

Effect of Starch and Plasticizer on Tensile Strength of Carrageenan-based Soft Capsule Film Sheets

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Abstract

Seaweed-based soft capsules are one of the innovations to package drugs with low availability and are suitable for the preparation of plant-based active ingredients. The manufacture of soft capsules using carrageenan as raw material is still minimal in information in Indonesia. This study aimed to determine the effect of starch and plasticizer on the tensile strength of carrageenan-based soft capsule film sheets. The method used experimental design with concentration starch and plasticizer 1:5; 1:10, and 1:15. The results showed that the best combination pati and plasticizer 1:15 with moisture contain (19.875 ± 0.17) %, thickness (1.25 ± 0.07) mm, tensile strength was using value (306.075 ± 0.1) gforce, stickyness (1316.25 ± 0.3) gforce, viscosity (2505 ± 7.07) cPs. In general, the appearance of soft capsule sheets showed a clear and transparent color and has good elasticity. Combination pati and plasticizer 1:15 was potential to develop produce prototype soft capsules.

Keywords: Carrageenan, elasticity, halal, stickiness, soft capsule

1. Introduction

Seaweed is one of the marine and fishery commodities that has important economic value. Seaweed raw materials can almost grow in all parts of Indonesia so that its availability is abundant. Seaweed can be developed into value-added products. Seaweed research is known to have been widely carried out for the development of cosmetics ([1]; [2]; [3]; [4]; [5]; and [6]). In addition, the development of bioactive components of seaweed as antioxidants ([7]; [8]; [9]; and [10]). The high potential of seaweed is also developed towards the pharmaceutical industry, namely the development of hard capsule shells and testing its shelf life ([11]). The development of seaweed as soft capsules has not been widely carried out so that research this is very important to do

Capsules are solid preparations consisting of one or more kinds of drugs or other inert materials which are enclosed in a capsule shell. Capsule preparations are a type of pharmaceutical preparation that is very widely used for practical reasons and can mask the unpleasant taste of drugs. In addition, the drug that is put into the capsule is also better maintained the stability of its active ingredients from environmental influences ([12]; [11]). There are two types of capsules, namely hard capsules and soft capsules. Soft capsules or soft capsules are medicinal preparations whose shells consist of sheets of film which are hermetically glued together. Soft capsule shells are used for drugs or active substances in the form of liquids or suspensions at certain doses. Soft capsule production data from year to year shows an increasing trend, even predicted to reach an average annual growth rate (CAGR) of 5.4% to reach 316.6 billion US dollars in 2025 [13] Regionally, one of the share The market that is growing quite rapidly is the Asia-Pacific market share, including Indonesia. Indonesia is a country with a majority Muslim population, so the issue of halal products is very important. Generally, the capsule shell is made of gelatin which is mostly produced from pork, so its halalness is doubtful. Gelatin is a polypeptide obtained by hydrolysis of animal connective tissue collagen. Gelatin has a unique property that can form a gel so that it is widely used in the food industry and the pharmaceutical industry. The gelatin industry generally uses pork skin and bones because apart from being easy and cheap to obtain, the process of making pork skin is faster and does not require a lot of ingredients. This is because the connective tissue in pig skin is not as strong as that of cattle, so the hydrolysis process becomes easier and does not require large amounts of hydrolyzing agents, neutralizing agents and washing agents [14].

The development of soft capsules from non-gelatin raw materials needs to be done so that they are guaranteed to be halal. One of the ingredients that are considered to have the potential to substitute gelatin in the formation of soft capsules is a seaweed derivative, namely carrageenan. According to [15] film sheets made from hydrocolloids have advantages in mechanical properties and good ability to protect the product against oxygen, carbon dioxide and lipids. However, it is not good at resisting the migration of water vapor. Carrageenan and starch are one of the hydrocolloid materials. According to [16] the film sheet of carrageenan can be formulated with other hydrocolloids such as starch to improve the mechanical properties of the film. Starch is a compound composed of polysaccharides (carbohydrates), polypeptides (proteins) and lipids. The three components that make up starch have thermoplastic properties, so they have the potential to be formed or printed as packaging films. In addition, the amylose in starch is commonly used to make strong films and gels. The use of starch is based on its relatively low cost compared to other materials such as protein, abundance of material, edible (sheet) and thermoplastic properties [17].

Plasticizers are added to improve the mechanical properties of the coating. The plasticizer prevents cracking of the film during handling and storage [18]. The types of plasticizers that are often used in the manufacture of film sheets are glycerol, sorbitol, propylene glycol and other polyols [19]. According to [20], the ability of plasticizers to reduce polymer interactions depends on the concentration, type of polymer and type of plasticizer (molecular size, molecular configuration, number of free hydroxyl groups and plasticizer compatibility with polymers). When several plasticizers are used in the film matrix, strong interactions can occur between the plasticizers which can enhance certain functional properties of the films [21]. This study aimed to determine the effect of starch and plastilizer on the quality of carrageenan film sheets in their application for soft capsule products.

2. Materials and Methods

2.1 Material and tools

The materials used in this research are kappa carrageenan (Brataco), glutinous starch (Sago Tani), plasticizer in the form of glycerol (Brataco), sorbitol (Brataco), and distilled water. The tools used are

analytical balance, spatula, thermometer, measuring cup, hotplate, acrylic mold, screw micrometer, texture analyzer, universal testing machine, and Rapid Visco Analyzer (RVA).

2.2 Methods

The research was carried out in three stages, namely determining the concentration of starch and plasticizer in the formulation, the process of making film sheets, and physical and chemical characterization of the film.

2.2.1 Research Procedure

2.2.1.1 Produce film sheets

Film sheet making is done by adding starch and plasticizer. The treatment variables for the combination of starch and plasticizer were 1:5, 1:10, and 1:15. The method of making film sheets is to weigh all the ingredients separately and mix all the powder ingredients consisting of carrageenan and starch until homogeneous. The next step is to weigh the plasticizer in a separate container and prepare distilled water. Then mixed most of the water with carrageenan at room temperature and stir until homogeneous. After a homogeneous solution marked with no lumps of ingredients, heat the dough on a hotplate / water bath while stirring with a stir rod and covered with aluminum foil. Then enter the plasticizer and then heated until the temperature of the solution reaches 85°C to 95°C. After the solution temperature reaches 85°C by maintaining the temperature for ± 1 hour without stirring. The temperature of the solution reaches $\pm 95^\circ\text{C}$ for 2 to 4 hours until the bubbles rise to the surface and the color of the solution is clear yellow. The next step after the solution is fully gelatinized, the solution is printed in a film mold. Then the sheet is tested for physical and chemical characteristics.

2.2.1.2 Procedure Analysis

Analysis was carried out on the sheet, namely water content using the [22] method, appearance, thickness using a micrometer screw which has an accuracy of 0.01 mm, tensile strength, adhesiveness using testing according to ASTM standards using a texture analyzer (txt) and viscosity using Rapid Visco Analyzer (RVA).

2.2.1.3 Tensile Strength [23]

Tensile strength using Universal Testing Machine (Texture Analyzer). Edible film is cut to a width of 5 mm and a length of 50 mm. Tensile strength (Gforce) is determined based on the maximum force (Newtons) applied to the film until it breaks divided by the area of the film (m^2).

2.2.1.4 Viscosity [24]

Analysis with RVA, concentration of 1% carrageenan solution, based on the water content of the sample. Each sample is weighed according to the water content, the concentration of each solution is 1%. The measurement process with RVA 39 includes heating at a temperature of 80 °C and then lowered to a temperature of 20 °C for 65 minutes with constant stirring at a speed of 160 rpm.

2.3 Data Analysis

The research was conducted in an experimental design using an experimental design with the treatment variables namely starch and plasticizer. Data processing is done by Analysis of Variance (ANOVA).

3. RESULT AND DISCUSSION

3.1 Moisture

The moisture content of the film sheet has an important role in the stability of the product it is coated with, therefore the film sheet is expected to have a low water content so that in its application as primary packaging it does not contribute water to the product which will have an impact on product damage and decrease shelf life. The resulting moisture content on the film sheet ranged from (19.875-28.4)% (Figure 1).

This is still relatively high when compared to the control. However, this water content value is also after the study [23] which is around 17-20.84 %. This is also the same as the results of the study [25] regarding the water content of the carrageenan film, which was 19.28%. The high moisture content of the film sheet with a combination of starch and plasticizer is due to the low concentration of solids in the formulation. [26] also reported that the low concentration of polysaccharides in the film-forming solution allowed more free water to participate in the polymerization reaction.

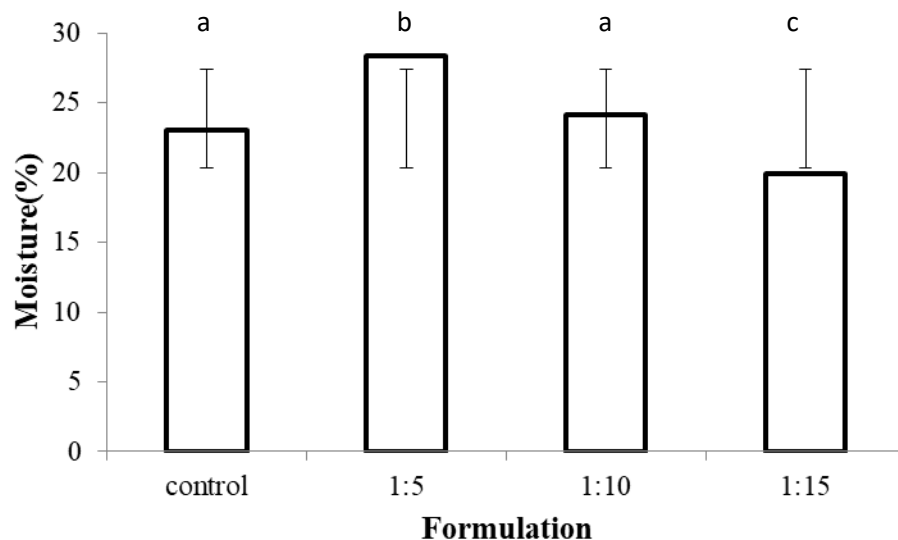


Figure1. Moisture content film sheets
Notation letter show significantly different ($p < 0,05$)

3.2 Appearance

The film sheets produced in various treatments showed that the solution had undergone complete gelatinization. This is due to the appearance of the sheet being transparent and easy to print. The 1:15 sheet yield was more transparent than the other treatments (Figure 2). The elasticity aspect produced was subjectively better than the other treatments. Appearance is one of the factors that greatly affect the quality of a food product. The morphological state of the film sheet is also known to affect the mechanical properties of the film because it is an indicator of the structural integrity of the resulting film [27].

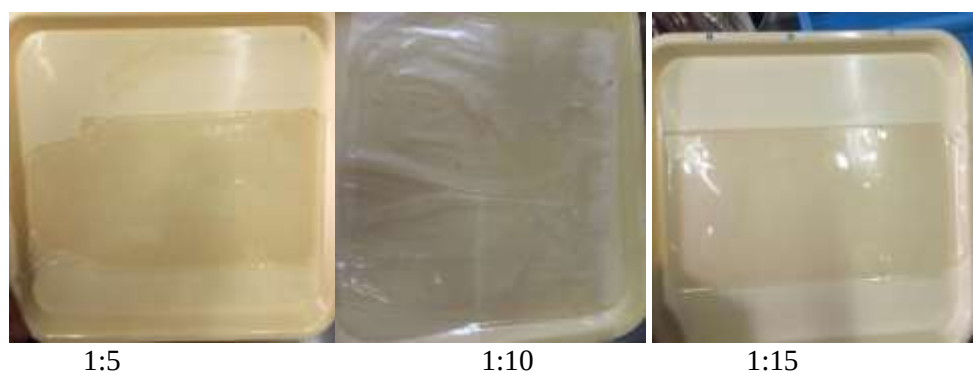


Figure 2. The appearance of the film sheet

3.3 Thickness

The film sheet must have a good thickness, so that the resulting film can match the characteristics of the roller drum on the soft capsule encapsulation machine. The resulting thickness is still higher when compared to the control. The standard film thickness for soft capsules ranges from 0.7 to 0.8 mm.

Variable combination of starch and plasticizer treatment resulted in thickness ranging from 1.15-1.25 mm (Figure 3). the addition of starch and plasticizer did not significantly affect the film thickness. The combination of plasticizer and carrageenan as dissolved solids causes an increase in the thickness of the film. The increase in film thickness is also related to the unique properties of colloid compounds as thickeners and suspenders, and the interaction between the components of the film [28]. According [29] reported that the plasticizers added for the manufacture of edible films can bind starch and form a starch-plasticizer polymer so that the starch bonds are replaced by starch-glycerol-starch bonds which causes an increase in film thickness.

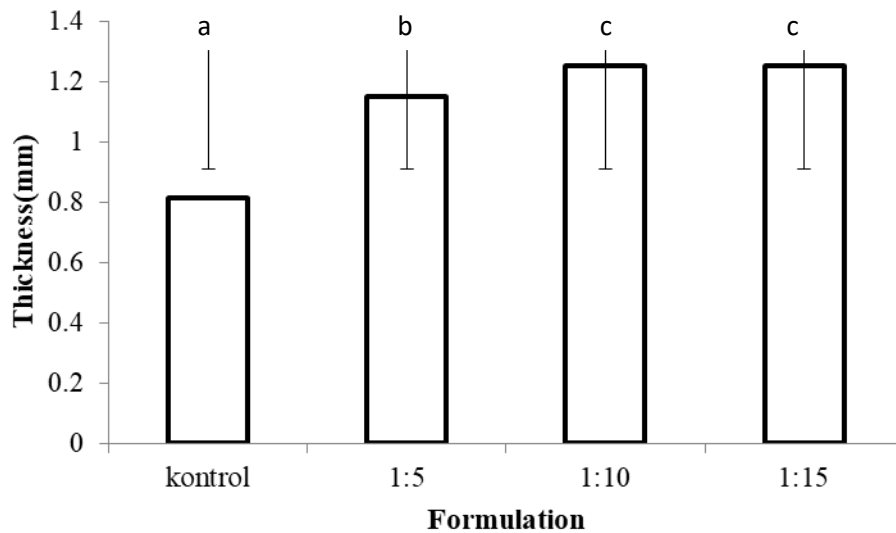


Figure 3. Thickness film sheets
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3.4 Tensile Strength

The results of the tensile strength of film sheets in various treatments showed that the tensile strength produced was not significantly different from the control. The resulting tensile strength value is based on the successive treatment variables, namely (253.75 ± 1.76); (280.75 ± 1.06); and (306.75 ± 0.1) gForce. Treatment of starch and palstilizer 1:15 resulted in higher tensile strength when compared to other treatments. The combination of starch, carrageenan, and plasticizer has a significant effect on increasing the tensile strength value. This is because the combination of carrageenan and plasticizer can form a strong and elastic solution, while starch provides sturdy properties and the sheet is not easily damaged. Moreover, [30] stated that films with plasticizers consisting of a mixture of glycerol-sorbitol showed better thermal stability and tensile properties than the use of individual plasticizers on films from palm starch. According [31] also stated that the hydrocolloid alginate added to the plasticizer also increased the effectiveness of the tensile strength and elasticity of the film sheet. The value of tensile strength will also have an influence on the level of elasticity and the sheet elongation process so that when the encapsulation process is for printing soft capsules, the sheet is not easily broken.

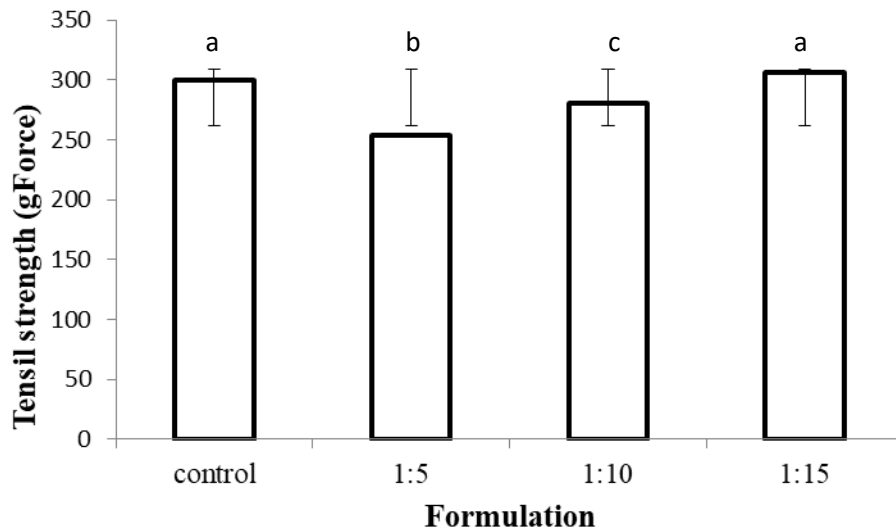


Figure 2. Tensile strength film sheets
Notation letter show significantly different ($p < 0,05$)

3.5 Stickyness

The results of the adhesiveness of the film sheet showed that the starch and plasticizer treatment variables were still low when compared to the control. A very significant difference with the control was due to the fact that the control was a gelatin which was dominated by the amino acid proline and hydroxyproline generally had a high level of stickiness. The adhesiveness produced by various treatment variables was ($900,625 \pm 0.17$); (1120.4 ± 0.14); and (1316.25 ± 0.35) gForce. The resulting adhesiveness is not very significant, but the 1:15 treatment gives a higher stickiness value. This is due to the presence of sorbitol and glycerin type plasticizers which can give the effect of increasing stickiness. In addition, the glutinous starch used also contains high levels of amylopectin so that it can also help increase the adhesiveness of the sheet [32]. The higher value of film sheet stickiness is expected to contribute to the successful sealing (sealing process) of soft capsule sheets into intact soft capsule units on a rotary die encapsulation machine. Besides being able to form a complete soft capsule unit, the success of sealing also affects the risk of leakage of the soft capsule unit. The better the sealing between the film sheets, the smaller the risk of soft capsule.

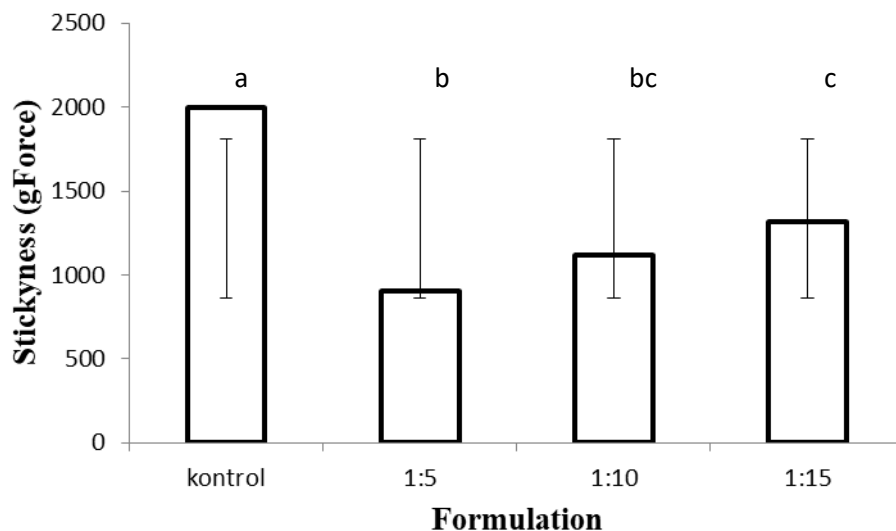


Figure 3. Stickyness film sheets
Notation letter show significantly different ($p < 0,05$)

3.6 Viscosity

Viscosity value indicates the level of viscosity of the resulting solution. The viscosity with the combination of starch and palstilizer is lower than the control viscosity, namely gelatin. Viscosity values of various treatment variables were (2005±7.07); (2314±5.65); and (2505±7.07) cPs. The 1:15 treatment gave a high viscosity value compared to other treatments. Viscosity is strongly influenced by increasing temperature. The viscosity of the solution will decrease with increasing temperature so that depolymerization occurs which is then followed by degradation of carrageenan [33]. This viscosity value is needed to determine the temperature that causes the solution to become viscous so that it cannot flow. The resulting solution shows that at the optimal temperature (95°C), the solution can flow well, while at a temperature of 75°C and below, the solution quickly thickens. The solution by adding the composition of carrageenan and plasticizer is reversible, meaning that the solution when it clots, if heated to a high temperature, the solution can still flow. However, if the composition of the solution is only starch, then the solution is irreversible, meaning that when it thickens and is reheated, the solution cannot flow. The value of viscosity is an important parameter in the technology of the melting solution process for soft capsules. The determination of the soft capsule molding temperature is highly dependent on the viscosity of the solution. If the solution clumps easily, it is necessary to set the temperature on the encapsulation device so that the solution can continue to flow process.

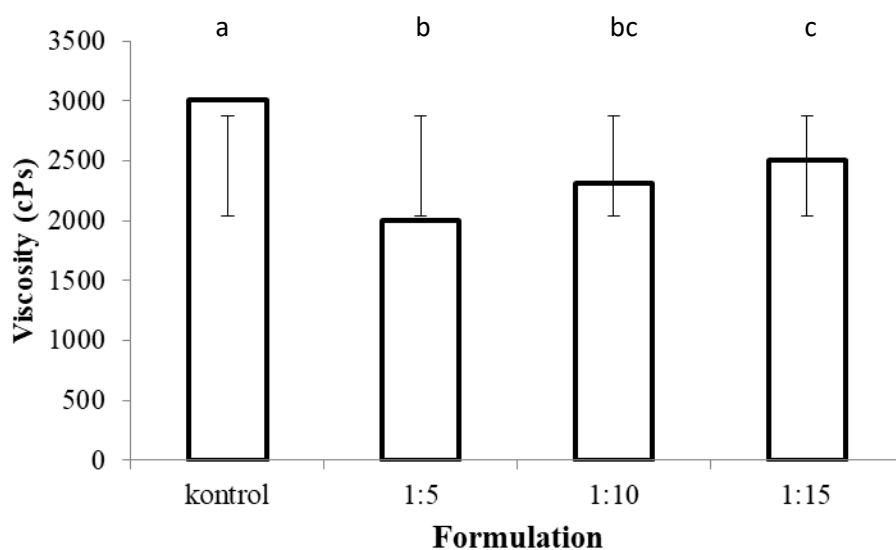


Figure 4. Viscosity film sheets
Notation letter show significantly different ($p < 0,05$)

4. Conclusion

The conclusion of this research was that combination starch and plastilizer with carrageenan can be used a film sheets. The best treatment is starch and plastilizer with ratio 1:15. This film sheet has entered several standard in the development films for soft capsul.

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