# BEESWAX COATING IMPROVES THE HYDROPHOBICITY AND SUSTAINABILITY OF SODIUM ALGINATE CELLULOSE NANOCRYSTAL/ANTHOCYANIN INDICATOR FILM

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## I. INTRODUCTION

Intelligent pH indicator films based on polysaccharide and anthocyanin reflect the freshness of raw meat in real time through colour changes [1]. Previous studies have found that in medium to high humidity conditions, the water barrier properties of intelligent indicator films decreased [1, 2]. This phenomenon negatively affects their indicator function and service life. To overcome this challenge, it is imperative to address the conversion of intelligent indicator films from hydrophilic to hydrophobic. Hydrophobicity can be achieved by the structural modification of the film surface [3]. Commonly used hydrophobic components include polymers such as fluorides, polyethylene, and long-chain alkyl groups such as waxes. Among them, food-grade beeswax (BW) are natural components and can be used in the fabrication of food contact materials. BW molecules contain hydrophobic methyl and have low surface energy properties [4]. Liquids cannot easily penetrate the surface of materials having lower surface free energy than that of liquids; droplets remain on the surface in the form of spheres, indicating their hydrophobicity [5]. Thus, BW may be applicable to achieve the hydrophobic modification of hydrophilic films. The aim of this study was to prepare sodium alginate/black soybean seed coat anthocyanin/cellulose nanocrystal intelligent indicator films and to form a BW waterproofing layer on its exterior by different methods (spraying, coating and soaking).

## II. MATERIALS AND METHODS

Intelligent indicator films were prepared by dissolving sodium alginate (1.5 g/100mL), black soybean seed coat anthocyanins (0.12 g/100mL), and cellulose nanocrystals (0.105 g/100mL) followed by casting and drying (30 °C, 48 h) in three steps. The hydrophobic solution (80 mL of hexane, 20 mL of polydimethylsiloxane, 5 g of BW) was applied to the surface of the indicator film by spray (SP), coating (CO), or soaking (SO) to obtain a hydrophobic layer. The water contact angle, light transmittance, pH sensitivity and water barrier properties of the films were measured. All experiments and the measurements for each sample were performed in triplicate. Data from three independent experiments were expressed by SPSS 21 as man ± standard error. Analysis of variance was conducted to compare the data at a significance level of $p < .05$.

## III. RESULTS AND DISCUSSION

The films showed excellent pH sensitivity after BW-SP and BW-CO layers treatment, as the film colour showed a significant colour change (dark brown—light reddish-brown—red-brown—yellow green) (Figure. 1A). The light transmittance of the films decreased after the BW layer treatment. Among them, the transmittance of the BW-CO layer was exhaustie with that of the uncoated film, indicating its highest transparency (Figure. 1B). The water contact angles (WCA) of BW-SP, BW-CO, and BW-CO layers was 116.1°, 111.4° and 122.5°, indicating that hydrophobic modification was achieved, as WCA was higher than 90° (Figure. 1C). As shown in Figure.1D, after 10 days, the water vapor permeability (WVP) of the films treated with BW layer decreased by 76.72%–99.37% compared with that of the uncoated film. Among them, the WVP of BW-CO and BW-SO layers was the lowest. In addition, WCA of BW-CO and BW-SO layers higher than 100° after 10 days, indicating their higher hydrophobic and durability (Figure. 1E). And both had a smoother surface (Figure. 1F).

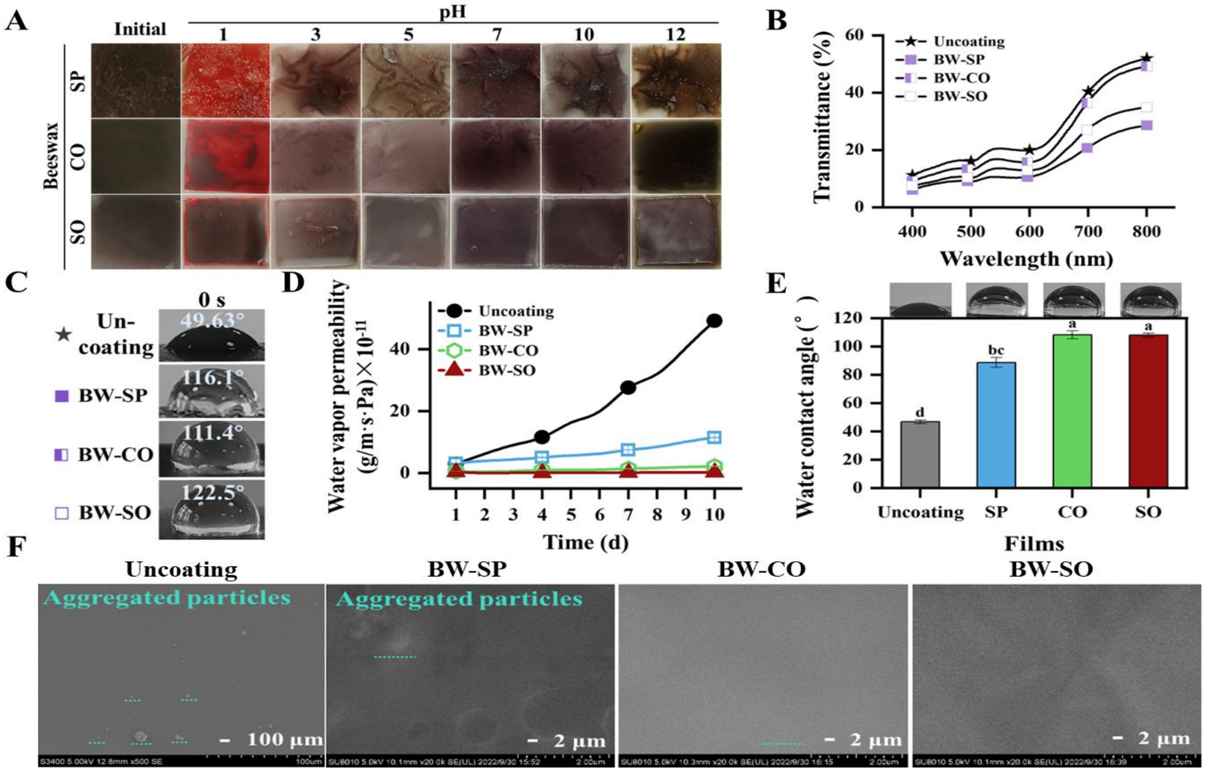


Figure 1. Effect of formation method of beeswax hydrophobic layer on pH sensitivity (A), light transmiitance (B), water contact angle (C) and water barrier properteis (D-E) of films. Different lowercase letters (a~d) indicate significant differences ($p < .05$).

## IV. CONCLUSION

BW-CO layer ensure the colour and pH sensitivity of sodium alginate/anthocyanin/cellulose nanocrystal films. BW-CO layer achieves hydrophobic modification of hydrophilic film with excellent water barrier and 10 days durability.

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## REFERENCES


1. Zhang, J. J., Huang, X. W., Shi, J. Y., Liu, L., Zhang, X. A., Zou, X. B., & Shen, T. T. (2021). A visual bi-layer indicator based on roselle anthocyanins with high hydrophobic property for monitoring griskin freshness. Food Chemistry 355: 129573.
2. Wang, X. Y., Zhai, X. D., Zou, X. B., Li, Z. H., Shi, J. Y., Yang, Z. K., & Xiao, J. B. (2022). Novel hydrophobic colorimetric films based on ethylcellulose/castor oil/ anthoyanins for pork freshness monitoring. LWT–Food Science and Techology 164: 113631.
3. Ge, D. T., Yang, L. L., Wu, G. X., & Yang, S. (2014). Spray coating of superhydrophobic and angle-independent coloured films. Chemical Communication 5: 2469.
4. Zhang, Y. W., Bi, J. R., Wang, S. Q., Cao, Q. P., Li, Y., Zhou, J. H., & Zhu, B. W. (2019c). Functional food packaging for reducing residual liquid food: Thermoresistant edible super-hydrophobic coating from coffee and beeswax. Journal of Colloid and Interface Science 533: 742-749.
5. Huang, J., Wang, S., & Lyu, S. (2017). Facile preparation of a robust and durable superhydrophobic coating using biodegradable lignin-coated cellulose nanocrystal particles. Materials 10: 1080.