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Fish Skin: A Good Source of Protein and Peptides

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SUMMARY

Fish skin waste accounts for part of the solid waste generated from seafood processing. Using fish skin by bioconversion into high-grade products would potentially reduce pollution and the economic cost associated with treating fish processing waste. Fish skin is an abundant supply of gelatin and collagen, which can be hydrolyzed to produce bioactive peptides of 2–20 amino acid sequences. The bioactivity of peptides purified from fish skin includes antihypertensive, antioxidative, antimicrobial, neuroprotection, antihyperglycemic, and anti-aging. Fish skin acts as a physical and chemical barrier through antimicrobial peptide innate immune action and other functional peptides. Small peptides have been demonstrated to possess biological activities based on their amino acid composition and sequence. Fish skin-derived peptides contain a high content of hydrophobic amino acids, contributing to the antioxidant and angiotensin-converting enzyme inhibitory activity. The peptide-specific composition and sequence discussed in the article can be potentially utilized in developing pharmaceutical and nutraceutical products.

INTRODUCTION

Fish is a versatile food commodity. The expansion of the fish processing industry results in the generation of large quantities of refuse and wastes estimated to reach up to 75% of the total volume. Fins, heads, skin, and viscera of fish are discarded as “fish waste”.Fish waste problem has become a global concern causing significant economic loss. Therefore, it has been proposed to use fish waste as a potential source of many by-products. Among fish processing by-products, fish skin accounts for around 30 % (Jamilah et al., 2011). Fish skin is largely processed to produce proteins and fish oil. Protein is a food macronutrient providing essential amino acids to fulfill basic nutritional requirements. Since ages, proteins have been classified based on their composition and biological value. Some of the proteins influence human well-being, mainly in a beneficial way, beyond their nutritional values. Further, specific degradation of basic proteins results in biologically active protein hydrolysates and peptides, which possess a broad spectrum of health-promoting abilities. Fish skin is generated from commercial fish filleting, which is nutritionally valuable and easily digestible, with a well-balanced amino acid composition.

Fish by-products like skin and frame must be processed into fish hydrolysates either by fermentation or hydrolysis techniques before they can be effectively utilized. This increases production costs. Therefore, using fish processing waste through bioconversion into high-grade products like bioactive peptides would be a better alternative. This would increase the economic value of the catch and reduce the amount of marine processing waste.The biological activity of peptides is based on their amino acid composition and sequence. This biological activity ranges from antioxidant, antihypertensive, immunomodulatory, and antimicrobial activity as demonstrated by several studies using different fish species like pollack, skate, nile tilapia, sea beam, yellow fish, and skipjack.Bioactive peptides are specific protein fragments derived from plants or animal sources which possess nutritional benefits and positively influence health.Bioactive peptides are inactive in their parent protein sequence but can be released by enzymatic hydrolysis; however, for effective use, bioactive peptides must reach the target organ or receptors in the intestinal lumen intact and survive enzymatic degradation. Collagen and gelatin are the main proteins extracted from fish skin and, apart from their uses as gelling agents, functional properties of fish skin-derived proteins have been discovered.Fish skin, in particular from larger fish, provides gelatin and leather for clothing, shoes, handbags, wallets, belts and other items. Acid/alkali procedures have treated carp and redfish scales to produce collagen peptides. The scales are also treated with suitable solvents to extract pearl essence, a suspension of quanine crystals. When quanine particles are deposited on the inside surface of solid beads, an optical effect similar to that of a natural pearl is obtained. Untanned shark skin, with rough denticles attached, is called shagreen and has been used as sandpaper in woodworking and other industries for centuries. It has also been used to cover sword hilts (providing a slip-free grip) and as a striking surface for matches. The greatest use for shark skin has been for leather. Shark skin is tanned in much the same way as other animals' skin.Shark leather maybe used to make various products, including furniture,bookbinding,shoes, and handbags.

Fish collagen and gelatin

Collagen is the most abundant protein of animal origin, comprising approximately 30% of total animal protein. There are at least 19 variants of Collagen, named type I to XIX. Types I, II, III and V are the fibrous collagens. Type I Collagen is found in all connective tissue, including bones and skins, and it is the most naturally abundant Collagen in animals and is found in skin, tendons, vascular ligature, organs, and bone. It consists of one-third glycine, contains no tryptophan or cysteine and is very low in tyrosine and histidine. Guanidine hydrochloride to solubilize the part of Collagen referred to as GSC and then RS-AL. Gelatin is not a naturally occurring protein. It is derived from the fibrous protein collagen, the principal constituent of skin, bone, and connective tissue. It is a source of lysine and methionine deficient in cereal protein. However, it lacks another essential amino acid, tryptophan, and hence cannot be considered a sole source of protein in animal and human nutrition. Gelatin is extracted from the skin and bones of various cold-water (cod, hake, Alaska pollock, salmon) and warm-water (ex., tuna, catfish, tilapia, Nile perch, shark and megrim) fish. Bovine hide, pig skin,or chicken waste are the common sourcesofCollagen and gelatin, but these are not in use due to religious issues and biological contamination. Gelatin is produced by partial hydrolysis of native Collagen. The conversion of Collagen into soluble gelatin can be achieved by heating the Collagen in either acid or alkali and also through enzyme solubilization. All gelatin manufacturing processes consist of three main stages: treatment of raw material, extraction of the gelatin, and purification and drying, extracted Collagen is solubilized with hot water treatment by breaking down the hydrogen and covalent bonds of the triple-helix, resulting in helix-to-coil transition and conversion into soluble gelatin.

Biomedical applications of Collagen and gelatin

Gelatin is a pharmaceutical excipient, non-toxic, non-allergenic, GRAS status, high purity, excellent biocompatibility, and low immunological properties. Gelatin is used in plasma substitutes in emergency medicine and surgery, vitamin coating, tablets, globules, paste dressings, sponges, and formulation of new vaccines. Around 90%of the pharmaceutical grade of gelatin is used in capsule production-soft and hard.Gelatin has preservative and regenerative effects in bones, cartilage, tendons, and ligaments. Gelatin hydrolysate in skin creams improves the water binding capacity, reduces trans-epidermal water loss,and improves skin feel. Gelatin is used in the optical industry to forma coatingfor light-sensitive materials like blueprint papers. It also preparesantioxidant and antimicrobial edible films by adding essential oils. Alcalase-derived glycosylates hydrolysate of fish gelatin have antioxidative and antimicrobial activity.The High hydroxyproline content of collagen reducescollagen shows great advantages as a carrier molecule of drugs, proteins, and genes through long-term maintenance of the concentration andcontrolled release at target sites, as shown in fig.1. Detailed studies revealed that collagen type I, with selective removal of its telopeptides, exhibit characteristic features of bioscaffolds for boneregeneration.

Fish protein hydrolysate

Hydrolysis of protein is done through acids, alkalis, or enzymes-mediated breakdown of parent proteins in the waste into smaller protein fractions, peptides, and free amino acids. Acid hydrolysis makes the product unpalatable due to tryptophan destruction and the formation of sodium chloride after the neutralization. Alkaline hydrolysis produces several toxic compounds that are undesirable for human consumption. Among protein hydrolyzing methods, enzymatic hydrolysis offers several advantages over others. Proteolytic enzyme sources are plants (papain, ficin, bromelain), animals (trypsin, pancreatic enzymes), or microbial (pronase, alcalase). They are employed for hydrolysis,depending on the type of processing waste and the desired functionality of the end product.This process undertakes certain conditions like pH, temperature, incubation time, and enzyme/substrate ratio. Hydrolysisimpairs some functional properties of food proteins or causes the development of off-hydrolysate flavors in hydrolysates.An ultrafiltration membrane system equipped with a molecular cutoff has been identified as an effective method to purify protein hydrolysates based on the molecular weight of protein factions. Serial enzymatic digestion in a multistep recycling membrane reactor combined with an ultrafiltration membrane system has been developed to produce protein hydrolysates with the desired molecular weights while preserving expensive photolytic enzymes.

Biological properties of Fish Protein Hydrolysates

FPHs provide advanced health-promoting abilities due to the improvement in functionality achieved through the high amount of polar groups and the solubility of hydrolysate and bioavailability. FPHs possess potent antioxidant activity, attenuating oxidative damage in the body where the endogenous antioxidant defense mechanism is not good enough.FPHs are good to combat for the production of superoxide anion (O 2−) and hydroxyl (OH 1−) radicals, which are considered causative agents for the initiation of Chronic diseases such as heart disease, stroke, arteriosclerosis, diabetes, and cancer—protecting against oxidative damage while providing additional nutritional value. Reduce the risk of cardiovasculardiseases (CVD) by triggering several key associated processes, including blood clot and platelet formation, angiotensin 1-converting enzyme activity,and cholesterol metabolism.FPHs derived from blue whiting suppress appetite via the enhancement of cholecystokinin (CCK) and glucagon-like Peptide-1 (GLP- 1) secretion in vitro STC-1 cells. The biological effects of CCK and GLP-1 stimulation have promising results on body weight reduction.

Bioactive peptides from Fish Skin

Most of the bioactive peptides are 2–20 amino acids long, and the amino acid composition of the sequence plays a critical role in its bioactivity. Bioactive peptides exert physiological hormone-like effects on humans beyond their nutritional value. The protein hydrolysis method and types of protein-proteinase employed are crucial factors affecting the biological activity of the peptide.The ultrafiltration membrane system has been identified as a useful tool to purify active peptides based on molecular weight. Fish skin showed antihypertensiveactivity inhibiting the activity of angiotensin I-converting enzyme (ACE),which plays a vital role in regulating blood pressure.ACE participates in the body's renin-angiotensin system by converting inactive angiotensin I into active vasopressor angiotensin II. This conversion increases blood pressure, triggering the function of the blood vessel dilator bradykinin. ACE in blood pressure regulation, several commercial ACE inhibitors, such as captopril, enalapril, alacepril, and lisinopril, were synthesized and employed to treat hypertension and heart failures. Gelatin isolated from fish skin has been used as a common source of biologically active peptides.

CONCLUSION

Processing plants generate so much waste, so there is a demand to minimize the waste forenvironmental and economic concerns. Fish skinwaste produces many by-products for human purposes like treating cancer, cosmetics, etc. Identifying biologically active materials and their potential application in growing fields such as biomedical, nutraceutical, and functional food has brought new insight into fish processing by-products.

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