

## Abstract

This research focuses on developing a peel-off facial mask gel containing lignin nanoparticles extracted from rice straw to improve skin condition. Lignin was extracted from rice straw using an alkaline solution extraction with sodium hydroxide under a certain autoclave condition. The yield of lignin was found to be 14.62% (w/w). Lignin nanoparticles were then prepared using high-frequency ultrasound, resulting in 6.07 mg/ml concentration. The physicochemical characteristics of the lignin nanoparticles were conducted to evaluate their specific properties by a Dynamic Light Scattering (DLS) analysis. The results revealed that the average particle size was  $256.53 \pm 12.89$  nm with the Zeta potential value was  $-24.17 \pm 1.82$  mV, indicating moderate stability, and the Polydispersity Index (PDI) was  $0.39 \pm 0.03$ , signifying uniform particle dispersion. The antioxidant activity of the extracted lignin nanoparticles was assessed using three methods. The results showed that lignin nanoparticles extracted from rice straw exhibited antioxidant activity, with an  $IC_{50}$  value of  $1.52 \pm 0.22$   $\mu\text{g}/\text{mL}$  as determined by the DPPH assay. The ABTS assay demonstrated the antioxidant activity of the lignin nanoparticles, with an  $IC_{50}$  value of  $2.38 \pm 0.45$   $\mu\text{g}/\text{mL}$ . In the FRAP assay, the lignin nanoparticles yielded a FRAP value of  $259.79 \pm 62.41$  mg per gram of lignin nanoparticles. Furthermore, the lignin nanoparticles exhibited slight effectiveness in the tyrosinase inhibitory activity. Afterward, a peel-off facial mask gel incorporating lignin nanoparticles derived from rice straw was formulated and peel-off facial mask gel was subjected to physicochemical property evaluations. The peel-off facial mask gel showed clear, smooth, and capable of forming a thin peelable film after drying for 15 minutes. The antioxidant activity of facial mask gel was assessed using the DPPH assay, revealing an  $IC_{50}$  value of  $7.02$   $\mu\text{g}/\text{mL}$ . This research indicated that lignin nanoparticles from rice straw had high potential antioxidant activities and could be used as an alternative cosmetics ingredient such as peel-off facial mask gel.

## Introduction

According to reports on agricultural waste in Thailand, rice straw production averages approximately 25.45 million tons per year, with a continuous increase annually. This surplus has led to environmental issues such as air pollution and the accumulation of untreated biomass waste due to open-field disposal. Therefore, this study focuses on extraction of lignin from rice straw for the preparation of lignin nanoparticles, investigation of their biological properties, and their application as an ingredient in peel-off facial mask gels. The formulated to enhance anti-aging properties, reduce dark spots, and improve overall skin condition.

### Lignocellulosic composition

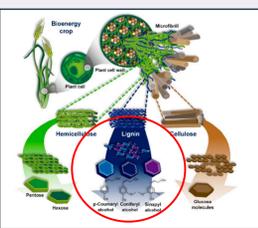


Figure 1 The structure of lignocellulose

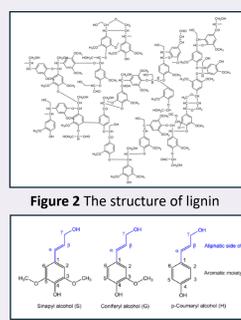


Figure 2 The structure of lignin

Figure 3 Monolignol structures of lignin

### Application of lignin nanoparticles



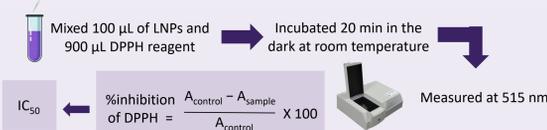
## Materials and Methods

### Extraction of lignin and preparation of lignin nanoparticles

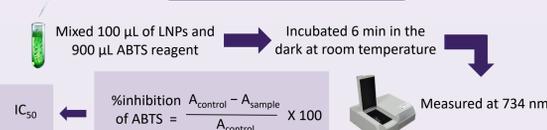


### Antioxidant activity test

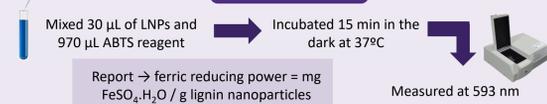
#### DPPH scavenging assay



#### ABTS scavenging assay



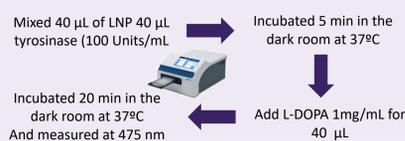
#### FRAP assay



### Characterization of lignin nanoparticles

Size distribution, Zeta potential and Polydispersity index (PDI) → Prepared Lignin Nanoparticles suspension

### Anti-tyrosinase activity



$$\text{Anti-tyrosinase activity (\%)} = \frac{A_{\text{control}} - (A_{\text{sample}} - A_{\text{blank sample}})}{A_{\text{control}}} \times 100$$

### Formulation of peel-off facial mask gel

Ingredients	
Lignin nanoparticles	
Propylene glycol	
Carbopol	
PEG-hydrogenate	
Glycerin 99.5%	
Polyvinyl alcohol (PVA)	
Deionized water	

Peel-off facial mask gel

## Results

### The yield of lignin and lignin nanoparticles concentration

The appearance of alkaline lignin extracts from rice straw was light brown and rigid power, and the alkaline lignin yield was 14.62 (w/w). After that, the concentrated lignin nanoparticles suspension was prepared and had a dark brown appearance containing lignin nanoparticles with a concentration of 6.07 mg/mL.



### The characteristic of lignin nanoparticles

The lignin nanoparticles exhibited an average size distribution indicating in nanoparticles size about  $256.53 \pm 12.92$  nm as shown in Table 1 and Figure 4. The zeta potential presented a slightly stable colloidal suspension with the zeta potential value at  $-24.17 \pm 1.82$  mV (Figure 5). Furthermore, Table 2 demonstrated that the polydispersity index (PDI) evaluated the lignin nanoparticles dispersion in a mid-range level of polydispersity.

Table 1 The particle size distribution, Zeta potential and Polydispersity index (PDI) of Lignin nanoparticles by dynamic light scattering

Sample	Size distribution (d.nm)	Zeta Potential (mV)	Polydispersity Index (PDI)
Lignin nanoparticles	$256.53 \pm 12.89$	$-24.17 \pm 1.82$	$0.39 \pm 0.03$

Figure 4 The particle size distribution of lignin nanoparticles from rice straw peel

Figure 5 Zeta potential of lignin nanoparticles from rice straw peel

### Antioxidant activity

For antioxidant activity of lignin nanoparticles compared to vitamin C, as evaluated using the DPPH and ABTS assay, revealed that lignin nanoparticles exhibited superior free radical scavenging activity due to its lower  $IC_{50}$  value as shown in Figures 6 and 7. Additionally, the chemical structure of lignin, which contains a high number of phenolic groups, enhances its ability to neutralize free radicals. For FRAP assay demonstrated that lignin nanoparticles exhibited a relatively lower electron-donating capacity (FRAP value) compared to vitamin C. This is attributed to its limited ability to reduce  $Fe^{3+}$  to  $Fe^{2+}$ .

Table 2 Antioxidant activity of the Lignin nanoparticles from rice straw

Samples	DPPH	ABTS	FRAP
	$IC_{50}$ ( $\mu\text{g}/\text{mL}$ )	$IC_{50}$ ( $\mu\text{g}/\text{mL}$ )	mg $FeSO_4 \cdot H_2O$ / g LNP
Lignin nanoparticles	$1.52 \pm 0.22$	$2.38 \pm 0.45$	$259.79 \pm 62.41$
Vitamin C	$20.93 \pm 0.44$	$55.00 \pm 1.28$	$2381.09 \pm 36.58$

Figure 6 DPPH scavenging activity ( $IC_{50}$ ) of the lignin nanoparticles from rice straw

Figure 7 ABTS scavenging activity ( $IC_{50}$ ) of the lignin nanoparticles from rice straw

Figure 8 Ferric reducing of the lignin nanoparticles from rice straw

Figure 9 Anti-tyrosinase activity of lignin nanoparticles

### Physical characterization of peel-off facial mask gel



Figure 10 Characteristics of peel-off facial mask gel containing lignin nanoparticles (A) Control, (B) LNP 0.04%, (C) LNP 0.08%, (D) LNP 0.16%

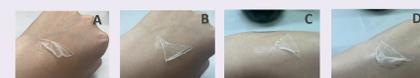


Figure 11 Characteristics of the film formed when tested on the skin (A) Control, (B) LNP 0.04%, (C) LNP 0.08%, (D) LNP 0.16%

### The antioxidant activity test for peel-off facial mask gel

The DPPH scavenging activity of peel-off facial mask gel as shown in Figure 12 demonstrated the  $IC_{50}$  value was  $7.02$   $\mu\text{g}/\text{mL}$ , compared to the lignin nanoparticles suspension ( $1.52 \pm 0.22$   $\mu\text{g}/\text{mL}$ ). Thus, to enhance the antioxidant efficiency of peel-off facial mask gel, the concentration of incorporated lignin nanoparticles must be increased.

Figure 12 DPPH scavenging activity ( $IC_{50}$ ) of the peel-off facial mask gel

## Conclusions

The yield of alkaline lignin from rice straw peel was found to be 14.62 (%w/w). The concentration of prepared lignin nanoparticles suspension was 6.07 mg/mL. The physicochemical characteristic of lignin nanoparticles, showed the average lignin nanoparticles diameter size about  $256.53 \pm 12.89$  nm. Polydispersity index and zeta potential were  $0.39 \pm 0.03$  and  $-24.17 \pm 1.82$  mV, respectively. The DPPH scavenging activity of the lignin nanoparticles were presented the  $IC_{50}$  value  $1.52 \pm 0.22$   $\mu\text{g}/\text{mL}$ . The  $IC_{50}$  value of the lignin nanoparticles obtained from ABTS radical scavenging activity were presented at  $2.38 \pm 0.45$   $\mu\text{g}/\text{mL}$ . The FRAP value of lignin nanoparticles was  $259.79 \pm 62.41$  mg  $FeSO_4 \cdot H_2O$ /g lignin nanoparticles through the FRAP assay. The lignin nanoparticles at concentration of 29.04 mg/mL resulted tyrosinase inhibitory activity about 50% and the value 0.27 mg/mL. The DPPH scavenging activity of peel-off facial mask gel of lignin nanoparticles were presented the  $IC_{50}$  value  $7.02$   $\mu\text{g}/\text{mL}$ . Thus, lignin nanoparticles from rice straw had high potential antioxidant activities and could be used as an alternative cosmetics ingredient such as peel-off facial mask gel.

## References

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