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Potential of Green Banana as Biodegradable Packaging Films

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Abstract. This study investigated the properties of green banana films as potential packaging films. Banana films from green banana (with concentrations 2-10% w/w) were prepared by using casting method. The mechanical properties (tensile strength (TS), elongation at break (EAB) and Young's modulus), water vapor permeability (WVP), and solubility of films were determined. TS and Young's modulus of banana films improved ($P < 0.05$) when the concentration of banana increased. However, WVP of the films inreased ($P < 0.05$) when the concentration increased from 2-6% with solubility of films decreased ($P < 0.05$). Concentration of banana used gave affect to the mechanical and barrier properties of films obtained.

Keywords: banana, biodegradable films, mechanical properties, permeability

1. Introduction

Musa paradisiaca is a type of plantain banana that has exceptionally high starch content at unripe stage. Among the different varieties of banana, *Musa paradisiaca* possesses excellent features for the preparation of biodegradable films [1]. Recently, losses during banana production are very high, (40% of the total) due to their highly perishable nature and inadequate post-harvest handling. These losses can be reduced by processing of surplus fruits and those unsuitable for fresh consumption [2] either for food or other industrial purposes.

2. Materials and Method

2.1. Materials

Unripe green banana of *Musa paradisiaca* was purchased from PasarBorong Selangor, Malaysia. Banana powder was prepared according to the methodology described by Sothornvit and Pitak [3] with slight modification.

2.2. Films preparation

Banana films were manufactured according to the method described by Pelissari et al. [4] by dissolving banana flour in water with concentrations 2-10% (w/w) with slight modification. Films manufactured were peeled and stored at temperature 23 ± 2 ℃ and relative humidity (RH) 50 ± 5% before further analysis.

2.3. Film testing

Before testing, the thickness of the films was measured using a micrometer Dial Thickness Gage (Mitutoyo, Tokyo, Japan) with an accuracy of 0.01 mm. The colour of the films, solubility, mechanical properties (tensile strength, elongation at break and Young's modulus) and water vapor permeability (WVP) of films produced were determined.

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2.3.1. Colour properties

The colour properties of the films were determined using a Colorimeter Minolta Chroma Meter CR-300 (Minolta, Japan) and the results expressed in accordance with the CIELAB colour space system. The parameters determined were L^* (L^*= 0 [black] and L^*= 100 [white]), a^* ($-a^*$= greenness and $+a^*$= redness) and b^* ($-b^*$= blueness and $+b^*$= yellowness).

2.3.2. Solubility

Solubility tests were performed in boiling water by cutting the films into 1.5×1.5 cm pieces. The films were weighted (*A*) before immersing for 4 minutes in hot distilled water (100 ℃) [5]. The samples were filtered and were dried in the hot air oven at 70 ℃ for 24 hr. Then, the films were weighted again (*B*).The percentage of solubility (%*S*) was calculated as:

$$\%S = \frac{(A-B) \times 100}{A}$$

2.3.3. Mechanical properties

Mechanical properties such as tensile strength (TS), elastic modulus (EM) and elongation at break (EAB) of films were determined according to the standard method of ASTM D638-77 using INSTRON 4302 Machine Series IX with 10N load cell.

2.3.4. Water vapor permeability

Water vapor permeability (WVP) of banana films were measured by following the standard method based on ASTM E96 with slight modifications.

2.3.5. Statistical analysis

The Excel (Microsoft Inc.) and Minitab 16 software (Minitab Inc.) were utilised to analyse data. The statistical analysis of the data was carried out by one-way analysis of the variance (ANOVA) and a Turkey test of multiple comparisons with a significance level of 5 %.

3. Results and Discussion

Visually, all manufactured banana films displayed uniform surface and transparent, except for banana films with 10% concentration, which became shrink after drying. Increasing the banana powder concentrations had increased the films thickness.

3.1. Colour

Hunter L*(lightness), a* (redness) and b* (yellowness) colour values of banana films are shown in Table 1. Results showed that the colour of banana films was affected by the concentration of banana powder used to form films. It was found that L*valuesof banana films were decreased significantly ($P < 0.05$) from 83.60 to 62.55 when the banana concentrations increased except for banana films with 4 and 6% concentrations. Meanwhile, there were no significant differencesof a* values among banana films with 2 to 6% concentrations. Increasing the concentration of banana did increase the b* values of banana films.

Table 1: Colour properties of banana films

Concentration (%)	Colour values		
	L*	a*	b*
2	83.60 ±0.745[a]	1.78 ±0.074[c]	0.93 ±0.628[c]
4	79.27 ±0.706[b]	1.68 ±0.064[c]	0.93 ±0.628[c]
6	79.22 ±0.874[b]	1.59 ±0.118[c]	5.97 ±1.145[b]
8	71.65 ±2.129[c]	2.09 ±0.241[b]	12.96 ±1.412[a]
10	62.55 ±3.921[d]	2.41 ±0.097[a]	12.50 ±2.481[a]

3.2. Solubility

The results in Fig. 1 demonstrate that the solubility of films in water reduced significantly ($P < 0.05$) when the concentration of banana powder increased from 2 to 6%. However, the films solubility was not significant when the concentration of banana powder increase from 6 to 10%.

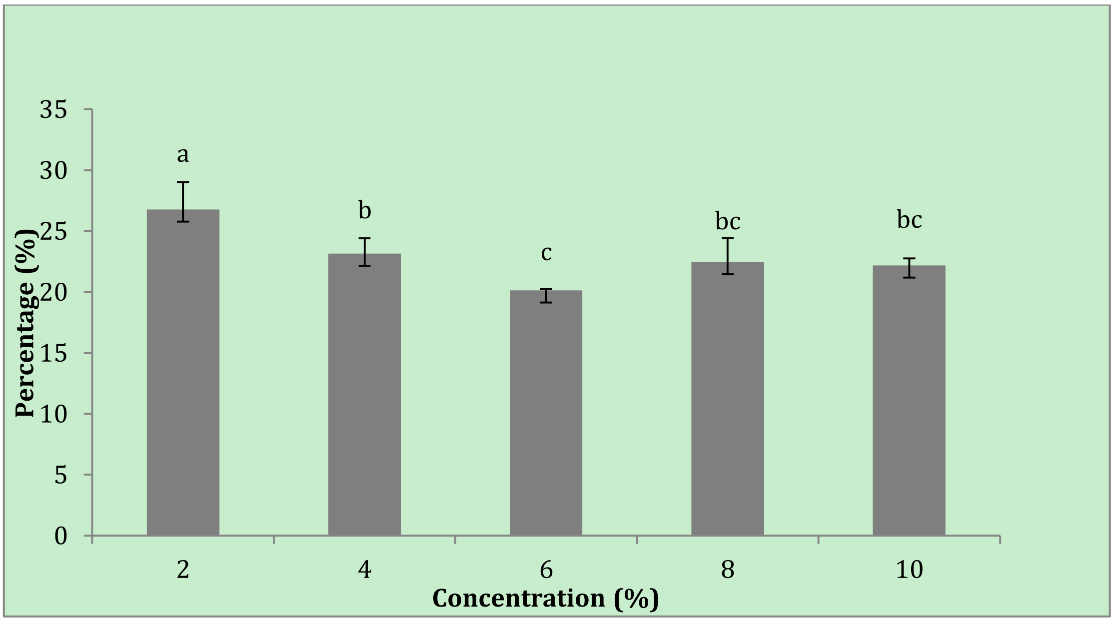

Fig. 1: Solubility of banana films

Table 2: Thickness, mechanical and barrier properties of banana films

Concentration of banana (%)	2	4	6	8	10
Tensile strength (MPa)	8.403 ±1.517[c]	23.557 ±5.038[b]	35.527 ±0.809[a]	35.837 ±2.317[a]	nil
Elongation at break (%)	7.71±2.419[a]	5.48±0.955[ab]	4.944±0.003[ab]	3.275±0.015[b]	nil
Young Modulus (MPa)	333.4 ±142.2[c]	713.5 ±128.8[b]	834.8 ±86.2[ab]	1001.5 ±46.3[a]	nil
WVP (gmm/m^{2}dayKPa)	2.949 x 10^{-4} ± 0.000071[b]	6.908 x 10^{-4} ± 0.00013[a]	7.3505 x 10^{-4} ± 0.000086[a]	nil	nil
Thickness (mm)	0.084 ±0.01673[d]	0.106 ±0.0114[cd]	0.118 ±0.01095[c]	0.152 ± 0.00837[b]	0.206 ± 0.01673[a]

3.3. Mechanical properties

The mechanical properties of banana films are shown in Table 2. The test indicated that TS improved significantly ($P < 0.05$) when the concentration of banana powder increased from 2 to 6%. Meanwhile, EAB values decreased with the concentration, however the differences were not significant. Also, Young's modulus values of banana films were increased with the concentration. However, after 4% concentration, the Young's modulus values of the produced films were not significant. Sothornvit et al. [3] reported that increasing banana flour helped to improve film strength, due to the higher polysaccharide content that helped forming the film structure. However, no data was obtained for banana films with 10%. This is due to the structure changes of the films which became shrink and too brittle.

3.4. Water vapour permeability (WVP)

Increasing the percentage of banana concentrations from 2 to 4% had increased significantly ($P <0.05$) the WVP values of banana films. Polysaccharide biopolymers are hydrophilic, thus increasing the concentration of banana powder helped to increase the WVP. Banana films produced at 8 to 10% were very brittle and hard, therefore WVP test were disregarded.

4. Conclusions

Banana films obtained from unripe banana are possible to manufacture with banana films with 6% concentration possessed lower solubility. The mechanical properties of the films improved with increasing banana concentrations. Further research is essential to investigate the potential of these films as packaging materials particularly for food applications.

5. References

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