LXXXII. THE RELATION BETWEEN CYSTINE YIELD AND TOTAL SULPHUR IN VARIOUS ANIMAL HAIRS.

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IN a recent communication [Rimington, 1929] it was shown that by employing the Sullivan [1926] method for the determination of cystine practically the entire sulphur of wool could be accounted for as cystine. In all, six different varieties of wool and two of Turkey Mohair were examined in this way with identical results.

In the present paper the same method has been applied to the examination of some animal hairs, many of which find important applications in the textile industries.

The results are similar to those obtained when working upon the wools; there is however one notable exception. Specimens of camel hair yield not more than 94 % of their total sulphur as cystine; there remains 6 % unaccounted for, which may represent a sulphur-containing compound other than cystine.

EXPERIMENTAL.

The experimental details of the present investigation differed in no way from those already described [Rimington, 1929]. All samples of hair were carefully degreased in warm benzene and subsequently washed, first in 0.1 % saponin solution and then in distilled water. Moisture and total sulphur were determined by weighing out representative samples of the air-dried materials—two samples for moisture (regain) determinations and two or three for sulphur determination. The loss in weight of the former was recorded when a current of dry air was drawn over the sample contained in a specially designed bottle and maintained at a temperature of 105° until constant in weight.

Total sulphur was determined by a modification of the Benedict-Denis method. It is hoped to publish the details of this modification in the immediate future.

Table I shows the results obtained during the course of a typical experiment, the material in this instance being white alpaca tops, whilst in Table II the results of the whole investigation are summarised.

Table I. *White alpaca tops. Hydrolysis of 6 g. by 20 % HCl.*

Time from commencement of hydrolysis hours	Cystine in hydrolysate	
	By Folin and Looney's method g.	By Sullivan's method g.
$\frac{1}{2}$	0.9200	0.1000
1	0.8800	0.2070
2	0.8800	0.4163
4	0.8850	0.6450
5	0.8850	0.6975
6	0.8950	0.7480
7	0.8850	0.7863
9	0.8900	0.7969
Total sulphur (determined upon a 5 cc. aliquot part) expressed as cystine		0.7937
Therefore	$\frac{\text{Total S (hydrolysate)} - \text{cystine (Sullivan)} \times 100}{\text{Total S}} = -0.40.$	

The mean moisture content of the alpaca on drying to constant weight was 10.675 % of the wet weight.

Total sulphur determinations:

- (i) (Benedict-Denis) 0.2631 g. moist alpaca gave 0.0659 g. BaSO_4 .
S = 3.44 % of wet weight.
- (ii) (Benedict-Denis) 0.2430 g. moist alpaca gave 0.0621 g. BaSO_4 .
S = 3.41 % of wet weight.
- (iii) (Carius) 0.4018 g. moist alpaca gave 0.1026 g. BaSO_4 .
S = 3.50 %.

Mean S = 3.86 % of dry weight.

Table II.

		Cystine in hydrolysate		Total S of hydrolysate (as cystine) g.	Ratio*
		By Sullivan's method (max. value) g.	By Folin and Looney's method g.		
Material	Total S % dry weight				
Dog's hair (white Samoyed)	5.07	1.0400	1.0080	1.0265	-1.31
Rabbit fur (white Angora)	4.59	0.7423	0.8117	0.7399	-0.32
White alpaca tops	3.86	0.7969	0.8860	0.7937	-0.40
Camel hair tops	3.25	0.6065	0.7975	0.6395	+5.16
Camel hair tops	3.25	0.5510	0.6300	0.5908	+6.73
Crossbred 40's wool	3.03	0.7430	0.6690	0.7420	-0.13
Tunisian goats' hair (black)	3.54	0.6792	0.6667	0.6751	-0.61

* $\frac{\text{Total S (hydrolysate)} - \text{cystine (Sullivan)} \times 100}{\text{Total S}}$.

DISCUSSION.

These results show clearly that animal hairs, which contain the highest percentage of sulphur found in any of the natural proteins, resemble the wools already examined [Rimington, 1929] in that all this sulphur can be accounted for as cystine except in the one case mentioned below.

The determinations of total sulphur show once more the variability in sulphur content of the hairs of different species. In general the results in this direction accord well with the findings of Barritt and King [1926].

Among the samples examined, camel hair has proved to be exceptional. Reference to Table II will show that in this particular case the extent to which the cystine accounted for fell short of that supposedly present, were the total sulphur of the hair expressed as cystine, was 5.16 % and 6.73 % of the calculated cystine value in two typical experiments. This difference is outside the range of experimental error.

The cause of this anomaly is at present under investigation. The specimens of camel hair used contained a very large proportion of coarse, outer-coat fibres. In the experiments described no attempt was made to remove these.

SUMMARY.

Several varieties of animal hairs have been examined, and, in all cases but one the entire sulphur of the purified hair has been accounted for as cystine.

In the case of camel hair, the cystine value falls short of that required, were all the sulphur present expressed as cystine, by an amount considerably greater than the experimental error.

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NOTE CONCERNING THE PUBLICATION OF MARSTON [1928].

While the first paper of this series [Rimington, 1929] was in the press a paper appeared in which Marston [1928] claimed to have established the fact that the entire sulphur of wool could be accounted for as cystine. In view of the fact, however, that the method of cystine estimation employed by Marston—namely, the colorimetric procedure of Folin and Looney [1922]—was rejected by the present writer on account of its non-specificity, which to his mind rendered it unsuitable when used alone to demonstrate such a point as that now under discussion, it was felt that a few words upon the subject would not be out of place.

Hunter and Eagles [1927] object to the method as originally described by Folin and Looney on account of the development of a blue colour in cystine-free solutions caused by the slow liberation of sulphurous acid. But much more serious is the fact that the Folin and Looney reagent appears to be sensitive to some substance or substances containing sulphur, but not identical with either cystine or cysteine.

Thus du Vigneaud, Jensen and Wintersteiner [1928], in a study of crystallised insulin, found that the hydrolysed product gave a value for cystine by the Folin-Looney reagent equal to the total sulphur but approximately twice as great as that obtained when using the Sullivan colorimetric method.

Sullivan's [1926] method is, so far as is known, absolutely specific for cystine and cysteine and it is this method which has been employed by the present writer in his investigations upon the cystine content of wools and hair. Cystine peptides, such as glutathione, give no colour with the Sullivan reagent whilst they do so with the Folin-Looney reagent.

In view of the work of du Vigneaud, Jensen and Wintersteiner, and since Marston's conclusions are based solely upon observations made with Folin and Looney's reagent, his conclusions must be regarded with some reserve.

REFERENCES.

- Barritt and King (1926). *J. Text. Inst.* **17**, T 386.
Folin and Looney (1922). *J. Biol. Chem.* **51**, 421.
Hunter and Eagles (1927). *J. Biol. Chem.* **72**, 177.
Marston (1928). The chemical composition of wool. Commonwealth of Australia Council for Scientific and Industrial Research, Bull. No. 38.
Rimington (1929). *Biochem. J.* **23**, 41.
Sullivan (1926). *U.S. Public Health Rep.* **41**, 1030.
du Vigneaud, Jensen and Wintersteiner (1928). *J. Pharm. Exp. Ther.* **32**, 367.