Role and function of gelatin in the development of the food and non-food industry: A review

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Abstract. Gelatin is a product of the partial hydrolysis of collagen in livestock. Gelatin has been used extensively in the food and non-food industries. Gelatin has a hydrocolloid form and plays an important role in influencing the properties of industrial products. Global gelatin demands is increasing every year along with the increasing human need for food and non-food industrial products. The properties of gelatin are influenced by the properties of collagen. Collagen is a derivative of fibrous protein which has an enormous role and benefit in forming gelatin molecules. Collagen is a long polypeptide chain that makes up about 50 to 1000 amino acid chains. The amino acid chain is dominated by the amino acids glycine, proline and hydroxyproline. Various studies related to the properties of gelatin produced from livestock and fish tissues have developed rapidly. Currently researchers have developed livestock and fish waste as an alternative source of gelatin. Alternative sources of gelatin have been widely published as an effort to find halal and hygienic sources of gelatin.

1. Introduction
Gelatin is a partial product of collagen hydrolysis, which is a water-soluble, thermo reversible and multi-functional hydrocolloid. Collagen has a high molecular weight and a type of protein that important to the livestock [1]. Gelatin is one of the major hydrocolloid products obtained from the hydrolysis of collagen proteins and is hydrophilic [2]. Gelatin is a source of protein that comes from large amounts of collagen. Characteristics of collagen proteins include at least 33% amino acid glycine and 22% proline [3]. In the 21st century, food technology has developed to produce foods that can be useful as a source of nutrition and also provide good functional properties. The functional properties are expected to have a positive influence on the human body [4]. Gelatin is the result of combining several polypeptide chains to form a triple helical conformation. Each of the three chains in the triple helical conformation require around 21 residues to complete one spin. Gelatin consists of rows of 50-1000 amino acids that are bonded together. Type I collagen is produced from the skin and bones consisting of two α1 (I) chains and one α2 (I) chain. The two chains each has a molecular mass of k 95 kD with a width of ≈ 1.5 nm and a length of ≈ 0.3 μm. Inter-chain bonds are formed into the hydroxyl group bonds between the amino acid hydroxyproline with carbonyl peptides forming hydrogen bonds with water molecules. Higher levels of proline produce a stronger gel [5]. The chemical structure of gelatin has been presented in figure 1. Gelatin in mammals has a relatively greater gel strength. The strength of the gel is directly related to the high hydroxyproline content of the structure of protein.
molecules [6]. Similar structures and properties of gelatin among animals can occur. This will provide difficulties in determining the gelatin nature of an animal [7]. Gelatin has a denatured biopolymer form. This product is obtained from the hydrolysis process of thermally collagen proteins. Based on chemical composition, gelatin is different from collagen. In collagen, the triple helix structure consists of three α chains while the gelatin structure consists of three different chains. These chains are α chains, β chains, and γ chains. Gelatin is structurally composed of chains of 3 recurrent amino acids composed of Glycine-Proline-Hydroxyproline. The functional properties of gelatin and the stability of the triple helix is largely determined by the involvement of amino acids proline and hydroxyproline [8].

Figure 1. Chemical structure of gelatin [5]

2. Gelatin sources

Gelatin can be produced from a variety of skins, such as: skin from tuna, chicken and frogs. Protein levels in frog skin gelatin reached 77.8% while chicken skin had hydroxyproline levels reaching 6.4%. Melting point of frog skin gelatin is much higher (42.7 °C) compared to tuna and chicken gelatin [9]. The use of gelatin from cattle is partly not considered. This is related to the outbreak of Bovine Syndrome Encephalopathy (BSE) outbreaks [10]. This certainly encourages researchers to look for alternative sources of gelatin that are safe from humans [11].

One potential source of gelatin is animals that come from the sea [12] such as skins from carp [13], as well as from the skins of Rohu and tuna [14]. Gelatin from tuna, especially the head, has excellent gel-forming properties [15]. Gujarat is one of the countries in India which is the highest fish producing area since 2014 with contributions reaching 7.86 lakh tons. A total of 16,237 tons of leatherjackets and 43,19 tons of grouper fish were imported in India in 2017. The export market is carried out specifically for several regions such as the EU and countries outside the EU such as China, Vietnam and Malaysia. The percentage of waste produced reaches 65-73%. Fishery products might be used as ingredients to produce fish meal, collagen or gel [16]. In Gujarat, Veraval and Porbandar produced seafood production reaching 5964 MT with the number of factories reaching 115 units [17]. Food originating from the sea is one of the important food resources for the community. In general, there are approximately 10-12% of people that have a livelihood in the field of marine fisheries. Nutrition and health needs encourage increased demand for fishery products and processed products [18]. The high demand for fishery products will have an impact on increasing waste production. This will certainly have a negative impact on the environment. Based on the data, the fish processing industry discards fisheries waste (skin, head, fins, bones, stomach contents) reaching 25–60% [19]. Parts of the skin and bones are the biggest waste that is thrown away. This part occupies a 30% proportion of the main ingredients. However, this waste actually has potential as a source of gelatin [20].

3. The role and benefits of gelatin

In the pharmaceutical field, gelatin has been developed as a main ingredient in treating skin burns. Gelatin has adhesion properties that can provide a lubricating effect. The use of gelatin as a lubricant in the event of burns is combined with several other materials such as methyl cellulose,
carboxymethyl cellulose, gellan and plasticizers such as glycerol and propylene glycol [21]. Gelatin is one of the most valuable proteins in the food and biomedical industries. In its use, gelatin requires modification to change its functional properties. Like the edible film packaging. Addition of other ingredients such as ribose to the gelatin formulation affects the film formation properties. Gelatin molecules will bind to ribose molecules [22]. Gelatin is used in the bread making industry to slow down the stale process. Gelatin inhibits the reassociate chain of starch molecules during the storage process [23].

Gelatin has been applied as an emulsifier, stabilizer, wetting agent, refined material, biodegradable packaging film, microencapsulation agent. The use of gelatin is caused by properties such as gel strength, viscosity, melting point and ability to form a gel. Besides being used in the food industry, it is also used in the fields of photography, pharmacy and cosmetics. The use of aquatic raw materials is due to the existence of several materials that are contrary to religion, related to diseases as well as the carrier media [24]. Utilization of by-products from industry is one of the main concerns because of the increasing demand and production of fish products [25]. One of the waste produced by the fishing industry is the head, thorns, fins, inners and leather [26].

4. Properties of gelatin

Gelatin has special properties related to surface properties such as cohesion and film forming capacity, function and stabilization of colloidal protectors. Besides that, it is also related to gel forming characteristics and texture, thickening and water binding capacity [27]. Gelatin has good functional properties at a lower cost. However, gelatin is less able to provide adhesion [28]. Gelatin derived from livestock that live on land is generally favored by consumers because of its viscosity and higher gel strength, and is in accordance with the melting point [29]. The properties of gelatin gel to depend on the source of the raw material. Physical properties are influenced by concentration, pH, interaction of material components, temperature and curing time. Viscosity, gel strength and melting point are among the parameters used to determine the physical properties of gelatin [30].

Gelatin is geling and comes from animals. The unique properties of gel from gelatin are melted in the mouth. This property is not owned by the type of gel from plant groups (polysaccharides) such as starch, alginate, pectin, agar and carrageenan. Gel from animals is colorless, has no taste for a softer texture than gels from polysaccharides [31]. Gelatin from unicorn leather jackets produced gelatin that was higher (12.2%) than reef cod skin (9.8%). Based on chemical composition, unicorn leather jacket has higher protein content (88.0-88.61%) than reef cod skin (87-87.73%). In addition, the water
content (9.51-9.91%), fat (0.18-0.29%) and ash (0.60-0.71%) were lower than the reef cod skin (10.29) -11.03%, 0.23-0.31% and 0.69-0.73%. The SDS-PAGE results show that all gelatin samples have α and β chains. Different oven drying temperatures do not affect the yield and quality of gelatin [32]. Hydrolysis products of fish exhibit excellent physicochemical and functional properties [33,34]. Besides the results of fish hydrolysis also functions as an antioxidant that can inhibit free radicals [35,36]. An overview of the process of forming gelatin nanoparticles (GNP) in full was presented in figure 2 [37].

Gelatin extracted from animal collagen via partial acid hydrolysis (Type A) or alkali (Type B). Type A gelatin with isoelectric point (IEP) (7-9) is derived from partial hydrolysis of acid using type I pig skin collagen whereas type B, IEP 4.8-5 is derived from bovine alkaline collagen [38]. The highest amount of gelatin produced from pork skins and their derivatives.

Total production reached (46%), followed by cow skin (29.4%), cow bones (23.1%) and other sources (1.5%) [39]. Protein hydrolyzed is one example of a product that has potential as a source of bioactive peptides [40]. Production of protein hydrolyzates is widely produced from by-products and food industry waste. This is done as an effort to reduce the cost of the final product and achieve frequent sustainable food resource management [41]. Various animal and fish products have been developed as halal sources of collagen. One of them is the skin and bones in cattle and broilers. It also can be obtained from the skin and bone of snake head fish (Channa striata). Collagen can be used to improve the quality of meat. [42-47].

5. Conclusion
Gelatin is a unique product and is only found in animal tissues. Gelatin can be produced through a heating method combined with a chemical method. The use of microbes as an agency in increasing the quantity and quality of gelatin has been widely studied by scientists. Gelatin is one product that has quite extensive benefits. Efforts to find sources of safe and halal raw materials need to be done. This is very important to produce products that can be utilized by the whole community.

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