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The potential of active packaging for tuna

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Abstract. Tuna is a food that is easily damaged and external appearance of tuna is an important consideration to determine the sale value, so handling tuna must be done carefully, quickly, and low temperatures are used immediately after catching. In addition, good handling can increase shelf life and maintain tuna freshness. Active packaging is one technique that can be developed to extend shelf life while maintaining product quality to stay fresh. A method of food storage that is safe and biodegradable is by packaging with edible coating or edible film. Several types of materials that can be used as materials for making edible coatings are sago starch, corn starch and chitosan. Active packaging developed with antimicrobials will play a role in reducing or inhibiting the growth of microbes that grow on food and maintain the integrity and prevent product damage during the shelf life. The advantages of products that are packaged with edible coating are able to reduce water activity on the surface of the material so that damage by microorganisms can be avoided, able to improve the surface structure so that the surface becomes shiny; able to reduce dehydration so that weight loss can be prevented.

1. Introduction

The major problem of the low economic value of fishery products is susceptibility to damage (spoilage) and short shelf life [1]. Then Gram et al. (1990) concluded that when fish die, spoilage bacteria grow rapidly reaching 108-109 cfu / ml during storage in ice within 2-3 weeks[2].

The development of methods for storing and preserving food is increasingly diverse as there is increasing public awareness of the importance of consuming healthy and safe food. Some food storage by using chemicals and microbes (fermentation), controlling water content, regulating food structures such as drying and membrane use, and using heat and frying [3].

Packaging has a significant role in the food supply chain and is an essential part of food processing and the entire food supply chain. Food packaging must fulfill various functions and requirements. The most basic packaging function is that packaging can facilitate distribution. Packaging protects food from environmental conditions, such as light, oxygen, humidity, microbes, mechanical pressure and dust. Another basic function is to provide information for buyers and provide convenience for consumers, for example easy to open and close again. Other basic requirements of a package are that it is easy to market, has an appropriate price, technical capabilities (for example, it can be used on automatic packaging machines and can be hemmed in), can be directly related to food, has a low effect on the environment and can be recycled or reused.

Factors that need to be considered in the packaging of food include the nature of food, environmental conditions, and the type of packaging material used. The relationship between the type of packaging material and the durability of the packaged food is determined based on its permeability. Permeability is the transfer of water or gas molecules through the packaging both from the product to the environment or vice versa. Permeability of packaged water vapor is the speed or rate of water

vapor transmission through a unit area of material with a certain thickness due to the difference in vapor pressure between the product and the environment at a certain temperature and humidity. The more surface area of the packaging used, the higher the water vapor entering the environment and will spread more widely in the package, so that the critical water content of the product will soon be reached and the shelf life of the product is not long [4].

A package must meet all these requirements effectively and economically. Some of these functions and requirements may conflict with each other so modern packaging must be optimized and actively integrated with the food supply chain [5-7]. According to Ahvenainen (2003) [5], modern packaging can be divided into two, namely active packaging and intelligent packaging. The Actipak Project which was formed 1999-2001 in Europe is trying to formulate an active packaging definition aimed at changing the condition of packaged food to extend shelf life or to improve safety, while maintaining the quality of packaged food. The condition of food in packaging is influenced by various factors, including physiological processes (for example respiration of fresh fruits and vegetables), chemical processes (for example fat oxidation), physical processes (for example spoilage in bread), microbiological aspects (damage due to microbes) and pest attacks (for example insect). The techniques in an active packaging system can be divided into three categories namely absorbent systems, release systems, and other systems.

Active packaging is a packaging technique that has the active ability to demonstrate the quality of the product being packaged. Active packaging usually has O₂ absorbent, O₂ absorbent or enhancer, ethanol emitters, ethylene absorbent, water absorbent, antimicrobial agent, absorbent material and which emit scents and flavors [8].

This active packaging can be used as an alternative to the packaging that is commonly used today, which is plastic because it has several shortcomings, including the nature of the plastic which is very difficult to decompose naturally, resulting in pollution. This active package has several advantages compared to plastic packaging, which has anti-microbial properties and contains anti-oxidants so it can reduce the addition of preservatives to food and also expected to provide additional protection in the form of anti-oxidants. The nature of the additional material used is also biodegradable so that this packaging is more environmentally friendly.

2. Methods

2.1. Types of data and data collection techniques

The data used in this study are secondary data. Secondary data were obtained from expert opinions based on literature studies, internet searches, journals and other supporting documents from relevant institutions.

2.2. Data analysis technique

The data collected is validated first.

3. Discussion

3.1. Tuna

Tuna is Indonesia's mainstay product as an export commodity after shrimp. Indonesia is one of the world's biggest producers and exporters of tuna. Total world tuna exports in February 2010 reached 22,445,970 kg, and the biggest export destination is Thailand, 11,143,083 kg or 49.64%. Indonesia is ranked second as an exporter of tuna which is 1,779,666 kg or 7.93% of total world exports. The main destination markets for tuna exports from Indonesia are the European Union, the United States and Japan. Tuna are exported in the form of fresh, frozen or canned fish.

The high selling value of tuna, a type of fish that is most sought after and stolen from the Indonesian sea, is due to its delicious taste. In addition, many nutrients are able to nourish adults and children. Fish is a food which is very high in demand. One type of fish that is in great demand, both in

local and international markets, is tuna, which in Latin is known as *Thunnus* sp and in English is called skipjack. Tuna has a very wide distribution area or almost all tropical and subtropical regions. The nutritional value of tuna is very good, its omega-3 content makes tuna has a thousand and one health benefits for body. However, this must be supported by good selection, processing and storage of tuna. Fresh tuna should be stored in the refrigerator (if it will be used soon) or frozen (if you want to keep it for some time).

According to Winarno and Betty (1983) [9], food damage can be caused by two things, the first is damage by the nature of the product that takes place spontaneously, the second is damage due to environmental influences. Therefore, packaging is needed to cover food from the environment to prevent or delay the process of damage so that tuna fillets have a longer shelf life for consumption.

From the nutritional composition, tuna has an extraordinary nutritional value. Protein levels in tuna are almost twice the protein content in eggs which is known as the main protein source. Protein content per 100 grams of tuna and eggs are 22 g and 13 g, respectively. Tuna fish is also rich in various essential minerals that are essential for the body. The iodine content in tuna reaches 28 times the iodine content in freshwater fish. Iodine is very important to prevent mumps and increase children's intelligence. In addition, tuna is also rich in selenium. Consumption of 100 grams of tuna is enough to meet 52.9 percent of the body's need for selenium. Selenium has an important role in the body, which activates the antioxidant enzyme glutathione peroxidase.

Tuna is a food that is easily damaged and external appearance of tuna is an important consideration to determine the sale value, so handling tuna must be done carefully, quickly, and low temperatures are used immediately after catching. In addition, good handling can increase shelf life and maintain tuna freshness.

27. Active packaging

Active packaging is one technique that can be developed to extend shelf life while maintaining product quality to stay fresh. Active packaging is referred to as interactive packaging because there is an active interaction of packaging material with packaged food items [10-12]. The use of active packaging has the potential to inhibit the growth of *Staphylococcus aureus*, *Pseudomonas aeruginosa* and *Escherichia coli* bacteria [13]. For example are active packaging of antimicrobial films and antimicrobial coatings (edible coating) [14,15]. According to Kerry et al. (2006); Pavlah and Orts (2009) [16,17] edible films are thin films made from edible materials, formed by coating products or placed between product components that function as a barrier to mass transfer (eg water vapor, gas, solutes, and light) and for improve handling of a food. Antimicrobial (AM) can be added by mixing AM substances into packaging materials which then in small amounts the AM will migrate into food [18,19]

A method of food storage that is safe and biodegradable is by packaging with edible coating or edible film. The difference between edible coating and edible film is the coating is applied directly to the surface of foodstuffs, while the film is a thin layer that is applied after printing in sheet form.

Edible coating is a thin layer made from edible material, formed to coat food (coating) or placed between food components (film) that serves as a barrier to mass transfer and to improve the handling of a food [20,20]. Edible coating is an alternative to replace plastic packaging because it is biodegradable as well as a barrier to control the transfer of water vapor, oxygen uptake, and lipid transfer. Edible coating can also be used to coat products that function as protectors from mechanical damage and are safe for consumption. Edible coatings that are environmentally friendly come from materials that can be decomposed in environment and are available in nature in large quantities [21].

Edible coating thin layer, made from material that can be consumed and can function as a barrier so as not to lose moisture, is permeable to certain gases, and is able to control the migration of water-soluble components that can cause changes in pigment and nutrient composition of the material [22].

Edible coating is a relatively new food preservation technique with safe packaging materials [3]. Edible coating constituent polymer material is safe, edible material, formed by coating the product or

placed between product components that function as a barrier to mass transfer such as water vapor, gas, solutes, and light [15]. The main constituents of edible coatings are grouped into 3 categories, they are hydrocolloids, lipids and composites [23]. Polysaccharides in food function as a texture enhancer (cellulose, hemicellulose, pectin, lignin) and as a source of energy (starch, dextrin, glycogen, frutan), which cannot be digested by the body, but are fibers that can stimulate digestive enzymes [24]. Here are some types of materials that can be used as material for making edible coatings :

3.2.1. *Sago starch.* Sago starch is a prime food ingredient because the carbohydrate is highest when compared to other carbohydrate-producing plants, such as corn, cassava and sugar cane [25]. Sago starch was extracted from the sago tree (*Metroxylon* sp.). Some important species that are widely used as starch producers are *M. longispinum*, *M. sylvestre*, *M. microcanthum*, *M. sago* and *M. rumphii*. Sago trees are important natural resources, especially among rural communities because of the diversity of their uses, such as producing sago starch, sago flour and pearl sago, and all species of sago trees are found in Maluku [26].

Good and safe sago starch for food has characteristics that have been determined by the National Standardization Agency (BSN). Some characters are designed to protect consumers, ensure food trade in a responsible way, and support the development of the sago starch industry. The criteria that have been set by BSN include visual properties, namely form: smooth; odor: normal (free of foreign odors); White color; taste: normal; and escaped the 80-100 mesh sieve. Proximate properties determined for sago starch are: water content: maximum 13%; maximum ash content of 0.5%; minimum starch content of 65%; maximum acid content of 4 ml (NaOH 1 N-1100g); and maximum crude fiber content of 0.1% The quality of starch is also determined by the color of the starch. The color of starch is influenced by the equipment at the extraction time and genetic factors that influence the color of the sago pith. The starch content in the pith is affected by the age of the stem. Sago that has already passed through the cutting process, the starch content will be reduced because it is used for flower and fruit formation. The starch content in stems has been greatly reduced so that sago is no longer suitable for harvesting [27].

Sago starch consists of amylose fraction at 28.84% and amylopectin at 71.16%. Amylose and amylopectin levels affect the functional properties of sago starch. Oval-shaped sago starch with a size of 7.5-55 μm , starch size also influences functional properties. The physicochemical properties of sago starch can be seen in Table 3. The content of amylose and amylopectin influences their physicochemical properties, including water absorption, solubility, degree of starch gelatinization, and swelling power.

The higher the amylopectin content, the starch tends to absorb less water, is wetter and stickier. In contrast, starches with high amylose content tend to absorb more water, are drier, and are less attached [28,29].

Edible coating of sago starch with the addition of 0.5% lemongrass oil is able to maintain the shelf life of tuna fish fillets for 15 days at cold temperatures [30].

3.2.2. *Corn starch.* Starch is a product produced from corn. Processing corn into starch has the prospect of increasing the additional value of corn. National starch needs ranging from 1.5-2.0 million tons apparently cannot be met from domestic production so at Indonesia still imports starch, both in natural and modified forms. Corn contains \pm 70% starch. Starch is composed of at least three main components, namely amylose, amylopectin and intermediates such as lipids and proteins. These components affect the functional properties of corn flour. The composition of amylose and amylopectin in corn seeds is genetically controlled. Pulut corn has a starch content of almost 100% amylopectin. Generally, the chemical physical and functional properties of starch can provide guidance in choosing suitable varieties of corn for the desired product [31].

The main component of corn is starch, which is about 70% of the weight of seeds. Other carbohydrate components are simple sugars, namely glucose, sucrose, and fructose only 1% -3% of the weight of corn kernels. Corn flour can be obtained by extracting corn kernels. The chemical

composition of corn flour is: carbohydrate (74.5%), protein (9%), fiber (1%), ash (1.1%) and fat (3.4%). Starch consists of two types of glucose polymers, they are amylose and amylopectin. Amylose structure is a straight structure with α - (1,4) -D-glucose bonds. Amylopectin consists of branched structures with α - (1,4) -D-glucose bonds and the amylopectin branching point is an α - (1,6) bond. In amylose the sugar units are connected by 1.4 bonds, whereas in amylopectin the bonds are at 1.6 or in other words the C1 atom of one sugar is connected to the C6 atom of the next sugar unit. Polysaccharides such as starch can be used as raw materials in making edible films. Starch is often used in the food industry as a biodegradable film to replace plastic polymers because it is economical, renewable and provides good physical characteristics [32].

3.2.3. Chitosan. Chitosan is a polymer compound produced from the extraction of hard-shelled animals (crustaceans). Mixing chitosan into composites will further enhance its characteristics in addition to cost efficiency [33].

Chitosan has been widely used as a material for making biodegradable films and food preservatives that are resistant to microbes. The antibacterial property of chitosan comes from the structure of the polymer which has a positively charged amine group, whereas other polysaccharides are generally neutral or negatively charged [34]. Chitosan amine groups can interact with the negative charge of a molecule such as proteins from microbes. Chitosan has antimicrobial properties with a broad spectrum, both against bacteria, fungi and mold. The mechanism of chitosan in inhibiting microbes can be grouped into three, namely 1) interaction by inhibiting cell membranes, 2) inactivation of enzymes, and 3) destruction of microbial genetic materials. Antimicrobial activity of chitosan depends on the degree of deacetylation, molecular weight, pH of the media, temperature, and other components [35].

The antibacterial properties of chitosan are derived from the structure of polymers which have positively charged amine groups, whereas other polysaccharides are generally neutral or negatively charged [32]. Chitosan amine groups can interact with the negative charge of a molecule such as proteins from microbes that cause leakage of proteins and intracellular structure of microbes [36]. Chitosan as a component of coating solution will be more effective as a preservative, while if mixed in the film media, chitosan will be trapped in the matrix so that microbial activity decreases [37,38].

3.3. Potential active packaging for tuna

In recent years, consumer demand for food products that are processed with the principle of minimally processed, easily served and / or ready-to-eat in a fresh condition, as well as the influence of globalization of food trade and distribution of processing centralization is one of the main challenges faced by the food industry to improve quality assurance and food safety.

Research on the coating of food products with edible coatings has been widely done and proven to be able to extend the shelf life and improve the quality of food products [3,39].

In addition, Iriani et al. (2013) [40], also states that edible coating is an active type of packaging whose prospects for use are greatly increased from 3300 tons in 2006 to 5480 tons in 2012. Active packaging developed with antimicrobials will play a role in reducing or inhibiting the growth of microbes that grow on food and maintain integrity and prevent product damage during the shelf life. Iriani et al. (2013) [40] said the mechanism of antimicrobial edible coatings in food is illustrated by the packaging having two layers, where the packaging layer which is directly related to the product is the antimicrobial packaging. During storage, antimicrobial active ingredients will be on the surface of the product so that food products will be protected from microbial spoilage and unexpected pathogens, and can be more efficient in regulating the process of migrating active ingredients into food products.

The advantages of products that are packaged with edible coating are able to reduce water activity on the surface of the material so that damage by microorganisms can be avoided, able to improve the surface structure so that the surface becomes shiny; able to reduce dehydration so that weight loss can be prevented; reduce oxygen contact with materials so that oxidation can be inhibited; the original

nature of the product is that the flavor does not change; and able to improve the appearance of the product.

Edible coating can be applied by brushing, spraying, dyeing⁴⁰ or thawing. Edible coating can be applied as primary packaging, barriers, binders and coatings. The use of edible coatings as primary packaging is in candy, fresh vegetables and fruits, sausages, meat and seafood. The use of edible coating as a barrier for example is edible coating made from zein (corn protein) used for confectionary products such as candy and chocolate. Edible coating can also be applied to snacks or crackers that are given a spice, that is as a binder or adhesive from the seasoning given so that it can be more attached to the product. Coatings are useful for reducing fat in fried ingredients by adding seasonings. Edible coating can be as a coating to improve the appearance of bakery products, which is to replace the coating with eggs. The advantage of coating with edible coating, is that it can avoid the entry of microbes that can occur if coated with eggs [41].³⁶

How to apply the coating depends on the shape, size and nature of the product to be coated [42]. According to Donhowe and Fenemme (1994) [23], the method for coating applications on fruits and vegetables consists of several ways, namely the method³¹ of dipping, foaming, spraying, casting, and controlling the application of controlled dripping. The dipping method is the most widely used method especially in vegetables, fruits, meat, and fish, where the product is dipped in the solution used as a coating material.¹¹

Edible coating research has been conducted with the addition of 15% garlic extract to have the best effectiveness in minimizing the decline in the quality of tuna fillets during storage.¹¹ The effectiveness can be seen from the resulting inhibition zone formation diameter. This can be seen from the smaller increase in the value of all parameters of fish rot compared to the addition of garlic extract with a lower concentration [43,44].

4. Conclusion¹⁷

This active packaging can be used as an alternative to the packaging that is commonly used today, which is plastic because it has several shortcomings, including the nature of the plastic which is very difficult to decompose naturally, resulting in pollution. This active package has several advantages compared to plastic packaging, which has anti-microbial properties and contains anti-oxidants so it can reduce the addition of preservatives to food and also expected to provide additional protection in the form of anti-oxidants. The nature of the additional material used is also biodegradable so that this packaging is more environmentally friendly.⁵

The advantages of products that are packaged with edible coating are able to reduce water activity on the surface of the material so that damage by microorganisms can be avoided, able to improve the surface structure² so that the surface becomes shiny; able to reduce dehydration so that weight loss can be prevented; reduce oxygen contact with materials so that oxidation³⁸ can be inhibited; the original nature of the product is that the flavor does not change; and able to improve the appearance of the product.

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