STUDIES OF THE PHYSICAL, CHEMICAL AND RHEOLOGICAL PROPERTIES OF LOHI WOOL FIBRES

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Lohi wool collected from the breed home tract was tested for physical characteristics such as diameter, length, medullation, moisture content and percentage regain. Strength and stress at 20 percent, 30 percent and at breaking point were also determined of the three types of wool viz. true, heterotypical and medullated. Moreover, the chemical characteristics such as nitrogen content, sulphur percentage, vegetable matter, scouring loss, wool wax and ash percent were also determined. It was concluded that Lohi wool can be utilized in the manufacture of carpets, rugs and blankets. Some suggestions for the development of this breed have been furnished.

Introduction

Pakistani wool obtained from about 17 different breeds of sheep, varies considerably in properties and specifications. Lack of reliable scientific data on the characteristics of Pakistani wool is a great handicap in its industrial exploitation. Earlier work on Pakistani wool was done by Haq[1,2] who discussed the different methods used for the production of wool in Pakistan, and furnished data on fineness of the various varieties found in the country. Burhan-ud-Din and Ahmed[3] determined the ash percentage and vegetable matter of wool of different colours. Rashid[4] studied the relationship between grease content and fineness and lastly Ishaq and S.M. Ali[5] studied medullation in Thalli, Salt range and Lohi breed district sheep. Study of the literature shows that no systematic work has been done on different breeds of Pakistan.

The Wool Research Division of these Laboratories has started systematic research on the various breeds with the aim of finding their characteristics in general and their utility for making wool tops and carpets in particular. In this respect the first paper was published by Maqsood,[6] who studied in detail the important physical characteristics such as medullation, length and diameter of Hashtnagri wool. Mumtaz[7,8] studied strength, length, diameter elongation percentage, tensile strength, crimps/inch and wool wax for Kaghani and Harnai wool. This is the fourth paper of the series in which all the physical characteristics i.e. diameter, medullation, length, crimps/inch, moisture content, regain percentage, diameter of the four types of wool, true, heterotypical, medullated and kempy as well as strength and stress at 2 percent, 20 percent 30 percent and breaking point of the three types of wool have been studied. The chemical characteristics such as sulphur content, nitrogen percentage, scouring loss, ash content, vegetable matter and wool wax have also been determined.

Lohi wool samples were collected from the home tract of the breed area i.e. Lyallpur, Multan, Montgomery and Lahore in the Autumn season (Sept.-Oct., 1962). Full fleeces were collected at random at various places spread over the home tract. About 65 full fleeces were tested for the various physical and chemical properties. Lohi wool is the largest sheep-breed in Pakistan. It comprises about 5.5 million sheep[9] yielding about 4-5 lbs. of wool per sheep annually.

Experimental

1. Physical Characteristics

(*a*) 65 full fleeces were collected at random from about 10 percent of each flock. Representative samples from the various parts of the body wool were tested for medullation. About 500 fibres of the body wool were isolated into true, heterotypical, medullated and kempy wool fibres. It was further tested for diameter and stretched length. In each sample a maximum of 100 in the case of true fibres and about 50 in the case of heterotypical, medullated and kempy fibres were tested for diameter and stretched length. The method employed for the determination of physical properties such as medullation, length, crimps/inch and diameter has already been discussed in the paper on Kaghani wool.[10]

(*b*) *Percentage of Moisture Content and Regain.*— The percentage of moisture content and regain were determined by using the oven method.[11] The empty bottles with covers were placed in the oven at 105°C. until a constant weight was obtained. The bottle was cooled in a desiccater and finally the weight of the empty bottle was noted. 10 g. of wool sample was placed in the oven at a temperature of 105°C. for three hours' until it gave a constant weight.

(*c*) *Load and Stress at Various Extensions.*—The load of the three types of fibres, true, heterotypical and medullated were noted at various extensions i.e. 2 percent, 20 percent, 30 percent and at breaking point by using a dynamometer apparatus. In the case of true wool the extension was kept at 20 percent, while in heterotypical and medullated fibres it was fixed at 30 percent, because true fibres break before 30 percent extension. The diameter of the same fibre was determined after breaking by using a lanometer. The readings were taken at 10 points along the length of the fibre and mean was taken and thus the stress was calculated at various extensions. The coefficient of variation (C.V.) in diameter was determined by using the rapid method.[12]

2. CHEMICAL CHARACTERISTICS

(*a*) *Sulphur Content.*—About 0.2 g. of scoured wool was warmed in a pure 10 percent soduim hydroxide solution until it was dissolved. A few drops of bromine were added and after a few minutes the solution was neutralized with 10 precent nitric acid. 10 cc. of the reagent (25 g. of copper nitrate, 25 g. of sodium chloride and 10 g. of ammonium nitrate was dissolved in water and the solution was made upto 100 cc.) were added and the mixture was evaporated to dryness. The residue was heated to dull redness for 10 minutes, cooled, dissolved in 10 percent HCl and filtered. Sulphate in the filtrate was determined by precipitation with barium chloride and subsequently the percentage of sulphur[13] was determined.

(*b*) *Estimation of Nitrogen.*—About 50 mg. scoured wool was weighed. To this, 1.30 g. of potassium sulphate, 40 mg. mercuric oxide and 2 cc. of sulphuric acid were added. It was heated till it was completely digested and nitrogen was estimated by Microkjeldahl method.

(*c*) *Ash Percentage.*—2-3 g. of scoured wool was first heated at 105°C. to remove moisture, cooled and weighed accurately. It was then charred over Bunsen burner and then placed in a muffle furnace and heated to about 800°C.

(*d*) *Scouring Loss.*—The various impurities such as wool grease, suint, dirt and soil etc. were removed by scouring with soap and alkali.[14]

(*e*) *Vegetable Matter.*—A.S.T.M.[15] method was used for the estimation of vegetable matter.

(*f*) *Wool Wax and Suint.*—Wool wax and suint were determined as recommended by Von Bergen and Mauersberger.[16]

Discussion

In estimating the value and suitability of wool, there are several characteristics which are important in determining the quality. First and the foremost is the fibre diameter or fineness. The length, medullation, moisture content, strength, vegetable matter, nitrogen content, sulphur percentage and ash percentage are also significant.

Lohi wool contains four types of fibres i.e. true, heterotypical, medullated and kempy. The various proportions of the above four types are given in Table 1. This coarseness is due to the absence of selective breeding. The sheep propagate their preservative coat from generation to generation without any improvement. In fine wool, medullation is completely absent or a very small percentage of medullation is present. Lohi wool contains 51 percent true, 10 percent heterotypical, 37.3 percent medullated and 1.8% of kempy wool. Carpet wool, according to Pakistani manufactures, contains lower percentages of true and kempy wool and higher percentages of heterotypical and medullated wool.

TABLE 1.—COMPOSITIONS OF LOHI WOOL FIBRES TYPE.

Type of wool fibre	No. of fibres*	Mean (%)	Range (%)
True ..	15320	50.9	12.8-75.4
Heterotypical ..	3010	10.0	8.7-44.9
Medullated ..	11227	37.3	11.2-79.7
Kempy ..	541	1.8	0–7.0

*Fibres were taken from 65 fleeces.

It is necessary to give a detailed account of fibre fineness as it is the main characteristic which determines the quality of wool. Table 2 shows the diameter of four types of wool along with their co-efficient of variation within single fibres. The co-efficient of variation of Lohi wool is greater than that of Harnai and Kaghani and less than that of Hashtnagri wool. Coarseness is not the only defect in Lohi wool, it is the very uneven spread or distribution of the fineness which is responsible for the inferiority of Lohi wool. The

TABLE 2.—DIAMETER OF LOHI WOOL FIBRES.

Type of wool fibre	No. of fibres tested	Mean μ	Range μ	Coefficient of variation % (C.V.)
True	6302	30.00	22.2-37.9	28.8
Heterotypical	1896	40.70	28.1-52.4	31.0
Medullated	3142	65.20	49.6-99.6	33.1
Kempy	541	57.50	50.8-86.7	35.2

distribution of general fibre diameter i.e. diameter of the staple as a whole, not separated into various types as well as of three types of wool, true, heterotypical and medullated is given in Table 4. The range of general fibre diameter is very wide viz. 10μ—150μ. Most of the fibres are in the range of 10μ-70μ. The mean general fibre diameter of Lohi wool is 45.7μ, which is much higher than Kaghani, Hashtnagri and Harnai wool already tested. Lohi wool, like Hashtnagri, has few crimps, the mean being 0.6 crimps/inch (range 0-4.0). Fibre length also plays a very important part in classifying wool for clothing, combing and carpet. Shorter fibres are suitable for clothing while long fibres are suitable for carpet manufacture.

It is usually seen that the extension of the fibre is proportional to the stress or load up to extension at about 2 percent. It is generally considered[17] that the hydrogen bonds stabilising the helices rupture at this strain to permit the fibre to extend rapidly with only a very small increase in stress. Beyond 2 percent extension, small increments of load bring about larger increments of extension and this continues up to 30 percent extension, at which the stress-strain curve bends over more or less sharply and the fibre becomes more difficult to stretch. True wool fibre breaks before or at this point, while heterotypical and medullated fibres extend to the post yield region.

The co-ordinates at 2 percent strain merit particular attention. The mean stress at 2 percent strain is 14.8 mg./μ² (range 11.3—18.9 percent). In heterotypical wool the mean stress is 7.0 mg./μ² (rang 5.1—11.2 percent) while in medullated wool the mean stress is 5.3 mg./μ² (range 0.9—11.1 percent). This point is extremely sensitive to variation in fibre diameter

TABLE 3.—STRETCHED LENGTH OF LOHI WOOL FIBRES.

Type of wool fibres	No. of fibres tested	Mean (Inches)	Range (Inches)	(C.V. %)
True	6470	3.8	2.6–5.8	30.5
Heterotypical	1903	4.6	2.7–6.2	27.6
Medullated	3212	4.2	2.0–5.6	25.8
Kempy	541	2.3	1.0–3.5	18.6

TABLE 4.—PERCENTAGE DISTRIBUTION OF DIAMETER OF TRUE, HETEROTYPICAL, MEDULLATED AND GENERAL FIBRES OF LOHI WOOL.

Interval (μ)	General fibre diameter (%)	True (%)	Hetero-typical (%)	Medullated (%)
10– 19.9	7.0	14.4	2.8	—
20– 29.9	21.7	46.8	18.2	—
30– 39.9	19.7	28.1	36.9	5.0
40– 49.9	15.1	8.7	27.5	24.8
50– 59.9	12.0	1.9	10.3	22.5
60– 69.9	8.6	—	2.0	16.9
70– 79.9	6.4	—	0.9	12.7
80– 89.9	4.2	—	0.7	6.7
90– 99.9	2.5	—	0.6	4.2
100–109.9	1.4	—	—	3.5
110–119.9	0.8	—	—	1.6
120–129.9	0.3	—	—	1.1
130–139.9	0.2	—	—	0.7
140–149.9	—	—	—	0.2
No. of fibres tested	12586	6302	1896	3142

along the length of the fibre. Coefficient of variation in diameter of true, heterotypical and medullated being 15.4 percent, 13.4 percent and 10.9 percent, respectively. At 30 pereent strain, the heterotypical wool gives a mean stress of 10.8 mg./μ² (range 7.9—16.7) and medullated wool has a mean stress of 7.5 mg./μ² (range 2.0—16.0). These samples give extremely variable results. The mean stress value at breaking point for true wool is 23.3 mg./μ² (range 15.4—28.2), for heterotypical fibre, 12.6 mg./μ² (range 8.5—19.0) and for medullated fibres mean 8.0 mg./μ² (range 2.0—15.5).

Compared with fine type carpet wool,[18] the values of stress at 2 percent, and 30 percent are very high, while the elongation percent at breaking points are very low. The other values such as co-efficient of variation and diameter are also higher. The high values of stress at 30 percent, show that the rheological properties of Lohi woolare similar to those of fibres used in the manufacture of felts and carpets.

There are two kinds of water in wool. The first is hygroscopic water, which is a water mechanically held in the pores of any hygroscopic material. This kind of water can be evaporated by means of heat and then regained when the material is exposed to a moist atmosphere. The other kind of water is the water of hydrate which is chemically bound to the wool substances. In the present work it is the former type that has been discussed. There are two ways in which the amount of moisture in wool can be expressed,

percent moisture and percent regain. In Lohi wool the mean percent moisture was 12.2 percent (range 9.83—14.82 percent) and mean regain 13.7 percent (range 10.82—17.32 percent). The readings were taken at a relative humidity 55 percent and at a temperature of 46°F.

Wool is composed of five elements, carbon, hydrogen, oxygen, nitrogen and sulphur. As most of the stability and instability of wool depends upon functional nitrogen and sulphur groups, we are chiefly interested in the proportion of these two elements in wool. The nitrogen content in wool averages 14.6 percent (range 14.3—14.8 percent). In fine merino wool, the nitrogen content was 16.8 percent. The mean percentage of sulphur in Lohi wool was 2.33 percent (range 2.0—2.7 percent). In fine wool, this percentage is 3.5.[19] The low percentage of sulphur in Lohi wool is due to the fact that the percentage of medullated fibre in this breed is high, for it is claimed that the medulla is completely free from sulphur.[20]

Wool contains various impurities, such as wool wax, suint, dirt, sand and vegetable matter. These impurities must be removed before processing. The scouring process removes wool wax, suint, dirt and sand. Scouring loss in Lohi wool was 17 percent, while the grease content was very low (0.53 percent) but in fine wool the scouring loss is less and wool wax is greater (18 percent).[21] Wool wax is a valuable by-product which is used in the cosmetic industry. In the case of Lohi wool the percentage of wool wax was 0.5 percent and suint was 2.5 percent. Vegetable matter is picked up by the sheep in grazing or lying down. The seeds of several plants have little hooks by which they become firmly attached to the fleece. In Lohi wool the average amount of vegetable matter was 1.2 percent (range 0.1—3.1).

TABLE 5.—STRESS-STRAIN DATA FOR TRUE WOOL FIBRES.

Sr. No.	Diameter (μ)	C.V. %	2% Strain		20% Strain		Breaking point		
			Strength (g. wt.)	Stress (mg./μ²)	Strength (g. wt.)	Stress (mg./μ²)	Strength (g. wt.)	Stress (mg./μ²)	Elongation %
1.	25.2	16.0	8.5	17.0	11.0	22.0	12.5	25.0	24.0
2.	26.8	11.1	10.0	17.7	12.5	22.1	15.0	26.6	24.0
3.	28.4	21.4	11.2	17.6	13.3	17.0	17.8	28.0	27.8
4.	29.4	11.5	10.0	14.7	11.3	16.6	14.3	21.0	29.3
5.	30.0	11.1	10.2	14.4	12.3	17.5	14.0	19.8	26.6
6.	30.0	16.6	11.2	15.8	14.3	20.2	18.8	26.6	26.6
7.	30.4	11.5	13.7	18.9	16.3	22.4	20.5	28.2	27.2
8.	31.2	7.6	12.5	16.3	16.0	21.0	17.8	23.3	27.8
9.	31.4	15.7	12.5	16.3	15.5	20.0	20.8	26.8	26.9
10.	31.4	21.8	10.0	12.9	11.8	15.2	17.3	22.3	26.9
11.	32.6	22.1	10.0	12.0	13.2	15.8	15.0	18.0	24.2
12.	33.2	12.4	11.2	12.9	13.3	15.3	19.3	22.3	32.0
13.	33.8	11.1	12.5	13.9	16.0	17.8	20.0	22.3	29.3
14.	35.2	15.2	10.0	11.4	22.5	23.1	23.0	23.6	21.3
15.	36.0	14.8	16.5	16.2	19.0	18.6	24.0	23.6	26.6
16.	39.0	17.9	13.5	11.3	16.0	13.4	22.5	18.8	26.6
17.	40.6	24.3	16.7	12.9	19.3	14.9	20.0	15.4	20.0
Mean	32.0	15.4	11.7	14.8	14.8	18.4	18.4	23.3	25.1
C.V. %				15.0		16.5		15.8	

TABLE 6.—STRESS-STRAIN DATA FOR HETEROTYPICAL WOOL FIBRES.

Sr. No.	Diameter (μ)	C.V. %	2% Strain		30% Strain		Breaking Point		
			Strength (g. wt)	Stress (mg./μ²)	Strength (g. wt)	Stress (mg./μ²)	Strength (g. wt)	Stress (mg./μ²)	Elongation %
1.	41.2	11.9	15.0	11.2	20.0	15.0	32.5	17.6	34.9
2.	42.6	21.3	11.0	7.0	21.0	14.7	27.0	19.0	37.6
3.	43.6	21.8	13.5	9.0	25.0	16.7	25.0	16.7	30.0
4.	45.6	22.8	15.5	9.5	24.0	14.6	24.0	14.6	30.0
5.	47.8	5.0	13.0	7.2	20.0	9.9	22.8	12.5	35.2
6.	50.6	18.0	12.5	6.2	22.5	11.1	27.5	13.7	37.3
7.	51.4	7.0	11.5	5.5	17.0	8.2	22.0	10.7	33.0
8.	52.0	9.4	15.0	7.0	19.5	9.2	23.5	10.6	35.5
9.	52.8	6.3	15.0	6.8	25.0	11.4	29.0	13.2	37.6
10.	53.4	11.7	19.5	8.7	24.0	10.7	28.0	12.5	37.4
11.	54.0	11.9	14.0	6.1	22.0	9.6	25.5	11.1	38.0
12.	54.0	9.6	14.5	6.3	21.5	9.4	24.5	10.7	34.6
13.	55.0	14.3	12.5	5.2	21.0	8.8	25.0	10.5	32.0
14.	55.6	3.1	13.0	5.3	22.5	9.2	27.0	11.1	37.3
15.	57.8	12.3	17.5	6.6	24.5	9.3	29.5	11.2	34.6
16.	62.2	12.2	15.5	5.1	24.0	7.9	26.0	8.5	32.8
17.	64.6	20.8	22.5	6.8	29.5	9.0	32.0	9.9	35.2
Mean	52.0	13.4	14.8	7.0	22.5	10.8	26.0	12.6	34.8
C.V. %				22.5		24.8		22.3	

TABLE 7.—STRESS-STRAIN DATA FOR MEDULLATED WOOL FIBRES.

Sr. No.	Diameter (μ)	C.V. %	2% Strain		30% Strain		Breaking Point		
			Strength (g. wt.)	Stress (mg./μ²)	Strength (g. wt.)	Stress (mg./μ²)	Strength (g. wt.)	Stress (mg./μ²)	Elongation %
1.	50.8	12.9	22.5	11.1	32.5	16.0	38.0	13.8	35.4
2.	51.6	8.5	20.0	9.5	27.5	12.0	32.5	15.5	35.2
3.	53.2	11.3	20.5	9.2	27.5	12.3	33.0	14.8	35.9
4.	58.2	10.8	22.0	8.3	30.0	11.3	32.5	12.2	34.8
5.	66.6	10.2	27.5	7.9	40.0	11.6	42.5	12.2	36.1
6.	70.4	7.2	21.0	5.4	28.0	7.2	28.0	7.5	33.8
7.	73.6	6.0	18.5	4.3	25.0	5.8	25.0	5.5	34.6
8.	74.0	7.5	21.0	4.5	29.5	6.8	29.5	6.8	34.2
9.	74.0	8.7	30.0	6.9	45.0	10.4	50.0	11.6	38.9
10.	77.2	8.1	24.0	5.1	36.0	7.7	42.5	9.0	37.8
11.	82.4	11.1	28.5	5.3	43.5	8.1	43.5	8.1	38.6
12.	84.8	11.0	23.5	4.1	32.0	5.6	32.0	5.6	37.4
13.	88.6	13.5	20.0	3.2	27.5	4.4	27.5	4.4	34.0
14.	96.2	10.9	15.0	2.0	24.0	3.3	25.0	3.4	31.4
15.	101.8	15.6	11.0	1.3	17.5	2.1	19.5	2.0	33.0
16.	105.4	13.9	13.0	1.5	18.5	2.1	18.5	2.1	34.6
17.	111.8	17.8	9.0	0.9	19.5	2.0	25.0	2.5	40.0
Mean	76.7	10.9	20.4	5.3	29.6	7.5	32.2	8.0	36.0
C.V. %				56.6		55.2		55.3	

TABLE 8.—CHEMICAL CHARACTERISTICS OF LOHI WOOL.

Sr. No.	Characteristics	Mean (%)	Range (%)
1.	Nitrogen ..	14.63	14.33—14.84
2.	Sulphur ..	2.33	2.06— 2.74
3.	Scouring loss ..	17.00	2.00—31.80
4.	Vegetable matter ..	1.25	0.13— 3.10
5.	Wool Wax ..	0.53	0.32— 1.10
6.	Suint ..	2.50	2.00— 3.50
7.	Moisture content ..	12.20	9.83—14.82
8.	Regain ..	13.71	10.82—17.32
9.	Ash ..	2.46	0.83— 4.31

Conclusion

The results of medullation test, length and fineness agree with the carpet standards[22] as well as the work on Bikaner wool[23] which is considered best for carpet manufacture. The only drawback is the high co-efficient of variation in diameter and length. Moreover, the strength of wool fibres as well as the stress is greater at 2 percent, 30 percent and breaking point, their rheological properties being similar to those of fibres used in the manufacture of fine felt and carpet. The other characteristics such as scouring loss, vegetable matter, wool wax and suint are also in the range of carpet wool. The nitrogen and sulphur content is low. In order to make Lohi wool ideal for carpet, certain measures must be taken in order to improve its quality as well as quantity. As this is the largest breed in Pakistan, its improvements needs consideration. Scientific breeding should be introduced. Shearing should be done on scientific lines so that the fibres should be clipped evenly and at regular intervals (two shearing seasons preferred) and lastly the sheep should be washed before shearing and the fleece should be separated into body and skirting wool.

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