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Synergistic Effect of Extracted Spent Coffee Ground and Citric Acid on Bioactive Properties of Polyvinyl Alcohol / Starch Film

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Introduction : Biodegradable polymer packaging has attracted much attention for replacement of non-biodegradable materials such a petroleum-based synthetic polymers. Starch has been widely used as biodegradable plastics due to its outstanding properties i.e. abundant availability and inexpensive. However, starch still has some drawbacks i.e. low water resistance and poor mechanical properties. To improve these properties, blending of starch with biodegradable polymer such as poly (vinyl alcohol) (PVA) has been utilized for packaging materials and biomedical materials [1]. The compatibility of PVA/starch film can be improved by adding crosslinking agent. Citric acid (CA) is a non-toxic crosslinking agent which has antibacterial properties. The PVA/starch incorporated CA can inhibit both Gram-positive and Gram-negative bacteria. The addition of antimicrobial agents into polymeric packaging is an alternative to extend shelf life and control the quality of food products. The extracted spent coffee ground (ex-SCG) is a major waste of coffee production containing beneficial antioxidant compounds. Currently, there is no information on bioactive film packaging containing active compounds combining such as CA and ex-SCG. This research aims to study the effect of CA and ex-SCG on PVA/starch film properties.

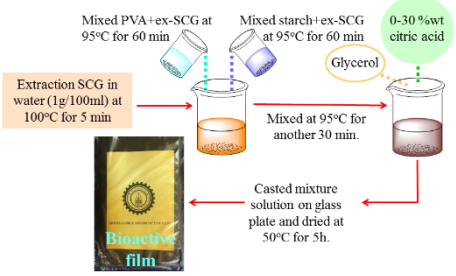

Fig. 1 preparation of film sample.

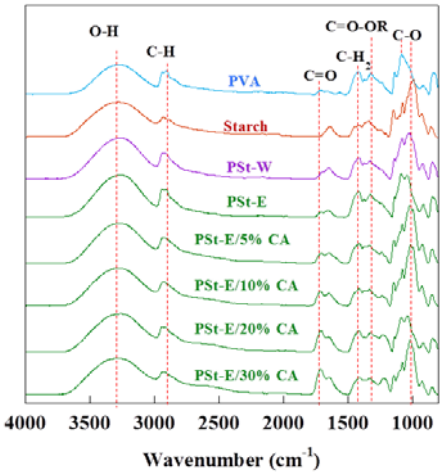

Fig. 2 ATR-FTIR spectra of sample.

Experimental : The preparations of ex-SCG and PVA/starch film are shown in **Fig. 1**. The structural interaction of sample was analyzed by Attenuated total reflection infrared (ATR-FTIR) spectra (JASCO 4200). The agar diffusion method was applied to determine the antimicrobial activity of samples.

Table 1. Antibacterial activity of sample.

Sample	Inhibition zone (mm)	
	E.coli	*S.aureus*
PSt-E	ND	ND
PSt-E/5%CA	ND	ND
PSt-E/10%CA	ND	ND
PSt-E/20%CA	ND	ND
PSt-E/30%CA	1.28	4.51
PSt-W/30%CA	0.96	3.48
ex-SCG	ND	ND
Citric Acid	23.67	25.53

Results and Discussion : ATR-FTIR spectra of the samples are depicted in **Fig. 2**. The PVA/starch blend film with distilled water (PSt-W) showed both of the characteristic peaks of PVA and starch without new peak, indicating the physical blend between PVA and starch. For PVA/starch blend film with ex-SCG (PSt-E), peaks assignable to ex-SCG compounds were also observed at 1740 cm^{-1}. The PSt-E incorporated 5-30 wt% CA increased the peak intensity at 1715 cm^{-1}, attributable to C=O stretching vibration. It was indicated that the esterification occurred between starch and citric acid as well as between PVA and citric acid. **Table 1** lists the minimum inhibitory concentrations against *Escherichia coli* (*E.coli)* and *Staphylococcus aureus* (*S.aureus)*. The synergistic behavior of combination between CA and ex-SCG is clearly observed in the antibacterial activity. The inhibition zones for *S.aureus* and *E.coli* of PSt-E with 30 wt% citric acid are larger than those of PSt-E and PSt-W with 30 wt% CA. The major effect of CA on antibacterial properties was acidulation and chelating effects, whereas the antibacterial agents of ex-SCG such as caffeic acid and chlorogenic acid also inhibited the growth of bacterial. Caffeic acid can against the bacterial RNA polymerase enzyme, whereas chlorogenic acids improved the permeability of outer and plasma membrane resulting in the decrease of barrier membrane properties and leakage of cytoplasm molecules. Based on this study, the incorporation of combined ex-SCG and CA into PVA/starch film has a highly improved performance for bioactive packaging.

[1] O. Moreno, A. Gil, L., Atares, A. Chiralt. *Starch/Stärke*, **2015**, 67, 780-789.

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