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Scientific Analysis of the Indicators of Strength, Elasticity, And Tension of Karakul Wool Fibers after Softening using Physico-Mechanical Methods

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Abstract: In Uzbekistan, the wool processing industry is not yet fully developed, and the semi-coarse fibers of local sheep are considered a difficult raw material due to their roughness, low elasticity, and disproportionate properties. This study analyzes changes in the strength, elasticity, and tensile characteristics of softened wool fibers. Based on regression modeling, technological trends and optimal parameters of seasonal fibers were determined. The results show that the softening of fibers increases production efficiency, and the developed models serve to prepare high-quality yarn and strengthen export potential.

Keywords: Uzbekistan, wool fiber, softening, yarn production, regression model, elasticity, elongation, quality, textile industry, export.

Uzbekistan is widely recognized as one of the largest cotton producers in the world, yet the development of wool-based technologies within its textile industry has been comparatively limited. Local sheep breeds, particularly Karakul and other regional varieties, provide semi-coarse wool fibers, which present significant technological challenges for yarn production. These fibers are characterized by high coarseness, limited softness, low elasticity, and inconsistent physical-mechanical properties, making them less suitable for producing fine-quality yarns. As a result, semi-coarse wool is often underutilized or exported in raw form, reducing its potential contribution to the national economy. Recent scientific studies have highlighted that fiber softening technologies can improve the processing suitability of such wools. Softened wool demonstrates better structural integrity, elasticity, and flexibility, which in turn improves yarn performance. In this research, statistical regression models were developed to analyze and predict changes in strength, elasticity, and elongation of fibers collected in different seasons. The models allowed for the determination of optimal processing parameters necessary for yarn production. Moreover, global practices in wool processing suggest that biochemical, physicochemical, and thermomechanical treatments can significantly enhance fiber properties, enabling the production of high-quality yarns even from semi-coarse fibers. By adapting these methods to Uzbekistan's specific conditions and applying them to Karakul wool, it becomes possible to meet domestic textile demand while also expanding export opportunities.

The production of high-quality yarns from semi-coarse wool fibers is a strategic priority for Uzbekistan's textile industry. The findings of this study confirm that untreated local wool fibers face serious challenges in industrial application due to their stiffness, weak elasticity, and variable elongation properties. Therefore, introducing softening technologies at the preliminary stage of processing is essential. Through regression analysis, it was demonstrated that softened fibers show significant improvement in strength, elasticity, and elongation, providing a scientific basis for identifying optimal processing parameters. Seasonal differences in fiber characteristics also revealed the importance of developing adaptive processing models. The outcomes of this research offer valuable technological solutions for transforming semi-coarse wool into competitive, high-quality yarns. Such an approach not only supports domestic industry by relying on local raw materials but also strengthens the export potential of Uzbekistan's textile sector. By fostering innovation, the country can enhance its global competitiveness and accelerate sustainable growth in the textile industry.

The fiber cut in the autumn season is given in *Table 4.6* processing is planned according to the change in the consistency value.

Table 1. Cut fiber in the softened autumn season Y_2 - the value of strength

u	Factors				Fiber strength indicators, $Y_{u\upsilon}$			Average fiber strength, $\bar{Y}\_u2$	$S_{u2}^2\{Y\}$
	x_0	x_1	x_2	x_3	Y_u2	$Y\_(u2^i$	$Y\_(u2^ii)$		
1.	+	-	-	-	3.5	6.5	3.5	4.5	3
2.	+	+	-	-	4	5	3	4	1
3.	+	-	+	-	4.5	6.5	3.5	4.8	2
4.	+	+	+	-	4.7	3.7	5.7	4.7	1
5.	+	-	-	+	3.7	2.7	4.7	3.7	1
6.	+	+	-	+	4.7	6.7	3.7	5	2
7.	+	-	+	+	5	3	4	4	1
8.	+	+	+	+	5.8	4.8	6.8	5.8	1

Cut fiber in the softened autumn season Y_2 - strength The assimilation of the results of the experiment made it possible to obtain the following regression model:

Y2= 4.6 + 0.313* X 1+0.263* X 2+0.062* X 3+0.113* X 12+0.463* X 13

Figure 4.6 shows the harvested fiber in the autumn season Y_2 - a surface graph built on the basis of the regression model of strength is presented.

The significance of the regression coefficient was checked. For this, $t_R\{b_i\}$ the calculated value t_T was compared with the tabulated value using the Student's t-test. If $t_R > t_T$ it is, then the hypothesis of the significance of the regression coefficient is not rejected.

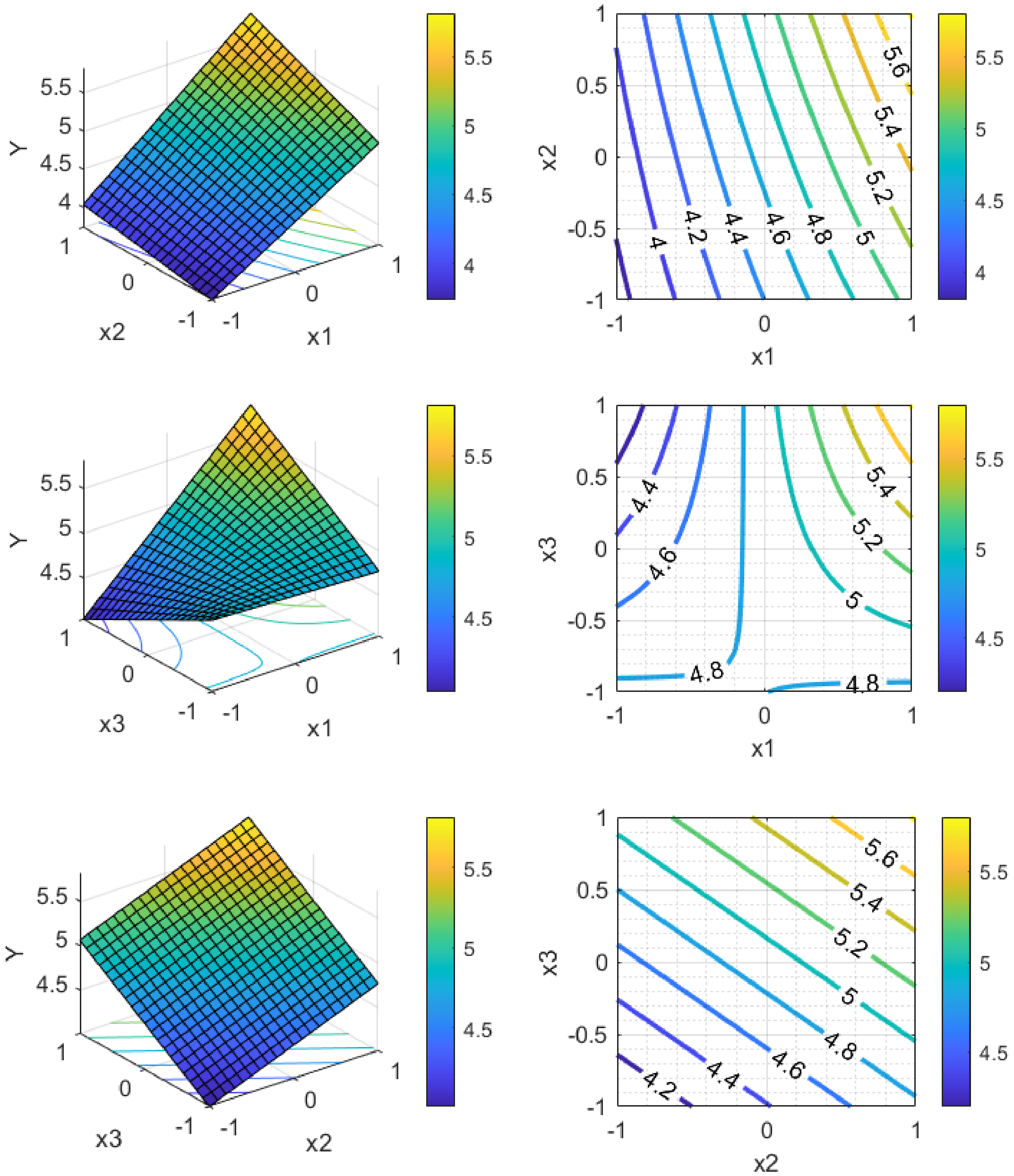


Figure 1 . The fiber is cut in the soft autumn season

Y_2 - Surface plot constructed based on the regression model of $p_D = 0{,}95$ robustness . The tabulated value of the Student's t-test and the number of degrees of freedom $f\{S_y^2\} = N(m-1)$ are equal to , . $t_T[p_D = 0{,}95;\ f = 8(3-2) = 16] = 2{,}12$

The calculated results of the Student's test were compared with the results in the table. Here, b_1, b_2, b_3, b_{12}, b_{13}, regression coefficients were found to be significant.

Calculated value according to Fisher's criterion $F_R^{/} = \frac{0{,}5}{0{,}33} = 1{,}5$

A tabular value of Fisher's criterion was found.

$F_T[p_D = 0{,}95;\ f\{S_y^2\} = 8(3-1) = 16;\ \ f\{S_{oct}^2\} = 8-5 = 3] = 3{,}24.$

Thus, since the multivariate regression model for $F_R^{/}$=1,5<F_T=3,24fiber harvested in the fall season is equal to , the hypothesis that the model obtained under the influence of the output parameter is significant, is not rejected.

The fiber cut in the autumn season is given in Table 4.7 processing is planned according to the change in the value of elasticity .

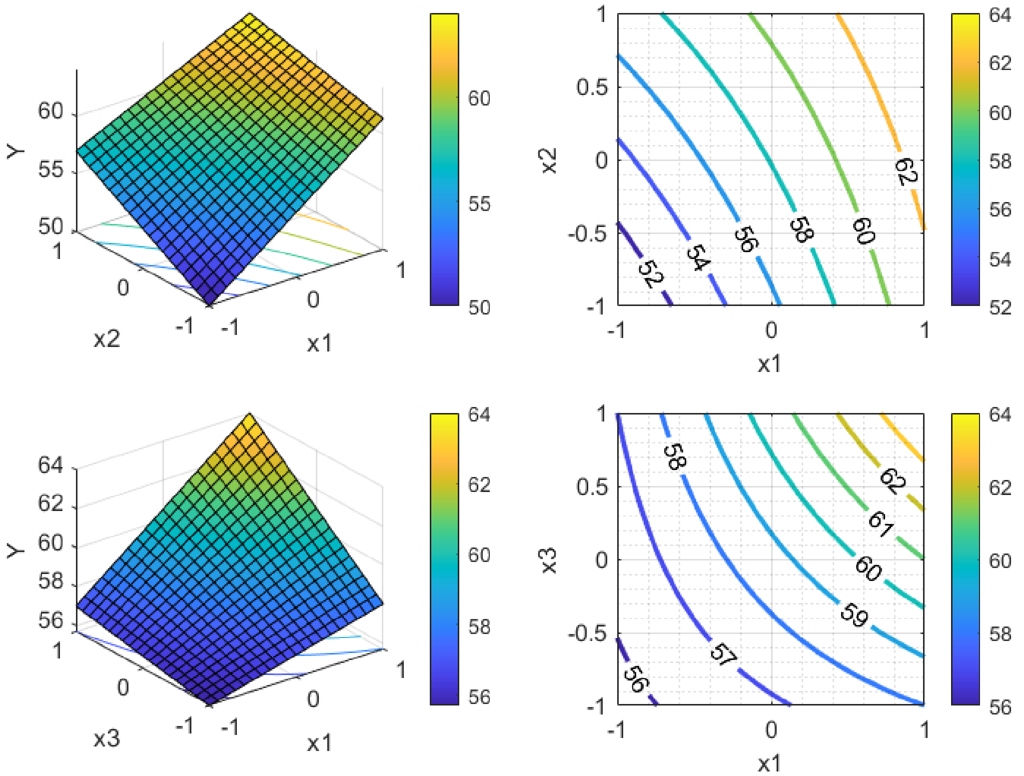
Table 2. Cut fiber in the softened autumn season the change in the value of the elasticity

u	Factors				Fiber elasticity indicators, Y_{uv}			Fiber elasticity The average of $\bar{Y}u3$	$S^2_{u2}\{Y\}$
	X_0	X_1	X_2	X_3	$Yu3$	$Y(u3^i)$	$Y(u3^ii)$		
1.	+	-	-	-	46	48	44	46	4
2.	+	+	-	-	52	50	54	52	4
3.	+	-	+	-	56	54	57	55.7	2
4.	+	+	+	-	58	56	60	58	4
5.	+	-	-	+	50	51	49	50	1
6.	+	+	-	+	60	61	63	61.3	2
7.	+	-	+	+	57	56	58	57	1
8.	+	+	+	+	63	66	63	64	3

Cut fiber in the autumn season Y_3 - elasticity The assimilation of the results of the experiment made it possible to obtain the following regression model:

Y3= 55.5+3.325* X 1+3.175* X 2-1* X 12+2.57* X 3+1.25* X 13-0.75* X 23-0.075* X 123

Figure 4.7 shows the surface graph constructed on the basis of the regression model of fiber cut in the autumn season.



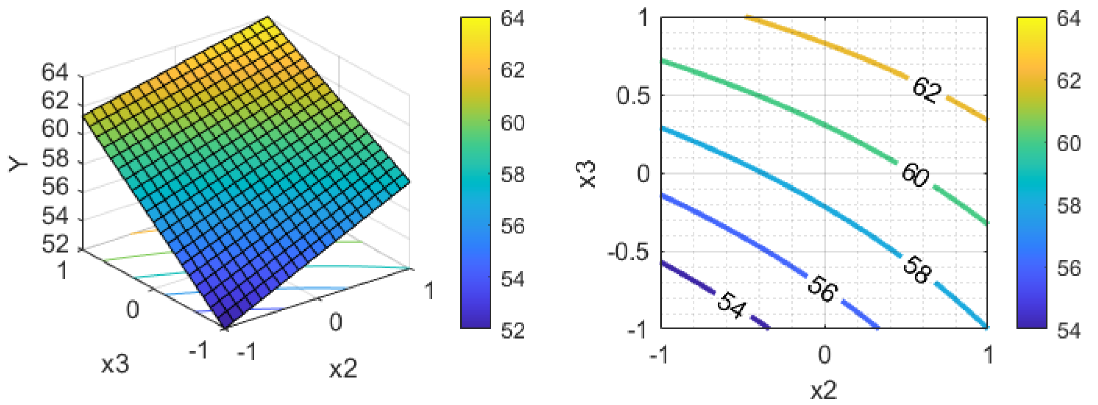


Figure 2. Surface graph constructed on the basis of the regression model of the elasticity of the sheared fiber in the soft fall season .

The calculated results of the student criterion were compared to the results in the table. That's all The regression coefficients were found to be significant. The calculated value of Fisher's exact test $F_R^{/}=\frac{0,875}{0,33}=2,625$is . The tabulated value of Fisher's exact test is found.

$F_T[p_D=0,95;\ f\{S_y^2\}=8(3-1)=16;\quad f\{S_{oct}^2\}=8-5=3]=3,24.$ Thus, since the model obtained under the influence of the output parameter is significant, the hypothesis is not rejected, since it is equal to the multifactorial regression model for $F_R^{/}=2,625<F_T=3,24$ the fiber cut in the softened autumn season [Sevostyanov A.G. Methods and means of studying mechanical and technological processes in the textile industry M.: NGTU im. A.N. Kosygina,

The fiber cut in the autumn season is given *in Table 4.8* Y_4- processing is planned according to the change in the value of the elongation at break .

Table 3. Softened fiber cut in autumn Y_4- change of values of elongation at break

u	Factors				Indicators of fiber elongation at break, Y_{uv}			The average value of the elongation at break of the fiber,$\bar{Y}$ўр4	$S_{u2}^2\{Y\}$
	X_0	X_1	X_2	X_3	$Y4$	$Y4$	$Y4$		
1.	+	-	-	-	3.5	2.4	4.1	3.3	1
2.	+	+	-	-	3.8	4.8	2.8	3.8	1
3.	+	-	+	-	3.2	3.2	5.6	4	2
4.	+	+	+	-	4.3	3.3	5.3	4.3	1
5.	+	-	-	+	3	5.3	3	3.8	2
6.	+	+	-	+	4.3	5.3	3.3	4.3	1
7.	+	-	+	+	4.1	3.1	6.1	4.4	2
8.	+	+	+	+	4.5	3.5	5.5	4.5	1

Softened fiber cut in autumn Y_4- elongation at break The assimilation of experimental results allowed to obtain the following regression model:

Y4= 4.1+0.175*x1+0.25*x2+0.2*x3+-0.075*x12+-0.05*x23

Figure 4.8 shows softened fiber cut in autumn a surface graph constructed on the basis of the regression model of elongation at break is presented.

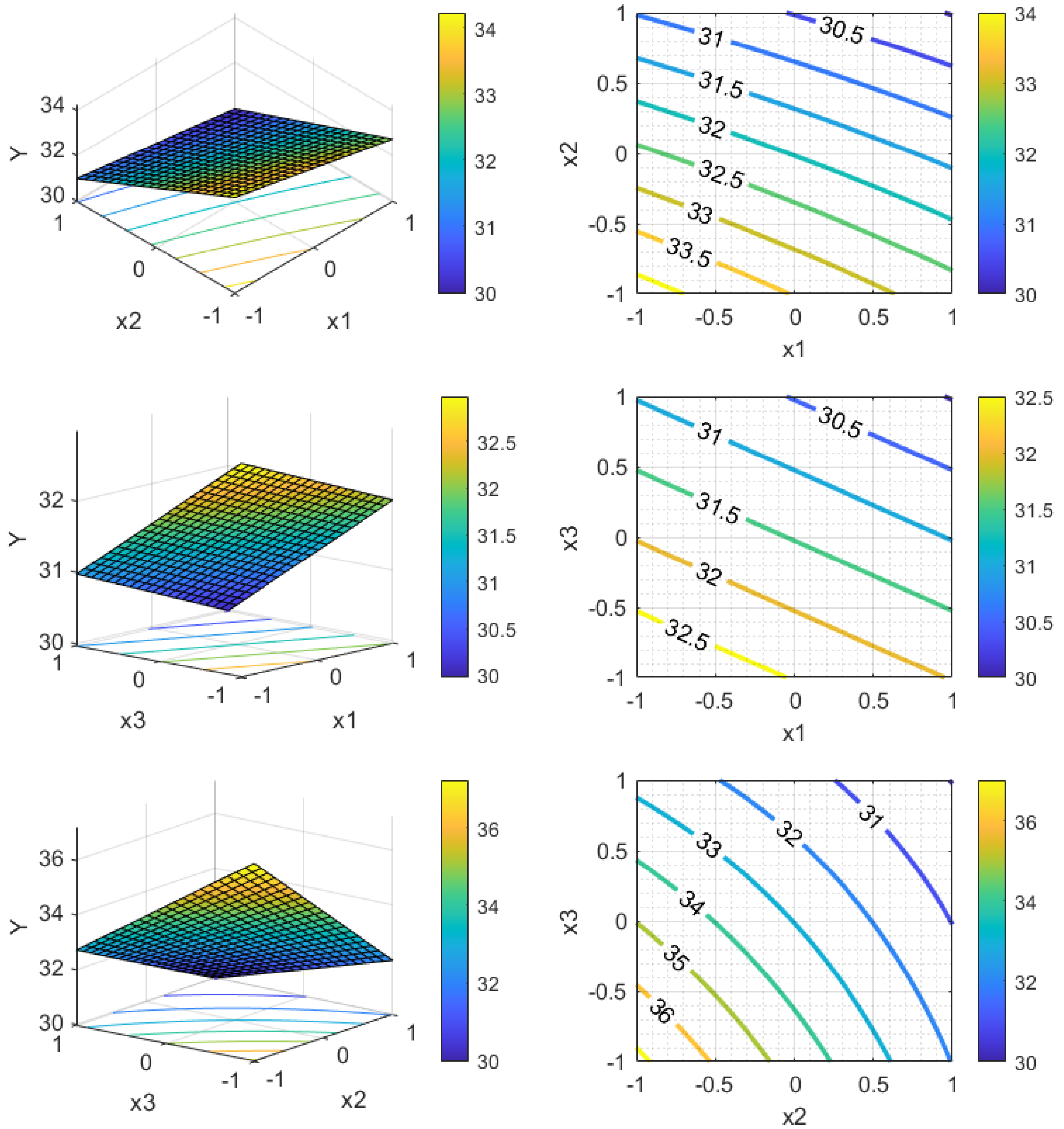


Figure 3. Softened fiber cut in winter surface graph constructed based on the regression model of elongation at break .

The calculated results of the student criterion were compared to the results in the table. That's all The regression coefficients were found to be significant. The calculated value of Fisher's exact test $F_R^/ = \frac{0,458}{0,33} = 1,375$was found. The tabulated value of Fisher's exact test was found.

$$F_T[p_D = 0,95;\ f\{S_y^2\} = 8(3-1) = 16;\ \ f\{S_{oct}^2\} = 8-5 = 3] = 3,24.$$

So, cut softened fiber in the winter season since the multifactorial regression model for $F_R^/ = 1,375 < F_T = 3,24$ the elongation at break is equal to

The production of high-quality yarns from semi-coarse wool fibers is a strategic priority for Uzbekistan's textile industry. The findings of this study confirm that untreated local wool fibers face serious challenges in industrial application due to their stiffness, weak elasticity, and variable elongation properties. Therefore, introducing softening technologies at the preliminary stage of processing is essential. Through regression analysis, it was demonstrated that softened fibers show significant improvement in strength, elasticity, and elongation, providing a scientific basis for identifying optimal processing parameters. Seasonal differences in fiber characteristics also revealed the importance of developing adaptive processing models.

The outcomes of this research offer valuable technological solutions for transforming semi-coarse wool into competitive, high-quality yarns. Such an approach not only supports domestic industry by relying on local raw materials but also strengthens the export potential of Uzbekistan's textile sector. By fostering innovation, the country can enhance its global competitiveness and accelerate sustainable growth in the textile industry.

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