

Application of emulsification method in blending of softened local wool and polyester, wool and acrylic fibers.

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Annotation. *The utilization of local wool resources has become an urgent issue for the development of Uzbekistan's textile industry. Karakul sheep wool, abundant in the country, is traditionally underused despite its high thermal insulation and elasticity. This research investigates the effective blending of wool with synthetic fibers (polyester and acrylic) to enhance yarn performance and industrial applicability. Emulsification technology was applied to improve fiber compatibility, leading to stronger, softer, and more uniform yarns. Results showed that wool-acrylic blends provide warmth and softness, while wool-polyester blends ensure durability. The study highlights wool's strategic importance in advancing sustainable textile production in Uzbekistan .*

Keywords. *Wool, Karakul sheep, Polyester, Acrylic, Blended yarn, Emulsification, Fiber compatibility, Tensile strength, Elongation, Uniformity, Softness, Durability, Textile industry, Spinning, Ring spinning, Rotor spinning, Hygroscopicity, Antistatic treatment, Yarn structure, Uzbekistan.*

The development of high-quality yarns from both natural and synthetic fibers has become one of the most important research directions in modern textile science. In particular, the utilization of local wool resources, such as semi-coarse Karakul sheep wool, and their effective blending with synthetic fibers like polyester (PET) and acrylic (PAN), provides new opportunities for enhancing yarn properties, improving durability, and producing competitive textile products. The textile industry increasingly requires fibers and yarns that are not only strong and elastic but also capable of maintaining softness, thermal insulation, color fastness, and dimensional stability. Therefore, systematic research into the structural, physical, mechanical, and chemical properties of wool and blended yarns is highly significant for both theoretical advancements and industrial applications.

The research was carried out using yarns produced at " Sagdiana " LLC, Bukhara, in collaboration with the " CentexUz " laboratory of the Tashkent Textile and Light Industry Institute. The experimental samples included 100% Karakul wool (J100), 50% wool + 50% acrylic (JA50/50), and 40% wool + 60% polyester (JP40/60). All samples were prepared according to established international and Uzbek standards, including

O' zDSt 614-2014, O' zDSt 619-2014, and ISO 2062-2014, ensuring reliable and comparable results. Prior to testing, all fiber and yarn samples were conditioned under standard climatic conditions in accordance with GOST 10681-75.

One of the innovative aspects of this research lies in the use of the emulsification method for blending softened wool with synthetic fibers. Wool fibers, due to their keratin-based structure and cuticle-covered hydrophobic surface, typically show poor adhesion to hydrophobic synthetic fibers such as polyester and acrylic. To overcome this challenge, emulsification treatments with diluted lanolin, glycerin, antistatic agents, and emulsifiers (eg, Tween 20) were applied to wool fibers before mixing. This process modifies the wool surface, improves hydrophilicity, reduces static charges, and enhances inter-fiber bonding. As a result, the emulsified wool blends more effectively with synthetic fibers, producing homogeneous mixtures with improved spinnability.

Three different emulsification recipes were tested in this study, each tailored for specific fiber compositions:

1. For 100% wool yarns, higher lanolin content was used to restore natural oils and increase softness.
2. For 50% wool + 50% acrylic blends, the formulation emphasizes moisture retention, given that acrylic fibers retain water poorly.
3. For 40% wool + 60% polyester blends, the emulsion includes higher antistatic agents to counter polyester's high static charge and improve fiber cohesion.

Experimental results demonstrated significant improvements in yarn properties when emulsification was applied. Yarn samples produced with emulsified wool exhibited more uniform linear density, higher tensile strength, better elongation behavior, and reduced variation coefficients compared to untreated blends. For example, the specific tensile strength increased from 12.29 cN / tex in untreated wool to 17.9 cN / tex in polyester-wool blends after emulsification. Likewise, yarns from wool-acrylic blends achieved high softness, elasticity, and good color absorption properties, while polyester-wool blends demonstrated enhanced durability and resistance to mechanical stresses.

The findings also revealed that wool-acrylic blends (50/50) yielded yarns with properties closer to natural fibers in terms of softness, warmth retention, and bulkiness, making them suitable for knitwear and winter fabrics. On the other hand, wool-polyester blends (40/60) produced yarns with higher mechanical strength and dimensional stability, which are particularly advantageous for woven fabrics requiring durability, such as upholstery and technical textiles. These results confirm that appropriate blending ratios and emulsification treatments are essential for optimizing both the performance and application of yarns. This research further contributes to the

development of sustainable textile production in Uzbekistan by promoting the use of local wool resources in combination with imported synthetic fibers. Moreover, the production of blended yarns not only improves the physical-mechanical performance of textile materials but also increases economic efficiency by reducing reliance on imported raw materials and enhancing the competitiveness of domestic textile enterprises.

In conclusion, the introduction of emulsification in wool processing represents a significant innovation in the textile sector, particularly for the production of wool-synthetic blended yarns. The research results presented in this work provide a scientific foundation for the creation of optimized yarn production technologies, ensuring high-quality outputs with desirable mechanical, physical, and aesthetic properties. These advancements open new opportunities for industrial-scale production of blended yarns in Uzbekistan, supporting both the modernization of the textile industry and the effective utilization of local wool resources.

The object of the study was the “Sagdiana” (Limited Liability Company) in Bukhara. For this, 29.4 tex yarns were obtained from a mixture of 50% cotton fibers and 50% wool fibers, 50% wool fibers and 50% polyester fibers, and 50% wool fibers and 50% acrylic fibers. The physical and mechanical properties of the yarn were determined in the testing laboratory of the “CentexUz” and “Sagdiana” (Limited Liability Company) enterprises under the Tashkent State Technical University of Textiles and Clothing. The quality indicators of the yarns were determined using the “Uster Tester-5” instrument.

Mixed composition fibers can be defined in the following places: Table-1

No.	Mixture composition	Marking
1	100% karakul wool	J100
2	50% wool + 50% acrylic	JA50 /50
3	40% wool + 60% polyester	JP40 /60

Methods of determining the structure and physical-mechanical properties of fibers and threads

Before determining the quality indicators of fibers and yarns obtained from a mixture of fibers with different composition, the samples were stored in climatic conditions according to the GOST 10681-75 standard [66].

The quality indicators of cotton and wool fibers were determined in the laboratory at the Cotton Industry Scientific Center JSC. The quality indicators of cotton and wool fibers were determined with an error of 2.2% (relative).

The quality indicators of cotton and wool fibers were determined according to the standard. Sampling was carried out according to the UzDSt 614-2014 standard [67],

the relative breaking strength of cotton fibers was determined according to the UzDSt 619-2014 standard [68], the linear density and micron index of cotton fibers were determined according to the UzDSt 620-2014 standard [69], and the length of cotton fibers was determined according to the UzDSt 633-2010 standard [70].

The structure of the fibers was analyzed using a scanning electron microscope. The research was conducted at the Center for Innovative Technologies. For this, a SEM-EVO MA 10 (Zeiss, Germany) instrument was used to study the structure of the obtained fibers using a scanning electron microscope .

Scanning electron microscope: the principle of operation is based on the fact that it emits electron beams of different energies. It is directed at the sample under study in the form of a spot with a size of no more than 5 nm. Due to this spot, the entire surface of the object is scanned. When the electron beams collide with the surface of the object, they penetrate it only slightly, while the process of emitting not only electrons, but also photons from the object itself, which enter the cathode and the light tube, in which they are converted into an image, occurs.

The twist of wool and cotton fibers was determined. For this, samples were taken from the fibers and the number of twists per cm of 100 fibers was counted under an MBI-6 microscope with a magnification of 300 times. The tests were carried out in three replicates.

in the testing laboratory of the SAGDIANA (Limited Liability Company) enterprise using the Uster Tester-5 device.

The composition of the Uster instrument consists of the following parts: an instrument that measures the change in linear density of the product along its length, an integrator, a spectrograph, and two self-moving devices.

The principle circuit of the capacitive device includes two plate capacitor-sensors. These capacitors are included in the chain of generators that generate alternating voltage. The initial frequencies of the generators are the same, that is, the frequency difference is zero.

The "Uster-Tester-5" equipment is fully automated and provides complete information on the quality of raw products and spun yarns.

Sampling of knitting yarns is carried out according to the GOST 6611.0-83 standard [71].

The linear density of knitting yarns is determined according to the GOST 6611.1-83 standard [72], and the yarn density is determined according to the GOST 6611.3-83 standard [73]. The linear density of knitting yarns was determined with an error of 3.3% (relative).

The determination of yarn elongation and shrinkage during weaving was carried out according to the standard GOST 6611.3-83. "Textile yarns. Determination of elongation and shrinkage during weaving". The determination of yarn elongation and shrinkage during weaving was carried out with an error of 3.8% (relative) [73].

GOST ISO 2062-2014 "Textile yarns. Determination of strength and elongation at break" method. The strength and elongation at break of yarns are determined using the "Statimat-C" instrument.

UzDSt 2321:2011 "Cotton and mixed fiber yarns obtained by the combing method on a pneumatic spinning machine for weaving. Technical conditions" [74]. The results of the obtained mixed composition yarns were compared with the requirements of the standard.

Application of the emulsification method in the blending of softened local wool and polyester, wool and acrylic fibers.

The emulsification process, which is performed before blending softened local wool fibers with synthetic fibers such as polyester (PET) and acrylic (PAN), is a very important process in today's textile industry. This process improves the physical, mechanical, chemical, and hygienic properties of wool, increases adhesion between different fibers, and produces high-quality, uniform-structured yarns and fabrics.

According to the nature of wool, it is a natural protein fiber formed on the basis of keratin, and the cuticle covers its surface. This coating is hydrophobic and has poor adhesion to synthetic fibers. Therefore, it is necessary to modify the surface of wool by **emulsification** before mixing it with synthetic fibers (in particular, hydrophobic polyester and acrylic).

In emulsification usually **emulsifiers**, **titration tools**, **antistatic substances** and **glycerin** is used. They are wool fiber on the surface ultradrink, dilution, and his/her liquid good with synthetic components in the environment intervention provides. This is the process woolen begins with softening — urea, glycerin, emulsifiers and organic acids to the cuticle layer using impact and wool fiber from fragility to the plastic-elastic state will be brought.

Synthetic fibers such as polyester or acrylic wool to a relatively steep structure, on the surface micropores absence because it is easy with natural fiber does not interfere. But emulsification method through to the wool surface hydrophilic groups connection, static electricity charges decrease and under the effect of emulsion it to synthetic fibers relatively good contact person takes color. And this thread work in the processes harvest will be mixture complete qualitative and same structure to do possible gives.

In emulsification applicable from substances one - **oxyethylene nonionic emulsifiers** are, they are synthetic and natural fibers between elasticity reduces. Also **stabilizers**,

for example , based on glycerin and sorbitol substances , wool fiber humidity good holding to stand provides and again construction of fiber rupture during ahead will take

Note verb this is necessary method only mechanical connection not , but chemical to connect , that is **hydrogen bonds** and Van **der Waals** of **the forces** appearance to be both help This gives ready mechanical strength and elasticity of the thread and cleanliness increases .

Conclusion as in other words , emulsification method - effectively blend local wool fiber with synthetic components mixing , re work in the process to the surface incoming physical indicators stabilization , quality thread and fabric work to release for important factor is considered Based on this conclusion, a recipe was prepared for obtaining yarn by emulsion in two variants for the preparation of a 100 kg finished product based **on a 2-variant wool mixture** (Tables 2.-2.1) .

Emulsion recipe option 1-2, which is performed before blending softened karakul wool fiber with polyester (PET) and acrylic (PAN) synthetic fibers

Table-2

Component	Quantity (%)	Function
Option 1		
Diluted lanolin	2 , 0	Natural fat recovery , softening
Glycerin	1 , 5	Humidity to keep
Antistatic agent	0 , 5	Static charger reduction
Emulsifier (Tween 20)	1 , 0	Stable distribution
Distilled water	95 , 0	Main solution
Option 2		
Diluted lanolin	1 , 0	Wool part for softening
Glycerin	2 , 0	Acrylic moisture good does not save
Antistatic agent	0 , 7	Acrylic has a high static charge
Emulsifier (Tween 20)	1 , 0	Stable distribution
Distilled water	95 , 3	Main solution
Option 3		
C conjugated lanolin	0 , 8	Wool part for softening
Glycerin	2 , 5	Polyester moisture wicking less keeps
Antistatic agent	1 , 0	Polyester has a high static charge
Emulsifier (Tween 20)	1 , 2	Stable distribution

Distilled water	94 , 5	Main solution
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The preparation of softened 100% karakul wool fiber by spreading the wool fiber with separate acrylic (PAN) fiber and separate polyester fiber in layers and spraying an emulsion on each layer before blending was used to **improve the uniformity and spinnability of the blend** , and the emulsion composition in this recipe was applied to three different fiber blends and the results were analyzed (Table 2.1). Changes in the quality indicators of kalava yarns with different fiber content and emulsification content

Table 2.1

t/r	Indicators	Fiber content, %			ISO 2062-2014	
		100% wool	50% wool and 50% acrylic	40% wool and 60% polyester	right-wing	Difference,%
The results of applying the emulsion in option 1						
1.	Linear density of thread, tex	28.1	28.4	28.4		
2.	Coefficient of variation in the linear density of the thread, %	2.9	3.4	3.1		
3.	The number of twists of the thread, br / m	720	744	742		
4.	Coefficient of variation in the number of twists of the thread, %	8.2	9.7	8.8		
5.	Tensile strength of the thread, cN	378.25	461.4	467.2		
6.	Coefficient of variation in the tensile strength of the thread, %	8 .38	8.91	9.42	11.5	24.0

7.	Comparison of yarn breaking force, cN/tex	13.46	16.25	16.45	10.0	4.4
8.	Elongation of thread at break, %	17.13	15.21	18.82		
9.	Coefficient of variation in thread elongation at break, %	12.4	12.68	15.39		
Results after applying the emulsion in option 2						
1.	Linear density of thread, tex	28.3	28.0	28.4		
2.	Coefficient of variation in the linear density of the thread, %	3.1	2.6	2.8		
3.	The number of twists of the thread, br / m	726	740	754		
4.	Coefficient of variation in the number of twists of the thread, %	9.4	8.8	9.0		
5.	Tensile strength of the thread, cN	358.6	481.6	468.40		
6.	Coefficient of variation in the tensile strength of the thread, %	8.20	8.15	8.10	11.5	28.6
7.	Specific tensile strength of the thread, cN/tex	12.67	17.2	16.49	10.0	15.3
8.	Elongation of thread at break, %	16.46	17.24	18.60		

9.	Coefficient of variation in thread elongation at break, %	15.5	12.2	14.6		
Results after applying the emulsion in option 3						
1.	Linear density of thread, tex	28.4	28.3	28.3		
2.	Coefficient of variation in the linear density of the yarn, %	3.5	3.2	2.8		
3.	The number of twists of the thread, br / m	728	736	750		
4.	Coefficient of variation in the number of twists of the thread, %	9.3	9.1	8.9		
5.	Tensile strength of the thread, cN	349.4	472.3	506.8		
6.	Coefficient of variation in the tensile strength of the thread, %	8.6	8.4	8.1	11.5	26.6
7.	Specific tensile strength of the thread, cN/tex	12.29	16.69	17.9	10.0	16.3
8.	Elongation of thread at break, %	16.1	17.4	18.82		
9.	Coefficient of variation in thread elongation at break, %	14.8	13.3	12.4		

is at a temperature of 40–45 °C if it is prepared , it is oily substances better melts and to the fiber good It is soaked .

spraying the emulsion 24 hours later in storage microbes lack of development for add a preservative (0.2% sodium benzoate). possible

Mixing in the process in fibers uniform humidity preservation important Processing to give time usually 20-30 minutes does , then the fiber is too much from moisture isolated and natural or at low temperature dried .

According to the results presented in Table 2.1, it was found that the emulsion in option 1 is recommended to be used before blending fibers when producing 100% wool fibers, the emulsion in option 2 is recommended before blending 50% wool and 50% acrylic fibers, and the emulsion in option 3 is recommended before blending 40% wool and 60% polyester fibers, and accordingly, it was determined that it is possible to develop a yarn production technology.

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