Antioxidant Properties of Granular Nanocellulose from Corncob for Use as a Functional Ingredient in Serum Balm Stick

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Abstract

Thailand generates substantial corncob agricultural waste annually that remains underutilized. Valorizing this waste is crucial for adding economic value, reducing burning-related environmental problems, and aligning with the beauty cosmetic trend emphasizing natural ingredient safety. This research aims to investigate the antioxidant properties of granular nanocellulose (GNC) from corncob for use as an ingredient in serum balm stick. GNC was produced via enzymatic hydrolysis under certain conditions. GNC particle size was measured using the dynamic light scattering technique, and antioxidant property was evaluated using DPPH, ABTS, and FRAP assays. The produced GNC was incorporated into serum balm stick formulation, followed by physical properties testing. The results revealed that corncob-GNC yield was 37.40 ± 3.49% with an average particle size of 342 nm, the zeta potential of −36.1 mV, and PDI of 0.356, indicating good particle stability and homogeneity. GNC exhibited antioxidant activity, with IC_{50} values of 24.46 ± 3.69 mg/mL in the DPPH assay and 2.12 ± 0.032 mg/mL in the ABTS assay. The ferric reducing antioxidant power of GNC was found to be 2.33 ± 0.0014 µmol TE/g. The serum balm stick incorporating GNC was formulated and demonstrated good stability with pH 4.5-5.5. Organoleptic evaluation of the GNC-incorporated serum balm sticks demonstrated that the formulations were safe, stable, homogeneous, non-irritating, and functionally effective as antioxidant cosmetic products. However, further optimization is required to improve miscibility and texture. This research indicated that corncob-derived GNC can be developed as a functional ingredient in cosmetic products, although relatively high concentrations are required.

Introduction

Thailand is one of the major corn producers in Southeast Asia, generating over 5 million tons of corn annually and producing large quantities of corncob waste commonly disposed of through open burning. Corncobs are lignocellulosic biomass composed of cellulose, hemicellulose, and lignin, making them a promising raw material for nanocellulose extraction. Nanocellulose is a bio-based nanomaterial possessing high specific surface area, outstanding mechanical strength, biodegradability, biocompatibility, and non-toxicity. Its abundant surface hydroxyl groups enable versatile chemical modification and contribute to free radical scavenging potential. Enzymatic hydrolysis is a particularly advantageous production method due to its environmental friendliness and low energy consumption. As demand for natural antioxidant cosmetic ingredients grows, nanocellulose has emerged as a promising multifunctional ingredient. However, the antioxidant activity of granular nanocellulose (GNC) derived from corncobs and its cosmetic application remain unexplored. This study therefore aims to transform corncob waste into value-added GNC, contributing to sustainable cosmetic ingredient development.

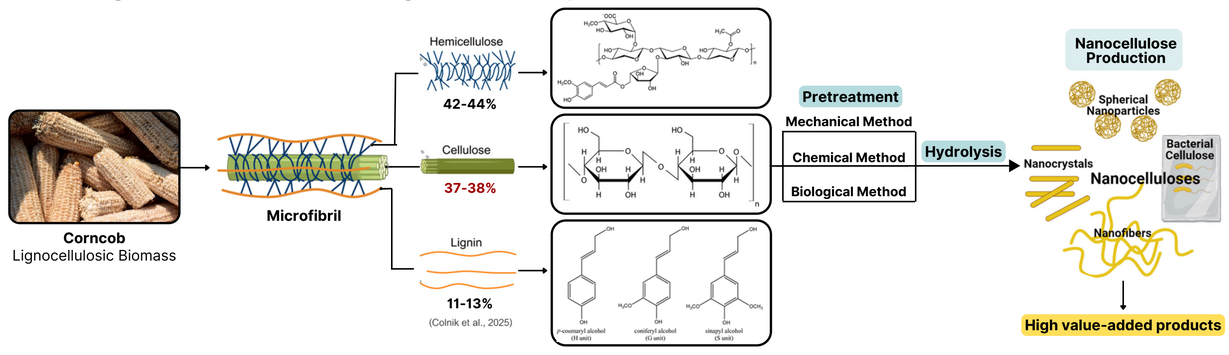


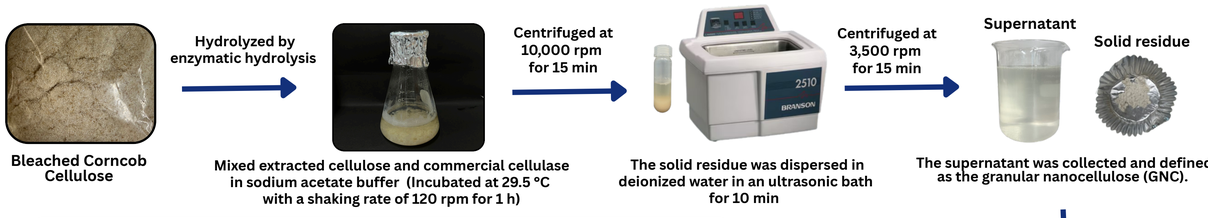
Figure 1. Corncob composition and nanocellulose production

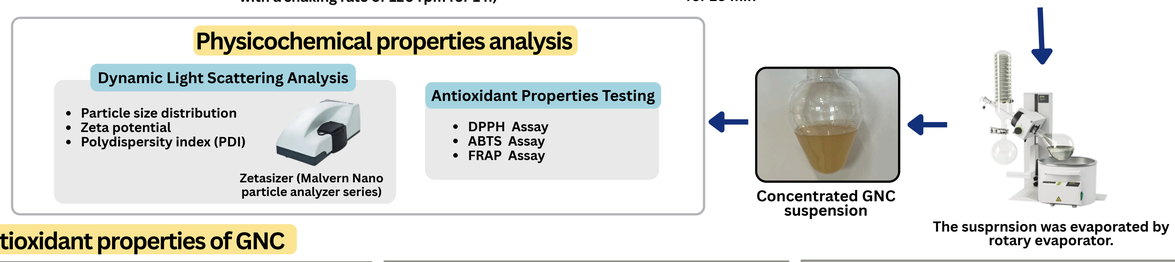
Objectives

- To produce and characterize granular nanocellulose (GNC) from corncob via enzymatic hydrolysis
- To evaluate antioxidant property using DPPH, ABTS, and FRAP assays
- To develop serum balm stick formulation incorporating GNC as active ingredient

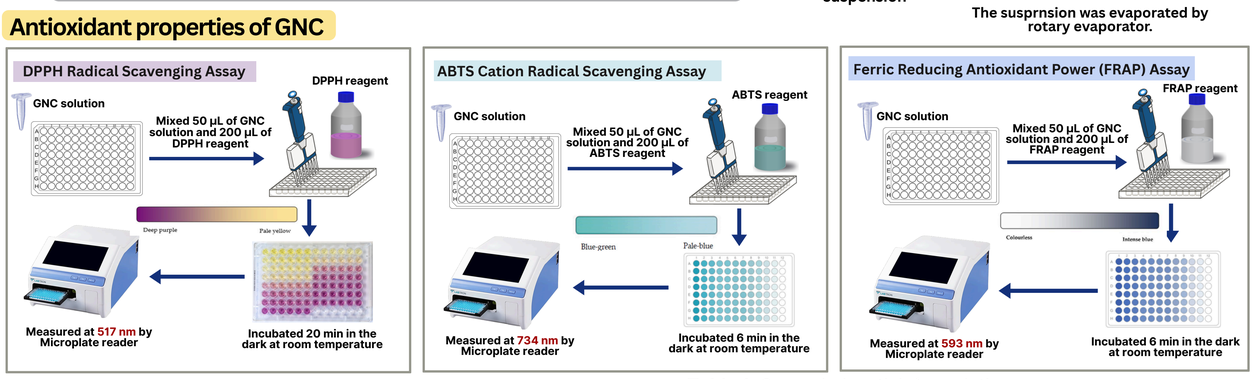
Materials and Methods

Nanocellulose production





Antioxidant properties of GNC



Serum balm stick formulation

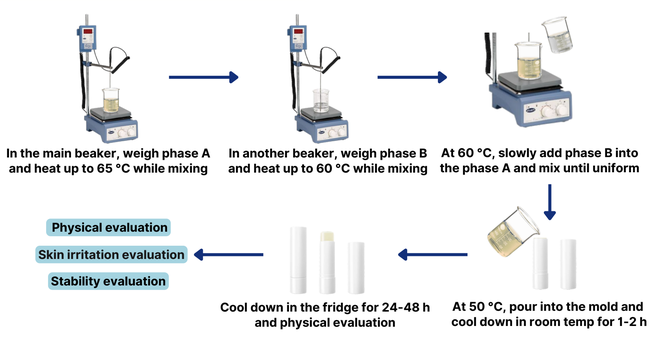


Table 1. Serum balm stick formulation

Phase	Materials	Functions	Content (%w/w) F0	F1	F2
A (Oil phase)	Squalane	Skin-identical ingredient, Emollient	29.00	29.00	29.00
	Beeswax	Structuring agent	18.00	18.00	18.00
	Shea butter	Emollient	13.00	13.00	13.00
	Span 60	Emulsifier, Surfactant	2.50	2.50	2.50
	Tween 80	Emulsifier, Surfactant	1.50	1.50	1.50
B (Aqueous phase)	Glycerin	Humectant	26.00	26.00	26.00
	GNC suspension	Active ingredient, Antioxidant	0.00	5.00	10.00
	Deionized water	Solvent	10.00	5.00	0.00
Total				100.00	

Results and Discussion

Physicochemical characteristics of GNC particles from corncob

- The nanocellulose was produced from corncob using enzymatic hydrolysis, achieving a yield of **37.40 ± 3.49%.**
- The size of GNC particles was average of **342 nm in diameter**, and the zeta potential was **−36.1 mV**, leading to their determination as suitable for good suspension stability with a negative charge. Moreover, the polydispersity index (PDI) was **0.356**, indicating the considerable homogeneity of the GNC size (Figure 2).

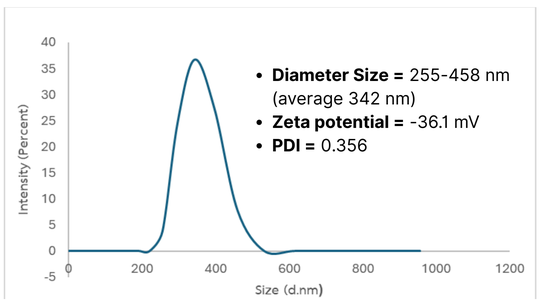


Figure 2. The particle size distribution of GNC particles

Antioxidant properties of GNC

GNC exhibited antioxidant properties with IC_{50} values representing the concentration required to scavenge 50% of free radicals, wherein lower IC_{50} indicates higher potency. As shown in Table 2, GNC showed significantly lower antioxidant activity, requiring substantially higher concentrations to achieve comparable radical scavenging effects. Among the three assays, **ABTS** showed the highest sensitivity for GNC, followed by **FRAP** and **DPPH**. ABTS radicals are soluble in both water and organic solvents, enabling effective interaction with the hydrophilic GNC surface. FRAP, conducted at acidic pH 3.6, likely promoted GNC aggregation and reduced surface accessibility, thereby limiting its efficiency. DPPH showed the lowest sensitivity, as its radical is soluble only in organic solvents, causing severe aggregation of the hydrophilic GNC and substantially impeding radical scavenging. Additionally, turbidity at high stock GNC concentrations may have slightly underestimated the true antioxidant capacity.

Table 2. Antioxidant properties of GNC

Sample	Antioxidant Properties (Mean±SD) IC_{50} of DPPH	IC_{50} of ABTS	FRAP value (µmol TE/g)
Trolox (µg/mL)	4.34 ± 0.04	3.94 ± 0.13	-
GNC (mg/mL)	24.46 ± 3.69	2.12 ± 0.032	2.22 ± 0.0014

Physical evaluation of serum balm stick

Table 3 demonstrates that an increase in GNC concentration leads to a higher pH level while simultaneously reducing miscibility. Although all formulations remained homogeneous, skin-safe, and exhibited similar spreadability (Figure 3). **Formulation 1** (GNC 2.5 mg/mL) is the optimal formulation due to high miscibility, moderate skin-compatible pH, and sufficient active ingredient without compromising stability and physical characteristics.

Table 3. Physical evaluation of serum balm stick

Formulation	pH	Homogeneity	Spreadability (mm)	Organoleptic properties
F0 (Control)	4.5	Homogeneous	12.17±1.46	Milky white, very high miscibility, shea butter odor and waxy texture
F1 (GNC 2.5 mg/mL)	5.0	Homogeneous	12.36±0.51	Milky white, high miscibility, shea butter odor and waxy texture
F2 (GNC 5 mg/mL)	5.5	Homogeneous	12.22±1.22	Milky white, medium miscibility, shea butter odor and waxy texture
Commercial Product	3.0	Homogeneous	13.82±1.40	Beige, very high miscibility, Artificial odor and waxy texture

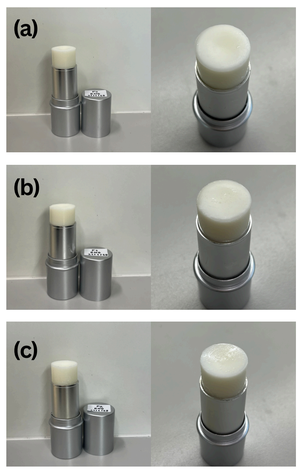


Figure 3. (a) F0 **(b)** F1 and **(c)** F2

The skin irritation evaluation revealed no adverse effects across all parameters, including redness, itching, hot/burn, rough, and sting when the product was applied to the inside part of the arm skin for 30 minutes. These results demonstrate that all three balm serum stick formulations are safe and non-irritating for skin application.

The stability evaluation of all formulations remains stable at 4 °C, room temperature and 65 °C on days 1, 3, and 5 with no significant changes in organoleptic properties.

Conclusions

- The extracted nanocellulose from corncob achieved a yield of 37.40 ± 3.49%
- The granular nanocellulose (GNC) showed good suspension stability and homogeneity with an average particle size of 342 nm, the zeta potential of −36.1 mV, and PDI of 0.356.
- The produced GNC exhibited measurable antioxidant activity across all assays, with IC_{50} values of 24.46 ± 3.69 mg/mL for DPPH and 2.12 ± 0.032 mg/mL for ABTS, and FRAP value of 2.33 ± 0.0014 µmol TE/g
- Formulation 1 is the optimal formulation due to its balanced properties.
- The formulated serum balm sticks incorporating GNC demonstrated good stability at 4 °C, room temperature and 65 °C over a 5-day period with skin-friendly pH range (4.5-5.5), maintaining homogeneity and non-irritating properties suitable for cosmetic use.

Acknowledgements

- BRL research group
- Department of Chemistry, Faculty of Science, Chiang Mai University

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