Fish Collagen: An Alternative Source of Mammalian Collagen

Md. Aman Hassan*, Parmanand Prabhakar, and Sarvendra Kumar

College of Fisheries Kishanganj, Bihar Animal Sciences University Patna, Bihar

Corresponding Author
Md. Aman Hassan
Email: madman.hassan@gmail.com

OPEN ACCESS

Keywords

Collagen, Structural Protein, Pharmaceutical, Cosmetics

How to cite this article:

Hassan, Md. A., Prabhakar P. and Kumar, S., 2024. Fish Collagen: An Alternative Source of Mammalian Collagen. *Vigyan Varta* 5(10): 170-173.

ABSTRACT

The utilization of fish-based collagen is growing fast due to its unique properties in comparison with mammalian-based collagen. Fish based collagen has no risk of transmitting diseases, a lack of religious constraints, a cost-effective process, low molecular weight, biocompatibility, and its easy absorption by the human body. Collagen is the most abundant structural protein in the extracellular matrix of the various connective tissues in the body such as skin, bones, ligaments, tendons, and cartilage. The application of collagen is used as biomaterials, especially as drug and gene carriers, tissue engineering, absorbable surgical suture, osteogenic and bone filling materials, hemostatic agents, immobilization of therapeutic enzymes etc.

INTRODUCTION

Collagen is the main structural protein of extracellular matrix, found in the bodies various connective tissue. As the main component of connective tissue, it is the most abundant protein in mammal. Mammal contains 25-35% of the whole-body proteins. Mammal such as cows and pigs are the main source of collagen. Collagen was discovered to the principal structural protein that support the skin and internal organs of the animals and fish. However, mammalian-based collagen has been limited by disease like bovine spongiform encephalopathy (BSE) and other religious beliefs. Now a days fish or aquatic animals also source of collagen. Fish collagen is similar to mammalian collagen. It is a component of food, cosmetics, medicine and biomedical products.

At least 29 different types of collagen have been reported and Type-I collagen is the most abundant collagen in connective tissue (Gomez-Gulen *et al.* 2011). According to Pati *et al.* (2010) Type-I collagen has been extensively used as biomaterial for the development of tissue engineering constructs and wound dressing systems due to its low antigenic and high direct cell adhesion properties. Skin, bone and cartilage tendon of vertebrates' species such as cow and pig are main source of collagen. The use of collagen is rapidly expanding in cosmetics and pharmaceutical industry. Outbreaks of mad cow disease have resulted in anxieties amongst users of cattle collagen. Besides, the collagen from pigs' skin and bone is not allowed to use in some regions due to religious reasons. Alternative source of collagen is fish skin, bone, scale, fins, squid skin jelly fish, and refiner discharge from surimi industries, because of their abundance and no risk of disease transmission (Heu *et al.* 2010). Some parts of the collagen from fish skin, bone and refiner discharge of surimi cannot be extracted with organic acid such as acetic acid and can only extracted by enzyme. The collagen has been extracted from the aquatic species comes under Type-I collagen. According to Heu *et al.* (2010), the molecular structure of type I collagen consists of 3 polypeptides means trimeric $[(\alpha_1)_2 \alpha_1]$, α-chains bundle together in a tight triple helix. The existence of at least two different polypeptides in collagen indicated Type-I collagen. The molecule weight of α_1 showed above 116kD, α_2 almost equal to 116kD and β chain showed below 238kD are indication of Type-I collagen. It has been sshown that collagen exists in different genetic forms and to date some 27 different types of collagen have been identified with Type-I collagen occuring widely, primerily in connective tissue (skin, bone and tendons), where as Type-II collagen occurs practically exclusively in cartilage tissue.

Structure of collagen:

The collagen produced by organisms is defined as endogenous, which consists of three helical structure and the triplet (Gly-X-Y)n repetition, where X and Y are the amino acids i.e, proline and hydroxyproline. Proline and hydroxyproline are most abundant and frequently found on location.

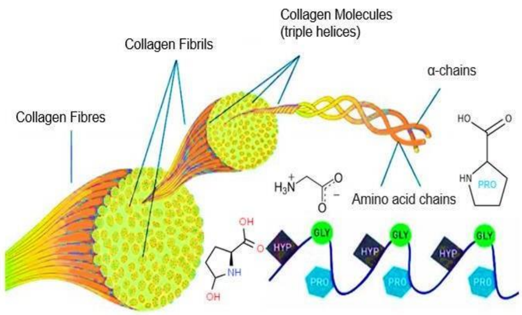

Figure 1. Triple helical structure of collagen protein

Collagen's unit is composed of three α-chains, the amino acid composition of which varies among collagen types. There are at least 28 types of collagen depending on the domain structure and their superstructural organization, but 80–90% of the collagen in the body consists of types I, II, and III. The most abundant type of collagen in the body, type I, can be found in the bones, skin, tendons, and organs. Type II can be found in cartilage, and type III can be found in reticular fibers, blood, and skin. Collagen type III can be found in the skin, vessel walls, and reticular fibers of the lungs, liver, and spleen (Figure 1). Types IX, XIV, and XIX (FACIT: fibril associated collagens with interrupted triple helices) are associated in low amounts with the fibril-forming types and types IV, XIX, and XVIII are found in basement membranes of cell membranes. Types I to IV collagens are the most prevalent invertebrates. Furthermore, function and distribution in tissues play a role in the diversity of collagen, as well as molecular and supramolecular organization, such as occurrence and length of triple helical domains, packing of the triple helices, etc. Collagen breaks down due to aging, exposure to ultraviolet light, and tobacco. The degradation of collagen results in wrinkles, sagging skin, stiff joints, and dry skin, and therefore, it is essential to identify new resources of collagen for regenerative tissue applications. A single collagen molecule is approximately 300 nm long and 1.5–2 nm in diameter and multi-collagen molecules make up larger collagen aggregates, such as fibrils. Collagen is characterized by a triple-helical-domain(s) structure named "tropocollagen", as it consists of three distinct-chains. These are three parallel polypeptide strands, each with a conformation of a left-handed helix coiled around each other in a rope-like manner to form a right-handed triple helix or "superhelix", which is the overall tightly packed triple-helical form of the molecule stabilized by many hydrogen bonds.

Source of collagen:

According to Caruso *et al.* 2015), it has been estimated that more than 50% of fish tissues, including fins, heads, skin, and viscera, are discarded as "waste", exceeding 20 million tonnes of by-products per year. However, the exploitation of seafood by-products represents a growing issue. Moreover, one of the most appealing features characterizing the seafood industry, which has been discarded, is the high content of valuable protein (10–25%) and lipid-rich compounds (17–35%). Collagen from fish skin, bones, and fins have a low denaturation temperature (25–30 °C for most fish species) compared to mammalian collagen (39–40 °C) and variable composition, which limits its use in biomedical applications. The low amino acid content (proline and Hyp) in marine collagen causes the low denaturation temperature, which makes fish collagen challenging to handle as it denatures at human body temperature. At present, collagen from marine invertebrate organisms is under investigation, including jellyfish and marine sponges.

Pharmacological applications of collagen:

Exogenous collagen is mostly used in food, biomaterials, and pharmaceutical applications. Dueto the wide range of applications of collagen, alternative sources, such as mammalian collagen from cattle and pigs, have been explored. Nevertheless, the outbreak of diseases such as bovine Exogenous collagen is mostly used in food, biomaterials, and pharmaceutical applications. Due to the wide range of applications of collagen, alternative sources, such as mammalian collagen from cattle and pigs, have been explored. Nevertheless, the outbreak of diseases such as bovine spongiform encephalopathy (BSE) and religious constraints have limited mammalian-based collagen applications. spongiform encephalopathy (BSE) and religious constraints have limited mammalian-based collagen applications.

Bio medical application:

Collagen-based products have a number of pharmacological applications because of their inimitable physiochemical properties like biocompatibility, accessibility, characteristic antibacterial property, and biodegradability. Biomedical field are nontoxicity, environment-friendly, immunomodulatory, bacteriostatic, excellent bioavailability, and tissue repair activity. The primary biomedical applications of collagen were in biomaterials, especially as drug and gene carriers, tissue engineering, absorbable surgical suture, osteogenic and bone filling materials, hemostatic agents, immobilization of therapeutic enzymes, and burn/wound cover dressings. Collagen is a crucial component of the wound-healing process; it acts as a natural structural scaffold or substrate for new tissue growth and plays an essential role in all phases of wound healing, including hemostasis, inflammation, proliferation, and remodelling.

Cosmetics application:

Collagen products in cosmetics are utilized for retaining moisture and heat loss from the injured site while shielding the wound from microbial attack and regenerating new tissues. Furthermore, vitamin-C eye gel with collagen is being utilized in ophthalmology as shields, micro-capsules, tablets for drug delivery, gels combined with liposomes for transdermal patches, and nanoparticles for genetic engineering technology. Collagen has different applications: in the cardiovascular system, collagen as an artificial blood vessel is grafted in patients with successful outcomes, in urological & genital diseases, corneal defects (contact lenses), neural migration, dental applications, osteoarthritis, and obese morbidities (Rastogi *et al*., 2021).

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