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STUDY THE EFFECT OF AGRO-WASTE STARCH ON THE PHYSICAL PROPERTIES OF BIODEGRADABLE COMPOSITE FILMS

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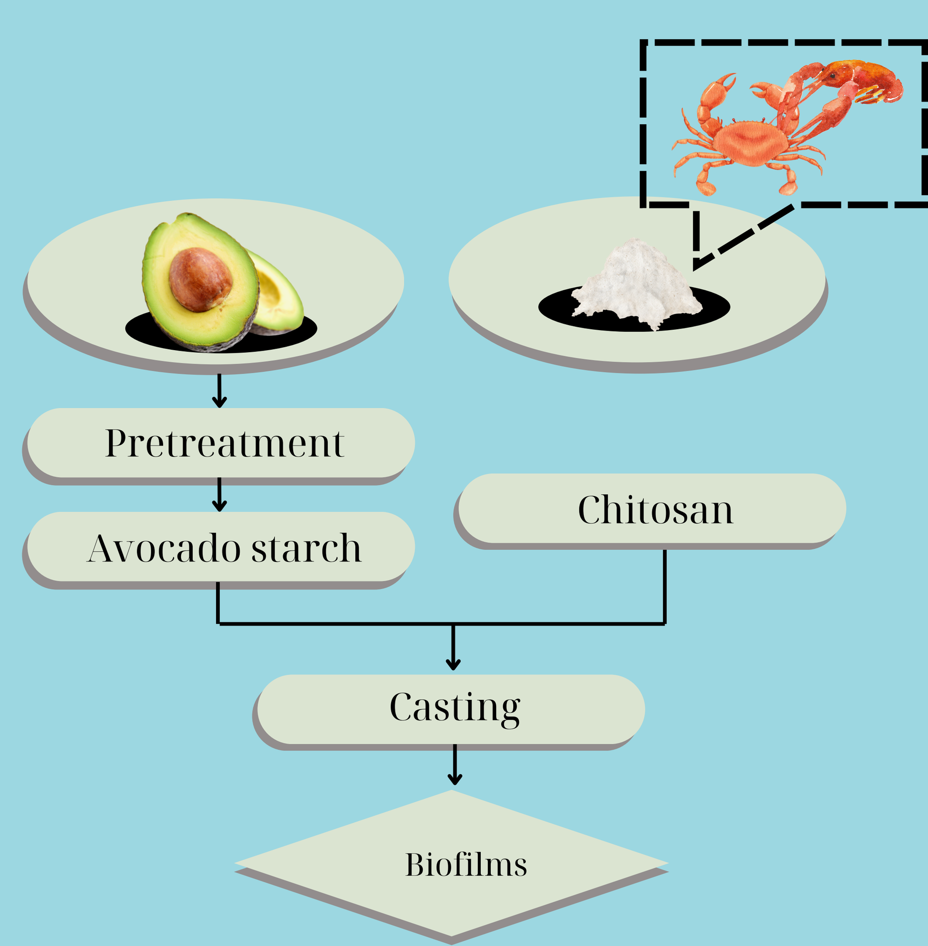
Introduction

Most food packaging is manufactured using petroleum-based non-biodegradable polymers, which threaten the environment and public health. Therefore, developing biodegradable films from renewable sources is important to replace plastics. The bottleneck in using biofilms is their poor mechanical properties and high-water absorption. Combining fruit-based starch and chitosan is a potential approach to producing biofilms with enhanced physical properties. This study aimed to formulate biofilms based on starch and chitosan, investigate the effects of different sources of starch, and evaluate the physical properties of these biofilms.

Methodology

- Two starches were investigated, including avocado starch and cassava starch. Avocado starch (AS) was extracted using a wet process, then dried and stored in a zip bag at room temperature before use, while cassava starch (CS) was purchased from Phuc Thinh Tapioca Factory (Thanh Hoa, Vietnam)

- Biofilms were formulated with starch and chitosan (C) at different ratios ranging from 1:9 to 9:1. The film-forming suspension was heated to 80 ± 2°C while being stirred continuously for 15 minutes, after which 20% plasticizer was added. The plasticized solution was then cooled to 40°C. Subsequently, the film-forming solution was poured into petri dishes (10 cm in diameter) and left to dry for 24 hours.



Evaluation:

- Mechanical properties of biofilms were determined by TA-XT Plus Stable microsystem, UK. Tensile strength at the breaking, elongation, and Young's modulus of produced films were recorded and calculated by an Exponent software (version 6.16.0, Stable microsystem, UK).

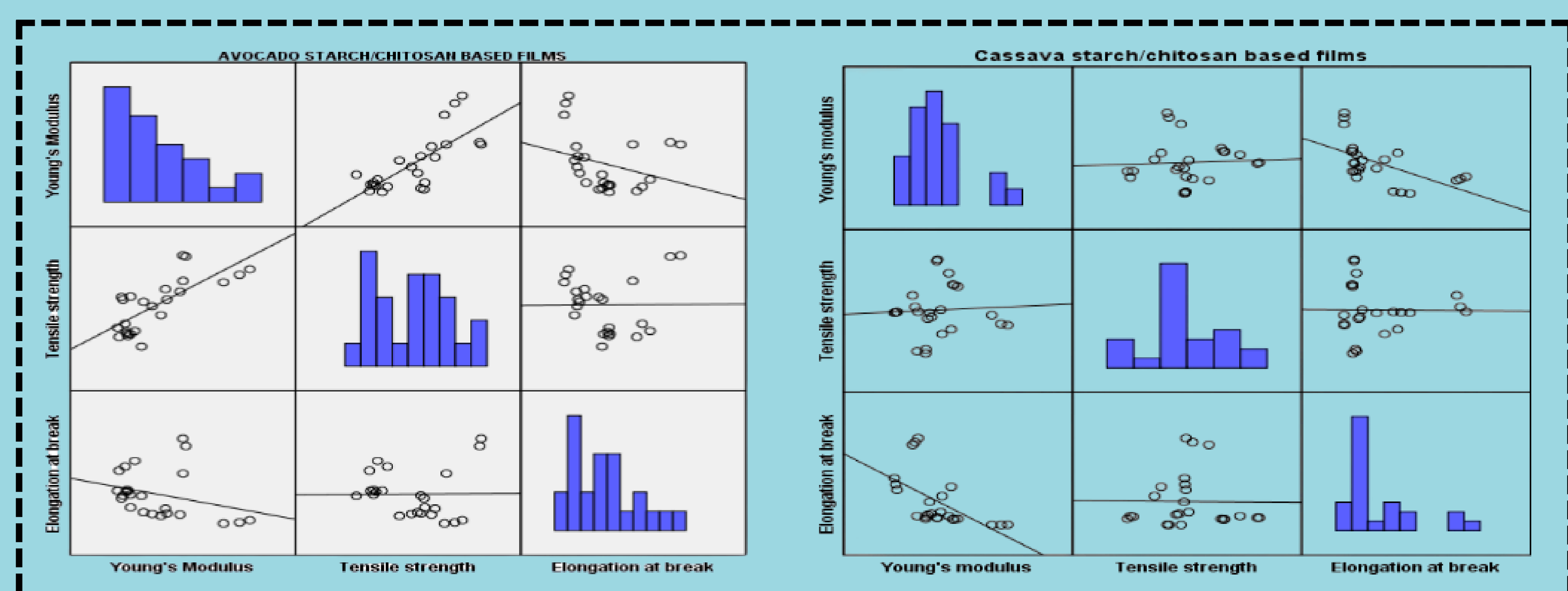
- Water absorption capacity evaluation was adapted followed ASTM D570. Dried sample was immersed in 20 mL distilled water at room temperature for 30 minutes, then being removed and blotting dried to determined water absorption.

$$\%\ Absorption = \frac{\text{Humid film weight} - \text{Dry film weight}}{\text{Dry film weight}} \times 100$$

Results & Discussion

Mechanical properties

An increased proportion of avocado starch in the composite film formulation markedly enhances the material's stiffness (Young's modulus). The 8:2 ratio exhibited the highest modulus value (~14 MPa), suggesting the formation of strong intermolecular hydrogen bonds and the development of crystalline domains upon retrogradation. Conversely, the 1:9 ratio resulted in the greatest elongation at break (~27%), indicating an inverse correlation between material stiffness and ductility.



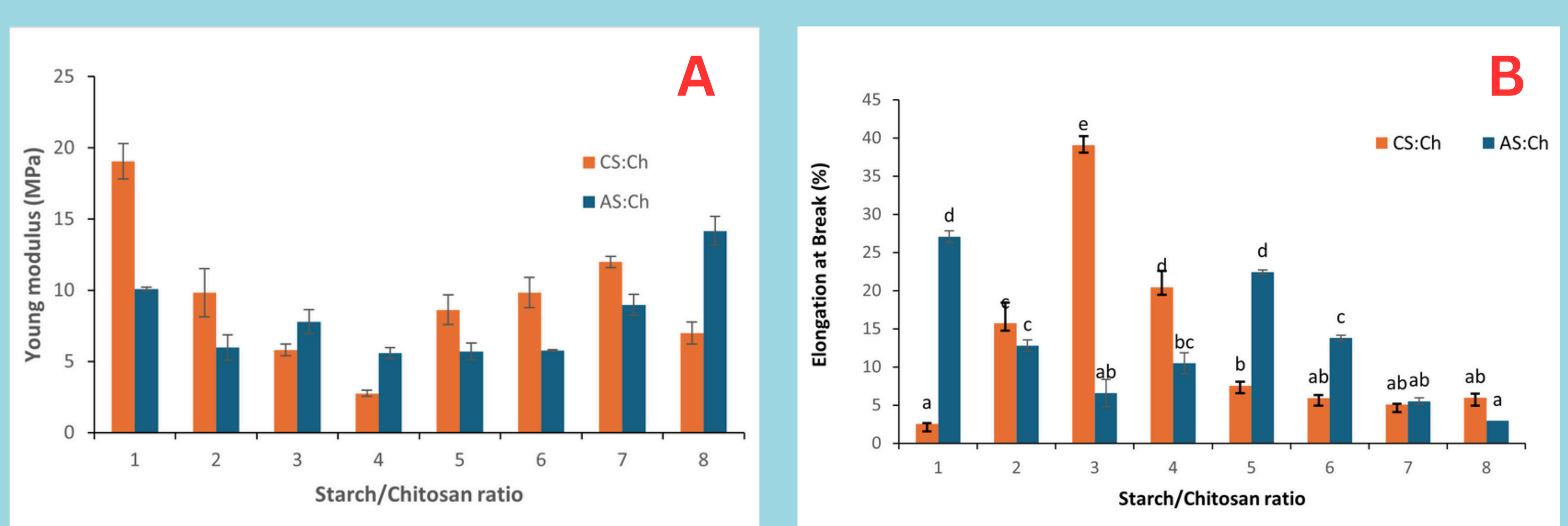


Figure 1. Mechanical properties of starch based biofilms at different formulation (A: Young Modulus; B: Elongation at break)

Cassava starch (CS) based film exhibits higher tensile strength when starch/chitosan ratio of 6:4 and 7:4 compared to Avocado starch (AS). The maximum elongation at break of 39% is recorded at the ratio of CS:Ch of 3:7. Likewise, AS based film with high tensile strength is formulated with high starch content, and its maximum elongation at break reach 27% at low starch content. Stiffness of CS and AS based films may be significantly influenced by the amount of chitosan or starch component, respectively. These findings indicate that cassava starch is more suitable for packaging application requiring flexibility and stretchability, whereas avocado starch is more appropriate for materials requiring higher stiffness and greater structural stability.

Water absoption capacity

Glycerol decreases the swelling capacity of the film by almost tenfold due to its ability to form hydrogen bonds with –OH/–NH_2 groups, effectively replacing water molecules. This interaction contributes to improved control over the moisture sensitivity of the biopolymer material.

Increasing the chitosan content enhances the film's water uptake, owing to chitosan's abundant functional groups that readily form hydrogen bonds with water. However, glycerol incorporation reduces water absorption due to competitive hydrogen bonding, where glycerol molecules displace water molecules. This antagonistic interaction allows for precise regulation of water uptake when the component ratios are optimally balanced.

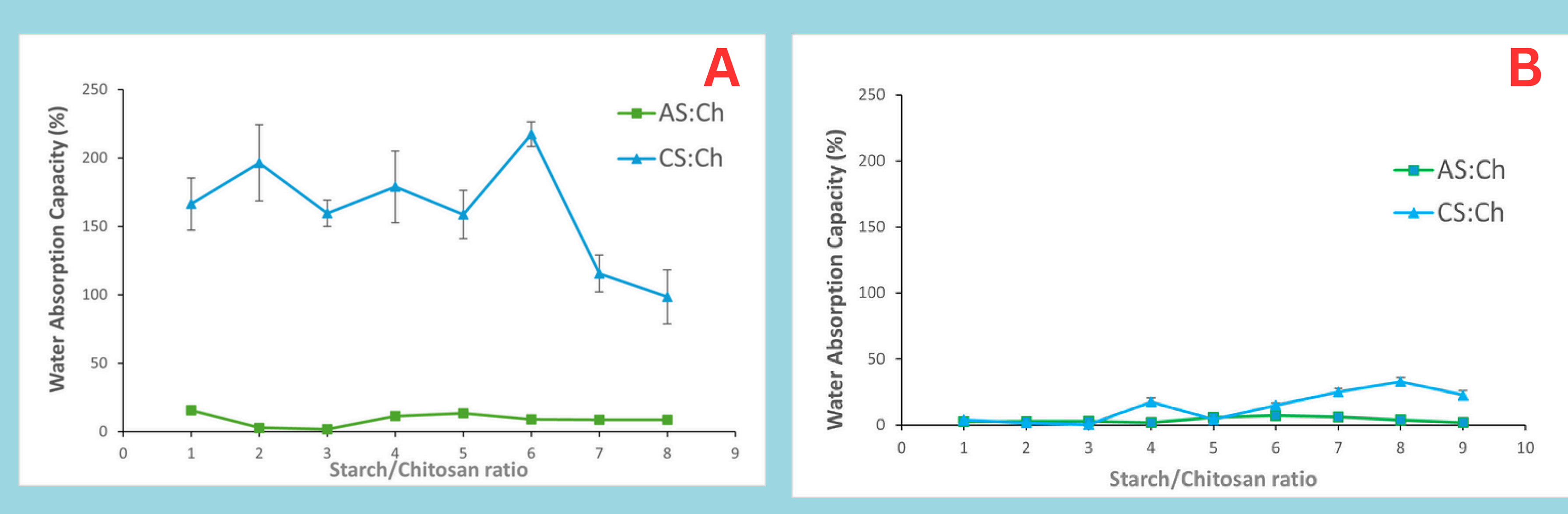


Figure 2. Water absoption capacity of starch based biofilms (A: no glycerol; B: with glycerol)

Conclusion

- Avocado starch based biofilm characterize with high stiffness at high concentration of starch and low flexibility. Likewise, cassava starch based films are more flexible, especially with CS:Ch of 3:7.
- Glycerol enhances flexibility and reduces swelling capacity of starch-based biofilms
- Chitosan-starch biofilms have good mechanical properties and can be tailored for specific application.