



Research progress of collagen in application

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Abstract

Collagen is the most abundant protein in the animal body, is the cartilage, tendon and ligament of the connective tissue and the key structural component of the skin. According to the source, collagen can be divided into terrestrial collagen and marine collagen, different sources of collagen in the safety and use of differences. In recent years, with the improvement of People's living standard, the demand of collagen products in cosmetics and health products industry is increasing, and the market income is increasing year by year. Based on the structure and classification of collagen, this paper mainly introduces the differences of different types of collagen in application, the aim is to provide a reference for people to choose which type of collagen to buy according to their needs.

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1. Introduction

Collagen is the most abundant protein in mammals (approximately 30% of the total protein mass), and its family consists of 28 members, which contain at least one triple helix structure ^[1]. Collagen is deposited in the extracellular matrix (ECM), most of which forms supramolecular assemblies. Different types of collagen often have different roles, for example Type I collagen is the most studied collagen, it accounts for more than 90% of the organic mass of bone, and is the main collagen of tendons, skin, ligaments, corneas, and many interstitial connective tissues. In most organs, except tendons and fascia, type I collagen provides stiffness, and in bones, it is used for load-bearing, stretching, etc ^[2]. Type II collagen is the main component of hyaline cartilage in the body. However, it is not limited to cartilage, which accounts for about 80% of the total collagen content, as it is also present in the vitreous body, corneal epithelium, notochord, intervertebral disc nucleus pulposus, and embryonic epithelial-mesenchymal transition ^[3]. Type III collagen is widely distributed in tissues containing type I collagen except bone ^[4], and it is an important component of reticular fibers in lung, liver, dermis, spleen and vascular interstitial tissues. Type V collagen usually forms heterofibril with type I and III collagen, and forms organic bone stroma, corneal stroma, muscle, liver, lung, and placental stroma ^[5]. To sum up, different types of collagen play different roles in the body. This paper mainly introduces the application direction of different types of collagen.

2. Overview of Collagen

2.1 Collagen structure

The structure of collagen has remarkable characteristics, and its primary structure is composed of glycyl-prolyl-Y, glycyl-prolyl-hydroxyprolyl, glycyl-XY (where X and Y represent prolyl and any other amino acid residue except glycyl) ^[1], which is expressed as a tripeptide repeat sequence. Collagen contains hydroxyproline and hydroxylysine, which are rare among other proteins. It also has more proline and lysine, lacks tryptophan, and contains less aromatic amino acids and cysteine. It's called an incomplete protein. The secondary structure is a special three-stranded helical structure ^[6] consisting of three left-helical alpha-peptide chains in parallel and right-handed form, which are wound to form a rope-like right-handed superhelix structure.

The tertiary structure reflects that in addition to the role of secondary bonds of collagen peptide chain, there are three kinds of intramolecular and intermolecular crosslinking of aldol condensation, aldol histidine cross-linking and aldol amine condensation cross-linking, which make collagen have high tensile strength. The quaternary structure indicates that procollagen molecules are arranged in parallel bundles according to certain rules, crisscrossing one quarter from the front end to the end, and are covalent to form stable collagen fibers, which are then further aggregated into larger fiber bundles^[7]. Collagen fibers are arranged in different tissues in different ways.

2.2. Collagen classification

Collagen is not the name of a protein, but a large and highly specialized family of fibrins. It has the same characteristics and structural differences. The known numbers are increasing. So far, 27 different types have been identified. According to the order of discovery, they are named type I collagen, Type II collagen, and Type III collagen using Roman numerals. According to different functions, collagen can be divided into fibrous collagen, reticular collagen, beaded collagen, etc^[8]. According to the tissue, it can be divided into fibrous collagen, cartilage collagen, vitreous collagen, elastin and so on. Due to the different source tissues, it is usually divided into skin collagen, bone collagen, squamous collagen, tendon collagen and so on.

Collagen is the most abundant protein in animals^[9], is the animal cartilage, tendon and ligament of the connective tissue, and many organs such as blood vessels in the connective tissue; The key structural components of bones, lungs, heart, kidneys, liver, teeth, and skin. In every organization, the ECM consists of two basic parts: 1) the extracellular basement membrane, which is used to separate the epithelium and endothelium from the mesenchyme and provides an anchor point for the epithelium; 2) a complex interwoven network of proteoglycans, glycoproteins, collagen and elastin in the interstitial matrix. The interstitial matrix of collagen includes fibrous collagen types I-III, V, XI, XXIV, XXVII, while the basement membrane collagen types include IV, XV, XVIII^[10]. However, each type of collagen is not uniformly distributed in the ECM of tissues and organs. Although many tissues may contain similar collagen types, the proportions of components in the matrix vary to complement the unique functions and structures of each organ. For example, type I collagen is commonly found in tissues such as tendons, bones, teeth, skin, lungs, and heart. Type II collagen is found in cartilage, and type III collagen forms fibers with type I collagen. Of the 28 different types of collagen, type I collagen is the most abundant in the human body.

2.3. Absorption difference of collagen and collagen peptide

Collagen is a large molecular fibrous hard protein with a relative molecular weight of up to 300,000 daltons and a very low absorption rate of only about 2.5%. It cannot be directly absorbed by the human body after consumption, and can only be absorbed by the human body after digestion and decomposition into small molecule polypeptides or free amino acids. Moreover, there is evidence that more than 63.4% of amino acid residues in collagen are absorbed in the form of peptides to play its function^[11], indicating that collagen is mainly absorbed by the human body in the form

of collagen polypeptides. The relative molecular mass of collagen polypeptide is several hundred to several thousand, and it can be effectively absorbed and utilized by the human body after consumption, and the utilization rate can reach 90% or even more. Therefore, we recommend direct purchase of collagen peptide products, which can be absorbed quickly by the human body and have a high absorption rate, especially for people with poor digestion and absorption.

3. Differences in collagen extracted from different kinds of animals

3.1 Security variance

Marine resources have many advantages over collagen extracted from land animals^[12], such as environmental friendliness, high collagen content and negligible biotoxins. Collagen derived from Marine animals is obviously superior to that from land animals in some aspects, such as low antigenicity, hypoallergenicity and other properties, and high safety. It has better absorption due to low molecular weight, minimal inflammatory response, is metabolically compatible, and has few regulatory and quality control issues. However, land livestock, especially mammals such as pigs, cattle and sheep, are vulnerable to pollution due to their feeding environment and food feeds, so the purity of collagen extraction is not as high as that of fish collagen. In addition, in terms of safety, due to the risk of mad cow disease, foot-and-mouth disease and other epidemics in pigs, cattle and sheep, it is easy to have a significant impact on the quality control of collagen.



Fig 1: Marine collagen

3.2. Difference in fat content

Collagen of land animals is mainly extracted from the skin and bones of land animals. Due to different animal characteristics and molecular composition, collagen of land animals contains higher fat and heat, and tastes greasy, which is easy to make the body fat after long-term drinking. Fish collagen is mainly extracted from deep-sea fish skin, in addition to containing rich collagen, but also has 0 fat and low calorie characteristics, effectively avoid long-term drinking easy fat problem.

3.3. Use difference

Collagen can repair broken and aging elastic fiber network, reorganize skin tissue structure and stretch wrinkles; In

addition, it can also remove free radicals from the body, resist oxidation and slow down skin aging. Collagen has good biocompatibility, biodegradability and bioactivity, so it is widely used in food, medicine, tissue engineering, cosmetics and other fields. Bovine collagen is commonly used as a temporary covering for oral injuries and body burns [11] and has a wide range of potential applications due to its beneficial properties and biocompatibility. Porcine collagen matrix has potential for soft tissue transplantation as it offers a biocompatible surgical material as an alternative to autologous transplantation. Fish collagen contains a large number of polar groups and can be widely used in beauty products. It has excellent affinity with human skin and can exert its functions such as penetration, moisturizing and repairing. It is also good for skin, eyes, bones, nails, internal organs, etc.

4. Collagen market and revenue

Collagen has rich sources and broad market prospects, and has a mature international consumer market at present. Among them, the foreign market started to take the lead, as early as 1980, Japan NIPPI company began to produce collagen peptide products and market sales, NIPPI company has collagen peptide special research Institute (NIPPI Biomatrix Institute). The U.S. Food and Drug Administration (FDA) has included collagen in its list of the highest level of safety, which gives a direct use food additive ingredient safety level, GRAS, to facilitate collagen peptides that are widely used in a variety of foods. The domestic start is late, and there is still a gap with the international. China's collagen peptide market is an emerging market, most of the domestic collagen peptide production enterprises were established after 2005, the overall scale is small, high-end products and the international process level still lags behind, industry standards to be standardized. In recent years, the domestic research field is active, as of January 21, 2014, in the country has publicly participated in the patent application of 750 collagen products, including powder, capsule, beverage, the domestic research field of collagen products is very active, but also shows that domestic companies emphasize the protection of products. From the perspective of the Chinese market, at present, with the growth of Chinese women's consumption and the promotion of male skin care awareness, China's cosmetics market continues to expand, and the demand for products with functions such as maintaining skin elasticity and "delaying aging" has expanded, driving the demand for collagen. According to the data of the National Bureau of Statistics, the retail value of cosmetics products in China's units above quota reached 261.90 billion yuan in 2018, an increase of 9.6%; From January to June 2019, the retail sales of cosmetics by units above quota reached 146.18 billion yuan, an increase of 13.2% year-on-year. The rapid development of the cosmetics industry has driven the expansion of the demand for collagen, and the consumer market of the industry is gradually maturing. In the field of health food, with the proposal of the strategy of "Healthy China", Chinese residents' awareness of health care and health has been further improved, and the demand for health food containing collagen ingredients has correspondingly expanded. According to the data of the State Food and Drug Administration, at present, China's domestic health food, through the registration of the record, the main component of collagen health products total 191 kinds, mainly protein powder, tablets, capsules, protein drinks are relatively few;

Among the imported health food, there are 8 kinds of health food whose main raw material is collagen, including 5 kinds of capsules and 3 kinds of protein drinks.



Fig 2: Collagen solid drink

5. Conclusion

To sum up, there are many types of collagen. The parts and methods of collagen extraction for different types are different, and their uses are also different. Marine collagen is also different from collagen extracted from terrestrial animals. Therefore, all cosmetics and medicines should indicate in their formulations the type of collagen they use and why. At present, bovine collagen is still the most commonly used source of collagen extraction and synthesis products because of the price and cost problems, as well as the high homology between pig and human. Pig collagen is the second most commonly used source of collagen extraction and related products. These two types of collagen are commonly used as surgical materials and alternative materials for autologous transplantation. However, due to the characteristics of low immunogenicity and high hydrophilicity, Marine collagen has a high application prospect in the cosmetics industry, especially Marine biological collagen products are currently popular products in the cosmetics industry, and its high-quality moisturizing, anti-aging and anti-wrinkle functions can be used to make various creams and gels. In addition, collagen from cattle and pigs also has the function of repairing wounds and burns, and this review provides a reference for people to choose which type of collagen to buy according to their needs.

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