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# SOME BASIC STUDIES ON KUKA WOOL FIBRES

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Forty samples of Kuka wool were selected at random from full fleeces. The fleeces were collected from the markets in the native habitat of the sheep, i.e. Dadu and Jacobabad. The samples were sorted into fibre types where necessary and were then subjected to dimensional measurements viz, diameter, length, medullation, mechanical properties and physico-chemical characteristics such as alkali solubility, clean wool content and vegetable matter, wool wax, suint, ash and regain were also determined.

***Key words:*** Physico-chemical and mechanical characteristics of indigenous wool.

## Introduction

In terms of quality, wool has generally been classified internationally into only four types [1], viz, fine, medium, long and carpet or mixed wool. Pakistan wool is carpet or mixed type and as such is recognised amongst the leading carpet wools of the world. Pakistan produced more than 53 million kg of wool [2] in 1986-87. After meeting the need at home, the surplus is exported as a mixed or carpet wool. Export in the same year was 9.42 million kg worth 19.42 million U.S. dollars. Pakistan imports pure fine wool for woollen and worsted spinning at home. The import was more than 6 million kg of scoured and greasy wool, the average price of our wool exported was 2.06 $/kg whereas the cost of imported wool was 2.95 $/kg.

Kuka breed [3,4] also pronounced as Kooka [5] and Koka [6] elsewhere, is located in Khairpur and Hyderabad Divisions representing Jacobabad, Larkana, Khairpur, Nawab Shah, Dadu and Hyderabad proper. The altitude of the Kuka habitat is approximately 500 ft., longitude is 66 to 70°, and latitude 28°. The average annual rain fall varies from 3.5 to 12.2 inches, with temperature as high as 110°F, and relative humidity ranging in between 14-78%. The area produces about 10% of the National wool clip.

The study provides an objective assessment of the quality of Kuka wool with the basis for its improvement on scientific lines, which is complimentory to our major project known as standardisation of Pak. wools. This work is completed analogous to earlier studies to gain indication of the relative suitability of Kuka wool for carpet manufacturing. The potential to improve the quality of wool is also discussed.

## Materials and Methods

*Wool samples.* Forty samples of uniform staple length were selected for the present study. Twenty sub-samples were sorted into true, heterotypical and medullated wool fibres, using the benzene test [7] for subsequent determination of diameter, length and strength. The remaining samples were mixed together thoroughly to make one representative sample. This was subsequently used in the determination of various physico-chemical characteristics and general average fibre diameter. In addition to the above, four samples of Lohi, Terahi, Damani and Kaghani wool were also included in this study, for the comparative purposes.

Dimensional Measurements.

*(i) Diameter.* The average diameter and the diameter of true, heterotypical and medullated wool fibres was determined using a Lanameter [8] at a magnification of x 500. To prepare the slide fibres were cut to the size of approximately 0.5 mm in length, aligned on the slide and covered with cover slips by securing with a layer of glycerine. About 500 readings were taken for each slide.

*(ii) Length.* A meter rod was used for the determination of the length of each of the true, heterotypical and medullated wool fibres. About 50 fibres of each type of 20 x 3 samples were used.

*(iii) Medullation.* A 5g sub-sample of wool from each of the 20 samples was separated into true, heterotypical and medullated fibres using the aforesaid benzene test. The percentage of each type was calculated by count.

Mechanical Characteristics.

*(i) Strength and strain measurement.* Force and elongation required to break the fibre was determined on about 20 representative fibres of each wool type *viz;* true, heterotypical and medullated from each of 20 samples. For this a hydraulically operated Schopper dynamometric apparatus [9] was used with the flow of water adjusted so that the time required to break the fibre was approximately 20 sec.

*(ii) Diameter.* Before determination of breaking strength and strain on each fibre the diameter was measured

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TABLE 1. DIMENSIONS OF KUKA WOOL FIBRES.

| Characteristics | General | | True | | Het | | Med. | |
|---|---|---|---|---|---|---|---|---|
| | Mean | C.V. | Mean | C.V. | Mean | C.V. | Mean | C.V. |
| Diameter (μm) | 40.7 | 45.30 | 23.50 | 31.7 | 42.2 | 36.3 | 60.3 | 26.5 |
| Fibre length(cm) | 4.8±.07 | 8.54 | 3.2±.05 | 11.0 | 5.4±.06 | 6.5 | 5.8±.08 | 8.2 |

by aligning the individual fibres on a glass-slide with glycerine and covered with glass-strip. Diameter was measured at about 20 different places and the mean value estimated and subsequently used for calculating [10] stress, tenacity and tensile strength.

PHYSICO CHEMICAL CHARACTERISTICS.

*(i) Alkali solubility.* Twenty five, one gram representative samples of each breed were used for each determination. The clean wool sample was dried, weighed and treated with 100 ml of decinormal NaOH solution at 65° for one hr at a constant volume [11]. The samples were filtered into a Gooch crucible, washed with plenty of water, dried at 105° and reweighed. The percentage of the loss in weight was then calculated.

*(ii) Clean wool content.* The clean wool content is based on the net weight and as a transanction necessity, it is pre-determined by applying correction for certain constants viz. moisture, ash, wax and vegetable matter depending upon local climatic conditions, i.e. temperature and relative humidity. The clean wool content has been determined by the ASTM method [12] and calculations are made according to Wool Test House, Karachi [13] incorporating the following fixed values of the various constants. Moisture 12%, vegetable matter 0.0%, wax 1.5% and ash 0.5%.

*(iii) Vegetable matter.* This aims at the determination [14] of the percentage of ash-free and wax-free vegetable matter such as seeds, burrs, twigs, leaves, stalks and grasses in the scoured and oven dried wool.

*(iv) Wool wax.* It was determined by the routine method using Soxhlet extraction apparatus with petroleum ether as a solvent.

*(v) Suint %.* The method adopted by A.H. Mohsin [15] was followed for the determination of suint percentage.

*(vi) Ash %.* 2g of wool after being dried at 105° and accurately weighed, was put in the muffle furnace at 800°.

*(vii) Regain.* Regain or moisture content was measured by the usual oven method [16] employing 2g of sample for each determination.

## Results and Discussion

The results of dimensional measurements, *viz.* diameter length and medullation of Kuka wool fibres are shown in Table 1. The average fibre diameter of 40.7 μm corresponds to a $36^s$ quality number, the diameter of true wool (21.6 μm) is of a $60^s$ quality. Higher variation in fineness of the diameter of heterotypical wool is observed while the medullated wool fibres are more uniform. The average length of true wool fibres ranges between 2.8 to 4.4 cm, that of heterotypical between 4.5 to 6.0 cm and medullated between 4.5 to 6.6 cm. The standard deviation in the lengths of true and heterotypical fibres was 0.35 while the same value for medullated fibres was 0.47. The proportion of true wool fibres in the samples of 59.1% is very close to the proportion in Damani wool fibres (60.3%), whereas the proportion of medullated wool fibres is the least (19.1%) after Kaghani wool fibres (16.5%). The contents of heterotypical wool fibres (21.8%) is almost identical with Tarahi wool fibres (21.9%) as given in Table 2.

TABLE 2. COMPARATIVE PERCENTAGE COMPOSITION OF TRUE, HETEROTYPICAL (HET.) AND MEDULLATED (MED.) WOOL FIBRES OF DIFFERENT WOOLS.

| Breed | True wool fibres (%) | Het. wool fibres (%) | Med. wool fibres (%) |
|---|---|---|---|
| Lohi | 51.4 | 18.1 | 30.5 |
| Terahi | 54.9 | 21.9 | 23.2 |
| Damani | 60.3 | 18.8 | 20.9 |
| Kaghani | 65.7 | 16.6 | 17.7 |
| Kuka | 59.1 | 21.8 | 19.1 |

Average tensile values at the breaking point and mean diameter of true, heterotypical and medullated wool fibres with their corresponding standard deviations and co-efficient of variations are shown together in Table 3. The mean of stress, tenacity and tensile strength of heterotypical and medullated wool fibres with their corresponding standard deviations and co-efficient of variations are shown together in Table 3. The mean of stress, tenacity and tensile strength of heterotypical and medullated wool fibres is less than the corresponding values of the true wool fibres. The true wool fibres are approximately 2.8 times stronger than the medullated wool fibres. The overall mean value of tensile strength of the true, heterotypical and medullated wool fibres taken together is 1947 kg/cm². This compares with a highest value recorded of 2090 kg/cm² for Makrani wool fibres

TABLE 3. STANDARD DEVIATION (S.D.), CO-EFFICIENT OF VARIATION (CV) AND MEAN VALUES OF DIAMETER AND TENSILE VALUES OF TRUE, HETEROTYPICAL AND MEDULLATED WOOL FIBRES.

| Types of fibres | SD/CV | Diameter (μm) | Strength (gms wt.) | Stress (mg/μm²) | Strain (%) | Tenacity (gms/den) | Tensile strength (kg/cm²) |
|---|---|---|---|---|---|---|---|
| | Mean | 21.60 | 9.30 | 25.90 | 24.30 | 2.22 | 2589 |
| True | SD | 2.99 | 1.90 | 5.26 | 4.87 | 0.49 | 592 |
| | CV | 13.80 | 20.46 | 20.32 | 19.64 | 22.00 | 22.87 |
| | Mean | 37.60 | 24.00 | 23.40 | 25.60 | 2.21 | 2323 |
| Het. | SD | 6.90 | 3.63 | 7.53 | 6.30 | 0.70 | 643 |
| | CV | 18.30 | 15.13 | 32.16 | 24.61 | 31.46 | 32.01 |
| | Mean | 56.40 | 23.30 | 9.30 | 19.00 | 0.89 | 929 |
| Med. | SD | 3.04 | 3.33 | 1.38 | 6.71 | 0.13 | 137 |
| | CV | 5.30 | 14.32 | 14.86 | 35.32 | 14.54 | 14.75 |

[17] and 1870 kg/cm² for Terahi wool [18].

Elongation percentage or strain at the breaking point of true, heterotypical and medullated wool fibres as presented in Table 3 is low. The true wool fibres are elongated to 24.3%; heterotypical to 25.6% and medullated to only 19.0%. These low values become more striking when viewed in comparison to tensile strength. The resultant low values of strain accompanied with high values of stress seems to be a special feature of the kuka wool fibres. This feature of the wool can be explained on the basis of the structural theory formulated by Blackburn [19] in terms of the crystalline to amorphous ratio occuring in a keratinised tissue, which ultimately governs the mechanical i.e. stress-strain or elastic and chemical behaviour of wool fibres. In this case of Kuka wool fibres, higher stress values with corresponding low values of strain suggest that the crystalline to amorphous ratio is likely to be higher. Such wool, on the basis of the above theory, may be described as having low plasticity, which requires investigations by employing modern techniques of X-rays.

The average elongation of kuka wool fibres, as given in Table 3, is 23.0%, which is less than 25% elongation required for weaving apparel cloth. This feature of the kuka wool fibres merits the special attention from wool growers of the area for its improvement through sheep breeding. Cross-breeding with the Lohi breed is a good option from within the country. The mean elongation of Lohi wool fibres [20] was recorded as 47.3% with a relatively low value of tensile strength (1162 kg/cm²). The cross breed wool so obtained may improve in elongation.

Damage due to weather conditions prevailing in the area inhabited by the breed is in the Table 4. The action of the attacking agents of weather such as air, rain, sunlight, etc. loosen the crystals or damage the amorphous structure of wool which is then dissolved more easily in alkali. The harder and orientated the crystalline region in the fibre structure, the more difficult it is to be attacked by any

TABLE 4. COMPARISON OF WEATHERING DAMAGE OF KUKA BREED WITH OTHER BREEDS OF PAKISTAN.

| Breed | Mean damage % | Co-efficient of variation % |
|---|---|---|
| Lohi | 18.5 | 32.1 |
| Terahi | 8.0 | 20.5 |
| Damani | 7.2 | 23.2 |
| Kaghani | 4.1 | 18.7 |
| Kuka | 2.8 | 10.3 |

reagent. Therefore, the measure of solubility of the fibre in NaOH solution would indicate the relative damage and hence, the crystalline nature of the wool fibres. Viewing the Table in this perspect, it becomes evident that kuka wool fibres have the damage (alkali solubility 2.8%) which is low relative to other breeds while the highest damage recorded is 18.5% for Lohi wool fibres. This indicates that the structure of kuka wool fibres is highly crystalline, and resistant to environmental factors such as sunlight, micro-organisms, rain and wind.

Clean wool content and other extraneous constituents of the Kuka wool fibres are reported in Table 5. Clean wool content commonly known as yield and regain are very important from a commercial point of view. The yield is variable and depends on the environmental conditions in which the breed dwells. Since the conditions in under-developed countries are usually rough and dirty; vegetable matter like seeds, twigs, burs, leaves etc. picked up by sheep during grazing. The average vegetable matter of 1.10% which is similar to the Lohi wool fibres of 1.25%. Suint and wax percentages for the Kuka wool fibres have been found as 2.82% and 0.92% while the same values for Lohi wool as reported earlier [21] are 2.50% and 0.53%. The ash at 2.40% is very similar to the ash percentage of Lohi wool (2.46%). The regain reported in the same Table is as 11.93% at 65% relative humidity and 25°.

The various measurements for kukâ wool when

TABLE 5. CLEAN WOOL CONTENT AND EXTRANEOUS MATTER OF KUKA WOOL.

| S.No. | Constituents | Mean (%) |
|---|---|---|
| 1 | Clean wool content | 52.90 |
| 2 | Wax | 0.92 |
| 3 | Vegetable matter | 1.10 |
| 4 | Ash | 2.40 |
| 5 | Suint | 2.82 |
| 6 | Regain | 11.93 |

compared with the tentative standards set by Johnson and Chen [22] for ideal carpet wool, are satisfactory in terms of fibre thickness and stretched length, but not of true wool fibre content. The true wool fibre content of the kuka breed is 59.1%, this is close to Vicanere wool (59.22%) of true wool fibres but is well below the other leading carpet wools, e.g. Allepo to Romney that range from 74.69% to 100%. The wool as such may be used for carpet manufacture, however, methods of selective cross breeding are required to produce the desired fibre for the carpet industry.

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## References

1. W.V. Bergerand and H.R. Mauers, *American Wool Handbook* (Textile Book Publisher Inc. New York, 1948), 2nd ed., pp. 78.
2. Anonymous, *Pakistan Textile Statistics* (T.I.R.D.C. Ministry of Industries, Government of Pakistan, 1958).
3. M.L. Ryder and S.K. Stephenson, *Wool Growth* (Academic Press Inc., New York, 1968), pp. 193.
4. I.L. Mason, A *World Dictionary of Livestock Breeds Types and Varieties* (Commonwealth Agricultural Bureaux Farnham Royal, Bucks, England, 1969).
5. Pakistan Wool Test House Report, Karachi (1964), pp. 16, 46, 70.
6. S. M. A. Shah, Mumtaz Fatima and A. H. Mohsin, Pak. j. sci. ind. res., **14,** 551 (1971).
7. *Wool Science Review* (International Wool Secretariat Department of Science and Technology, London, 1954), Issue no. 13, 38
8. A.A. Wakil and Amir Mohammad Khan, Pak. j. sci. ind. res., **6,** 13 (1963).
9. Reference 8.
10. Reference 8.
11. John H. Shinkle, *Textile Testing* (D.B. Tarapore Vala Sons and Co. Private Ltd., 1972), 2nd ed., First Indian Reprint, pp. 299.
12. ASTM *Standards on Textile Materials* (American Society for Testing Materials, Philadelphia, 1961), 32nd ed., pp. 290.
13. Reference 5, pp. 23.
14. Reference 12, pp. 422.
15. A. H. Mohsin and S. M. A. Shah, Pak. j. sci. ind. res., **12,** 286 (1970).
16. Reference 11, pp. 29.
17. Taj Ali Wazir, Faizullah Khan (Late) and A. A. Wakil, Pak. j. sci. ind. res., **10,** 91 (1967).
18. Ghulam Nabi, A. Khaliq and A.A. Wakil, Pak. j. sci. ind. res., **9,** 186 (1966).
19. Blackburn, *Wool science review* (I.W.S., The Department of Science and Technology, London, 1965), Issue no. 22, 8-9.
20. A. A. Wakil and Mumtaz Fatima, Pak. j. sci. ind. res., **9,** 159 (1966).
21. Mumtaz Ahmed, Ghulam Nabi, Pak. j. sci. ind. res., **8,** 272 (1965).
22. H. Mark, Textile Res. J., **8,** 362 (1946).