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Review article

Study on Utilization of Grasshoppers Gelatine as Edible Film in Optimizing Environmentally Friendly Packaging

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Abstract: The use of plastic packaging as food wrappers cannot be separated from everyday life. This will certainly cause many environmental problems because of the nature of plastics that are difficult to degrade naturally. One alternative to overcome the use of plastics in food products is edible film. Edible film can be made from gelatine as raw material. World gelatine production currently stands at 330,000 MT and less than 2% is halal. This raises concerns for Muslims about the halalness of gelatine. Grasshoppers have a fairly high protein content, which is about 24%. The method used in this study is the manufacture of edible films using grasshopper gelatine extracted by the alkaline method using NaOH and acid precipitation using HCl. The extraction process produces 55.2% raw gelatine powder from the dry weight of grasshoppers. Grasshoppers protein has high foaming properties (43.3-45%) and high solubility (45%). The solubility of grasshopper proteins depends on concentration. The more acidic the more soluble. The potential of grasshoppers to be used as gelatine is considered suitable with Indonesia's natural resources in the manufacture of edible films as an effort to optimize environmentally friendly packaging.

Keywords: Edible Film; Gelatine; Grasshopper; Alkaline Method.

1. INTRODUCTION

Plastic is a material that is strong, flexible, lightweight, rust-resistant, not easily broken, easy to shape, easy to colour [1], with these plastic properties making plastic used as product packaging so that it has a long shelf life. Karuniastuti, (2013) stated that around 100 million tons of people around the world consume plastic annually [2]. Excessive use of plastics can adversely affect the environment because plastics made from petroleum are difficult to degrade in nature, it is estimated that 100 to 500 years are needed for plastics to decompose in nature. And burning plastic will produce toxic gases that are not good for the environment, health and cause the greenhouse effect. Plastics that are used as food and drink lovers are not good for health, because other ingredients added to plastic can be dissolved in hot food and drinks which can trigger cancer [3]. Therefore, to reduce the adverse effects caused by plastics on the environment and health, the use of plastics as food packaging can be replaced with edible films.

The edible film is a thin layer made of edible material [4]. Edible films can be made of proteins, polysaccharides, and lipids because they have biopolymers that can be used as plastic films (Han, 2014). One material that has protein and can be used as a film is gelatine with a protein content of 84-86%. The manufacture of gelatine can be done by two methods, namely the acid and base methods. The acid method is used for soft raw materials such as young animal skins so that they can quickly soften due to immersion in an acid solution. While the alkaline method used for hard raw materials such as old animal skins or bones in alkaline solution immersion. Gelatine can come from skin and bones which are rich in collagen. While the need for gelatine in Indonesia is increasing every year, it must be imported from several countries such as China, Australia, and European countries [5]. World gelatine production currently stands at 330,000 MT and less than 2%

is halal [6]. This raises concerns for Muslims about the halalness of gelatine. Whereas when using gelatine from the skin or bones of cows or other large animals, it has a long process and requires a lot of washing water and chemicals (less economical), with the result that gelatine is of lower quality than gelatine from pigs [7]. Therefore, an alternative source of gelatine is made from grasshoppers. This is because grasshoppers have a high protein content of 24,4% [8]. Moreover, grasshoppers are available very much and very easy to find in Indonesia [9]. Animal feed accounts for 60-80% of poultry, piggery, and aquaculture production cost, with protein ingredients accounting 70% of the feed costs [10]. Grasshopper as source protein can reduce the economic cost. Also insect farming such as grasshoppers produces less greenhouse gas emission per kg mass gain, uses less land per kg protein and less feed per kg edible weight [11].

Locust is a family of grasshoppers that can be obtained from farms. It can be more environmentally sustainable than the widespread use of insecticides. Harvesting insects from the fields is a solution to improve and regulate this protein source for better. In addition to reducing overall costs, systematic agriculture can improve the quality and safety of insect-based materials for breeding control of agriculture, control of agricultural conditions, sanitation and a balanced diet for insects. There are several examples of sustainable agricultural practices for many insects, one of which is a pest grasshopper species *Sphenarium purpurascens* for human consumption. Therefore, rearing insects such as grasshoppers in a farm setting is probably the logical answer to increase and better manage this protein source [12].

In addition to abundance and ease found in nature, grasshoppers are also clearly lawful to eat even though they have become carrion, Rasulullah SAW. He said, "Two carcasses and two bloods have been made lawful for you. The two carcasses were fish and grasshoppers. The two blood types are the liver and the spleen" (HR. Ahmad and Baihaqi). So this writing aims to determine grasshopper gelatine as a raw material for edible films as environmentally friendly packaging.

2. MATERIALS AND METHODS

Insect protein extraction begins with the drying and milling steps to obtain flour, followed by defatting process, then solubility of protein, and precipitation uses the method of isoelectric point (pl) and the last is drying process [13]. The method of making grasshoppers power is stored in bags with -20 C, then separated from its legs and wings. Grasshoppers are dried using Alpha 1-2 LDplus pressed and stored in a vacuum temperature of -20 C until it becomes powdered. Defatted grasshopper powder with hexane and stirring at room temperature for an hour. After that, appear hexane deposits with the fat which separated. The powder is extracted back in the same way and left overnight and dried at temperature 35 C and stored in plastic with temperature -20 C [14]. The most reliable protein extraction method is alkaline. Alkaline methods show high suitability for industrial scaling, due to the availability and low cost because it uses NaOH [13].

The dried grasshopper powder was dissolved in distilled water at a ratio of 1:5 and pH was made to 10 by adding 0,1 m NaoH, then stirred for an hour at 40 C. After that, separate insoluble residues by centrifugation for 20 minutes at 4 C. Following acid precipitation pH was made to isoelectric point (pl) by adding 0,1 M HCl and in cessing for an hour at room temperature. Extraction process uses sonication-assistant extraction (SON). After that, the solution was centrifuged for 20 minutes at 4 C. Protein were neutralized to pH 7 and freeze-dried and stored at 20 C [14].

The method of making edible film from gelatine begins with grasshopper gelatine powder 5%, 10%, 15%, 20% (w/v) in 100 mL of distilled water. The mixture was heated in a water bath and stirred at temperature 50 C for 30 minutes. After that, the solution was added with glycerol 10% as a plasticizer. Then the edible film is poured into a 20x20 acrylic mold in the oven at 45^0C for 24 hours. Tests based on the parameters of the edible film include tensile strength test, thickness test, elongation test, and water vapor transmission [15].

3. RESULTS AND DISCUSSION

Edible film can be defined as a thin layer that can be eaten. The quality of edible film is largely determined by its constituent materials. The composition of edible films consists of materials that can migrate water vapor, oxygen, microbes, and so on [16]. One of the constituents of edible film is hydrocolloid. Hydrocolloid properties can be obtained from gelatine. According to [17] Murtini, et al., (2009) in [18] Julianto, G. E, et al., (2011) stated that gelatine has properties that can form a thin layer that is elastic, transparent, and strong. Generally, gelatine has a very high protein. This is because the protein contained in gelatine is a conversion protein obtained through the hydrolysis of collagen [18].

Gelatine is a protein derived from the partial hydrolysis of collagen from skin, white connective tissue and animal bones. Amino acids will determine the properties possessed by gelatine [19]. Chemically, the collagen hydrolysis process will convert the collagen protein into gelatine. The reaction that occurs is as follows:

$$\underset{\text{collagen}}{C_{102}H_{149}N_{31}O_{38}} + H_2O \rightarrow \underset{\text{Gelatine}}{C_{102}H_{151}N_{31}O_{39}}$$

Figure 1. Chemical reaction of collagens to gelatine [20].

One source of high collagen protein is found in grasshoppers. Grasshoppers have high enough protein so that they can be used as raw materials in making gelatine. This is because grasshoppers have a high protein content of 24.4% [8]. Grasshoppers are also very available and are very easy to find in Indonesia [9]. Almost every animal has protein, but grasshoppers have a higher protein content. The protein values in some animals are presented in Table 1.

Table 1. The protein values in some animals [8].

Animal	Protein (%)
Cow	15,8
Sheep	14,6
Pig	13,0
Fowl	20,5
Grasshopper	24,4

Most edible insects have nutrients that are high in fat, protein, and other mineral content. At least 80% of protein comes from grasshoppers, 60% fat and 35% fiber in longhorn beetle maggots. Grasshoppers and crickets are commonly consumed insects, accounting for about 13% of all insects eaten. Grasshoppers have good nutrition with 57-77% protein, 4-22% fat, 7-12% fiber, amino acids, fatty acids, minerals and vitamins [12]. Mishyna, et al., (2018) says desert locusts contain more than 70% protein and can be a good source of nutrients [14]. The components of locusts such as protein, fat and energy are higher than those of meat. It is approximately 18-29%, 1-32% and 106-353 kcal/100 g. Based on research that has been done, protein extraction using alkaline method and acid precipitation. Extraction was done with pH 10 by adding 0,1 m NaOH. The extraction process uses sonication-assisted extraction (SON). Then, the solution was centrifuge and separated from insoluble fractions. Following acid precipitation pH was made to isoelectric point (pl) by adding 0,1 M HCl. After that, the solution was centrifuged for 20 minutes at 4 C. Proteins were neutralized to pH 7 and freeze-dried and

stored at 20 C. Protein yield obtained 55.2% raw powder. Protein from locusts is high foaming (43.3-45%) and high solubility 45%. The solubility of locusts' proteins depends on concentration of all fractions. The more acidic the more soluble. The proximate composition of locusts based on percentage dry matter is shown in Table 2.

Table 2. The proximate composition of locusts based on percentage dry matter [10]

Species	***Schistocerca* sp.**	**Desert locust**			**Migratory locust**		**Bombay locust**		
Life stage	**Undefined**	**Adult**	**Adult**	**Adult**	**Adult**	**Adult**	**Adult**		
Location	**Mexico**	**Poland**	**Sudan**	**Kenya**	**Belgium**	**Thailand**	**Thailand (markets)**		
Source	**Wild**	**Reared**	**Wild**	**Wild**	**Reared**	**Reared**	**Raw**	**Blanched**	**Fried**
Dry matter	-	-	-	-	27	95.3	-	-	-
Protein (%)	61	76.0	53.8	46.3	-	71.1	27.6	20.6	16.6
Fat (%)	17	13.0	29.8	32.3	7.7-11.7	11.4	4.7	6.2	14.8
Fibre (%)	10	2.5	11.0	4.8	-	-	-	-	-
Ash (%)	4.6	3.3	5.1	6.7	-	3.3	-	-	-
Enercy (kcal/100 g)	-	432.0	527.5	450.8	-	-	157	169	221
Carbohydrate	7	1.7	0.02	9.9	-	-	-	-	-

Insects particularly from the Acrididae family (grasshoppers) are commonly consumed by humans. Grasshopper species *Chorthippus parallelus* have protein content of 69% with very good amino acids and protein digestibility 97% [21]. Grasshoppers are being eaten widely around the world. The protein content of grasshoppers can reach almost 800 g/kg on a dry basis with high digestibility and contain essential amino acids such as lysine and leucine. Functional properties of protein from edible insects such as foaming, gelation, and emulsion capacity and also insects have potential functional in the food industry [11].

Asmurdono, et al., (2019) explained the characteristics of edible films from gelatine [15]. The addition of gelatine will affect the value of tensile strength, elongation, and thickness. The higher the concentration of gelatine, the value of the tensile strength will be smaller. The higher the gelatine concentration, the higher the elongation value of the edible film. This is because the addition of gelatine can increase the stretching of the intermolecular spaces of the edible film matrix structure and become more flexible so that it is not easily damaged and brittle. Increasing the concentration of gelatine will also increase the thickness of the edible film. This is because the addition of gelatine will increase the total solids solution so that the polymer constituent of the edible film matrix will be more and more. According to Wijayani, et al., (2021) different types of gelatine do not have a significant effect on the thickness of the edible film [22]. However, the addition of gelatine will affect the tensile strength of the edible film because the higher the protein content and the gel strength value of the gelatine, the higher the tensile strength will also be. Gel strength indicates the presence of strong intermolecular forces between the polymer chains in the gelatine matrix and bind to each other so that the distance between the polymers will be closer. The elongation value will increase with the addition of gelatine because the more polymer chains the flexibility value will increase, besides that the gel strength will also affect the elasticity of the resulting product. The addition of gelatine will affect the value of the water vapor transmission rate (WVTR) because the more gelatine, the better the ability of the edible film to hold water vapor. This is because the permeability of edible films is getting smaller and a good edible film is an edible film that has a low value of water vapor transmission rate so that it can maintain the water content of the product, slow down the oxidation reaction and protect the product.

4. CONCLUSION

Based on several journals, grasshoppers can be used as gelatine because of their high protein content. Grasshopper gelatine can be extracted by the alkaline method using sonication-assisted extraction (SON) and acid precipitation using HCl. The resulting gelatine has high solubility and high foaming properties so that grasshopper gelatine has the potential to form edible films, environmentally friendly packaging.

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