

STARCH-BASED EDIBLE FILM AND COATING FROM LOCAL *PACHYRHIZUS EROSUS*

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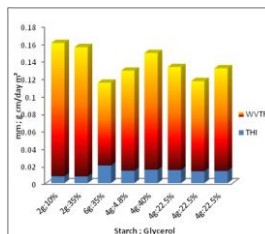
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Graphical abstract



Abstract

Edible films and coatings usage are constantly increasing in the food industry. It can be consumed, coated on food or placed as barrier between the food and the surrounding environment. It can also help extend food shelf-life and quality of the food. *Pachyrhizus* known by the locals as sengkung was used in search of their novelty to be used as starch-based edible films and coatings products. Through this project research, significant findings were found in the starch-based edible films and coatings made. A compatible amount of plasticisers were used to help the product in flexibility. Apart from a nice clarity appearance, the physical testing results showed low values of 34.53% for solubility, 19% for swelling, 0.014 mm for thickness and 0.112 g cm/day m² for water vapor permeation. These indicated that the product has a high water resistance. The mechanical test also gave impressive results with 0.313 for coefficient of friction (COF) and 7.9 MPa for tensile strength value. Since their application is still underutilised, this research is carried out in search of cost efficient resources for the production of edible-films and coatings as well as to utilise this food crop in Malaysia.

Keywords : Starch-based edible films, *Pachyrhizus spp*, Underutilise fruit

Abstrak

Penggunaan filem penyalut pembungkus boleh makan sedang meningkat di dalam industri makanan. Ia merupakan sejenis lapisan nipis yang boleh dimakan, menyalut makanan atau sebagai lapisan yang memisahkan antara makanan dan persekitarannya. Ia turut digunakan untuk memanjangkan jangka hayat dan kualiti makanan. *Pachyrhizus* yang turut dikenali sebagai sengkung oleh masyarakat tempatan, dalam pencarian sifat novelnya untuk menghasilkan filem penyalut pembungkus boleh makan berasaskan kanji. Melalui ujikaji, beberapa penemuan yang signifikan di perolehi dari hasil filem penyalut pembungkus boleh makan yang terhasil. Selain daripada menampilkan lapisan nipis yang lutsinar, ujian fizikalnya menunjukkan bacaan yang rendah iaitu 34.53% keterlarutan, 19% bagi ujian pembengkakan, 0.014 mm bagi ketebalan dan 0.112 g cm/day m² bagi ujian penelapan wap air. Ini menunjukkan bahawa produk yang terhasil merupakan produk yang kadar ketelapan airnya adalah fingsgi. Keputusan bacaan bagi ujian mekanikal pula menunjukkan 0.313 bagi pekali geseran (COF) dan 7.9 MPa bagi nilai kekuatan regangan. Oleh kerana penggunaannya masih kurang, maka penyelidikan ini khususnya dilakukan bagi mencari sumber yang lebih kos efektif dalam menghasilkan filem penyalut pembungkus boleh makan disamping membangunkan penggunaan terhadap hasil tanaman ini di Malaysia.

Kata kunci: Filem penyalut pembungkus boleh makan berasaskan kanji, *Pachyrhizus spp.*, Buah nadir

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1.0 INTRODUCTION

Pachyrhizus spp. is one of the important crops in tropical countries. The plant is easy to cultivate with growth cycle of approximately 6 to 8 months. In Malaysia, the Agricultural Department recorded a total of 198.5 hectares planted *Pachyrhizus* every year with production capacity of 33.4 metric ton per hectare [2]. Previous studies showed that the starch extracted from *Pachyrhizus* is similar to the cassava starch functional properties [3]. Starch-based edible films will form into a clear film with vary water resistance capability through the physical testing and the mechanical test that measure the film elasticity. Based on the previous study on starch-based edible film from other sources, plasticisers were used to help in film flexibility. The objective of this project is to generate an alternative starch from local resources to produce edible films and coatings with cost effective in order to achieve halal and safe films and coatings products.

2.0 EXPERIMENTAL

2.1 Preparation of Edible Films

Solutions with various proportions of starch and glycerol were processed to form film by modified casting method [5]. The composition of edible film forming solutions were prepared by mixing starch and additives in distilled water and gradually heating it up to 80 ± 2 °C with stirring (100 rpm). The solution was transferred to 9 X 1.5 cm petri dishes and was dried in a controlled temperature chamber at 25 °C at 50% relative humidity (RH) for 48 h. The films were then carefully separated from the petri dish and equilibrated at 27 °C at 73% RH for at least 48 h.

2.2 Thickness

The electronic digital micrometer (Mitutoyo Co., Japan) was used to determine the dried films thickness with an accuracy of ± 1 μm . Five thickness measurements were taken on each dried films (triplicate) and the mean values of each films were calculated and recorded in millimeter (mm).

2.3 Water Vapor Permeability (WVP)

The water vapor transmission rate (WVTR) was determined gravimetrically using a modification of ASTM Standard Method E 96, which is known as the cup method. Anhydrous calcium chloride (0% RH) was taken in a permeation cell and the circular mouth (area = 0.3 m²) of the cell was sealed with the film to be tested. The permeation cell was placed in the desiccators that were maintained at 80% RH across the film. The water vapor transport was determined from the weight gain of the permeation cell after the steady state condition was reached. Weight measurements were made at regular time intervals and the changes in the weight were plotted as a function of time. The

slope was calculated by linear regression method and the water vapor transmission rate (WVTR) was calculated from the slope of the straight line (g/s) divided by the transfer area (m²). After the permeation test, film thickness was measured and WVP (g Pa⁻¹ s⁻¹ m⁻¹) was calculated.

2.4 Moisture Content (MC)

Film moisture content was determined in a hot air oven at 105 °C overnight. Determination was performed for 3 films specimens of each formulation and the average value of the initial weight of the film and the final weight of the film was reported.

2.5 Solubility (SOL)

Solubility of the film was measured according to the method described by Romero-Bastida *et al.* [1]. Discs of film (2 cm diameter) were cut, weighed, immersed in 50 ml of distilled water. The beaker was sealed to prevent the evaporation of water, and stored at 25 °C for 24 h, and was periodically wobbled slightly. Then the samples were dried in a vacuum oven at 40 °C until the weight of the samples became constant.

2.6 Tensile Properties Determination

Tensile measurement was performed following ASTM method D882-02. Film strips ends were mounted and clamped with rubber-lined aluminium grips on a universal testing machine (Instron LRX) with a 500N load cell. The speed of the crosshead was 1mm/min. Tests were conducted at room conditions of 50% \pm 5% RH and 23° \pm 2 °C. Tensile properties were reported as maximum tensile strength (MPa) and elongation at break (%). Five average of each film were tested and an average value is reported.

2.7 Coefficient of Friction

Coefficient of friction was performed following to ASTM method D1894. Measurements of frictional properties may be made on a film or sheeting specimen when sliding over itself or over another substance. Tests were conducted at room conditions of 50% \pm 5% RH and 23° \pm 2 °C. The cross speed was at 150mm/min with travel distance of 5 in.

3.0 RESULTS AND DISCUSSION

Figure 1 showed that high amount of starch will relatively increase the thickness. All formulation were found to be >85% moisture content. This high moisture content and also high water permeation of 0.112 g cm/day m² were due to the addition of glycerol as plasticiser. The plasticiser also lowers the solubility value up to 34.53%. Plasticisers not only promote high elasticity to a film but the high polarity of a plasticiser will attract RH of the surroundings [8]. The moisture content determined

the amount of water present in the film. The plasticizer added does not increase nor decrease the film moisture content, but in terms of solubility, at certain amount of starch with compatible amount of glycerol added, hydrophobic character was distinguished. Hydrophobic characteristic had decreases the O-H bonds and the film structure had changed because of the presence of the aliphatic groups [4].

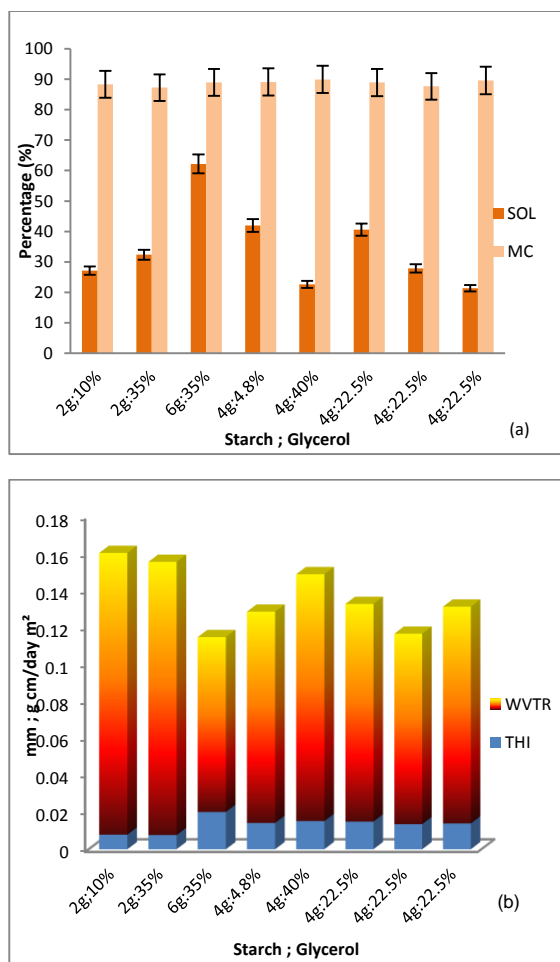


Figure 1 Physical testing through SOL, MC (a), WVTR and (b) THI of *Pachyrhizus* starch-based edible film formulation gained using 2 x 5 factorial design

Box-Behnken experimental design was performed in order to study the individual and interactive effects of the independent variables (Starch and Glycerol) on the barrier properties (SOL, MC, WVP and THI) of the edible films. Fitting of data to various models were carried out to obtain the regression equations (data not shown). Second order polynomial models obtained in this study were utilized for each response to obtain specified optimum condition. Combination of factors levels that simultaneously satisfies each response requirements in the design will evaluates a point that maximizes the desire function. The statistical significance of the ratio of mean square variation due to regression and mean square residual error was tested using the analysis of variance (ANOVA). The models as fitted for MC, THI, SOL, and WVP with significant and not significant effects are adequate for predicting. The model gives the coefficient of

determination (R^2) values of 0.901 for MC, 0.981 for THI, 0.963 for SOL, and 0.933 for WVP (Figure 2). The data points on this plot were plotted practically close to the straight line. It shows that the developed model is sufficient and the suitability between the developed quadratic models and the optimum values are valid within the specified range.

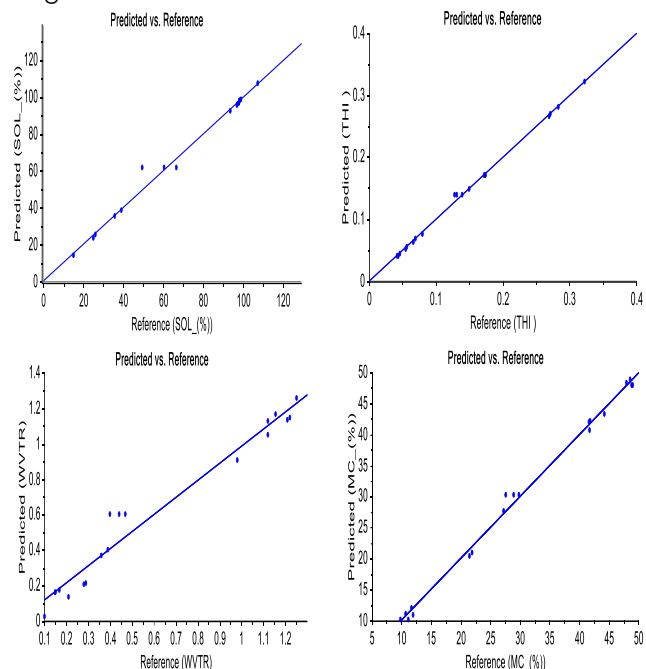


Figure 2 Comparison between predicted and experimental values of solubility, thickness, moisture and water vapour permeation (clockwise)

Figure 3 showed the TS and COF ability of the selected film formulation earlier. Commercial LDPE plastic strip was used as control. The tensile strength results of 7.9 MPa of film sample showed considering value to control strips. Indeed there was increasing in intermolecular attractions between polymeric system caused by the plasticiser [7] which resulted in increasing value of the tensile strength and Young's Modulus value. Static friction is a state where it can prevent an object from sliding down a sloped surface. In many cases, kinetic friction best describe between surface roughness and contact area resistance sliding in relative motion. The COF value of 0.313 showed the dynamic and static value of the film sample (Figure 3). Static- and dynamic friction congregate towards a stable value after approximately 30 minutes, this behavior can probably be explained by a stable wear rate is reached (data not shown).

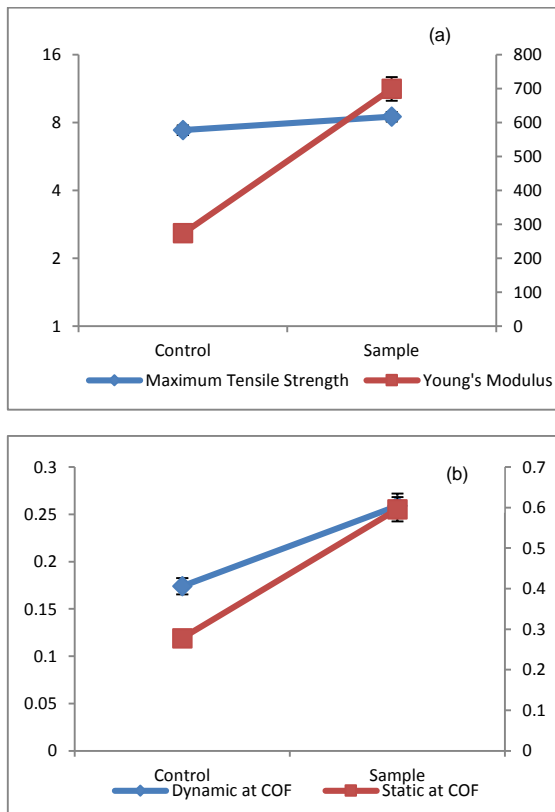


Figure 3 Mechanical testing of TS and (a) COF of the optimized film formulation (b)

4.0 CONCLUSION

The effect and interactions of *Pachyrhizus* starch and plasticizers on the properties of these starch-based edible films were studied using RSM. Results showed that all these ingredients influenced the properties of the resulting film blends. Together with a compatible amount of plasticizers, to help in flexibility, thin film coatings produced demonstrated amazing discoveries. Compare to other starch-based resources of edible films, this edible film had showed tremendous results with low swelling, solubility values and less permeable to

water. In addition, it also had given a good tensile strength and coefficient of friction values even though no additive was added. As an underutilized crops, this finding was as an alternative to one of cost efficient resources in producing edible-films and coatings.

Acknowledgement

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