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Review Article

COLLAGEN FROM SQUID AND ITS BIOLOGICAL ACTIVITY

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ABSTRACT

Collagen is the sole protein found predominantly in the animal kingdom. The main source of collagen which had been land animals previously is being replaced by other alternative sources due to certain health related, religious and social concerns. Thus additional reliable, safer and productive options for collagen extraction have been studied extensively since then. Its wide-ranging application, especially in the biomedical and cosmetic field, is also a basis for its study to have become a topic of interest among the researchers. Isolation of collagen from the processing wastes of marine organisms has been receiving a lot of attention recently due to the promising outcome it brings forth. In the current review, we have focused upon squid, mainly its processing waste, as an alternative source of collagen including the studies carried out on the same to a certain extent.

Keywords: Type I collagen, Fish collagen, Squid, etc

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INTRODUCTION

Collagen is the primary and most profuse structural protein found in the animal kingdom, comprising nearly 25-30% of the whole-body protein content. It is typically found in fibrous tissues such as skin, ligaments, tendons, skin, corneas, cartilage, bones, blood vessels, teeth, etc. It exists predominantly in the form of a network like structure or as extracellular fibrils. Collagen has a unique ability to form insoluble fibers known as fibrils possessing high tensile strength [1]. Depending upon the degree of mineralization, collagen tissues may be classified as rigid (bone), complaint (tendon) or a gradient from rigid to the complaint (cartilage). Each collagen containing tissue fulfills its specific function as a result of the variation in the physical and chemical characteristics, composition of its amino acid, polypeptide chain, etc. It is involved in a variety of biological functions [2]. It also plays an indispensible role in cellular processes such as its motion, proliferation, apoptosis, etc [3]. Collagen exhibits exceptional biocompatibility, safety, biodegradability, cell-adhesive properties, low immunogenicity, etc [4, 5].

Structure and chemistry

Collagen is 300 mm long with a diameter of 1.5 to 2 nm and axial ratio of 150. The collagen protein (ie the mature collagen is also known as tropocollagen) exists in the form of a triple helix consisting of three polypeptide chains (alpha chains) in its 3-D form. These 3 chains may be either identical as in type II and III, known as homotrimer or may have two or more different chains as in type I, IV and V known as heterotrimer. Each of these polypeptide chains are coiled in the form of a left-handed helix and all the three winds up together form a right-handed helix. The polypeptide chain has nearly 1000 amino acid residues (with a molecular weight of nearly 100kDa) in it with a pattern of Gly-X-Y in it, where the X and Y positions are occupied by the imino acids, proline and hydroxyproline. Considering the helix structure, glycine is centrally located whereas the Pro and Hyp are arranged along its outer side [6]. The glycine content in most fish species is nearly 30-33% and about 16-18% of proline and hydroxyproline [7]. The Pro and Hyp are mainly responsible for the stabilization of the triple helix through hydrogen bond by the promoting polyproline II conformation [8]. It limits the rotation of the polypeptide chains involved and thus renders stability to its structure. The interchain hydrogen bonds are responsible for the stabilisation of the three polypeptide chains. The non-helical telopeptide zone at the terminal region of the molecule is usually involved in inter and intramolecular covalent cross-link of the alpha chain. At this region, the helical behaviour of the molecule is lost due to the presence of globular proteins which are involved in the crossliking. The hydrogen bond formed between the glycine residues amino group and the carbonyl group of other chains residues also contributes for the stabilization of the collagen triple helix [9]. Extracting the collagen with acid solution helps in obtaining the same with its alpha-helical configuration intact.

Types of collagen

There are nearly 28 different types of collagen classified based on the chain difference in their molecule [10]. The common types are type I-V. Some of them form network-like structures (Type IV, VIII, X, etc) whereas the others for a fiber-like structure. Different types of collagen are found in different sites of the body such as type I in bones and tendons, type II in cartilage, type III in skin, type IV in basement membrane, etc. [11] Among the various types present, type I collagen is considered the most important as it is present in almost all sites of the body and is the most abundant one. Type I collagen has α and β chains in the ratio of 2:1.

Applications of collagen

Collagen provides various health benefits such as

- Acts as a digestive aid.
- Exhibits anti-aging property.
- Contributes in weight loss.
- Makes the joints and bones healthy.
- Helps improve athletic performance by an increase in muscle mass.
- Improves sleep quality.
- Strengthens hair, nail and teeth.

Collagen is widely used in the food, pharmaceutical, medical, biomedical and cosmeceutical fields, leather and film industries, etc. It is widely used as a biomaterial in the biomedical field. Additional uses, especially in the food industry, include the production of gelatin, sausage casings, nutritional supplements, etc. In the cosmeceutical field, it is available in different forms as an anti-ageing product. Since collagen can be made available in varied forms such as sponges, tubes, powders, sheets, dispersion, injectable solution, etc; it is applicable in tissue engineering, ophthalmology, wound dressing, burn treatments, etc [12, 13].

Sources of collagen

Collagen has been extracted mainly from the connective tissues of various sources such as animal as well marine source. Till recently, the animal source had been used commercially for collagen extraction, especially the porcine and bovine skin and bones. But it was due to the onset of diseases such as Bovine spongiform encephalopathy (BSE), Transmissible spongiform encephalopathy (TSE), Foot-and-mouth disease (FMD), etc and also cultural and social concerns, other alternative and safer sources of collagen were probed for [14]. Since then serious studies have been carried out on collagen extraction from marine vertebrates and invertebrates such as fishes, starfish, sponges, octopus, squid, sea urchin, cuttlefish, sea anemone, jellyfish, prawn, etc [15-18].

Collagen content varies among different species. The properties of collagen extracted from different sources, be it animal or marine source, greatly depends on its habitat, species, targeted tissue and body temperature of the organism used, etc. [19, 20].

Marine processing wastes which are a threat to the environment can be utilized effectively for the extraction of many value added products which also includes collagen. Fish wastes such as skin, bones, fins, scales are being studied extensively.

The processing wastes of squid includes its skin, head, viscera, backbones or pens, ink, tentacles, fins, mantle, etc. It makes up 60% of its total body weight [21]. While considering the squids, its collagenous membrane which becomes detached during the mechanical processing procedure can be utilized for the same [22]. Collagen content found in the mantle of the squid constitutes nearly 10% of its total protein content. Due to the commercial importance and the presence of high protein content especially collagen in the squid, we have chosen squid for our research. Till date, squid collagen that has been studied are included in table 1.

Table 1: Squid collagen studies

Squid	Scientific name	Tissue	Collagen	Ref
Atlantic short-finned squid	*Illexillecebrosus*	Mantle	3-11%	23
Atlantic long-finned squid	*Loligopealei*			
Jumbo/Giant squid	*Dosidicusgigas*	Fin, arms, mantle.		24 33
Squid	*Todarodespacificus*	Skin		25
Squid	*Todarodespacificus*	Mantle muscle	Type SQ-I and SQ-II	26
European squid	*Loligo vulgaris*	Mantle	ASC(5.1%) and PSC(24.2% on Dry weight basis	27
Persian Gulf squid	*Uroteuthisduvauceli*	Skin	Type I	28
Squid	*Ommastrephesbartrami*	Skin	ASC and PSC type I collagen	29
Diamondback squid	*Thysanoteuthis rhombus*	Skin	ASC(1.3%) and PSC(35.6% on dry weight basis) 27.5°C,	30

Squid collagen was found to have a porous structure which encourages cell adhesion, morphogenesis, aggregation and growth. Collagen concentration in the mantle of certain squid species like *Loligo* and *Ilex* were found to be from 3 to 11.1% while in *Dosidicusgigas*, it was up to 18.33% [31, 32]. Variation in concentration of collagen obtained is seen as a result of high rate of protein turnover occurring in the muscles of the squid. This is evident due to their fast growth requiring just one to two years to attain maturity. Much more studies are still being carried out with different species from different parts of the world.

Applications of squid collagen

The collagen extracted from the Persian Gulf Squid was shown to be suitable to be used as a substrate in three-dimensional cell culture system, which in turn could be used effectively as a tool in biomedical research. This can be made use of for the development of newer drugs and treatment protocol particularly in the case of cancer. The collagen extracted from the mantle of Jumbo squid (*Dosidicusgigas*) mantle collagen has potential to be used as a plasticiser agent and can be used for biofilm preparation when blended with chitosan. Jumbo squid fin and skin collagen hydrolysates exhibited antioxidant activity. The by-products of Jumbo squid, mainly its fin and arm collagen hydrolysates were shown t exhibit antioxidant, anti-mutagenic and anti-proliferative activity and it was concluded to be studied further to confirm its role as a food additive. The enzymatic hydrolysates of the collagen obtained from the skin of squid (*Todarodespacificus*) showed antioxidant, anti-elastase and tyrosinase inhibitory activities. The mantle of the squid *Loligo vulgaris* demonstrated its potential as a substituted source of collagen-derived materials.

CONCLUSION

Collagen is a protein with numerous applications in varied fields such as biomedical, pharmaceutical, cosmetic, etc. Collagen can be obtained from various sources. Out of all sources available, collagen from marine source is being focused upon lately. Considering the aquatic source, the processing wastes are being targeted as it helps to prevent environmental pollution apart from providing a safer, economic and reliable source of collagen. In the current review, we had tried to summarise the research work carried out on squid and its collagen, especially from its processing waste. The squid was found to be a promising source of collagen and further research needs to be carried out to further explore its potential.

CONFLICT OF INTERESTS

Declare none

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