

THE AMINO ACID CONTENT OF SOME SCLEROPROTEINS

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Knowledge concerning the amino acid content of the scleroproteins is far from complete. The summary tables of Block and Bolling (1), Cohn and Edsall (2), Schmidt (3), and Hawk *et al.* (4) offer the best available data, but there is much disagreement. Lindley (5) and Geiger (6) have recently reported on the constitution of wool.

We are reporting on the content of fourteen amino acids in seven scleroproteins. In some instances, our values differ substantially from reports in the literature. In other instances, the content of certain amino acids is reported for the first time.

EXPERIMENTAL

Methods

The samples were hydrolyzed and prepared for assay as described by Hier *et al.* (7). Amino acids were determined by the following microbiological procedures: methionine and threonine with *Streptococcus faecalis* and the medium of Stokes *et al.* (8); arginine and tyrosine with *Lactobacillus delbrueckii* and the above medium; lysine, histidine, and aspartic acid with *Leuconostoc mesenteroides* with Medium D of Dunn *et al.* (9); leucine, isoleucine, valine, phenylalanine, and glutamic acid with *Lactobacillus arabinosus* according to the method of Hier *et al.* (7); and proline by the method of Barton-Wright *et al.* (10). Cystine was determined by the chemical method of Kassell and Brand (11).

Preparations Analyzed—The nitrogen values are reported on a water- and ash-free basis.

Achilles Tendon—Bovine origin; trimmed from extraneous fat and muscle tissue, hashed, and dried *in vacuo*; total nitrogen, 16.9 per cent.

Gelatin—Wilson's pure food gelatin derived from pork skin; nitrogen content, 17.6 per cent.

Yellow Tendon—Bovine ligamentum nuchae, trimmed, hashed, and dried *in vacuo*; total nitrogen, 15.5 per cent.

Elastin—Prepared by the method of Richards and Gies (12) from yellow tendon; total nitrogen, 16.6 per cent.

Wool—Sheep wool defatted with benzene and dried *in vacuo*; total nitrogen, 16.2 per cent.

Feathers—Chicken feathers, washed with water and dried *in vacuo*, total nitrogen, 15.0 per cent.

Hair—Hog hair, washed with water and dried as above; total nitrogen, 16.6 per cent.

Horn—Cattle horn; washed with water and dried *in vacuo*, total nitrogen, 15.6 per cent.

Results

Table I shows the results of the analyses of the preparations described above.

TABLE I

Amino Acid Content of Some Scleroproteins

The values (in per cent) are on a water and ash-free basis.

Amino acid	Achilles tendon (1)	Gelatin* (2)	Yellow tendon (3)	Elastin (4)	Wool (5)	Feathers (6)	Hair (7)	Horn (8)
Arginine.....	8.0	8.0	3.1	1.1	10.6	7.5	10.9	10.7
Aspartic acid.....	6.9	6.7	2.9	0.6	7.2	7.0	8.0	7.7
Cystine.....	0.3	0.07	0.7	0.6	13.7	8.2	14.4	12.1†
Glutamic acid.....	10.4	11.5	5.0	3.3	15.6	9.7	17.9	13.8
Histidine.....	0.9	0.79	0.3	0.04	1.1	0.4	1.1	1.0
Isoleucine.....	1.9	1.4	4.3	3.4	4.5	6.0	4.7	4.3
Leucine.....	3.5	3.2	7.6	7.3	8.1	8.0	8.3	8.3
Lysine.....	3.5	4.1	1.3	0.5	3.3	1.3	3.8	3.6
Methionine.....	0.9	1.0	0.3	0.03	0.6	0.5	0.5	0.5
Phenylalanine.....	2.5	2.2	4.3	4.8	4.0	5.2	2.7	3.2
Proline.....	10.5	18.0	12.6	15.6	8.1	8.8	9.6	8.2
Threonine.....	2.5	1.9	1.5	1.1	6.7	4.4	6.3	6.1
Tyrosine.....	0.9	0.44	1.7	1.4	5.6	2.2	3.5	5.6
Valine.....	2.9	2.5	13.6	13.8	5.7	8.3	5.9	5.5
Nitrogen.....	16.9	17.6	15.5	16.6	16.2	15.0	16.6	15.6

* A part of these data is taken from the paper of Hier *et al.* (7).

† Sample taken from middle of horn. A sample from the horn tip assayed 15.7 per cent cystine.

Achilles tendon is characterized by its high content of collagen from which gelatin is derived. For comparison, the amino acid content of gelatin is given in Column 2. There are no great differences in the amino acid content of these two materials.

The principal constituent of yellow tendon is elastin and these two preparations are compared in Columns 3 and 4. It will be noted that both are high in valine in contrast to Achilles tendon and gelatin. Yellow tendon also differs from Achilles tendon in that it contains less arginine, aspartic acid, and lysine but more isoleucine, leucine, phenylalanine, and valine.

Our results for the leucine-isoleucine content of elastin are much lower than those reported in the literature. Thus, Abderhalden and Schitten-

helm (13) report a leucine content of 21.38 per cent, and Hawk *et al.* (4) indicate a combined leucine-isoleucine value of 31 per cent. Block and Bolling (1) report a value of 28 per cent for the total of these two amino acids in elastin. Different samples prepared in our laboratory indicate a combined leucine-isoleucine content of about 11 per cent on repeated assays.

Our values for wool compare very well with those recently reported by Lindley (5), except for proline. Our value for this amino acid is higher and compares better with 9.8 per cent and 9.3 per cent reported by Schmidt (3) and Block and Bolling (1) respectively. The sum of our values of 4.5 per cent for isoleucine and 8.1 per cent for leucine compares well with the total for these two amino acids as reported in several sources (1-3). In the case of valine, we find 5.7 per cent and thus agree with the summary tables of Block and Bolling (1), in contrast to the value of 2.8 per cent reported by Abderhalden and Voitnovici (14).

Incomplete data for the amino acid content of feathers are to be found in the literature. Our figures agree with those available (1) and in Table I a more complete assay of this scleroprotein tissue is presented.

For hair, we agree in general with the values of Block and Bolling (1), except for aspartic acid which we find higher. Our values for arginine, glutamic acid, proline, tyrosine, and valine are higher than those recently reported by Beveridge and Lucas (15) for human hair by isolation methods.

Our values for horn agree with those of Block and Bolling (1), except for leucine which we find lower and for aspartic acid which we find higher. Values for methionine and proline have been added.

DISCUSSION

According to the literature, the organic matter of Achilles tendon consists mainly of collagen, while that of yellow tendon is principally elastin but contains a small amount of collagen (4). Our analytical figures bear this out.

In the preparation of elastin, collagen is removed as gelatin. Collagen contains a much higher percentage of arginine, aspartic acid, glutamic acid, histidine, lysine, and methionine than yellow tendon. Elastin is relatively lower than yellow tendon in its content of these amino acids, since the collagen has been removed during its preparation. Collagen contains a relatively low percentage of the remaining amino acids and their concentration in elastin is thus similar to that in yellow tendon.

It is of interest that the amino acid patterns of the keratins from mammals, namely sheep wool, hog hair, and cattle horn, resemble one another closely. However, the avian keratin, chicken feathers, differs from these in being lower in arginine, cystine, glutamic acid, histidine, lysine, and tyrosine and slightly higher in isoleucine and valine.

SUMMARY

Achilles tendon, yellow tendon, elastin, wool, feathers, hog hair, and cattle horn have been analyzed for fourteen amino acids, and the values are compared with those previously reported. In the case of feathers and horn, several values have been added which were not formerly available.

Differences in the amino acid content of Achilles tendon and yellow tendon are noted.

Elastin has been prepared from yellow tendon and the leucine-isoleucine content has been found to be much lower than that reported in the literature.

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Addendum—Since this paper was submitted, we have discovered the paper of Stein and Miller (16) on the composition of elastin. Their values for the amino acid content of this protein agree very well with ours except in the case of the "leucine fraction," which they report as 30 per cent. These authors believed that this fraction contained other amino acids in addition to leucine and isoleucine.

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