\right)=P_j\left(x_i<X<x_{i+1}\right)=F_j\left(x_{i+1};\theta_j\right)-F_j\left(x_i;\theta_j\right)$$

is theoretical relative frequencies; $P_j\left(x_i<X<x_{i+1}\right)$ – probability of acceptance of the value from the interval $\left[x_i;x_{i+1}\right]$ by a random variable under the j law of distribution from the mixture; $F_j\left(x;\theta_j\right)$ – an integral function of the probability distribution of the j distribution law from the mixture.

The important problem of this method is a choice of the number of homogeneous groups of **k**. In practice the value of **k** parameter is determined either visually, or by solving a task by a few values of **k**; the chart of dependence of the functional (4) from the **k** parameter is built and the least value of **k** parameter, in which the chart has a sharp jump, is selected. Such a criterion is called the sharp slope criterion.

The determined task of nonlinear optimization (4) is solved by the method of generalized reducing gradient that is built-in in a package "Search of solution" of Excel tabular processor. The initial values of the parameters of distributions were appointed after the analysis of the histogram of experimental frequencies.

The adequacy of the obtained model of probabilistic distributions mixture is estimated by the value of determination index of a nonlinear model.

5. The results of homogeneity investigation of the experimental samples of oil flax fibres of the Ukrainian and Polish selection by length

5. 1. Defining the law of probabilistic distribution of fibre lengths of oil flax of the Ukrainian selection

According to the experimental researches of oil flax fibres, performed by the author, the empirical law of distribution of a random variable – a length of oil flax fibres that is given in Table 1 and on the histogram of frequencies, was obtained (Fig. 1).

Table 1

The empirical distribution law of a random variable – a fibre length of oil flax of the Ukrainian selection

№	Interval, mm			Empirical frequencies	
	beginning	end	middle	absolute	relative
1	2	3	4	5	6
1	0	5	2.5	173	0.0335
2	5	10	7.5	229	0.0443
3	10	15	12.5	262	0.0507
4	15	20	17.5	218	0.0422
5	20	25	22.5	189	0.0366
6	25	30	27.5	234	0.0453
7	30	35	32.5	311	0.0602
8	35	40	37.5	348	0.0674
9	40	45	42.5	406	0.0786
10	45	50	47.5	249	0.0482
11	50	55	52.5	283	0.0548
12	55	60	57.5	222	0.0430
13	60	65	62.5	292	0.0565
14	65	70	67.5	214	0.0414
15	70	75	72.5	230	0.0445
16	75	80	77.5	177	0.0343
17	80	85	82.5	201	0.0389
18	85	90	87.5	121	0.0234
19	90	95	92.5	149	0.0288
20	95	100	97.5	106	0.0205
21	100	105	102.5	159	0.0308
22	105	110	107.5	51	0.0099
23	110	115	112.5	74	0.0143
24	115	120	117.5	51	0.0099
25	120	125	122.5	51	0.0099
26	125	130	127.5	42	0.0081
27	130	135	132.5	43	0.0083
28	135	140	137.5	21	0.0041
29	140	145	142.5	37	0.0072
30	145	150	147.5	16	0.0031
31	150	155	152.5	8	0.0015

According to the visual analysis of the histogram in Fig. 1, it is determined that the initial number of the distributions of the mixture components is essential to be chosen an equal to 4, by the number of the clearly defined modes of the empirical distribution law. Considering the expressed dissymmetry of histogram bell areas, for the theoretical distribution law, we choose the logarithmically normal law. Similarly, the initial approximation of parameters of distributions from a mixture is defined (Table 2).

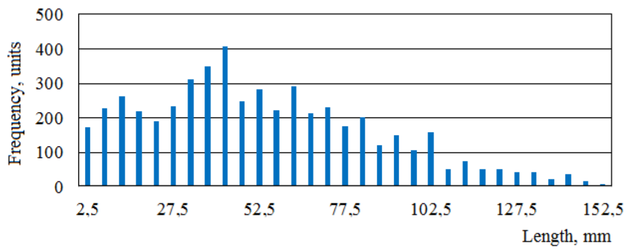

Fig. 1. Histogram of empirical frequencies of oil flax fibres length of the Ukrainian selection

Table 2

Initial approximation of parameters of distributions from a mixture

j	μ_j	σ_j	π_j
1	3.3	1.1	0.40
2	3.7	0.2	0.25
3	4.2	0.1	0.10
4	4.2	0.2	0.25

After assigning the initial approximation of parameters of distributions from a mixture and forming the functional expression (4), the so-called package "Search of solution" of Excel system is opened and with its help the task of minimizing is solved (4). The extreme estimates of parameters of distributions from a mixture are shown in Table 3. Thus, the random variable – a length of oil flax fibres – has the density function of probability distribution, which is a linear combination of relevant functions of 4 logarithmically normal laws of distribution (Fig. 2) with the parameters that are listed in Table 3:

$$f(x)=\sum_{j=1}^{4}\pi_j\cdot\frac{1}{\sqrt{2\pi}\cdot x\cdot\sigma_j}\cdot e^{-\frac{(\ln x-\mu_j)}{2\sigma_j^2}}. \qquad (5)$$

Table 3

Extreme estimates of parameters of distributions from a mixture

j	μ_j	σ_j	π_j
1	3.3070	1.1362	0.4221
2	3.7322	0.2290	0.2546
3	4.1585	0.1156	0.0760
4	4.4641	0.2350	0.2473

Combined histograms of empirical and theoretical frequencies are shown in Fig. 3.

The adequacy of the constructed nonlinear model (5) with the parameters (Table 3) will be estimated by the index of determination that is calculated by the formula [17]:

$$R_{xy}^2=1-\frac{SS_e}{SS}, \qquad (6)$$

where

$$SS_e=\sum_{i=1}^{n}\left(f(x_i)-\hat{f}(x_i)\right)^2;$$

$$SS=\sum_{i=1}^{n}\left(f(x_i)-\overline{f}\right)^2;$$

$$\overline{f}=\frac{1}{n}\cdot\sum_{i=1}^{n}f(x_i);$$

$f(x_i)$ – empirical values of frequencies; $\hat{f}(x_i)$ – calculated by the model of frequency values.

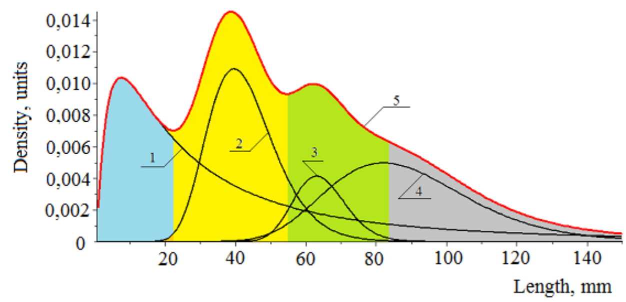

Fig. 2. Charts of density functions of probability distribution by the laws: 1 — $\pi_1\cdot f_1(x;\theta_1)$; 2 — $\pi_2\cdot f_2(x;\theta_2)$; 3 — $\pi_3\cdot f_3(x;\theta_3)$; 4 — $\pi_4\cdot f_4(x;\theta_4)$; 5 — mixture $\sum_{j=1}^{4}\pi_j\cdot f_j(x;\theta_j)$

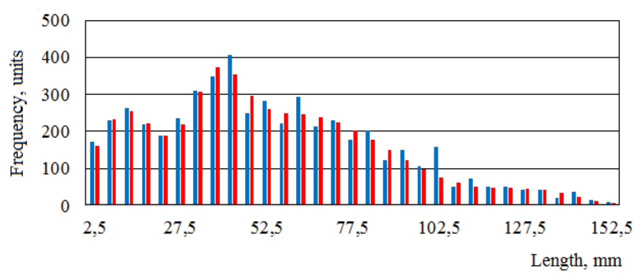

Fig. 3. Histograms of empirical and theoretical frequencies of fibre length of oil flax of the Ukrainian selection

The calculations are performed by the formula (6) in the tabular processor Excel. They lead to the determination index 0.89, that indicates a good coherence of the constructed model with the experimental data.

5. 2. Defining the law of probabilistic distribution of fibre lengths of oil flax of the Polish selection

Similarly, let us perform the calculations for oil flax fibres of the Polish selection as for the fibres of the Ukrainian selection (Table 4).

According to the visual analysis of the histogram in Fig. 1, it is determined that the initial number of the distribution mixture components is essential to be equal to 4, by the number of the clearly defined modes of the empirical distribution law. Similarly, the initial approximation of parameters of distributions from a mixture is defined (Table 5).

Table 4

The empirical distribution law of a random variable – a fibre length of oil flax of the Polish selection

№	Interval, mm			Empirical frequencies	
	beginning	end	middle	absolute	relative
1	0	5	2.5	234	0.043277
2	5	10	7.5	228	0.042168
3	10	15	12.5	258	0.047716
4	15	20	17.5	234	0.043277
5	20	25	22.5	241	0.044572
6	25	30	27.5	261	0.048271
7	30	35	32.5	263	0.048641
8	35	40	37.5	251	0.046421
9	40	45	42.5	246	0.045497
10	45	50	47.5	231	0.042722
11	50	55	52.5	241	0.044572
12	55	60	57.5	208	0.038469
13	60	65	62.5	265	0.049011
14	65	70	67.5	216	0.039948
15	70	75	72.5	239	0.044202
16	75	80	77.5	232	0.042907
17	80	85	82.5	208	0.038469
18	85	90	87.5	198	0.036619
19	90	95	92.5	195	0.036064
20	95	100	97.5	203	0.037544
21	100	105	102.5	189	0.034955
22	105	110	107.5	120	0.022193
23	110	115	112.5	104	0.019234
24	115	120	117.5	54	0.009987
25	120	125	122.5	52	0.009617
26	125	130	127.5	50	0.009247
27	130	135	132.5	46	0.008507
28	135	140	137.5	44	0.008138
29	140	145	142.5	23	0.004254
30	145	150	147.5	19	0.003514
31	150	155	152.5	14	0.002589
32	155	160	157.5	12	0.002219
33	160	165	162.5	8	0.00148
34	165	180	172.5	12	0.002219
35	180	190	185	8	0.00148

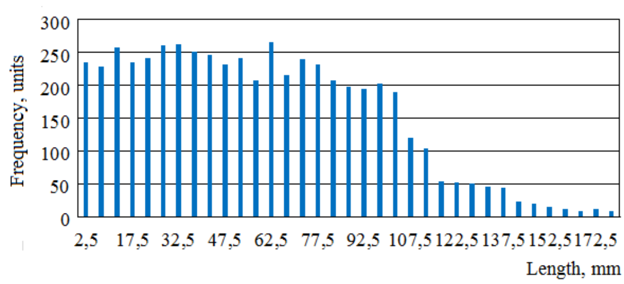

Fig. 4. Histogram of empirical frequencies of oil flax fibres length of the Polish selection

Table 5

Initial approximation of parameters of distributions from a mixture

j	μ_j	σ_j	π_j
1	8.4	6.7	0.15
2	3.8	0.6	0.50
3	4.4	0.25	0.30
4	4.6	0.05	0.05

Similarly to the preceding subparagraph, it is defined that the random variable – a fibre length of oil flax of the Polish selection – has a density function of probability distribution, which is a linear combination of the respective functions of one normal law of distribution and 3 logarithmically normal laws of distribution (Fig. 6) with the parameters, listed in Table 5:

$$f_1(x)=\frac{1}{\sqrt{2\pi}\cdot\sigma_1}\cdot e^{-\frac{(x-\mu_1)^2}{2\sigma_1^2}}, \tag{7}$$

$$f_j(x)=\frac{1}{\sqrt{2\pi}\cdot x\cdot\sigma_j}\cdot e^{-\frac{(\ln x-\mu_j)^2}{2\sigma_j^2}},\ j=\overline{2;4}. \tag{8}$$

Table 6

Extreme estimates of parameters of distributions from a mixture

j	μ_j	σ_j	π_j
1	8.3995	6.6745	0.1410
2	3.7667	0.5558	0.5004
3	4.4427	0.2811	0.3287
4	4.6055	0.048	0.0300

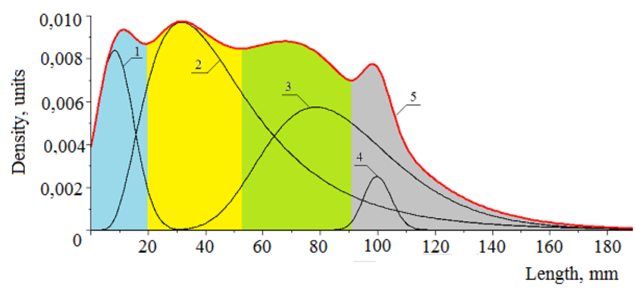

Fig. 5. Charts of density functions of probability distribution by the laws: 1 – $\pi_1\cdot f_1(x;\theta_1)$; 2 – $\pi_2\cdot f_2(x;\theta_2)$; 3 – $\pi_3\cdot f_3(x;\theta_3)$; 4 – $\pi_4\cdot f_4(x;\theta_4)$; 5 – mixtures $\sum_{j=1}^{4}\pi_j\cdot f_j(x;\theta_j)$

Combined histograms of empirical and theoretical frequencies are shown in Fig. 6.

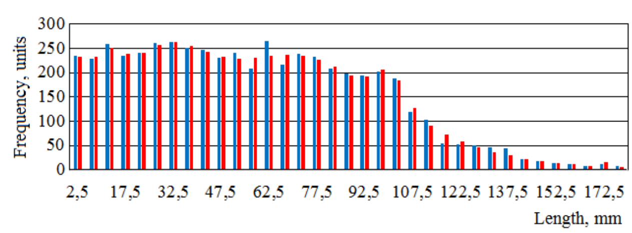

Fig. 6. Histograms of empirical and theoretical frequencies of fibre length of oil flax of the Polish selection

The adequacy of the constructed nonlinear model (1) with the functions (7) and (8) with the parameters from Table 6 are also estimated by the index of determination. The calculations are made with the help of the formula (6) in the tabular processor Excel. They lead to the determination index 0.99, that indicates a good coherence of the constructed model with the experimental data.

5. 3. Comparative analysis of probability distributions of fibres' length of oil flax of different selections

Checking the homogeneity by the length of oil flax fibre samples of different selections. Let us investigate the laws of distribution of general totalities, from which the samples of oil flax fibres of the Ukrainian and Polish selections were obtained. To test the hypothesis about belonging of two independent samples to one of the distribution laws, let us use the Kolmogorov-Smirnov criterion [9, 18].

The investigated value of the Kolmogorov-Smirnov criterion is calculated by the formula:

$$\lambda_{\text{observed}} = d_{\max} \cdot \sqrt{\frac{n_1 \cdot n_2}{n_1 + n_2}}, \tag{9}$$

where $d_{\max} = \sup\left|w(x_i) - w(y_i)\right|$ – module of the biggest difference between relative frequencies of the corresponding elements of two samples X and Y; n_1 – sample volume X; n_2 – sample volume Y.

The critical value of the Kolmogorov-Smirnov criterion for the significance level of α=0.05 is λ_{cr}=1.36.

Let us implement the application rule of the Kolmogorov-Smirnov criterion in Excel tabular processor.

Table 7

Comparison of the relative frequencies of distributions of oil flax fibres of different selections by length

Interval, mm		Relative frequencies		Module of difference
Beginning	End	UA	PL	
0	5	0.033481711	0.043277233	0.009795522
5	10	0.044319721	0.042167561	0.002152160
10	15	0.050706406	0.047715924	0.002990482
15	20	0.042190826	0.043277233	0.001086407
20	25	0.036578285	0.044571851	0.007993566
25	30	0.045287401	0.04827076	0.002983359
30	35	0.060189665	0.048640651	0.011549014
35	40	0.067350494	0.046421306	0.020929188
40	45	0.078575576	0.045496579	0.033078997
45	50	0.048190439	0.042722397	0.005468042
50	55	0.05477066	0.044571851	0.010198809
55	60	0.04296497	0.038468652	0.004496318
60	65	0.056512483	0.049010542	0.007501941
65	70	0.041416683	0.039948215	0.001468468
70	75	0.044513257	0.04420196	0.000311297
75	80	0.034255854	0.042907342	0.008651488
80	85	0.038900716	0.038468652	0.000432064
85	90	0.023417844	0.036619197	0.013201353
90	95	0.028836849	0.036064361	0.007227512
95	100	0.020514805	0.037543925	0.017029120
100	105	0.030772208	0.034954688	0.004182480
105	110	0.009870331	0.022193453	0.012323122
110	115	0.014321657	0.019234326	0.004912669
115	120	0.009870331	0.009987054	0.000116723
120	125	0.009870331	0.009617163	0.000253168
125	130	0.008128508	0.009247272	0.001118764
130	135	0.008322044	0.008507490	0.000185447
135	140	0.004064254	0.008137599	0.004073345
140	145	0.007160828	0.004253745	0.002907083
145	150	0.003096574	0.003513963	0.000417389
150	155	0.001548287	0.002589236	0.001040949
155	160	0	0.002219345	0.002219345
160	165	0	0.001479564	0.001479564
165	180	0	0.002219345	0.002219345
180	190	0	0.001479564	0.001479564
–	–	–	sup	0.033078997

Thus, $d_{\max} \approx 0{,}0331,$ and the observed value of the Kolmogorov-Smirnov criterion is:

$$\lambda_{\text{observed}} \approx 0{,}0331 \cdot \sqrt{\frac{5167 \cdot 5407}{5167 + 5407}} \approx 1{,}70. \tag{10}$$

Since $\lambda_{\text{observed}} > \lambda_{cr}\ (1{,}70 > 1{,}36),$ the hypothesis about the same distribution of general totalities, from which the samples were obtained, is rejected. The laws of distribution of selections differ significantly.

Determination of fibre groups by length of oil flax of different selections. Let us define the borders of the conventional fibre groups by length with the help of the general laws of distribution [19]:

– by the law (5) for flax of the Ukrainian selection;

– by the law that is described by the formulas (1), (7) and (8) for flax of the Polish selection.

The borders of groups are necessary to be chosen (Fig. 4, 7):

– at the minimum points of the general law of probability density distribution;

– at the point of the graphics' inflection of the general law of probability density distribution.

For this purpose, it is necessary to solve numerically the equation:

– In the first case

$$\frac{d}{dx} f(x;\theta) = 0;$$

– In the second case

$$\frac{d^2}{dx^2} f(x;\theta) = 0.$$

Their numerical solutions are given in Table 8.

Table 8

Borders of the conventional fibre groups by length

Selection	I group		II group		III group		IV group	
	Start	End	Start	End	Start	End	Start	End
UA	0	22.49	22.49	54.60	54.60	84.62	84.62	155
PL	0	19.26	19.26	52.50	52.50	85.00	85.00	190

Determination of the specific weight of fibre groups in the total distribution. By such a division into groups (Table 8), the specific weight of each group can be calculated as the ratio of the area of the curvilinear trapezoid, which is bounded above by the function graph of a mixture of densities in the interval of the group, to the area of the curvilinear trapezoid throughout the total range of possible lengths of fibres [20]:

$$\frac{\int_{a_j}^{b_j} f(x;\theta)dx}{\int_a^b f(x;\theta)dx} \cdot 100\ \%, \tag{11}$$

where $\left[a_j;b_j\right]$ – interval of lengths of fibres; $\left[a;b\right]$ – interval of lengths of fibres in the sample; $f(x;\theta)$ – function of mixture of densities of probability distributions.

The results of calculations by the formula (11) are shown in Table 9.

Table 9

Specific weight of fibre groups in the samples, %

Selection	I group	II group	III group	IV group
UA	18.87	37.12	26.06	17.95
PL	15.75	30.88	28.16	25.21

Thus, the oil flax fibres of the Ukrainian selection have a more pronounced tendency to stratification by a fibre length. Such a fibre is easily divided into factions. The oil flax fibres of the Polish selection have a higher overall proportion of short and extra-long fibres.

6. Discussion of the results of homogeneity investigation of oil flax fibres of different selections

Many leading scientists of the Southern region of Ukraine conducted the study of fibre distribution by length, but these studies require an annual system analysis, because the quality indexes change depending on a great number of external factors. The obtained data are the extension of the previously conducted researches and they allow us to investigate the dynamics of changes in physical and mechanical properties of oil flax, depending on annual climatic conditions and areas of growing.

The obtained results are useful for scientists and specialists, who work at the flax processing enterprises, as they allow a substantiated approach to the selection of raw materials, depending on the manufactured products. It is clear that for manufacturing ropes and cords the oil flax of the Polish selection should be used, and for non-woven materials (fibre clothes, natural geotextile materials, batting) – of the Ukrainian selection.

The studies and the conclusions made on their basis concern the physical and mechanical properties of oil flax of the same year's harvest, which is their certain disadvantage. Therefore, such studies should be continued in order to obtain the generalized results.

The advantage of the used method of calculation is verifying the assumptions with the help of calculation of the adequacy of the constructed nonlinear models. It was determined by the value of the index of determination, which is 0.89 and 0.99 respectively. The results of the studies show that the fibres of the Ukrainian and Polish selections differ significantly. The calculations of the specific weight of fibre groups in the studied samples show that in the samples of the Polish selection there is a larger number of short and extra-long fibres.

The obtained dependences confirm the theoretical assumptions and prove the need for different processing modes on the technological equipment for fibres of the Polish and Ukrainian selections. They also indicate different target purposes of raw materials. Namely, according to the distributions of general totalities and borders of the conventional fibre groups, as already mentioned above, the oil flax of the Ukrainian selection is intended for the production of non-woven materials of different target purposes, and the Polish one – for the production of ropes, cords, etc.

7. Conclusions

1. The structure of the distribution laws of oil flax fibres of the Ukrainian selection by length has a density function of probability distribution, which is a linear combination of relevant functions of 4 logarithmically normal laws of distribution. The distribution of oil flax fibres of the Polish selection is a linear combination of the functions of one normal distribution law and 3 logarithmically normal laws of distribution.

2. The determination index of the constructed nonlinear models for the fibres of the Ukrainian selection is 0.89 and for the Polish selection is 0.99. This indicates a good congruence of the theoretical models with the experimental data.

3. The probabilistic distributions of fibre lengths of oil flax of the Ukrainian and Polish selections vary significantly. The parameters of the corresponding components of the total distribution laws are different. The fact, that the difference between the general distribution laws is not accidental, is confirmed by the Kolmogorov-Smirnov statistical criterion.

4. In accordance with the distribution of general totalities and borders of conventional fibre groups, it is obvious that the Ukrainian selection of oil flax is intended for the production of non-woven materials of different target purposes, because it contains the most fibres of the II and III groups. The raw material of the Polish selection is intended for manufacturing ropes, cords, etc., because it contains a larger overall share of short and extra-long fibres.

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