Physical characteristics of artificial nori made from *Ptilophora pinnatifida* and *Moringa oleifera* leaves

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Abstract. Artificial nori is a potential alternative to fulfil the need of nori (dried *Porphyra*) in Indonesia. *Ptilophora pinnatifida* naturally does not have green colour. *Moringa oleifera* leaves can give natural green colour to the artificial nori made from *Ptilophora pinnatifida*. The aim of this study was to produce an artificial nori which had a close physical characteristics as the commercial nori. This study was an experimental research using the concentrate of *Moringa oleifera* leaves as variable. The concentrate was consisted of 4%, 6%, and 8% (w/w) of *Moringa oleifera* leaves. The artificial nori made from mixture of *Ptilophora pinnatifida* and *Moringa oleifera* leaves were analized it’s colours (L, a, and b), thickness, tensile strength, and elongation. The result showed, the artificial nori with 8% addition of *Moringa oleifera* leaves had the closest physical characteristics as the commercial nori. It had 0.25 mm of thickness, 1.22 kg/cm² of tensile strength, 7.67% elongation, colour L 28.05, colour a 2.90, and colour b 10.31. The concentrate of *Moringa oleifera* significantly affected the colours, tensile strength, and elongation of the artificial nori, while the tickness was not significantly affected by the concentration of *Moringa oleifera*.

1. Introduction
Nori is a dried seaweed made from *Porphyra* sp. Raw *Porphyra* sp. is washed and cut into small pieces then dried. *Porphyra* has green pigment (chlorophylls) and red pigment. The red pigment will turn green during the thermal processing. Dried *Porphyra* is seasoned and toasted before packaging to enhance the flavour and texture. Nori also is marketed as plain nori or without seasoning for the ingredient of soups [1]. *Porphyra* grows in intertidal zone from subtropical to polar zone [2]. It is widely cultivated in China, Korea, Japan, throughtout Eastern Asian and less in Southeast Asia [3]. *Porphyra* is hard to find in Indonesia. It is caused Indonesia can not produce nori and needs to import nori from abroad.

Artificial nori is a potential solution to supply the needs of nori in Indonesia. Artificial nori can be made from another kind of seaweed or non seaweed material. Some studies reported other kind of seaweed, such as *Gelidium* sp. and *Ulva lactuca* [4], *Gracilaria* sp. and *Ulva lactuca* [5], *Eucheuma spinosum* and *Sargassum* sp. [6], *Eucheuma cottonii* [7], and *Gracilaria* sp. [8], could be the raw material of nori. Non seaweed material especially leaves also can be a potential raw material for nori production. Cassava leaves is one of non seaweed material to produce artificial nori with the addition
Another study reported artificial nori could be made from mixture of *Carica papaya* leaves with seaweed powder and it reduced blood pressure and arterial stiffness on hypertensive rats [10].

*Ptilophora* is red alga which has 16 species and can be found in Indo-Pacific Ocean [11]. *Ptilophora pinnatifida* can be found in wild and have been cultivated in Indonesia. It mostly has been used as the source of agar. *Ptilophora pinnatifida* is a potential source of raw material for nori production. But, it lacks of green colour. Green colour is an important characteristic to make the artificial nori looks similar with the commercial nori. *Moringa oleifera* is a major crop in Asia and Africa. *Moringa oleifera* grows well in Indonesia and it’s leaves widely consumed by people in Indonesia. Previous studies reported it has many bioactive properties, such as vitamins, phenolic acids, flavonoids, isothiocyanates, tannins, and saponins [12].

This study was an experimental study to produce artificial nori from *Ptilophora pinnatifida* and *Moringa oleifera* which had similar characteristics with the commercial nori. The physical characteristics of the artificial nori was determined and compared with the commercial nori.

## 2. Materials and method

### 2.1. Materials

The ingredients for artificial nori were consisted of *Ptilophora pinnatifida*, *Moringa oleifera* leaves, water, NaOH, salt, sugar, garlic powder, and sesame oil.

### 2.2. Preparation of artificial nori

The preparation of artificial nori was based on method by previous study [13] with modification. *Ptilophora pinnatifida* was sorted and cleaned, then soaked in water (seaweed : water = 1:2). As much as 0.01% NaOH was added into the water. Seaweed was soaked for 12 hours. After 12 hours, it was washed with clean water and drained. Seaweed was mashed using blender and water was added to the blender (seaweed : water = 2:1 w/w). Seaweed was mashed until it became smooth porridge.

*Moringa oleifera* leaves was sorted and cleaned. Leaves was mashed using blender and water was added to the blender. It was mashed until it became paste.

The seaweed porridge was boiled for 5 mins at 100°C. *Moringa oleifera* paste was added to the porridge. There were 3 different concentration of *Moringa oleifera*, 4%, 6%, and 8%. Other ingredients were also added to the mixture. As much as 1% garlic powder, 0.5% sugar, 0.2% salt, and 0.2% sesame oil were added to the mixture. The mixture was filtered using 80 mesh filter. Filtered mixture then was put inside the square mold (19 x 13 cm). It was dried inside the oven for 16 hours at 70°C.

### 2.3. Physical characteristics analysis

Artificial nori made from *Ptilophora pinnatifida* with different concentration of *Moringa oleifera* were analyzed for its colour, thickness, elongation, and tensile strength. Colour was determined using colorimeter. Colour parameter used was based on CIE-LAB colour space. It was consisted of L (lightness), a (+ red to - green colour), and b (+ yellow to - blue colour). Each parameter was determined at eight point of nori and repeated for 3 times. The colour analysis method was based on previous study [14]. The thickness was measured using digital micrometer with sensitivity 0.01 mm. It was measured at 10 different point and repeated 3 times. The thickness analysis was based on method by previous study [15]. Tensile strength and elongation was measured using tensile stress analyzer. Each sample was tested for 3 times.

### 2.4. Data analysis

The best artificial nori based on the concentration of *Moringa oleifera* was determined using Multiple Attribute method by Zeleny (1982) [20]. The data was analyzed for variance test (ANOVA) and further tested by Duncan’s Multiple Range Test (DMRT). The statistic analysis had done using SPSS and Microsoft Excel software.
3. Result and discussion

3.1. Colour

Colour is one of important characteristic of food and it also contribute in quality of food. Commercial nori has green colour because of Porphyra natural green colour. Ptilophora pinnatifida does not have natural green colour. The addition of Moringa oleifera helped to enhance the colour of artificial nori to be as green as the commercial nori. Artificial nori made from Ptilophora pinnatifida and Moringa oleifera had green colour with smooth surface. The colour got darker due to the enhancement of Moringa oleifera concentration. Artificial nori with 8% addition of Moringa oleifera (A8) has the darkest green colour compare to the others (Fig.1).

![Figure 1](https://example.com/figure1.png)

**Figure 1.** Artificial Nori From Ptilophora pinnatifida and Moringa oleifera

A4 = Artificial nori with 4% addition of Moringa oleifera
A6 = Artificial nori with 6% addition of Moringa oleifera
A8 = Artificial nori with 8% addition of Moringa oleifera

The colour of artificial nori based on CIE-LAB space showed artificial nori with 4% addition of Moringa oleifera (A4) has the highest L*, a*, and b* colour. It indicated that A4 has light colour with less green colour compared to the others. Artificial nori with 8% addition of Moringa oleifera (A8) had the closest score of L* and a* with the commercial nori (A0), while the b* score of A6 and A8 had the closest with A0 (Table 1). The a* score indicated the red-green colour. High a* colour indicated less green colour. The b* score indicated yellow-blue colour. High b* colour indicated more yellow colour [16]. Based on L*, a*, and b* scores, artificial nori with 8% addition of Moringa oleifera has the closest similar colour with commercial nori. The result of variance test ANOVA showed Moringa oleifera concentration significantly affected the colour L*, a*, and b* of artificial nori (p: L*= 0,000; a*=0,000; b*=0,016).

| Group          | Colour Parameters |
|----------------|-------------------|
|               | L*    | a*    | b*    |
| A0            |       |       |       |
| A4            |       |       |       |
| A6            |       |       |       |
| A8            |       |       |       |

**Table 1.** Colour of commercial and artificial nori
A0 = commercial nori, A4 = artificial nori with 4% addition of *Moringa oleifera*, A6 = artificial nori with 6% addition of *Moringa oleifera*, A8 = artificial nori with 8% addition of *Moringa oleifera*.

### 3.2. Tensile Strength

Tensile strength of artificial nori was decreased as the concentration of *Moringa oleifera* increased. Artificial nori with 8% concentration of *Moringa oleifera* (A8) had the lowest tensile strength while artificial nori with 4% concentration of *Moringa oleifera* (A4) had the highest tensile strength (Table 2). Tensile strength is the optimum stress that a material could handle before breaking. It was determined by dividing the tensile force with the width and thickness of the material [17]. Tensile strength is affected by the fiber strength, fiber length, and the bonding [18]. Variance test (ANOVA) result showed concentration of *Moringa oleifera* significantly affected tensile strength of the artificial nori (p= 0.000). Further test DMRT showed artificial nori with 8% concentration of *Moringa oleifera* (A8) had the closest tensile strength with the commercial nori (A0). Nori A0 tensile strength was 0.5 kg/cm$^2$ and artificial nori A8 was 1.22 kg/cm$^2$. Among all the groups, commercial nori had the lowest tensile strength and artificial nori with 8% concentration of *Moringa oleifera* was the second.

### 3.3. Elongation at Break

Elongation at break of artificial nori also decreased as the concentration of *Moringa oleifera* increased. Artificial nori with 8% concentration of *Moringa oleifera* (A8) had the lowest elongation compared to other groups (Table 2). Elongation at break is the maximum elongation between the initial length and changed length of material after the breakage. It showed the ability to avoid shape’s alteration without breaking the material [19]. Commercial nori had the lowest elongation at break among all. Variance test (ANOVA) result showed concentration of *Moringa oleifera* significantly affected elongation at break of artificial nori (p= 0.000). Artificial nori with 8% concentration (A8) had the closest elongation at break with commercial nori (A0). A0 had 6.33 % elongation at break while A8 was 7.67% elongation at break. Nori usually have a crispy texture but still easy to roll. Elongation at break is indeed an important characteristic of nori.

### Table 2. Tensile strength, elongation at break, and thickness of commercial and artificial nori

| Group | Tensile Strength (kg/cm$^2$) | Elongation at Break (%) | Thickness (mm) |
|-------|-----------------------------|-------------------------|----------------|
| A0    | 28.57 ± 0.22 a              | 3.19 ± 0.96 a           | 9.75 ± 0.37 a  |
| A4    | 36.06 ± 0.46 c              | 6.16 ± 0.27 c           | 12.17 ± 0.93 b |
| A6    | 31.46 ± 0.30 b              | 4.70 ± 0.23 b           | 10.38 ± 0.79 a |
| A8    | 28.08 ± 0.33 a              | 2.90 ± 0.38 a           | 10.31 ± 0.66 a |

A0= commercial nori, A4= artificial nori with 4% addition of *Moringa oleifera*, A6= artificial nori with 6% addition of *Moringa oleifera*, A8= artificial nori with 8% addition of *Moringa oleifera*.

### 3.4. Thickness

Artificial nori made from *Ptilophora pinnatifida* and *Moringa oleifera* had the thickness 0.21-0.25 mm. The thickness of artificial nori and commercial nori was not significantly different. Variance test (ANOVA) result showed the concentration of *Moringa oleifera* was not significantly affected the thickness of artificial nori (p= 0.424). It may because the amount of *Ptilophora pinnatifida* and *Moringa oleifera* mixture put inside the mold was same for every groups.

### 3.5. The Best artificial nori

The best artificial nori was determined using Multiple Attribute method [20]. The parameters were
consisted of colour L*, a*, and b*, tensile strength, elongation at break, and thickness. The result was showed artificial nori with 8% concentration of *Moringa oleifera* (A8) as the best artificial nori made from *Ptilophora pinnatifulda*. It also supported with the result of variance test (ANOVA) and further test DMRT for every parameters. Colour L*, a*, and b*, tensile strength, elongation at break, and thickness of A8 were not significantly different with commercial nori.

4. Conclusion
Artificial nori made from *Ptilophora pinnatifulda* and *Moringa oleifera* is a potential alternative to substitute nori from Porphyra. Based on the research’s result, artificial nori with 8% concentration of Moringa oleifera had the closest physical characteristics with commercial nori. It had 0.25 mm of thickness, 1.22 kg/cm² of tensile strength, 7.67% elongation at break, colour L 28.05, colour a 2.90, and colour b 10.31. The concentration of Moringa oleifera was significantly affected the number of tensile strength, elongation at break, and colour of artificial nori.

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