Onderstepoort Journal of Veterinary Science and Animal Industry, Volume 15, Numbers 1 and 2, July and October, 1940.

Printed in the Union of South Africa by the Government Printer, Pretoria.

Studies on the Basic Characteristics of South African Merino Wool. III.—Moisture Adsorption.

By C. M. VAN WYK, Wool Research Section, Onderstepoort.

Introduction.

Wool adsorbs moisture readily from the surrounding atmosphere, the amount adsorbed being greater than in the case of other textiles. This characteristic plays an important part in enhancing the suitability of wool as a clothing material. Also since the moisture content has a marked influence on its physical properties, the testing of wool for various attributes has to be carried out under controlled conditions of humidity and temperature.

Several authors have studied the adsorption of moisture by wool, the most notable contributions being those of Speakman (1930) and Speakman, Stott and Cooper (1936). It was shown that a marked hysteresis exists in the moisture content of wool between adsorption and desorption conditions. In dealing with six different types of wool, Speakman (1930) asserted that "the adsorptive powers of different wools are remarkably similar, and such differences as do exist may be generalised in the statement that the affinity for water appears to increase slightly as the wool becomes coarser".

Although the work recorded deals with wool from different breeds and sources, no direct investigation has previously been made of the moisture adsorptive capacity of South African Merino wool or of possible differences in this characteristic among different types of South African Merino wool.

Studies of this nature would establish the moisture adsorptive capacity of South African Merino wool and would indicate to what extent the testing of wool is reliable under controlled conditions of humidity and temperature. Appreciable differences in the moisture adsorptive capacity of merino wool would also have a bearing on clean yield determinations. The present paper is the result of a preliminary investigation into differences in adsorptive powers of different types of South African Merino wool.

Experimental Procedure.

Two samples for duplicate determinations were drawn from each of ten types of South African Merino wool selected for their widely differing properties. The bulk of the grease and dirt was removed by a preliminary washing in cold benzene, after which adhering foreign matter was carefully extracted by hand with the aid of finely pointed forceps. The wool was then purified by extraction in succession with benzene, alcohol and ether in a Soxhlet apparatus, and finally washed in several changes of distilled water, to the first of which 0·1 per cent. saponin had been added. When air dry, each sample was placed in a regain bottle of the type described by Barritt and King (1926).

A current of air from a water blower was allowed to pass slowly through four flasks in succession. The second, third and fourth of these each contained a litre of a solution of sulphuric acid made up to a definite concentration. The solution in the first flask was of a slightly higher concentration in order to reduce the high moisture content of the air from the water blower. After passing through the four solutions the current of air was divided into five portions. Each portion passed in succession through a spray trap, a regain bottle containing wool, and finally through a trap containing a solution of the same concentration as before. The last trap served the double purpose of preventing access of moisture from the surrounding atmosphere and of allowing for the adjustment of the rate of flow of air through each regain bottle separately. The whole apparatus was placed in a constant humidity chamber, the temperature of which was maintained at 21·1° C. The generation of the airstream by pressure instead of suction reduced the possibility of leakage of the surrounding air into the system.

The solutions were successively diluted to correspond to relative humidities of 20 per cent., 40 per cent., 60 per cent., 80 per cent., 90 per cent. and 97·5 per cent. according to data given by Wilson (1921). Observations beyond 97·5 per cent. relative humidity were considered impracticable owing to condensation of moisture on the wool as a result of small unavoidable temperature fluctuations. Before exposing the samples to the air current at each humidity they were subjected to a current of dry air so as to ensure adsorption conditions.

The regain bottles were weighed daily and when the weights became constant, weighing was continued for another five days, each bottle being allocated to a different portion of the airstream between weighings. This was to ensure that the humidity of any portion of the stream of air had not been affected during its passage through the trap or connecting tubing. In order to allow for possible changes in weight of the bottles the wool was removed and the bottles weighed separately after constancy at each humidity had been obtained. The specific gravity of the solutions was checked at frequent intervals with the aid of a Westphal balance. No appreciable changes in the solutions occurred. Desorption was studied at 80 per cent., 60 per cent., 40 per cent. and 20 per cent. relative humidities.

Finally the dry weights of the samples were determined by heating to 100° C. at 5 cms. Hg. pressure in the presence of sulphuric acid, an Abderhalden drying apparatus being used for the purpose.

Results.

Table 1 gives the amount of moisture adsorbed by the ten samples at each humidity, expressed as a percentage of the dry weight of the wool. The mean values are plotted in Fig. 1.

Table 1.

Sample.	Relative Humidity.					
	20 Per cent.	40 Per cent.	60 Per cent.	80 Per cent	90 Per cent.	97·5 Per cent.
			Adsorption.			
1	6·6	10·0	14·2	19·2	23·0	28·2
2	6·4	9·7	13·8	18·6	22·5	28·1
3	6·5	9·8	13·9	18·7	22·3	27·4
4	6·6	9·9	14·1	19·1	22·9	28·1
5	7·4	10·9	15·0	20·1	24·0	28·3
6	6·9	10·2	14·3	19·0	22·5	27·2
7	6·9	10·2	14·4	19·2	22·7	27·7
8	6·8	10·1	14·3	19·1	22·7	27·8
9	6·6	10·0	14·5	19·3	23·1	28·2
10	6·7	10·0	14·3	19·0	22·6	27·5
Mean	6·7	10·1	14·2	19·1	22·8	27·9
			Desorption.			
1	8·1	12·3	16·0	20·9	—	—
2	7·9	11·8	15·3	19·7	—	—
3	7·9	12·0	15·4	19·7	—	—
4	8·1	12·3	15·6	20·2	—	—
5	8·4	12·7	16·2	21·0	—	—
6	8·3	12·2	15·9	20·2	—	—
7	8·2	12·1	15·8	20·4	—	—
8	8·2	12·2	16·0	20·3	—	—
9	8·0	12·2	16·1	20·6	—	—
10	8·0	12·1	15·7	20·3	—	—
Mean	8·1	12·2	15·8	20·3	—	—

An analysis of the variance of the results is given in Table 2.

Table 2.

Analysis of Variance.

Variance.	D.F.	Sums of Squares.	Mean Squares.	S.D.	Log S.D.
Between samples	9	11·2242	1·246935	1·1166	0·1101
Between humidities	5	6319·68742	—	—	—
Error	45	3·88508	0·086335	0·2938	—1·2249
Between totals of duplicates	59	6334·79492	—	—	—
Within totals of duplicates	60	3·24500	0·054083	0·2325	—1·4592
Total	119	6338·03992	—	—	—

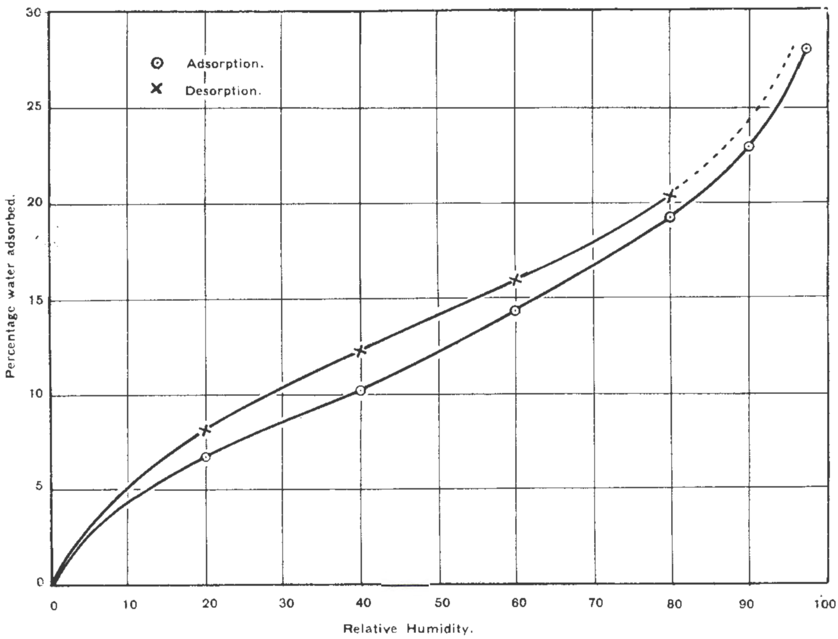

Fig. 1.

The variance between samples differs significantly from the error variance at P = ·001, while the error variance does not differ significantly from the variance within duplicate determinations at P = ·05. The existence of definite differences between the adsorptive capacities of the different types of wool considered is thus proved. According to Table 2, the standard error of the mean of duplicates is $0 \cdot 2325/\sqrt{2}$ or 0·1644, a value which is satisfactory for the purpose of the present study.

The greatest difference was found in the case of samples 3 and 5, the results for which are given in Table 3.

TABLE 3.

Sample.	Relative Humidity.					
	20 Per cent.	40 Per cent.	60 Per cent.	80 Per cent.	90 Per cent.	97·5 Per cent.
3...............	6·5	9·8	13·9	18·7	22·3	27·4
5...............	7·4	10·9	15·0	20·1	24·0	28·3
DIFFERENCE....	0·9	1·1	1·1	1·4	1·7	0·9

At all values of the relative humidity, sample 5 adsorbed more moisture than sample 3, the excess being of the order of 1 per cent. of the dry weight.

The variation in adsorptive capacity of the ten samples at the different values of relative humidity is illustrated in Table 4.

TABLE 4.

Relative humidity.	20%	40%	60%	80%	90%	97·5%
Standard deviation	0·29	0·31	0·35	0·39	0·48	0·37

While the standard deviation increases with humidity up to 90 per cent. relative humidity, the value at 97·5 per cent. relative humidity shows a slight decrease and corresponds with that at approximately 80 per cent. relative humidity.

The wools used were representative of types that differ among themselves in other physical properties. The averages of the experimental results are therefore only applicable to the series and do not represent the average adsorptive capacity of the South African Merino wool clip.

The samples, which gave the lowest and highest values (viz. Nos. 3 and 5, Table 1) were a "ropy" type and an extremely hairy type respectively, wools that form a small portion of the South African clip. The influence of these two samples on the variation found is evident when they are omitted in the calculation of the standard deviation, which at 90 per cent. relative humidity is then halved. It can thus be reasonably presumed that the average of the South African clip lies between the limits given by these types and will not differ greatly from the average of the values given in Table 1.

Except for the fact that the extremely hairy sample gave the highest values, the results do not follow Speakman's (1930) observation that the affinity for water appears to increase slightly as the wool becomes coarser, though this difference may be due to the fact that Speakman used wools from different breeds of sheep whilst the present study confines itself to Merino types only.

Differences in the amount of water adsorbed at any value of the relative humidity have an important bearing on the method of estimating the regain of samples by weighing them under the same conditions as a standard sample of known dry weight. This method is used for large-scale determinations of the clean yields of fleeces where the final results have to be expressed in terms of a definite regain.

Roberts (1930) suggested that a standard sample should be made up of a number of smaller samples taken from different wools. Applying this principle to the ten wools used in the present study, a standard sample may be supposed to have been made up of equal portions taken from all the samples, and the ten samples weighed together with the standard at 60 per cent. relative humidity. If the dry weights of the samples are calculated on the assumption that all contain the same amount of moisture as the standard, then the errors due to different adsorptive powers have a standard deviation of $\pm 0 \cdot 2857$ per cent. This means that an error exceeding 0·3 per cent. of the dry weight will occur once in every third case. The three samples of which the dry weight estimates differed from the true values by more than 0·3 per cent. consisted of the hairy and " ropy " types already mentioned. In cases such as occur in the laboratory, a selection of sampless will rarely contain so high a proportion of these types and will often lack them altogether. It can, therefore, be concluded that the standard sample method of estimating regain is satisfactory when an accuracy greater than 0·2 per cent. is not required, as in the case of clean yield determinations provided that samples of the hairy and " ropy " types are not included in the series under examination.

Summary and Conclusions.

The adsorption of moisture at various relative humidities by ten samples representing different types of South African Merino wool was investigated.

The samples differed significantly in adsorptive powers. At 90 per cent. relative humidity the extreme values of 24·0 per cent. and 22·3 per cent. with a mean value of 22·8 per cent. were obtained. At 97·5 per cent. relative humidity the corresponding values were 28·3 per cent. and 27·4 per cent., showing a smaller difference than at 90 per cent. relative humidity. The highest values were obtained in the case of an extremely hairy sample, and the lowest in the case of a sample of the " ropy " type.

The use of a standard sample for estimating the dry weights of samples is discussed. It is concluded that the method is suitable where an accuracy greater than 0·2 per cent. is not required, provided that samples of the hairy and " ropy " types are not included.

Acknowledgments.

The author wishes to record his appreciation to Dr. V. Bosman for his interest and assistance during the investigation.

This paper forms part of a project on " Studies on the Basic Characteristics of South African Merino Wool ", which is financed by the Wool Council out of Wool Levy Funds.

REFERENCES.

BARRITT, J., and KING, A. T. (1926). The sulphur content of wool. Part I. Inherent variations according to the type of wool. *J. Text. Inst.*, Vol. 17, No. 8, pp. T386-T395.

ROBERTS, J. A. F. (1930). Fleece analysis for biological and agricultural purposes, I. The average fineness of a sample of wool. *J. Text. Inst.* Vol. 21, No. 4, pp. T127-164.

SPEAKMAN, J. B. (1930). The adsorption of water by wool. *J. Soc. Chem. Ind.* Vol. 49, No. 18, pp. 209T-213T.

SPEAKMAN, J. B., AND COOPER, C. A. (1936). The adsorption of water by wool. Part I. Adsorption hysteresis. *J. Text. Inst.*, Vol 27,, No. 7, pp. T183-T185.

SPEAKMAN, J. B., AND STOTT, E. (1936). The adsorption of water by wool. Part II. The influence of drying conditions on the affinity of wool for water. *J. Text. Inst.*, Vol. 27, No. 7, pp. T186-T190.

SPEAKMAN, J. B., AND COOPER, C. A. (1936). The adsorption of water by wool. Part III The influence of temperature on the affinity of wool for water. *J. Text. Inst.*, Vol. 27, No. 7, pp. T191-T196.

WILSON, R. E. (1921). Humidity control by means of sulphuric acid solutions, with critical compilation of vapour pressure data. *J. Ind. Eng. Chem.*, Vol. 13, No. 4, p. 326.