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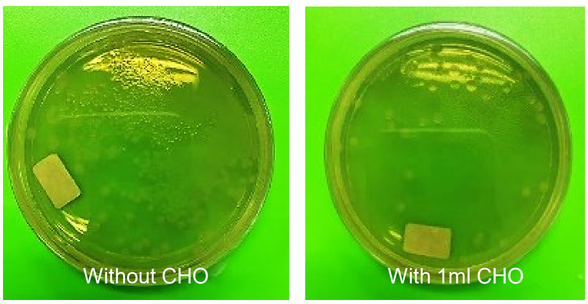
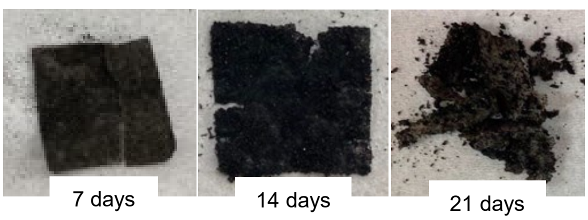
Cassava Starch Biopolymer Film Incorporated with *Citrus Hystrix* Oil for Food Packaging



Bacteria colony of film



Biodegradability of film with 1 ml CHO

Food products easily deteriorate because of the growth of bacteria and the loss of moisture, gases, and nutrition. It becomes spoilage in a short period and reduces its quality. Artificial or chemical-based food preservatives are widely used in the food industry, but they are toxic and can cause adverse effects on human health. Antimicrobial or active packaging film serves as a new approach to food preservation and packaging that protects the foods from environmental conditions and can delay food spoilage. Thus, incorporating natural additives such as essential oil into film formulation is nontoxic and safe for humans. Essential oil contains active compounds to retard microbial activities. Therefore, the biopolymer film incorporated with essential oil could improve food quality, extend food's shelf life and make it biodegradable. This study explores the potential of *Citrus Hystrix* oil (CHO) as an active ingredient in the film formulation. The CHO was extracted using the hydrodistillation method, and then it was incorporated into the film formulation, which consisted of cassava starch and glycerol. The film was produced using the casting technique, and its characterization was determined.

The major compounds in the extracted CHO were a-pinene (17.660%), citronellol (13.683%), linalool (11.022%), a-thujene (7.773%) and terpinene-4-ol (7.606%). The film's antimicrobial activity shows that CHO can inhibit the growth of *Escherichia coli*. Incorporating 1 ml CHO reduced the bacteria colony to 81% compared to film without CHO. The presence of the isopropyl group in a-pinene and the hydroxyl group in citronellol and linalool and cyclohexene ring of terpinene-4-ol are likely to contribute to the antimicrobial activity of CHO. The increase in CHO decreased the biodegradability of the films. The film without CHO and the film with 0.2 ml and 0.4 ml CHO were fully degraded in the soil after 21 days. The film containing 1 ml CHO had the lowest weight loss, 43.9%.

The water intake by the film in the soil promotes the entry of microorganisms; thus, due to the higher water availability within the material, the films were degraded in the natural environment.

The film without CHO presented the highest tensile strength (3.35 MPa). The incorporation of CHO from 0.2 ml to 1 ml reduced the tensile strength by 26 % - 41 %. The addition of CHO up to 0.8 ml caused an increase in water vapour permeability, which is related to the decrease in tensile strength. The TGA shows that the presence of CHO reduced the degradation rate of the film, indicating better thermal stability than film without CHO. The incorporation of CHO suggested a promising natural antimicrobial additive for cassava starch film to be utilized as food packaging. The film resulted in good tensile strength and water vapour permeability, is thermally stable, is well degraded, and possesses antimicrobial activity. The developed film is possibly an eco-friendly packaging that is able to prevent food deterioration and prolong food's shelf life.

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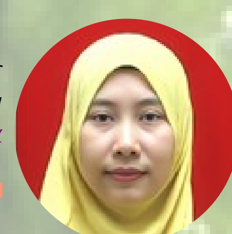

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