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Synthesis and characterization of water-soluble polyvinyl alcohol/pomegranate peel powder films

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ABSTRACT
Biodegradable plastics had gained much attention among the researchers due to the arising of sustainability and environmental issues caused by petrochemical-based plastics. In this study, PVA films incorporated with pomegranate peel powder (PPP) were synthesized by using solution casting method. The effect of PPP on the surface morphology, physical properties, barrier properties and antibacterial activity of PVA based films were studied through FE-SEM, water solubility test, water contact angle test and Kirby-Bauer test. The incorporation of PPP had significantly enhanced the water solubility and surface energy of PVA-PPP films with the increasing of PPP content that caused reduction in water contact angle of the films. However, the films do not show a significant effect on the antibacterial efficacy against *E.coli*. In conclusion, PVA-PPP films have great potential to be used as green packaging materials for cosmetics products provided that further study on antibacterial efficacy against gram positive bacteria should be conducted.
Keywords: *Water-soluble; polyvinyl alcohol; pomegranate peel powder; antibacterial.*

1. INTRODUCTION
Packaging plays an important role in preserving cosmetics products. Good packaging material can protect cosmetics products from microbial contamination, UV photo degradation and oxidation. Cosmetics are products that normally applied to human skin mainly for beautifying, cleansing and protecting purposes [1]. These products are basically non-sterile, therefore inappropriate preservation of these products can provide beneficial environments for the growth of microorganisms.

Most of the cosmetics packaging is made of plastics due to light weight, durable and attractive properties. However, not all plastics are environmentally friendly. For instance, the breakdown of petroleum-based plastics releases various kinds of toxic chemicals that pose a threat to the environment. In order to solve this global concern, development of biodegradable plastics is one big step to lessen the usage of non-biodegradable plastics.

Bioplastics can be synthesized using various types of natural resources based on their desired properties. Pomegranate peel powder which poses good antioxidant and antimicrobial properties is an alternative to chitosan in producing antimicrobial bioplastics [2, 3]. It is a by-product obtained during pomegranate juice processing. The pomegranate peel has an abundant amount of polyphenols, including a wide variety of tannins, which possesses unique biological activities, inhibits microbial growth and reduces the risk of cancer and cardiovascular diseases [4]. Current study focused on the synthesis of water-soluble polyvinyl alcohol (PVA) based films incorporated with 1% to 5% pomegranate peel powder (PPP). The physical, mechanical and barrier properties of the PVA based film were investigated and antibacterial activity of PVA-PPP films against *E.coli* was also examined in this study.

2. MATERIALS AND METHODS
2.1. Materials.
PVA and glycerol were purchased from R&M Chemicals. Pectin from citrus peel and PPP were purchased from Sigma Aldrich and Craftiviti, respectively. Nutrient agar powder was purchased from MERCK while *Escherichia coli* stock was purchased from Sigma Aldrich.

2.2. Solution casting of PVA/PPP films.
The film solutions were prepared by dissolving 0.25% citrus pectin in 100 ml preboiled distilled water under magnetic stirring (800 rpm). The pectin solution was cooled down until 90 °C before the 5% PVA crystals were dissolved under 200 rpm stirring for 30 mins. 1% glycerol was then added into the solution and continues heated at 90 °C under 200 rpm for another 30 mins. Then, pomegranate peel powders (PPP) with concentration of 1% to 5% were added into the film solution and continue stirred at 200 rpm for an additional 30 mins at room temperature. Another film solution without adding PPP was used as the control. The film solutions were left cool overnight on the bench to reduce air bubbles. The film solutions were filtered to remove insoluble PPP fiber from the polymer solution. After that, 10 g of film solutions was casted onto 17 cm × 6 cm glass plate and oven dry for 10 hrs at 40 °C. The thickness of the films was controlled by casting a constant amount of film solutions on the same dimension glass plates. The dried films were then peeled off from the glass plate and stored in zip-lock bag for further analysis.

2.3. Characterization.
2.3.1. Field emission scanning electron microscopy.
The surface microstructure of the PVA control film and 5% PVA-PPP film surface was investigated by JSM-7800F Field Emission Scanning Electron Microscopy (FE-SEM). The films were coated with platinum and adhered to sample holder by using carbon tape to allow the image to be captured without distortion