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## Effect of nano silica concentration on physical and mechanical properties of sweet shorgum protein-based edible film

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# Effect of nano silica concentration on physical and mechanical properties of sweet shorgum protein-based edible film

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**Abstract.** Edible films are safe for consumption because they compose of organic compounds such as proteins. The aim of this research is to determine the effect of nano silica concentration on physical and mechanical properties of sweet sorghum protein-based edible film. Edible films were synthesized using solution casting method. The characteristics of the films were evaluated by Fourier Transform Infrared Spectroscopy (FTIR), Scanning Electron Microscopy (SEM), Water Vapor Transmission Rate (WVTR) and mechanical testing. The edible film that has been synthesized has a tensile strength of 0.075 N / mm<sup>2</sup>-0.232 N / mm<sup>2</sup>. Modulus young 0.167 N/mm<sup>2</sup>-5.135 N/mm<sup>2</sup>. Elongation 5.969% -12.018%. WVTR 4.08 g / m<sup>2</sup>.h-4.23 g / m<sup>2</sup>.h. Their functional groups of C=O and N-H indicate the presence of protein while S=O and glycosidic functional groups at FTIR spectra showed carrageenan. Silanol found in region 848cm<sup>-1</sup>-849cm<sup>-1</sup> showed silica. Morphology of surface edible films was rough because the edible film has granules. It was found out that an increase of nano silica concentration can improve the tensile strength of the edible film.

## 1. Introduction

Food packaging has an important role in protecting food conditions. One type of food packaging material is plastic. The advantages of plastic are simple and economical. The development of food packaging studies has been growing. One of the food packaging studies is an edible film. Edible films are safe for consumption because it composes of organic compounds such as proteins. Proteins contained in sweet sorghum can be used as raw material for making edible films. Sweet sorghum plants can tolerate drought and puddles so, their availability can be guaranteed [1]. The use of sweet sorghum protein as a raw material for making edible films can to the advantage and added value of sweet sorghum. One of the edible film studies is by adding nanoparticles. Nanoparticles can be used as fillers. The presence of a filler will give effect to the composite properties formed and filler will fill empty spaces in the material so it can improve the mechanical properties of the edible film [2]. One type of nanoparticles is nano-silica. The addition of nano-silica to edible films as a filler can have an effect on the mechanical properties of the edible film [3]. Edible films that will be applied to food must have the ability to protect food structures. The quality of edible films can be seen from the physical and mechanical properties of edible films produced. Therefore, this research was to look at the physical and mechanical properties that are influenced by nano silica concentration.



## 2. Method and Experiment

### 2.1. Materials

The main raw material is powder of sweet sorghum from PT Agri Indah Permata (Bogor, Indonesia). The other materials are carrageenan from CV Ocean Fresh (Bandung, Indonesia), sorbitol, nano silica and surfactant Tween-80.

### 2.2. Methods

**2.2.1. Preparation of edible film.** The 40 g of sweet sorghum powder was dissolved in 360 mL of 55 mM NaOH. The solution was stirred for 24 hours at 25°C and 120 rpm on a hot plate stirrer [4]. After that, the solution was centrifuged for 15 minutes at 4°C and 10000 rpm. Nanosilica solutions were made separately with different concentration (0.5%, 1%, and 1.5% %w/w carrageenan) then it was dissolved in 50 mL distilled water then sonicated for 5 minutes [3]. The blends among protein in a supernatant phase that was resulted of centrifugation, carrageenan solution (the ratio P/C is 6/4) and nano silica solution were mixed using hot plate stirrer for 30 minutes at 40°C and 200 rpm. In the 20th minutes, sorbitol (4%) as plasticizer and Tween-80 (3%) as a surfactant was added in solution. Edible film solution was sonicated for 60 minutes at amplitude 40% and 20 kHz. Before casting process, an edible film solution was stirred by hot plate stirrer for 10 minutes at 50°C. Finally, edible film solution was prepared to pour on glass mold 18x20 cm<sup>2</sup> at 70°C by casting method.

**2.2.2. Physical properties characterization.** Physical properties were evaluated by Fourier Transform Infra Red (FTIR) and Scanning Electron Microscopy (SEM). The aim of FTIR was to determine the functional groups that exist in edible films. The aim of SEM has observed the surface structure and homogeneity of the edible film produced. All edible film samples were prepared in a 1.5 cm x 1.5 cm for the characterization.

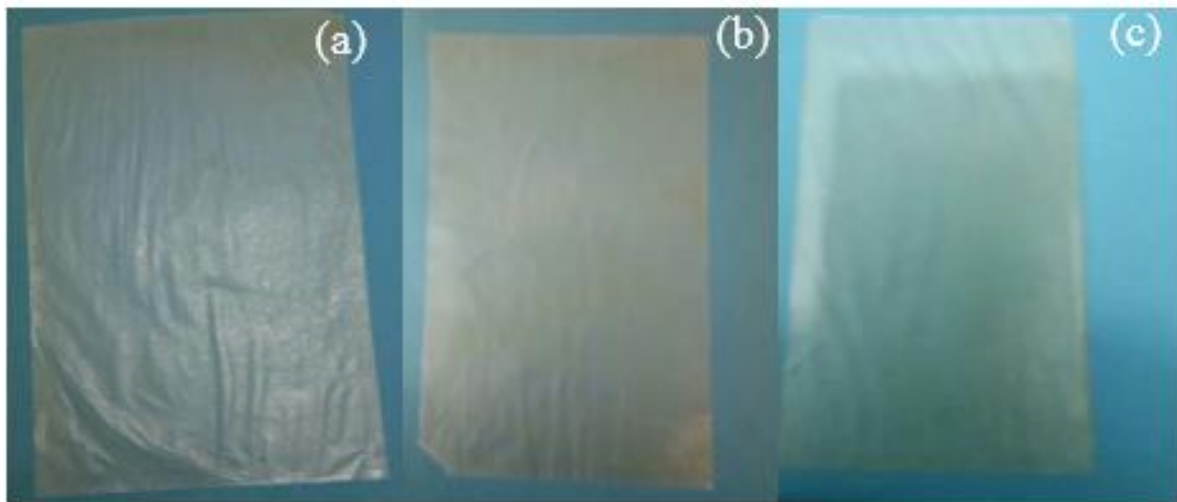
**2.2.3. Mechanical properties characterization.** The mechanical test aims to determine the value of tensile strength, modulus young and percentage of elongation. Edible films were tested using Toorsee's Electronic System Universal Testing Machine with ASTM D 882 standard and a speed of 5 mm/minute.

**2.2.4. Water vapour transmission rate (WVTR).** Edible film samples were prepared in 1.5 cm x 1.5 cm, edible films were placed on top of a container containing 10 g of silica gel. After that, put the container into a desiccator that has been filled with water and closed tightly. Measurements were observed for 24 hours then, WVTR was calculated with dividing between the edible film mass probe ( $\Delta m$ ) and multiplying the area of the edible film (A) by 24 hours (t) as shown in mathematical formula:

$$WVTR (g/m^2/24\text{ hours}) = \frac{\Delta m}{A \cdot \Delta t}$$

## 3. Results and Discussion

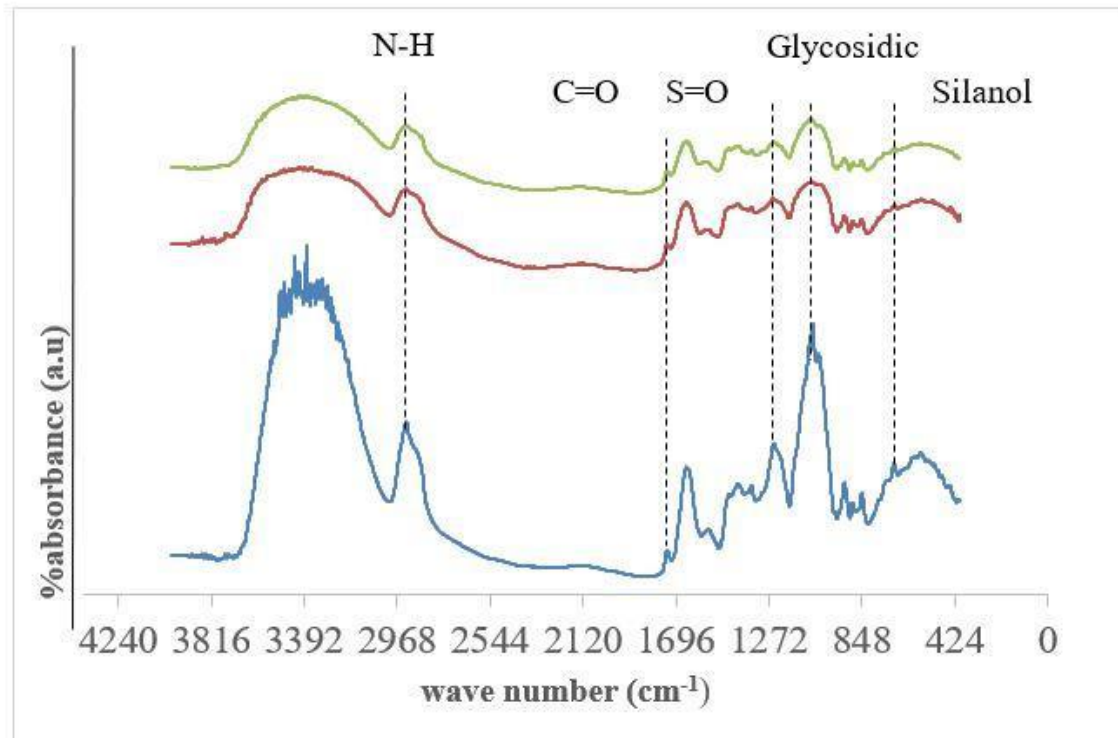
Edible films which were produced has a brown color and different thickness. The edible films have different thickness with a range from 0.1 mm to 0.5 mm. The different thickness caused by uneven casting process [5]. The results of the synthesis of edible films can be seen in Figure 1.



**Figure 1.** Protein-based edible film of (a) 0.5% concentration nanosilica and (b) 1% concentration nanosilica and (c) 1.5 % concentration nanosilica.

### 3.1. Physical properties analysis

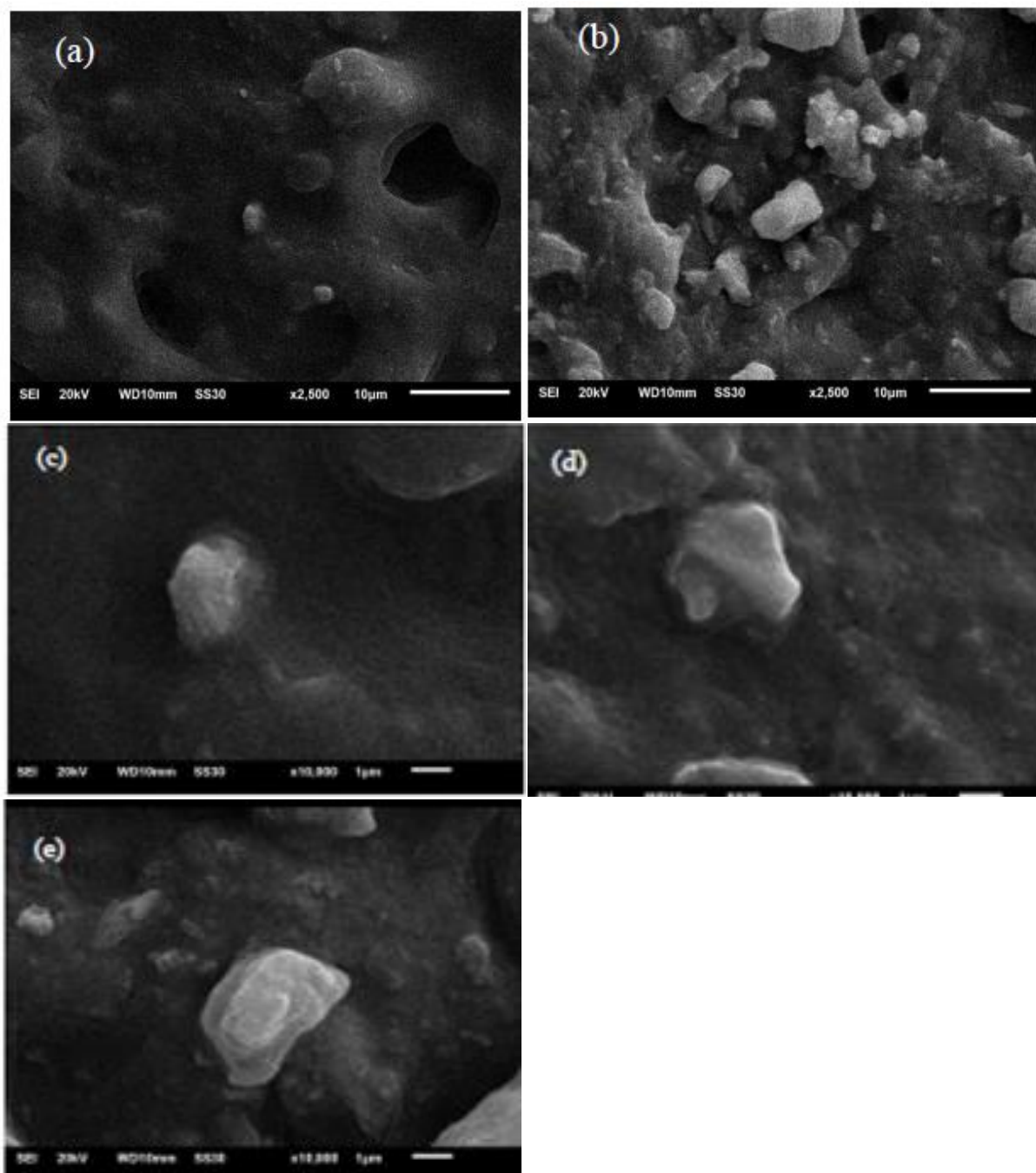
The main materials for making edible films were sweet sorghum protein, carrageenan, and nano-silica. Physical properties were evaluated by FTIR and SEM. The result of FTIR characterization can be seen in Figure 2.



**Figure 2.** Protein-based edible film of 0.5% concentration nanosilica (Blue) and 1% concentration nanosilica (Red), and 1.5 % concentration nanosilica (Green)

Figure 2 informed that their functional groups of C=O and N-H indicate the presence of protein while S=O and glycosidic functional groups at FTIR spectra showed carrageenan [6,7]. Nanosilica groups in the form of silanol were indicated by the FTIR spectrum in area  $848\text{cm}^{-1}$ - $849\text{cm}^{-1}$  [8]. The effect nano silica concentration can be seen from peak position formed on the result of FTIR.

The morphological was evaluated by SEM. The result of SEM shown morphology of surface edible films. The result of SEM characterization as shown in Figure 3.



**Figure 3.** Protein-based edible film of (a) 0.5% concentration of nanosilica and 2500x magnification (b) 1.5% concentration of nanosilica and 2500x magnification (c) 0.5 % concentration nanosilica and 10000x magnification (d) 1% concentration nanosilica and 10000x magnification (e) 1.5% concentration nanosilica and 10000x magnification.

Figure 3 informed that the granules were increasing along with increasing nano silica concentration and the presence of granules found on the surface of the edible films, it indicates edible films surface were rough.

### 3.2. Mechanical properties analysis

The results of this analysis showed the effect of nano silica concentration on mechanical properties of edible film. It can be seen in Table 1.

**Table 1.** Mechanical properties of edible film

Concentration of nano silica	Tensile Strength (N/mm <sup>2</sup> )	Modulus Young (N/mm <sup>2</sup> )	Elongation (%)
0.5%	0.075	0.167	12.018
1%	0.135	1.526	7.538
1.5%	0.232	5.135	5.969

Table 1 informed that increase of nano silica concentration can improve tensile strength and modulus young of edible film. It was different with elongation, elongation decreases were caused by a concentration of nano silica increases. Elongation occurs when weakening of the intermolecular forces, whereas nano silica can increase intermolecular interactions.

### 3.3. WVTR analysis

The transmission rate of water vapor is the rate of water vapor permeating into the edible film. In general, the rate of water vapor transmission is influenced by the thickness of the edible film. The thicker the edible film is the lower the water vapor migration [9]. WVTR analysis can be seen on Table 2.

**Table 2.** WVTR Analysis of Edible Film

The concentration of nano silica	WVTR (g/m <sup>2</sup> .24 hours)
0.5%	4.190
1%	4.230
1.5%	4.080

Table 2 informed that addition of nano silica as a filler can inhibit water vapor to migrate. From this result, it can be said that the factors that influence WVTR are not only the thickness of edible films but the constituent material can also influence WVTR.

## 4. Conclusions

The study informed that nano silica as a filler can be the effect on mechanical properties and physical properties of edible film. The result of physical properties showed the morphology of surface edible film are rough and they have different thickness. The result of mechanical properties showed nano silica can improve tensile strength and modulus young of edible film.

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