CXXI. THE EFFECTS OF CYSTINE DIET ON KERATIN COMPOSITION IN RABBIT WOOL.

By JOHN BARRITT, ALBERT THEODORE KING,
AND JAMES NICHOL PICKARD.

*From the Chemistry Department, Wool Industries Research Association, Leeds,
and the Department of Animal Genetics, University of Edinburgh.*

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THE variability of the sulphur content of wool from type to type and along individual fibres may now be said to be firmly established [Barritt and King, 1926, 1929]. The factors influencing the sulphur content of a particular wool, *e.g.* breed, environment, diet, etc., have yet to be fully investigated, but the variation in sulphur content is obviously of special significance in the bio-synthesis of wool keratin. The arguments in this connection put forward in 1927 [King, 1927] and in more detail in 1929 [Barritt and King, 1929] may be briefly summarised as follows.

In the coarser hairs of the fleece the three types of cell formation present, comprising scale, cortex and medulla cells, are all derived from the substantially sulphur-free plasmic material constituting the basal epidermal layer.

The finer fibres, which are composed only of scale and cortex cells, are higher in sulphur content than the coarser ones where the medullated core is present. A comparison of the sulphur content of non-medullated fibres with that of medullated, or kempy fibres of measured medulla content, affords indirect evidence that the medulla cells are substantially sulphur-free.

Thus it appears that the biochemical changes during keratinisation are accompanied by incorporation of sulphur in the case of the scale and cortex cells, but not in that of the medulla cells. This is in agreement with the histological view that the medulla channel is an upward protrusion of the basal epidermal layer. The medulla being sometimes continuous and sometimes intermittent indicates a continuous or intermittent requisitioning of sulphur-free material to make up for a deficiency in production of normal sulphur-containing cortex cells.

The variable "sulphur stimulus" must therefore be a highly important factor in hair growth, and the view that this is in the form of a cystine nucleus is supported by Rimington's proof [1929] that the sulphur present in wool and other animal hairs is wholly accounted for as cystine. In non-kempy wools the extremes of sulphur content so far observed are 2.93 % and 4.11 %, calculated on the dry weight, corresponding to 10.98 % and 15.41 % of cystine respec-

tively. The relative quantities of cystine and glutamic acid found in wool hydrolysate are in fair agreement with the supposition that the actual keratinising agent is glutathione.

This variable incorporation of the cystine nucleus, apart from its influence on textile properties, will obviously enter into biological problems of wool production, and will be determined partly by hereditary and partly by environmental and pathological conditions. If, as Robertson and Marston [1928] claim, wool keratin is of constant sulphur content, any factor inducing in the fleece an increase in keratin-sulphur would be reflected merely in an increased weight of fleece.

If the variability recorded by Barritt and King [1926, 1929] is not entirely an hereditary effect suitable modifications in diet may be expected to modify not only the total fleece weight, but also the percentage of sulphur in the wool.

Regarding the effect of diet it has recently been recorded by several observers [Hartwell, 1921, 1925; Evvard, Fox and Guernsey, 1914] that the cystine content of the diet is a limiting factor in the growth of hair, *e.g.* rats fed on a low cystine diet suffer a loss of hair which can be restored by a normal diet. All these observations have, however, been general in character and information as to any variation in the sulphur content of the hair with variation in the cystine content of the diet is lacking.

The purpose of the present experiments was to observe the effect, if any, on the sulphur content of the fur of rabbits resulting from a varying cystine diet. Angora rabbits were selected because of the ease of control of the experiments and the quick growth of the fur.

EXPERIMENTAL.

The 24 rabbits employed were all white Angora bucks of adult age and similar strain. They were housed and fed in a manner which prevented matting and soiling of the wool.

The rabbits were fed on a normal diet consisting of whole oats in the morning, and in the evening of poor meadow hay, turnips and a damp mash of broad bran and flaked maize. Grass replaced the turnips and hay from the beginning of June to the conclusion of the experiment. The average amount of food consumed by each rabbit per day was as follows:

Whole oats	...	34 g.	Hay	...	...	54 g.
Broad bran	...	16	Turnips	...	...	96
Flaked maize	...	32				

The first group of six rabbits was maintained on this diet. With the second, third and fourth groups this was supplemented by 0.05, 0.1 and 0.2 g. of cystine respectively.

The cystine was obtained from the hydrolysis of wool as described by Barritt [1927], 400 g. being used for each hydrolysis. The cystine was not entirely freed from tyrosine and traces of inorganic matter and had a sulphur

content of 25 % to 26 % for the various samples prepared. (Cystine contains 26.67 % S.)

The requisite amounts of cystine were thoroughly mixed into part of the bran ration and fed to the rabbits, the rest of the diet being offered as soon as this was eaten. This method ensured the eating by each rabbit of the full dose of cystine each day.

The rabbits were clipped on April 18th (the date of clipping prior to April 18th was January 3rd, 1929) and on July 11th, 1929 (a growth period of 84 days), the wool being removed as close to the skin as possible. The fleece was weighed to the nearest g. and 20 g. were taken at random from the whole fleece for the analysis.

The rabbits were weighed daily for 5 days at the beginning and conclusion of the experiment, the figures quoted being the average of these weights. Undue importance should not, however, be attached to these, as it has been found [Pickard, 1928] that the weight of the rabbit has little, if any, influence on the wool yield.

It is difficult to compare the weight of the April clip with that of the succeeding quarter, as the seasonal variation in the wool yield is considerable.

The animals remained in good health throughout the experiment. The wools were sampled, purified and analysed as described in earlier papers [Barritt and King, 1926, 1929].

The results are given in Table I.

Table I.

Group	No. of rabbit	Beginning of experiment			Cystine per day (g.)	End of experiment		
		Weight of rabbit (kg.)	Weight of clip (g.)	Sulphur on dry weight %		Weight of rabbit (kg.)	Weight of clip (g.)	Sulphur on dry weight %
I	103	2.094	47	5.10	(Controls)	1.924	35	5.05
	140	2.434	70	4.90		2.434	47	5.07
	237	3.057	96	4.86		3.453	62	5.06
	243	2.378	59	4.64		1.953	30	4.98
	301	2.038	33	4.29		2.717	35	5.03
	302	2.491	64	4.12		3.056	35	4.79
II	5	3.113	70	5.22	0.05	3.226	35	5.23
	22	3.170	56	4.99		3.198	54	4.98
	75	2.462	47	4.98		2.321	34	4.93
	226	2.378	55	4.66		2.604	31	5.16
	229	2.349	61	4.93		2.377	27	5.21
	254	2.434	77	4.44		2.773	51	4.97
III	28	2.745	49	—	0.1	2.660	35	—
	63	2.378	58	4.93		2.434	36	5.11
	214	2.858	58	—		3.170	45	—
	218	2.802	58	4.84		3.283	30	4.99
	224	2.349	76	—		2.887	54	—
	235	2.575	69	4.77		2.660	45	4.91
IV	107	3.170	75	—	0.2	3.283	57	—
	193	2.887	72	4.92		2.717	37	5.02
	221	2.378	84	—		2.321	52	—
	238	2.123	49	4.85		2.434	41	5.05
	242	2.292	47	—		2.773	30	—
	253	2.292	40	4.57		2.717	32	4.89

DISCUSSION OF RESULTS.

The results indicate very clearly a large seasonal variation in almost every sample, there being in the majority of cases an increase in the sulphur content; in the case of rabbit no. 301 the increase was almost 18 %. The limiting value for sulphur content in this type of rabbit (Angora) appears to be about 5.2 %.

The results thus support the previous work of Barritt and King [1926, 1929] on the variable sulphur content in wool fibre, particularly variation along its length, which may thus also be a seasonal effect. They further illustrate the variability in another type of hair keratin, as opposed to the finding of Robertson and Marston [1928] that the sulphur content of wool keratin is constant. A further point of interest, as to whether in the cases of increased sulphur content the sulphur is still wholly accounted for as cystine is at present under investigation.

In so far as the effect of the cystine itself is concerned no real differences in sulphur content are to be found between the control rabbits and those fed on the cystine-rich diet, and evidence that feeding of cystine as such has any effect on the sulphur values is at present lacking. It was observed, however, that among the twelve rabbits comprising the controls and those having 0.05 g. cystine per day, four developed suspension of fur growth on the back, whereas among those fed with 0.1 and 0.2 g. cystine per day, no such suspension occurred.

The negative results may be variously explained as due to:

- (1) the cystine having been fed as cystine itself and not as protein-cystine;
- (2) the amount of cystine fed being insufficient to give any appreciable effect;
- (3) the period of the experiment coinciding with the maximum natural seasonal variation, thus masking the effect of the additional cystine.

It is proposed to continue the experiments by increasing the amount of cystine; also by giving diets rich in plant-cystine, and by measuring the effect over the 3 months' period which in the present series has been found to correspond with a naturally low sulphur content.

SUMMARY.

1. Angora buck rabbits have been fed for 3 months on a normal diet and on diets with the addition of varying amounts of cystine obtained from wool hydrolysate.

2. In general, a large increase in the sulphur content of the fur of individual rabbits has been found between the two successive 3-month periods, January to April, and April to July, in the controls as well as in the cystine-fed animals. The maximum increase observed was 18 % and this occurred with rabbit no. 301 on normal diet throughout.

3. While the fleece weights are generally less for the shorter second period, the fleece weight ratios for the two periods are substantially the same with the cystine-fed animals as with the controls.

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