# Physical Quality of Edible Film with the Addition of Isolate Whey Protein on Water Content, Solubility, Thickness and Transparency




## ABSTRACT

Edible film is a thin layer used to coat food, which functions as a barrier against mass transfer, such as water, oxygen, and fat. Edible film is a packaging material formed first in the form of a thin layer (film) before being applied to food ingredients and products. Adding whey protein isolate (WPI) to edible film can improve its physical quality. This research aims to determine the effect of adding whey protein isolate to edible film on the physical quality of edible film. The method used in this research was a completely randomized laboratory experimental design with five treatments and four replications. The addition of WPI 0.3%, 0.6%, 0.9%, and 1.2% to Edible Film gave a high significant effect ($P<0.01$) on solubility, degree of swelling, thickness, and transparency, and gave no significant effect ($P>0.05$) on water content. The results of testing edible films made from chitosan with the addition of 0.3%, 0.6%, 0.9% and 1.2% isolate whey proteine produced a water content 16.60-20.64%, solubility of 17.44-23.08%, swelling degree 71.08-76.42%, thickness 0.0725-0.0975 mm, and transparency 0.20-1.69. The addition of whey protein isolate (WPI) to edible film is thought to improve the physical quality of edible film.


## 1. INTRODUCTION

Edible film is an environmentally friendly primary packaging that packages and protects food. It can reveal food products because it is transparent and can be eaten directly with the packaged product because it is made from specific ingredients (Nair et al., 2023). The edible film inhibits the movement of water vapour and gas exchange, prevents loss of aroma, prevents fat transfer, and improves the physical characteristics of food products. The edible film can be applied as packaging material, protecting specific components (water vapour, gas, flavour, fat), forming the structure of food products, and carrying additives. The edible film functions as a mass transfer barrier (air humidity, oxygen, carbon dioxide, lipids, light, and dissolved substances), which is used to reduce O2, increase CO2, and maintain the quality and safety of food products (Alvarado et al., 2015). Edible film is used as food packaging to extend the product's shelf life and not pollute the environment. According to Apriliyani et al. (2022), meat coated using edible coating can maintain the stability of sensory analysis (smell, colour, texture (surface and bottom), physical deviations, and overall acceptability).

Edible films are produced using polysaccharides, proteins, and lipid components (Shilpi et al., 2016). Proteins are excellent candidates for producing biodegradable packaging in hydrocolloids because they have suitable mechanical, optical (transparency), and physical (flexibility and durability) properties. One of the proteins used in making edible film is isolated whey protein. Isolate whey protein is one of the protein components needed to use edible film. Isolate whey protein in edible film has biodegradability properties. According to Kandasamy et al. (2021) edible film based on whey protein isolate is edible, transparent, resistant to heat, and has a sound oxygen barrier and elastic properties. Isolate whey protein also has odourless and tasteless properties when added as an additional ingredient to a product (Suciati and Safitri, 2021). This research aims to determine the effect of adding whey protein isolate to edible film. The use of whey protein isolate is expected to improve the physical quality of edible film.

## 2. MATERIAL AND METHODS

The research method used was a laboratory experiment with a Completely Randomized Design (CRD) with five treatments and four replications. The treatment given was the addition of whey protein isolate P0 (0%), P1 (0.3%), P2 (0.6%), P3 (0.9%), and P4 (1.2%) to the isolate-based edible film whey protein and chitosan. Edible film without adding whey protein isolate was used as a control treatment (P0). Control edible film was compared with edible film that added whey protein isolate. The variable tested are water content, solubility, degrees swelling, thickness, and transparency.

**Manufacture of edible film**

The process of making an edible film is carried out by dissolving whey protein isolate using distilled water in a ratio of 2.5 g whey protein isolate: 100 ml distilled water and dissolving chitosan using 2% acetic acid in a ratio of 2 grams of chitosan: 100 ml (98 ml distilled water and 2 ml acetic acid ) (Fabra et al., 2011). The chitosan solution was homogenized for 1 hour at a temperature below 50°C; during the heating process, 0.28% glycerol was added to the solution and homogenized using a magnetic stirrer at a temperature of ≤ 50°C for 30 min. The whey protein isolate solution is made by dissolving the whey protein isolate in distilled water with a whey protein isolate percentage of 0.3% (P1), 0.6% (P2), 0.9% (P3), and 1.2% (P4). The solution was homogenized using a magnetic stirrer at a temperature of ≤ 50°C for 30 min, and 0.28% glycerol was added. The chitosan and whey protein isolate solutions were then homogenized and heated at ≤ 50°C for 2 hours. Poured 25 ml of the edible film solution into a 95 mm diameter petri dish and dried at room temperature. The dry edible film is tested for Water Content, Solubility, Swelling Degree, Edible Film Thickness, and Transparency.

**Water Content**

Measurement of water content was carried out using the drying method using an oven (AOAC, 2005). Calculation of water content is carried out as follows:

$$\text{Water Content}(\%) = \frac{\text{BS} - (\text{BCS} - \text{BC})}{\text{BS}} \, x \, 100\%$$

Information:
BS = initial dry sample weight (g)
BC = weight of the cup (g)
BCS = weight of sample and cup (g)

**Solubility**

The solubility of edible films is calculated as follows (Silva, et al., 2019):

$$\text{Solubility}(\%) = \frac{\text{W0} - \text{W}}{\text{W}} \, x \, 100\ (\%)$$

Information :
W0 = initial sample dry weight (g)
W = final sample dry weight (g)

***Swelling* Test**

*Swelling* to describe absorption or ability edible film in binding to water. Swelling degree of edible film carried out using the oven drying method (Gohargani et al., 2020). Test calculation swelling of edible films as follows:

$$\text{Degrees Swelling}(\%) = \frac{\text{W0} - \text{W}}{\text{W}} \, x \, 100\ (\%)$$

Information :
W0 = initial sample dry weight (g)
W = final sample dry weight (g)

**Thickness Edible Film**

Thickness testing edible film using a micrometer Digital Thickness (SanSanMall) with an accuracy of 0.001 mm (Santacruz et al., 2015).

**Transparency**

Transparency edible film measured using a UV-Vis spectrophotometer at λ 600 nm (Hernandez, et al., 2017). Calculated transparency edible film with the formula:

$$\%\text{T} = \frac{\text{A}}{x}$$

Information:
T = Transparency
A = Absorbance at λ550 nm

x = thickness edible film

## 3. RESULTS AND DISCUSSION

**Water Content**

Water content is a physical characteristic of a material that shows the amount of water contained in the material. The results of the edible film water content test with the addition of whey protein isolate can be seen in Table 1.

Table 1. The results of the edible film water content test with the addition of whey protein isolate

| Sample | Water Content (%) |
|---|---|
| P0 | 16.60 ± 1.70 |
| P1 | 19.69 ± 2.42 |
| P2 | 19.93 ± 1.45 |
| P3 | 20.04 ± 1.20 |
| P4 | 20.64 ± 2.51 |

Table 1 shows that the treatment of adding whey protein isolate to edible film had no significant effect (P>0.05) on the water content of edible film. The addition of whey protein isolate composition can increase the water content. Whey protein isolate can bind water so that the water content in the edible film formed has a high water content because it does not evaporate during drying (Galus and Lenart, 2019). The materials used influence the water content of edible film (Basiak et al., 2018). The water content of the edible film has a vital role in the stability of the product in which it is coated. Therefore, edible film is expected to have a low water content (Apriliyani et al., 2020). Low water content produces a strong film that does not change quickly and can form a good structure. The water content of edible film has a vital role in the stability of the coated product. Therefore, edible film is expected to have a low water content (Apriliyani et al., 2020). Low water content produces a strong film that does not change quickly and can form a good structure.

**Solubility**

Solubility is a parameter that an edible can dissolve when consumed and is also a determining characteristic of biodegradable film when used as food packaging. The results of the edible film solubility test with the addition of whey protein isolate can be seen in Table 2.

Table 2. The results of the edible film solubility test with the addition of whey protein isolate

| Sample | Solubility (%) |
|---|---|
| P0 | $17.44^{a}$ ± 0.44 |
| P1 | $19.00^{b}$ ± 0.75 |
| P2 | $19.39^{b}$ ± 1.75 |
| P3 | $20.16^{bc}$ ± 0.63 |
| P4 | $23.08^{c}$ ± 0.22 |

$^{a,b,c,d,e}$Different superscripts indicate adding WPI on edible film gave a very significant difference (P<0.01).

Table two shows that the treatment of adding whey protein isolate to edible film had a significant effect (P<0.01) on the solubility of edible film. The addition of whey protein isolate composition can increase the solubility of edible film. This is caused by the increased dissolved solids content originating from the essential ingredients for making edible films and the increase in the number of intermolecular bonds in the solution for making edible films. Solubility is an important physical property of edible film because it is related to the ability of the edible film to retain water (Bourbon et al., 2011). According to Sitompul and Zubaidah (2017), an increase in solution molecules causes more film matrix, so a strong film structure with an increasingly compact and sturdy film network structure can increase the film's strength so that it is not easily destroyed by water. Pitak and Rakhsit (2011) stated that high solubility causes the edible film to dissolve easily in water, reducing its ability to hold water.

**Swelling Degree**

The swelling test tests the ability of edible film to swell when placed in a solution. The results of the edible film swelling test with the addition of whey protein isolate can be seen in Table 3.

Table 3. The results of the edible film swelling test with the addition of whey protein isolate

| Sample | Swelling (%) |
|---|---|
| P0 | $71.08^{a}$ ± 1.35 |
| P1 | $73.65^{b}$ ± 1.19 |
| P2 | $75.73^{bc}$ ± 0.90 |
| P3 | $76.33^{c}$ ± 1.63 |

| | |
|---|---|
| P4 | $76.42^{c} \pm 2.58$ |

$^{a,b,c,d,e}$Different superscripts indicate adding WPI on edible film gave a very significant difference (P<0.01).

The table shows that the treatment of adding whey protein isolate to edible film had a very significant effect (P<0.01) on the degree of swelling of edible film. The addition of whey protein isolate composition increases the degree of swelling of edible film. This is caused by whey protein, which has hydrophilic properties, so the swelling degree value will increase because the edible film absorbs much water (Schröder et al., 2017). The swelling test is a test to determine how much water absorption capacity edible film has expressed in per cent swelling. In contrast, edible films with the highest water absorption capacity have a high swelling percentage (Binsi et al., 2013). An edible film that absorbs little water indicates a lower water absorption rate in the edible film (Galus and Kadzinska, 2016).

**Thickness**

Thickness is an important parameter that influences the use of film in the formation of the product to be packaged. The results of the edible film thickness test with the addition of whey protein isolate can be seen in Table 4.

Table 4. The results of the edible film thickness test with the addition of whey protein isolate

| Sample | Thickness (mm) |
|---|---|
| P0 | $0.0725^{b} \pm 0.01$ |
| P1 | $0.0700^{a} \pm 0.01$ |
| P2 | $0.0925^{c} \pm 0.02$ |
| P3 | $0.0975^{e} \pm 0.01$ |
| P4 | $0.0950^{d} \pm 0.01$ |

$^{a,b,c,d,e}$Different superscripts indicate adding WPI on edible film gave a very significant difference (P<0.01).

The table shows that the treatment of adding whey protein isolate to edible film had a very significant effect (P<0.01) on the thickness of the edible film. The thickness of the edible film is influenced by the base material used; the greater the concentration of the material used, the more the thickness of the edible film will increase (Arham et al., 2016). The greater the whey protein isolate concentration, the more the edible film's thickness increases. The high thickness of edible film causes gas permeability to decrease, which can protect the product better. However, in its use, the thickness of edible film must be adjusted to the product being packaged. Factors influencing the thickness of edible film include the mould plate's area, the suspension's volume, and the components that make up the edible film. Apart from that, drying and adding glycerol can reduce the intermolecular distance of the bound polymer chains so that the elasticity decreases and reduces the bound water so that the thickness decreases (Wijayani et al., 2021). The addition of whey generally increases film thickness but not always by a significant amount (Papadaki et al., 2022). The edible film thickness value is taken from the average at five different film points using a screw micrometre. The maximum edible film thickness is 0.25 mm (Japanese Industrial Standard, 1975).

**Transparency**

Transparency is the ability of a material to transmit light. The results of the edible film transparency test with the addition of whey protein isolate can be seen in Table 5.

Table 5. The results of the edible film transparency test with the addition of whey protein isolate

| Sample | Transparency |
|---|---|
| P0 | $0.2023^{a} \pm 0.04$ |
| P1 | $1.485^{b} \pm 0.34$ |
| P2 | $1.6873^{b} \pm 0.34$ |
| P3 | $1.4590^{b} \pm 0.20$ |
| P4 | $1.4690^{b} \pm 0.36$ |

$^{a,b,c,d,e}$Different superscripts indicate adding WPI on edible film gave a very significant difference (P<0.01).

Table five shows that the treatment of adding whey protein isolate to edible film had a significant effect ($P<0.01$) on the transparency of edible film. The greater the whey protein isolate concentration, the more the edible film's transparency value increases. The high transparency value of edible film can absorb UV light, thus preventing the oxidation process of lipids and compounds that can be catalyzed by UV light (Kwon et al., 2018). The transparency of edible film is proportional to thickness and concentration. If the thickness or concentration of the composition being passed increases, more light will be absorbed. Apart from that, the factor influencing transparency is the amount of ingredients in the solution (Yoo and Krochta. 2011). The thinner the edible film, the higher the transparency value will be (Sun et al., 2018).

## 4. CONCLUSION

This research concludes that adding WPI with different concentrations will increase water content, solubility, swelling, thickness, and transparency. Increasing the WPI concentration will produce better physical quality of Edible Film than edible film without the addition of WPI.

## CONSENT (WHEREEVER APPLICABLE)

All authors declare that 'written informed consent was obtained from the patient (or other approved parties) for publication of this case report and accompanying images. A copy of the written consent is available for review by the Editorial office/Chief Editor/Editorial Board members of this journal.

## ETHICAL APPROVAL (WHEREEVER APPLICABLE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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