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The potential of cocoa waste as a component of edible packaging films

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KOŁO NAUKOWE TECHNOLOGÓW ŻYWNOŚCI

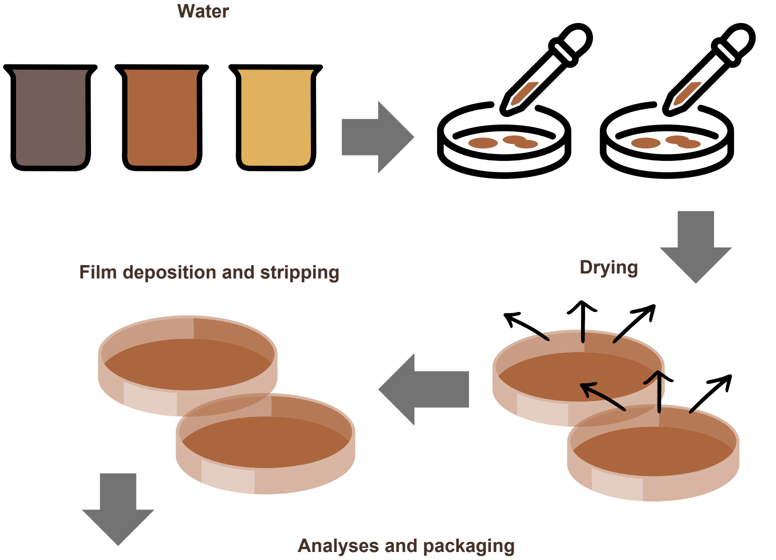
INTRODUCTION & AIM

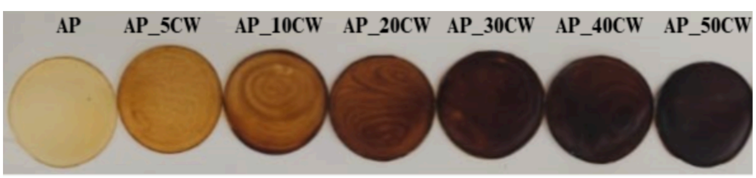
Edible film and coating is defined as a **thin, continuous layer of edible material used as a coating or as a film placed between food components to provide a barrier to mass transfer** (Gaspar & Braga, 2023). They can prevent the product from **losing its quality** by the formation of oxygen, oil or moisture barriers. The edible packaging market is growing due to consumer interest in **health, nutrition and sustainability**. In order to produce edible films, cocoa waste (CW) and apple pectin (AP), and glycerol were used. **Cocoa husk** is a major by-product generated during the production of Cocoa (*Theobroma cacao L*). It is sourced while removing the cocoa beans from the pod and is estimated to be 75% of the entire pod (Kapun et al., 2024). Currently, most of the cocoa husk is returned to the soil and used as fertiliser, but it has a significant **economic potential**.

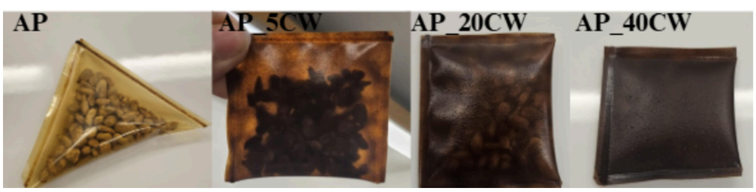
This project aims to investigate the possibility of using cocoa waste to produce packaging films as one of the actions to minimise waste in a circular economy approach. Cocoa powder does not show film-forming capacity. Thus, apple pectin, also extracted from by-products, was used to obtain a continuous structure.

METHOD

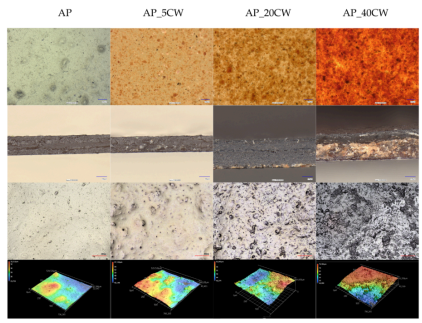
Aqueous film-forming solutions were produced using apple pectin at a concentration of 5% and cocoa waste at the concentrations of 5-50% relative to pectin (0.25-2.5g per 100g of water). Mixtures without the cocoa waste were treated as controls. Glycerol as a plasticiser at 50% relative to pectin (2.5 g per 100 g of water) was added.





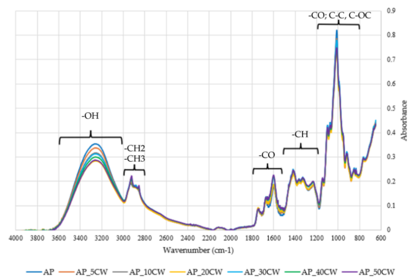


RESULTS & DISCUSSION



MICROSTRUCTURE

CW significantly altered the structure of pectin-based films. It increased structural heterogeneity and surface roughness. Scanning electron microscopy observations demonstrated migration of CW towards the surface of the film during the drying process, which promoted the development of granular textures and topographical irregularities. Even the addition of 5% CW caused the films to exhibit particle dispersion and slight surface roughness, despite their relatively continuous and compact structure. Films with 40% CW had high irregularity and heterogeneity, particle accumulation was noted in the bottom part of the films. This analysis indicated good compatibility between CW and AP at low concentrations.



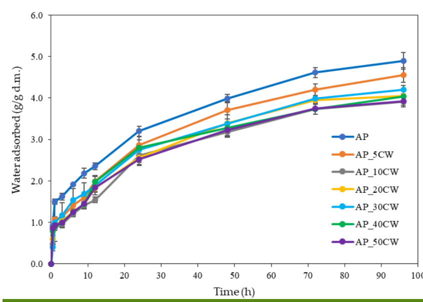
FOURIER TRANSFORM INFRARED SPECTRA

This analysis indicated the presence of hydroxyl groups, C-H aliphatic groups, carbonyl groups, methane groups and the presence of carbohydrates. The bands and peaks were uniform for all samples, which proves good compatibility between CW and AP.

ANTIOXIDANT ACTIVITY

Film	ABTS	DPPH
AP	78.22 ± 1.28 a	66.77 ± 3.72 a
AP_5CW	78.78 ± 4.54 a	67.24 ± 1.98 ab
AP_10CW	82.55 ± 1.40 ab	69.85 ± 2.11 ab
AP_20CW	83.67 ± 1.57 ab	72.79 ± 1.50 bc
AP_30CW	85.48 ± 0.61 bc	77.46 ± 1.46 cd
AP_40CW	89.67 ± 1.14 c	80.26 ± 1.51 de
AP_50CW	95.95 ± 0.28 d	85.21 ± 0.70 e

Antioxidant activity analysis showed that samples without CW addition had lower antioxidant activity than other samples in ABTS as well as DPPH tests. Highest antioxidant activity was present in samples with the highest CW addition (AP_50 CW) at values of 95.95% in the ABTS test and 85.21% in the DPPH test. CW was succesful in improving antioxidant activity of pectin-based films. The greater the amount of CW, the greater the antioxidant activity.



WATER VAPOUR SORPTION KINETICS

This analysis showed that enrichment of pectin-based films with CW causes lower moisture absorbance. Notably, all films displayed water vapour sorption kinetic curves of similar shapes, which, indicated uniform sorption kinetics and suggested that all samples had consistent compositional characteristics.

CONCLUSION

This study investigated the effect of CW addition on pectin-based packaging films. CW concentrations varied, affecting the structural, optical, mechanical, and chemical aspects of the films under investigation. After considering all of the films' qualities, it was discovered that films with 20% and 30% CW were best suited for packaging application. The most suitable structures for sealing were AP_20CW and AP_30CW, which retained adequate structural and mechanical qualities. Further research is needed to investigate the scalability of these films in practical applications and evaluate their performance under real-world settings. The incorporation of additional reinforcing agents or composites may improve functional qualities, making the films more appropriate for a broader range of food packaging applications.

REFERENCES

1. Gaspar, M. C., & Braga, M. E. M. (2023). Edible films and coatings based on agrifood residues: A new trend in the food packaging research. Current Opinion in Food Science, 50, 101006. https://doi.org/10.1016/j.cofs.2023.101006
2. Kapun, T., Karlovits, I., & Dimitrov, K. (2024). Cocoa husk biomass conversion for application in fibre packaging. Biomass Conversion and Biorefinery, 14(10), 11165–11173. https://doi.org/10.1007/s13399-022-03330-2