Bioactive Packaging Based on Polyvinyl Alcohol/Starch Film Enriched with Antioxidants from Spent Coffee Ground and Citric Acid

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ABSTRACT:

Recently, replacement of petroleum-based polymers by bio-based polymers has attracted much attention because the wastes from petroleum-based polymers is non-biodegradable and difficult to recycle. Bio-based polymers produced from abundant natural resource such as starch is good alternative materials. Starch blended with synthesized biodegradable polymer has been developed to overcome its shortcomings i.e. low water resistance and poor mechanical properties. Polyvinyl alcohol (PVA) has been selected to blend with starch due to their compatibility and facile film casting ability. Furthermore, crosslinking agents such citric acid (CA) has been applied to improve the tensile strength of the blend film. CA is also used as antibacterial additive for polymeric packaging to extend shelf life of food products. Nowadays, antioxidant agent based on a waste product such as extracted spent coffee ground (ex-SCG) has been focused to utilize the beneficial antioxidant compounds in various applications. Therefore, this study aims to investigate the effects of CA and ex-SCG on the properties of PVA/starch film.

PVA/starch films containing ex-SCG (PSt-E) and different amounts of CA (0-30 wt%) were prepared using a solvent casting process. The agar diffusion method was applied to determine the antimicrobial activity of the samples. DPPH radical scavenging activity of film was determined using the method proposed by Brand-Williams et al.[1] Moisture content (MC) and total soluble matter (TSM) were determined from the different weight ratios of initial weight and the weight of a dried sample.

A PSt-E film containing 30 wt% CA showed a minimum inhibitory concentration against *Escherichia coli* (*E.coli*) and *Staphylococcus aureus (S.aureus)*, as shown in Table 1. The incorporation of ex-SCG and CA into the films showed a synergistic effect on antibacterial activity. Fig. 1 shows the antibacterial activity of combined bioactive compounds such as ex-SCG and CA. Fig. 2 shows the antioxidant releasing of PVA/starch film containing distilled water (PSt-W) containing 30 wt% CA, PSt-E, PSt-E containing 30 wt% CA in three food simulants such as distilled water, 10 % ethanol (aq.) and 95 % ethanol (aq.) which represent aqueous food, alcoholic food, and fatty food, respectively. A similar trend of DPPH scavenging activity was observed for all the simulant foods. The presence of ex-SCG in the films showed that the DPPH scavenging activity was higher than that of PSt-W incorporated 30 wt% citric acid. The antioxidant activity of PSt-E film containing 30 wt% citric acid was 4 folds greater than that of PSt-W film containing citric acid at the same ratio. The bioactive film containing antioxidant agents can thus be applied for prevention of lipid oxidation and maintaining quality of foods. Table 2 shows the values of MC and TSM for PSt-E containing 0-30 wt% CA. Both of MC and TSM were significantly decreased with increasing the CA content up to 10 wt%. It was due to the crosslinking effect of citric acid on PVA and starch via ester linkage. The addition of CA content higher than 10 wt% led to excess amount of unreacted CA.

Table 1 Inhibition zone of the film samples

Sample	Inhibition zone (mm)	
	E.coli	*S.aureus*
PSt-E	ND	ND
PSt-E/5 wt% CA	ND	ND
PSt-E/10 wt% CA	ND	ND
PSt-E/15 wt% CA	ND	ND
PSt-E/20 wt% CA	ND	ND
PSt-E/30 wt**% CA**	**1.28**	**4.51**
PSt-W/30 wt% CA	0.96	3.48
ex-SCG	ND	ND
Citric acid	23.67	25.53

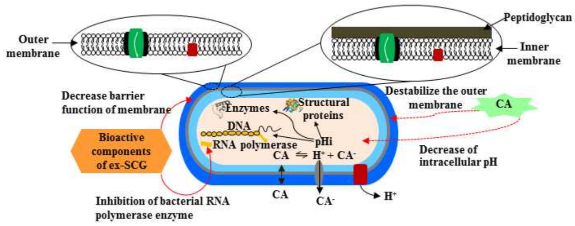

Fig.1 Antibacterial activities of citric acid and ex-SCG.

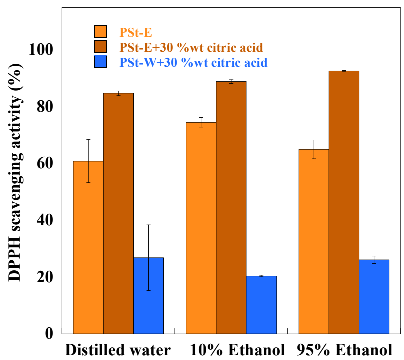

Fig. 2 Antioxidant releasing of the film samples.

Table 2 Water resistance of the film samples.

Sample	MC (%)	TSM
PSt-E	22.44 ±0.2	55.48 ±6.5
PSt-E/5 %wt CA	20.04 ±0.7	46.83 ±2.9
PSt-E/10 %wt CA	18.63 ±0.5	41.45 ±7.6
PSt-E/20 %wt CA	18.26 ±0.2	41.13 ±3.8
PSt-E/30 %wt CA	18.24 ±0.5	41.67 ±0.7

Reference: [1] Brand-Williams W, Cuvelier ME, Berset C (1995) LWT - Food Sci Technol 28(1):25-30

Key words: Synergistic antibacterial activity; Bioactive film; Spent coffee ground; Citric acid