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Study of traditional and modern applications of feathers-a review

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ABSTRACT

Keratin protein extraction from feather is developed and largely used because it is cheap, environment friendly, economically beneficial for biomaterial. Keratin extracted from feather has 10kDa molecular weight. In feather 50% part is consist of fibers and quill. A feather has fibers and further, fibers contain α-helix and β-sheet. In a fiber ratio of α-helix has larger percentage as compared to β-sheet. While in a quill the fraction percentage of β-sheet is higher as compared to α-helix. Cysteine residues amount extracted depend on the source of keratin, that vary in feather ranging from 7%. Birds feather are used in different ways for various purposes e.g. decoration pieces and toys. Different species of birds are used in different ways for folk therapies e.g. *Phalacrocorax brasilianus* used for cure of flu, *Ceryle rudis* used for treatment of cough, *Nothura boraquira* used for cure of typhoid and headache, *Meleagris gallopayo* used for treatment of asthma, *Coragyps atratus* used to get rid of alcoholism, *Coryus splendens* used for love poison treatment. *Corythaeola cristata* used for whooping cough cure and *Columba livia* used for paralysis treatment. In industries feathers are used for different purposes e.g. dressing of wounds, bio-sorbent, modify antibacterial activity, enhance viability of cell, as micro-and nano particle as well as in cosmetics. Graphene Oxide and its derived forms are used as biomaterial like, for ruminants as feeding supplement, protein fibers growth, films of keratin in supply system of drugs, regenerated fibers, along with microorganisms used for decomposition in waste management system, processing of leather, handspun yarn, in electrode material used as micro-porous substance, films of thermoplastic, textile thread (fibers), fire resistant substance, bio-fertilizer, in detergent making keratinases, in pharmacy, reformation of tissue, formation of paper, bio-plastic, bio-composites, wound dressing and healing.

Keywords: Feathers, Folklore, Protein, Keratin.

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INTRODUCTION

Feathers contain keratin that is potential source of commonly used, cheap, eco-friendly and economically beneficial biomaterial (Poole et al., 2009). Feather keratin contains 10kDa molecular weight (Kamarudin *et al.*, 2017). Feather has 50% of fibre as well as quill its by weight (Reddy and Yang, 2007). Inside a feather, fiber consist of 41% α-helix that is greater than 38% of β-sheet and in quill β-sheet amount is 50% than 21% of α-helix (Barone *et al.*, 2006). Previous research (Sun *et al.*, 2009), shows that feather consists of 9.38% alpha-helix, 47.19% beta-turns 32.25%. Cysteine residues amount rely on the source from which keratinis extracted and in a feather it changes from 07% (Fraser *et al.*, 1972).

TRADITIONAL MEDICINAL USES OF FEATHERS

It was documented that birds feather utilized for various purposes in our life e.g. in decoation and toys (Altaf *et al.,* 2017). Different species of birds are used in various folk therapies e.g. *Phalacrocorax brasilianus* used for treatment of Flu, *Ceryle rudis* beneficial for cough, *Cathartes aura* help in cure of cancer and epilepsy, *Nothura boraquira* utilized in snake bite treatment, *Payo cristatus* used for cure of headache and typhoid, Meleagris gallopayo help for treatment of asthma, *Coragyps atratu* found helpful to get rid off alcohlism, *Coryus splendens* used for love poison, *Corythoeola crstata* found to be used against whooping cough and *Columba livia* used for paralysis cure (Table 1).

Table 1: Traditional medicinal uses of feathers

Name	Traditional uses	References
Phalacrocorax brasilianus	Flu	(Martínez, 2013)
Ceryle rudis	Cough	(Vijayakumar *et al.*, 2015)
Cathartes aura	Cancer and epilepsy	(del Rosario Jacobo-Salcedo *et al.*, 2011; Alonso-Castro, 2014)
Nothura boraquira	Snake bite	(Bezerra *et al.*, 2013; dos Santos Soares *et al.*, 2018)
Pavo cristatus	Headache and typhoid	(Padmanabhan and Sujana, 2008; Lohani, 2011)
Meleagris gallopavo	Asthma	(Alves *et al.*, 2009)
Coragyps atratu	Alcoholism	(Alves *et al.*, 2009)
Corvus splendens	Love poison	(Haileselasie, 2012)
Corythaeola cristata	Whooping cough	(Bobo *et al.*, 2015)
Columba livia	Paralysis	(Altaf *et al.*, 2017)

INDUSTRIAL USES OF FEATHERS

Feathers played important role from industrial point of view by utilizing in different forms e.g. bio-sorbent, dressing of wound, cosmetics, enhancer of antibacterial activity, enhance viability of cell by regulating its function and survival. In nano- and micro-particles Graphene Oxide and its derived forms are useful in biomaterial, like for the ruminants these are added as dietary supplement, synthesis of protein fibers, keratin films production for drugs supply system, fibers regeneration, decomposition of waste by help of microorganisms, processing of leather, handspun yarn, in electrode material used as micro-porous source, thermoplastic films preparation, textile industry yarns, fire extinguisher, bio-composite or composite fabrication, organic bio-fertilizer, in detergents preparation keratinases is used, medicinal application, regeneration of tissue, paper formation, bioplastic and in wound dressing that help wound healing (Table 2).

Extraction of nano- and micro-particles from feather is tough because cystine form high cross-linking; therefore few researchers formed micro and nanoparticles from keratin of feather. For this purpose keratin was changed into beneficial micro-particles by ionic liquid treatment, 1-butyl-3 methylimidazolium chloride (Sun *et al.*, 2009). In wound dressing it is used. Feather that have been treated pocess less surface area but have more sorbing ability as compared to untreated feather because of its hydrophilic nature. Xu *et al.* (2014b) extracted nanoparticle from feather keratin of size ranging from 50-130nm, which depicted biocompatibility as well as good stability required for regulated drug release. These nanoparticles were extracted from poultry feather keratin and utilized as anti-hemorrhagic agent that causes reduction of bleeding in amputation and liver scratch as seen in rat sample by decreasing blood loss time (Wang *et al.*, 2016). As antibacterial role it was seen that keratin extracted from quail feather mixed with silver nanoparticle that formed nano-fibrous scaffold was helpful to 99.9% and 98% shielded from activity of Gram-positive i.e. *Stapylococcus aureus* as well as Gram-negative i.e. *Escherichia coli* bacteria. So, it could be used in biomedical application (Khajavi *et al.*, 2016). It help in wound healing. Chitosan sugar pocess good biodegradator and biocompatibility ability scaffold form when mixed with nanoparticle of keratin. Adsorption of scaffold increased by biodegradation and keratin protein that was found noncytotoxic for ostoblastic cells of human. Therefore scaffold act as biomimetic substrate in application of bone-tissue engineering (Saravanan *et al.*, 2013). The keratin nanopowder was extraxted from chicken feather by electrospraying technique that contain smaller particle size and minimum crystalline form as compared to raw keratin (Rad *et al.*, 2012). From feather keratin hydrostable nanoparticles were formed. Long polymer chains of amino acid join to form keratin protein having molecular weight of about 10,500 Da in a feather (Starón *et al.*, 2011). These polypeptide chains have hydrogen bonding among carboxyl and amino group, resulting α - helix and β-plated sheet form because of continuous bends and folding in polypeptide chain backbone.

In α-helix structure, hydrogen bond form having high leveled link with carboxyl group of amino acid group and amino group of other amino acid in polypeptide chain. Alpha-helix structure has diameter of 7-10 nm, with 40-68kDa molecular weight (Wang *et al.*, 2016). Alpha-keratin form is mostly present in mammals. It is present in the coiled formed and therefore take part in formation of compactly packed structural arrangement that causes elongation of polypeptide chain (Crick, 1953). In β-sheets between carboxyl and amino group intra-molecular hydrogen bonding is present. Beta-sheet has 3-4 nm diameter and 10-22kDa molecular mass.

Since ancient times human were curious to know the mechanism how birds fly, and during swimming and rain how they protect wings from getting effected by water. It was noted that their wings neither get messy and filthy when expose to water during swimming and rainy season. Therefore, it is thought that keratin protein's β-sheet is the factor that helps to supply mechanical assistance to feather against getting sloppy and messy. For more clearance, Filshie and Roger (1962) worked by using transmission electron micrograph, and they analyzed and concluded that along β-keratin filament another filament matrix is present having 3nm diameter and is found inserted in amorphous matrix.

In a research conducted by Fellahi *et al*. (2014) it was documented that every year poultry, flesh and leather industries dump huge amount of keratin containing waste material. Globally per year 8.5 million feather wastes is extracted from poultry processing industries. Recently research work done by Agrahari and Wadhawa (2010) reported that, to get rid off from keratin containing waste are buried in soil that is utilized for land filling, but they are causing difficulties like deposition, radiations and ash discarding. It was reported by Sinkiewic *et al*. (2017) by the help of multiple chemical conversions keratin protein is extracted from feather. Keratin extracted from poultry feather consist of, 90% keratin protein with additional amino acids such as cysteine, threonine and arginine.

It was reported by Shama *et al.* (2018) that in alkaline condition and by using sodium sulphide as reducing agent keratin protein was obtained from poultry feathers. This process was conducted in incubation time of 6 h at temperature of 50 °C by using sodium sulphide of 500 Mm concentration nearly 80.02% wt. of keratin protein was maximum obtained extraction. Ramakrishnan *et al*. (2018) documented that bioplastic having good mechanical qualities can be manufactured by help of keratin.

Sinkiewicz *et al*. (2017) and Ayutthaya *et al*. (2015) performed another experiments for keratin extraction in short time for this purpose they used sulphitolysis reaction on feather, it was observed that by using 0.5 M concentration of bisulphite and metabisulphite ions 82% and 63% of keratin protein could be extracted at 50 °C in just 2 h. While Ayutthaya et al. used metabisulphite ions in reaction at 65 °C for 5 h, obtained maximum yield 88% by help of metabilphite concentration of 0.2 M.

Nagai and Nishikawa (1970a) used 0.1 M concentration of NaOH at temperature of 90 °C applied on powdered feather for 15 minutes (1g of powder in 40 mL of liquid) and highest extracted yield of keratin protein in shortest time was 90%. Alkali were used to extract free of amino acids water soluble keratin protein from feather. In the extract amino acids were separated by using paper and column chromatography techniques. However, it was observed that amino acids extracted by chromatography technique were different from those amino acids that were analyzed on start in feather. It was assumed about them that amino acids present in keratin residue were broken up during extraction process while remaining protein was found to having high amount of methionine, lysine and glutamic acid with minor amount of threonine, serine, cystine and arginine as compared to non-spoilt powdered feather.

Nagai and Nishikawa (1970b) documented that poultry powdered feather when treated with Schweitzer's reagent that was obtained by precipitates formed from aqueous solution of Copper sulphate in presence of NaOH then mix formed precipitates with ammonia solution. For extraction experiment was conducted on room temperature for a day (24 h). In precipitates Cu (Copper) was added to gain maximum protein at 7 pH. Onward acidification cause decrease in protein extraction because in more acidification protein start dissolving in acid. Extracted precipitates of protein were dissolved at 7.5 pH in minor amount of phosphate buffer and dialyze for copper removal. However, mechanism of keratin dissolution by using Schweitzer's reagent was not elaborated despite of known mechanism of cupric ion binding with protein. The last product obtained by using this mechanism was keratin-copper complex because copper was not removed during dialysis. Moreover, in Schweitzer's reagent by using atmospheric oxygen at high pH cystine residue in powdered feather was changed to cysteic acid and no lanthionine was produced.

Table 2: Industrial uses of feathers

Feathers of birds	Industrial Application	References
Rock pigeon	Biosorbent, wound dressing and cosmetics	(Nanthavanan *et al.*, 2019)
Quail	Enhance antibacterial properties and cell viability	(Khajavi *et al.*, 2016)
Waterfowl	Improve fibers	(Tsuda and Nomura, 2014)
Chicken	Development of protein fibers, Keratin film for drug delivery system, Regenerated fibers, Micro- and nanoparticles, Graphene oxide and its derivative in biomaterials, As a diet supplement for feeding ruminants, Micro-porous material used as electrode material, Thermoplastic films, Waste management using microorganisms for degradation, Leather processing, Handspun yarn, Textile yarns, keratinases in detergents, Formulation, Flame retardant, Bio-composites or composite fabrication, Bio-fertilizer, pharmaceutical application, Tissue regenerative applications, Paper production, bioplastic and wound healing	(Coward-Kelly *et al.*, 2006; Karthikeyan *et al.*, 2007; Reddy and Yang, 2007; Poole *et al.*, 2009; Rouse and Van Dyke, 2010; Zhan and Wool, 2011; Gurav and Jadhav, 2013; Flores-Hernández *et al.*, 2014; Manivasagan *et al.*, 2014; Reddy *et al.*, 2014a; Reddy *et al.*, 2014b; Xu *et al.*, 2014; Amieva *et al.*, 2015; Kumar *et al.*, 2017; Sharma *et al.*, 2017a; Sharma *et al.*, 2017b; Tesfaye *et al.*, 2017; Wang *et al.*, 2017; Ramakrishnan *et al.*, 2018)

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