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Methods for Determining Quality Characteristics Wool Fibers

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Abstract:
This article presents the distinctive characteristics of methods for determining an important qualitative characteristic of wool fibers such as fineness, which determines the different industrial purposes of wool and is the basis for differences in spinning ability.

Keywords: wool, average diameter, projection microscope, Air-Flow device, OFDA device, LASERSCAN, AIR-FLOW.

1. Introduction

One of the key factors in the development of the wool industry in any country is the sustainable development of its own raw material base and, above all, the development of domestic sheep breeding and the production of natural wool [1].

Wool possesses a specific set of attributes that directly or indirectly determine its productivity and quality characteristics, ultimately influencing the technology used to process wool into finished products. Most researchers focus primarily on fineness, placing it at the forefront of wool's properties. Wool quality varies depending on two main factors: fineness and the standard deviation of fineness. Other quality factors include strength, length, contaminants, uniformity, and color [2].

Fineness is one of the most important properties of wool, determined by the thickness of the fibers that form it. The thickness and, consequently, the quantity of yarn obtained depend on the fineness of the wool fibers; this, in turn, determines the thickness, weight, and footage of the fabric. The fineness of wool fibers depends on the breed, sex, age, and individual characteristics of the animals. However, the wool of the same animal never grows to exactly the same fineness from shearing to shearing. The greater the fluctuations in the feeding of sheep, the more dramatic the changes in the supply of nutrients to the hair root cells and the greater the unevenness in its thickness. Abrupt changes in the fineness of wool fibers due to underfeeding or illness are called hunger wool fineness [3], [4], [5]. Thinner zones of wool fibers, easily visible to the naked eye, surrounded by zones of normal wool fineness, are called traces (interception, step). The technological quality of wool improves as we move toward finer types of wool obtained from animals provided with normal feeding and maintenance. For the processing of wool into yarn and fabric, uniformity of fiber fineness along its entire length is of utmost importance. Therefore, ridges and poor fineness of wool are major defects [6].

2. Materials and Methods

Fineness is one of the important systematic features in the evaluation and classification of sheep and wool, which is defined as follows :

Visual (organoleptic) method. In animal science, wool fineness is determined by an organoleptic, expert method, comparing it to various standards. The method consists of determining the fineness of the fibers that make up the staple by visual inspection. During inspection, the staple is clamped longitudinally between the index finger and thumb of the right and left hands and spread apart to form a mesh of fibers between the fingers. Fineness is also determined by comparison with a fineness chart or standard samples. A wool fineness chart is a series of reference (standard) samples of wool fineness of 70, 64, 60, and 58 qualities, enclosed in a transparent plexiglass box [7].

To more accurately determine the fineness, a bundle of wool being tested should be split in several places to reveal individual fibers, and then placed against a standard of equivalent fineness. It should be kept in mind that the more the wool is split, the finer it appears. Therefore, when determining wool fineness by expert means, it is important to combine visual assessment using a standard with the expert's fingertips. The organoleptic method is used in industrial settings for sheep grading, wool classification, and sorting, which requires extensive experience and high qualifications.

In addition to those specified by the standard, other visual methods for determining wool fineness are also used, including the UATSh-2M device. This device is an improved modification of the fineness tablet and allows for the examination of compared samples under magnification. A magnifying glass with diopter adjustment serves as the eyepiece. A cassette, consisting of two microscope slides secured with clamps, is mounted in a carriage so that both the cassette with the test sample and the reference sample are simultaneously within the eyepiece's field of view. The carriage can be moved along the holder from reference to reference and perpendicularly across the test and reference samples [8].

Over the past 200 years, the wool industry has been pioneering in its efforts to develop technology for measuring the diameter distribution characteristics of wool. Important attention Before selecting a technology for potential evaluation, consideration is given to ensuring that the technology is capable of measuring a characteristic directly or indirectly related to one or more geometric properties that actually determine the fiber's fineness, namely, the cross-sectional area and the width of the two-dimensional projected image. A number of devices, such as a micrometer and a micrometer caliper, are available for measuring the thickness, in fractions of a meter, of various thin materials [9], [10].

3. Results and Discussion

A projection microscope, optical fiber diameter analyzer, and laser beam directly measure the average fiber diameter in a wool sample, while Airflow (AF) and near-infrared methods measure it indirectly. Measurements that are characteristic of fiber groups (e.g., staple characteristics, contamination and volume, resistance to compression (RtC)) can also be measured directly or indirectly [11].

In production conditions, wool fineness is determined organoleptically, with 3-5 staples selected from different parts of the fleece. Each staple is alternately grasped by the ends between the thumb and index finger of both hands, spread until a grid is formed, and examined to determine the fiber fineness and uniformity of fineness. When determining the fineness class of homogeneous wool, reference wool samples are sometimes used (in cases of disagreement, etc). For a more precise determination of wool fineness, a laboratory method is used, in which the cross-sectional diameter of the wool fiber is determined under a microscope or with a lanameter and expressed in micrometers [12].

A laboratory method for determining wool fineness is known from a literary source, which includes the following operations: sampling and preparation of the preparation, determination of fiber fineness, calculation of the average diameter and degree of equalization of fibers. A laboratory mass of at least 20 g is separated from the total sample using the stencil-mesh method , information about which is recorded in the passport. The laboratory sample is washed in two tanks in a soap-soda solution containing 2 g of 60% soap and 3 g of soda ash in water at 45-50 °C. In the third tank, the wool is rinsed in clean water at 38-40 °C. The washed sample is kept in a drying cabinet at 60-70 °C for about an hour; then for 2 hours at room temperature . After drying, three weighed portions of 3-5 g each are prepared from the sample; two are analyzed, and the third is left as a control. Each sample is averaged by extracting fiber staples from it and stacking them in such a way that the tops of some are at the bases of others. From this bundle, fiber segments no longer than 1 mm are cut from each end along its entire length with scissors or a special razor knife at every centimeter . The resulting fiber segments from each sample are placed in separate cups with immersion liquid and thoroughly mixed with a glass rod until a homogeneous suspension is obtained. One or two drops of the suspension are applied to a glass slide with a glass rod or needle and covered with a coverslip. The prepared preparation is placed on the stage of a microscope or lanameter. A microscope with a magnification of 400x is used, with the value of one division of the micrometer eyepiece no more than 4 μm, and a lanameter – 500 times with a division value of 2 μ m [13].

In total, 200 fibers are measured in each sample of uniform wool (400 in total); in each sample of non-uniform wool , 300 fibers are measured (600 in total). When measuring the fineness of wool from For animals from breeding farms, the number of fibers evaluated can be reduced to 200 (100 in each sample) for uniform wool and to 300 (150 in each sample) for non-uniform wool. The results are recorded in the wool fiber fineness analysis card [14].

Another method for measuring wool fineness is using an Air-Flow device . In this method, a pre-selected sample is purified of all impurities using a Shirley analyzer (or laboratory mixer), then placed in a climate chamber for 24 hours, where it is maintained under standard conditions: temperature of 20°C, relative humidity of 65%, and atmospheric pressure of 1000 Hg [8].

It is especially important to maintain standard conditions in the climate chamber, since their influence on the result of measuring the wool fineness using the Air-Flow device is very significant (Table 1.).

The influence of climate chamber parameters on the result of wool fineness measurement using the Air-Flow device [15].

Table 1. Fineness of wool, μ m

Standard conditions	Non-standard conditions	
	Atmospheric pressure 800 ммHg	**Relative humidity 50%**
20	20.2	20.3
25	25.2	25.4
30	30.3	30.5

From pre-prepared subsamples for fineness testing using the Air-Flow instrument. Each sample weighs 2.5 g (±0.004 g). Each sample is analyzed twice (removed from the instrument and inverted). It is recommended to test it on two independent instruments, which significantly improves the accuracy of the results.

In their textbook " Wool Science, " authors V.I. Trukhachev and V.A. Moroz describe various designs and operating principles of devices for assessing the fineness of wool fiber. For example, the OFDA device. As early as the 1970s and 1980s, research began in Australia, and later in other countries, into various designs of fineness assessment devices based on the analysis of an optical sample scanned by a laser beam or other device. The OFDA device has found greatest application in New Zealand and South Africa, although it was developed by the Australian company BSC. The following sequence is followed when preparing samples for testing and analysis. First, fairly compact samples are prepared—more than 2,000 pieces of wool fibers, each approximately 2 mm long [7].

In this case, preparation is carried out using special devices: a guillotine knife or a mini-corr with an internal diameter of about 2 mm.

The fiber pieces are then placed in a special chamber, from which they are then passed sequentially (one at a time) into a channel containing a transport fluid, where the fiber sample is scanned by the beam. The scanning results are transferred to a computer for recording and subsequent analysis. The OFDA instrument's software eliminates questionable scanning results. Therefore, approximately 50% of readings are not included in the final scan results. The entire scanning process, involving 2,000 samples, takes 2 minutes [6].

The OFDA-2000 is a software-based optical wool fiber diameter analyzer. Using the OFDA-2000 allows you to obtain the following parameters and characteristics:

1. Average diameter of wool, μ m ;
2. Histogram of the average wool diameter;
3. Standard deviation of diameter, μ m ;
4. Coefficient of variation, %;
5. The point of minimum wool diameter, μ m ;
6. Comfort factor (the percentage of fibers with a diameter of 30 microns or less. A higher comfort factor indicates the possibility of producing higher-quality fabric);
7. Staple profile;
8. Fiber curvature (twist), which is characterized by the angle of inclination of the fibers or the value of fiber bending in degrees per millimeter.

Important feature device is quantity studied V samples hairs. If when determining the tone wool on lanometer is being investigated 100–200 fibers, That device OFDA-2000 measures up to 15000, what significantly increases accuracy definitions [5].

Laserscan device. Samples for wool fineness analysis on the Laserscan device are prepared similarly to the method described for the OFDA device.

This device not only determines the fineness and coefficient of variation of wool fiber fineness but also analyzes the degree of development of the internal canal (medulla). The Laserscan uses an 8% aqueous isopropanol solution as the transport fluid. The scan results are transferred to a computer for recording and subsequent analysis. The Laserscan software rejects questionable scan results; therefore, approximately 30% of readings are not included in the final scan results. The entire scanning process, involving 2,000 samples (fiber pieces), takes 2 minutes [5]. When examining hair with a Laserscan device, it is recommended to first remove various impurities from the fibers (by performing laboratory washing, pressing, and drying). These three devices allow for a quick determination of average fineness, but do not provide an indication of the uniformity of the fibers in the staple and are therefore considered unsuitable for sheep evaluation. In the article by the authors N.K. Timoshenko and N.T. Razgonov "Methods and problems of measuring the fineness of wool in domestic practice", various methods for determining the fineness of wool fibers are analyzed and the errors in measuring fineness are calculated [9]. Based on the laboratory testing carried out by the International Association of Wool Textile Laboratories (Interwoollabs), the reliability of the average diameter measurement for each named method is generally accepted [9], which is presented in Table 2.

Table 2. Error in measuring the fineness (average diameter) of wool using different evaluation methods

Name of the method	**Method error (P=0.95)**	
	22.0 µ m	**37.0 µm**
Optical methods		
Microscope	±0.90	±1.15
OFDA	±0.36	±0.65
LASERSCAN	±0.32	±0.70
Air flow method		
AIR-FLOW (constant pressure)	±0.45	±0.90
AIR-FLOW (constant flow)	±0.45	±0.90

It is in the above-mentioned literature that it was revealed that registration experimental data And processing results V in accordance with international demand IWTO - 28 - 93 "Determination of the average diameter of wool fibers by the air method", where a device based on the air flow method is used several easier. Table 3 shows the IWTO standards for the accuracy of measuring wool fineness using various devices depending on the average fiber fineness [10].

Table 3. Comparison of the accuracy of wool fineness measurements using various instrumental methods

Name of the method	**Measurement accuracy (at confidence level P=0.95), µ m at wool fineness**	
	20.0 µ m	35.0 µm
Projection microscope	±0.87	±1.07
AIR-FLOW	±0.45	±0.80
OFDA	±0.36	±0.67
LASERSCAN	±0.32	±0.70

4. Conclusion.

Disadvantage named methods is their high labor intensity and big cost time on tests. That's why optic method With using microscope for definitions indicators fineness wool V wool-producing farms, How rule, Not works, Yes And V industry He is used enough rare. Method definitions average diameter fibers wool method air flow Not received ubiquitous applications By reason high cost of foreign devices type Air-

Flow, OFDA [9].

Thus, the most important indicator at sorting wool is indicator average diameter fiber (fineness), which is main criterion assessment of its spinning ability and is used in setting the price. Correct organization sorting And classifications local woolen fiber that depends from quality measuring processes and the accuracy of the measuring instruments used will ensure rational usage raw materials, stable leaks technological processes spinning , weaving And finishing, which ensures the production of competitive products. In connection with this situation, scientific and research aimed at on development And implementation more perfect testing devices For accurate fast, objective definitions average diameter (fineness) of wool fibers And corresponding methods assessment of its properties.

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