

Exploration on Amino Acid Content and Morphological Structure in Chicken Feather Fiber

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ABSTRACT

Converting poultry feather biomass into useful products presents a new avenue of utilization of agricultural waste material. However, not much is understood about the poultry feather structure or methods to process it. Fibers from non-traditional textile sources have the potential to offer novel properties at a reduced cost compared to traditional textile fibers. Feather constitutes over 90% protein, the main component being beta-keratin, a fibrous and insoluble structural protein extensively cross linked by disulfide bonds. An attempt has been made to analyze the amino acid content and the morphological structure of chicken feather fibers for prospective use as natural protein fibers. The study reveals that the presence of both hydrophobic and hygroscopic nature of amino acid makes the feather partially hygroscopic in nature. The presence fat content is about 1.53%. Using the cheap and plentiful feathers as protein fibers will save the cost and benefit the environment.

Keywords: Chicken feather fiber, Keratin, Structure, Amino acid content, SEM

1. Introduction

It is possible to find in nature an almost unlimited source of high performance materials which remain to be critically studied to establish them as basis for innovative technologies and useful raw materials. This is the case for keratin fibers abundant in chicken feathers. Keratin, considered as the main structural component of these materials, contributes to a wide range of essential functions, including temperature control and physical and chemical protection. Structural studies of hair fibers, including wool, reveal highly organized subcomponents that could be also found in feather fibers starting from their

complex branched structure that grow by a unique mechanism from cylindrical feather follicles. This branching structure, a distinctive morphological feature of feathers, has its origin in the biological evolution of feathers. [McGovern, 2000]

Figure 1 shows the contour feather has a feather shaft and a flat vane extending from it [Bartels, T. 2003]. Feathers are highly ordered, hierarchical branched structures, ranking among the most complex of keratin structures found in vertebrates. Feathers not only confer the ability of flight, but are essential for temperature regulation. [Yu, M, 2002]

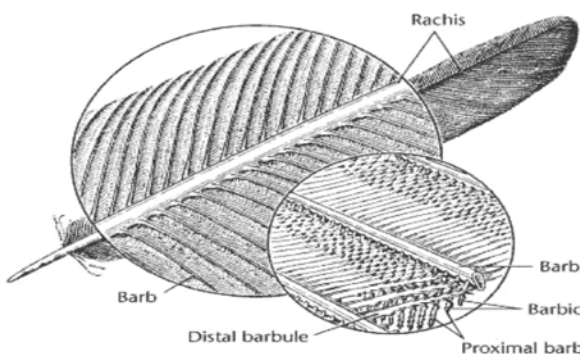


Figure 1. A contour feather [Bartels 2003]

2. Materials and Methods

2.1 Materials

The Chicken feather fibers (CFF) were obtained from the poultry farms. Then it is purified by washing and sterilization. The untreated CFF was washed with the 5% soap solution followed by rinsing. The wet washed CFF was dried on moderate heat. The barbs are removed from the quill and the short fibers (10 to 32 mm) were obtained. Sterilization process is carried out by washed CFF and were dipped at room temperature (21°C for 30 minutes respectively) in polar solvent and water, with pH adjusted to 8, then rinsed with water,

HPTLC ANALYSIS

<u>Group I</u>	<u>Group II</u>	<u>Group III</u>	<u>Group IV</u>
<u>Asparagine</u>	<u>Aspartic acid</u>	<u>Lysine</u>	<u>Histidine</u>
<u>Glutamine</u>	<u>Glycine</u>	<u>Glutamic acid</u>	<u>Arginine</u>
<u>Serine</u>	<u>Alanine</u>	<u>Threonine</u>	<u>Cystine</u>
<u>Proline</u>	<u>Valine</u>	<u>Tyrosine</u>	<u>Tryptophan</u>
<u>Methionine</u>	<u>Phenyl alanine</u>	<u>Isoleucine</u>	<u>Leucine</u>

Morphological Structure

The Scanning Electron Microscope, Optical Microscope and Tunneling Electron Microscope were used to study the

longitudinal and cross-sectional features of the barbs. Barbs were mounted on a conductive adhesive tape and sputter coated

then soaping process is carried out and air-dried.

2.2 Methods

Analysis of Samples for Amino acids by High Performance Thin Layer Chromatography (HPTLC)

Sample Digestion

The given Chicken feather samples each 250mg were weighed accurately in an electronic balance and transferred into labeled glass test tubes (BOROSIL). 3ml of 6M Hydrochloric acid solution was added with sample in specified test tubes. All the sealed tubes were kept in a hot-air oven at 110°C for 48hrs continuously.

Test Solution Preparation

After completion of digestion, broken the tubes at the top and transferred the digest into glass beaker (BOROSIL), rinsed the tubes 5 times with distilled water. The acid in the digest was evaporated to core dry under vacuum using Roto-vac evaporator. The residual content was dissolved with distilled water and made-up to 6ml in a centrifuge tubes. This solution contains 41.6µg dried raw sample in 1µl distilled water and used as test solution for amino-acid profile analysis by HPTLC technique.

with gold palladium prior to observation in the SEM. A 15 kV voltage was used for all the observations.

3. Result and Discussion

3.1 Composition and Amino Acid Sequence of Chicken Feather Fiber

Chicken feathers are approximately 91% protein (keratin), 1% lipids, and 8% water [Lederer, R]. The amino acid sequence of a chicken feather is very similar to that of other feathers and also has a great deal in

common with reptilian keratins from claws. The sequence is largely composed of cystine, glutamine, proline, and serine, and contains almost no histidine, lysine, Tryptophan, Glutamic acid and Glycine.

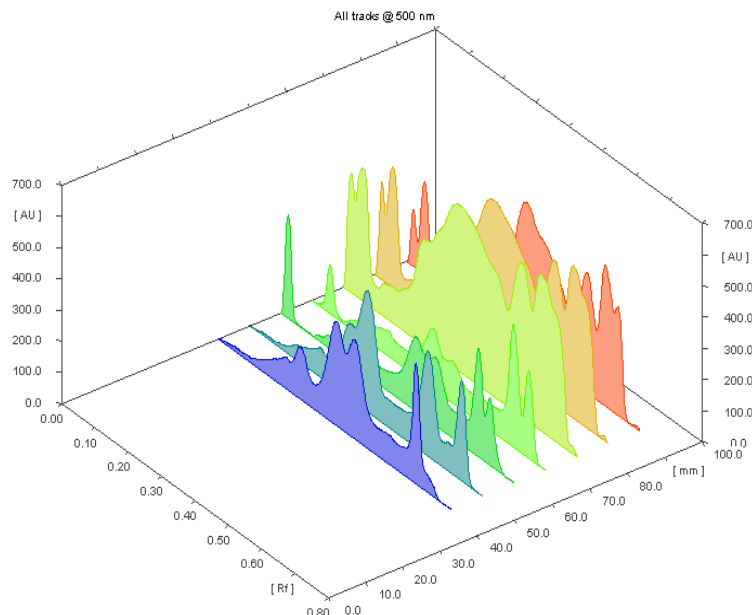


Figure 2. 3-D Display of all tracks

From Figure 2, it is confirmed that the following amino acids are present in the chicken feather fiber and the percentage of the same are also given in Table 1.

Table 1. Amino acid content in keratin fiber from chicken feather

Functional Groups	Amino acid	% Contents
Positively charged	Arginine	4.30
Negatively charged	Aspartic acid	6.00
	Glutamine	7.62
Hygroscopic	Theronine	4.00
	Serine	16.0
Hydrophobic	Tyrosine	1.00
	Leucine	2.62
	Isoleucine	3.32
	Valine	1.61
	Cystine	8.85
	Alanine	3.44
	Phenylalanine	0.86
	Methionine	1.02
Special	Proline	12.0
	Asparagine	4.00

Serine (16%) is the most abundant amino acid and the -OH group in each serine residue helps chicken feathers to absorb the

moisture from the air. Feather fiber is, therefore, hygroscopic. Chicken feather

fibers and quill have a similar content of moisture, around 6%.

The presence of amino acids in the chicken feather fiber which is hydrophobic in nature contributes to a percentage of about 22%, therefore, hydrophobic. Hence, the chicken feather fiber possesses both Hydrophobic and Hygroscopic character and approximately the ratio will be 60:40 percentages.

The estimated value of total Fat content in Chicken Feather is 1.53%

Feather keratins are composed of about 20 kinds of proteins, which differ only by a few amino acids. The distribution of amino acids is highly non-uniform, with the basic and acidic residues and the cystine residues concentrated in the N- and C-terminal regions. The central portion is rich in hydrophobic residues and has a crystalline β -sheet conformation.

Feather keratin is a special protein. It has a high content of cystine (8.85%) in the amino acid sequence (see Table 1), and cystine has -SH groups and causes the sulfur-sulfur (disulfide) bonding. The high content of cystine makes the keratin stable by forming network structure through joining adjacent polypeptides by disulfide cross-links.

The feather keratin fiber is semi-crystalline and made up from a crystalline fiber phase and an amorphous protein matrix phase linked to each other [Schmidt, W.F., 1998]. The crystalline phase consists of α -helical protein braided into micro-fibrils where the protein matrix is fixed by intermolecular interactions, especially hydrogen bonds. In protein, hydrogen bonds are many and strong.

The feather barb fraction has slightly more α -helix over sheet structure, whose melting point is 240 °C. The quill has much more sheet than α -helix structure and has a melting point of 230 °C. Feather keratin has

an average molecular weight of about 60,500 g/mol.

The human hair contains α -helical polypeptide feather keratin can contain both α -helical and β -sheet conformations. Chicken feather fiber primarily consists of α -helical conformations, and some β -sheet conformations are present [Naresh *et al* 1991]. Chicken feather outer quill consists almost entirely of β -sheet conformations, and few α -helical conformations are present [Schmidt, W.F. *et al* 2003]. Hard β -sheet keratins have a much higher cystine content than soft α -helix keratins and thus a much greater presence of disulfide (S-S) chemical bonds which link adjacent keratin proteins (Fig 3). These strong covalent bonds stabilize the three-dimensional protein structure and are very difficult to break [Alberts, B, 1994].

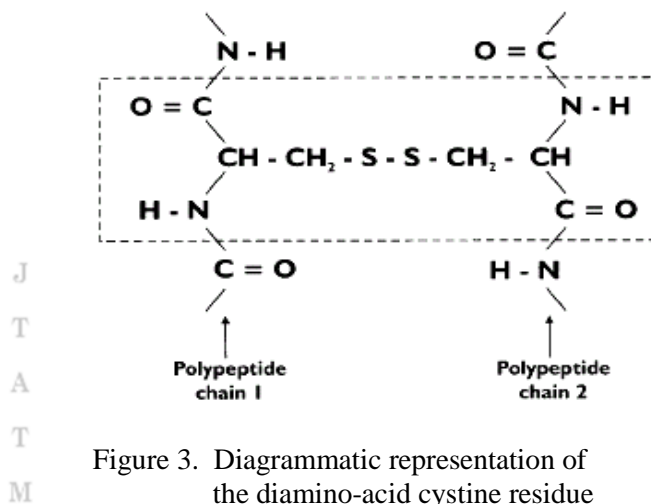


Figure 3. Diagrammatic representation of the diamino-acid cystine residue linking two polypeptide chains by covalent bonding (Alberts, B, 1994)

3.2 Structural Study

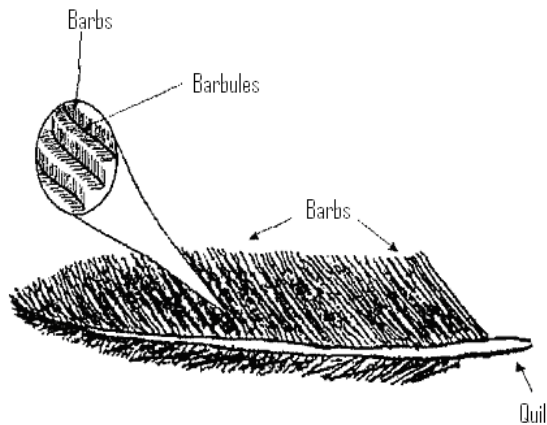


Figure 4. A schematic diagrams of chicken feathers

Barbs coming from the thick central quill and also nodes along each barb are shown in Figure 4; it can be assumed that the nodes are similar to the cuticle scales in wool. The cuticle consists of layers of scales and its function is to protect the fiber's cortex. Nodes and barbs on the feather fiber are related to “memory” properties and improve structural strength. Keratin fibers have a high degree of flexibility, mechanical property that depends on its small diameter, high elastic modulus and shape, and that should be used to modify bulk elastic properties of new materials.

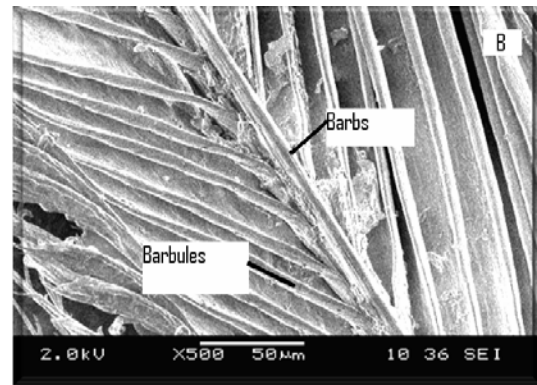
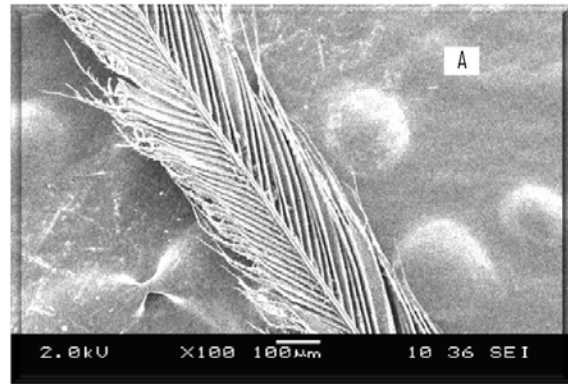


Figure 5. A & B: SEM figures - Longitudinal structure of chicken feather fiber

Figure 5 A & B shows the SEM. The microfibrils are twisted forming a helix that is responsible of the fiber's high mechanical strength. It is clear from the picture that the barbs are having branches called as barbules, which can contribute to the resilience property of the feathers. The cleave lines or striations along the fibers give rise to a certain surface roughness, which can contribute to interfacial strength that in addition to the high length to diameter ratio reached for the fiber can be useful for reinforcing composites (one of the possible applications for this fiber).

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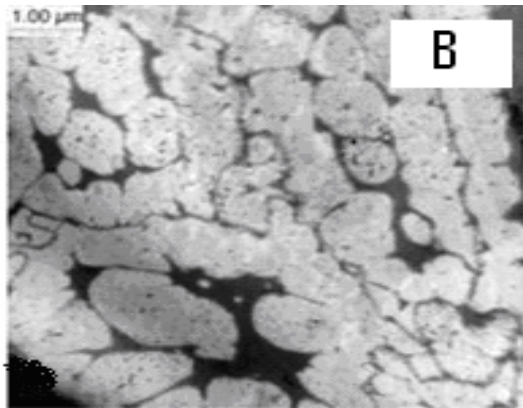
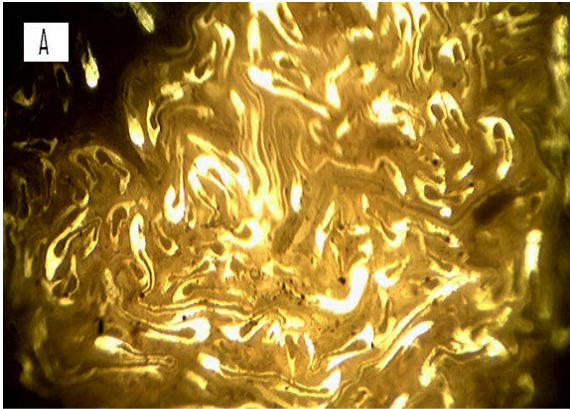


Figure 6. Optical Microscope (A) and TEM (B) - cross sectional views of chicken feather fiber

Figure 6A shows the honeycomb structure of the feather and confirms the possibility of more air pockets in the feather which contributes to the high thermal resistance characteristic. Figure 6B confirms the presence of two different structures inside the bio-fibers: micro-fibrils and proto-fibrils. The former has a more order and crystalline structure than the matrix. The proto-fibrils are inside the micro-fibrils and are also surrounded by the matrix.

4. Conclusion

The amino acid content reveals that the fiber is highly hydrophobic and partially hygroscopic in nature. The microscopic study allow us observe and describe the feather fibers characteristics that it is hierarchical and extremely ordered structure, starting from their internal parts. The

exceptional shape, a center fiber with many branching fibers, makes feather fibers, useful for different applications like filter material, storing material, composite material etc.

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