Production and Evaluation of Cassava Starch Based Edible Film as Food Packaging Material

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Abstract

Expanding production of non-biodegradable plastic packaging material is raising global concerns regarding environmental pollution. The production of synthetic packaging materials depletes non-renewable natural resources. The main purpose of this study is to develop an agriculture by-product-based renewable packaging material that can replace plastic packaging and serve as a food and to evaluate its properties. The study investigated how different portions of lime waste and *Aloe vera* gel influenced the properties of cassava starch-based edible films. Cassava starch was extracted from fresh cassava tubers; lime waste was taken from the valorisation of kitchen waste citrus; *Aloe vera* gel was extracted from fresh leaves and food-grade glycerol were used as raw materials. 3% (w/v) cassava starch, 1% (w/v) lime waste (peel/pulp/mixture of peel and pulp), Aloe vera gel (0-10% v/v), 1% (w/v) glycerol were incorporated in distilled water to produce six different edible film treatments via the casting method. The produced packaging materials were analysed based on their thickness, moisture content, solubility, migration test, microscopic observation, Fourier Transform Infrared Spectroscopy (FTIR) and X-Ray Diffraction (XRD). These measurements were used to investigate their properties. All six edible films showed similar, insignificant results for thickness and moisture content. P1A0 (lime peel-based film without *Aloe vera*) showed the highest significant migration of polyphenols and exhibited the lowest solubility in water, and a smooth, pale-yellow microscopic image. In addition, FTIR and XRD results were similar for all edible films. In conclusion, P1 A0 edible film delivers promising results for producing an edible film that can function as a food packaging material, while replacing synthetic plastic packaging and promoting a sustainable, eco-friendly solution.

Key words: *Aloe vera*; Cassava starch; Edible film; Food packaging; Lime waste;

1.Introduction

Food packaging plays a pivotal role in the food industries due to its significant role in protecting the food from biological, physical and chemical hazards. According to statistics synthetic packaging materials such as plastic are widely used worldwide due to their versatile nature even though in the long run it is detrimental to the environment due to its non-biodegradable nature which leads to environmental threats. Nonetheless, demographic growth paves the way to increasing demand in production of these materials which increase environmental issues. Though, nowadays consumers food habits have changed towards natural, fresh quality food which requires a biopolymer to ensure safe and quality of food while simultaneously being ecofriendly.

Biopolymers have the ability to mitigate the usage of synthetic plastic packaging materials. One of such promising polymers is starch which can be obtained from cassava which is an under-utilized, renewable, locally available, cheap, eco-friendly nature. Also, it has the ability to produce a colourless, odourless film with good film properties. Hence, it has great potential to serve as an edible film. But in order to emphasis its value and produce an active packaging, it is recommended to incorporate materials which have antioxidant, antibacterial, antifungal, anti-diabetic properties.

Valorisation of agro-industrial waste products helps to produce a sustainable, renewable food packaging material. One of such promising material is Lime waste portion such as used peel, pulp and mixture of peel and pulp. It is rich in polyphenols, flavonoids, waxes and pectin present. Also, incorporation of Aloe vera which is a natural herb helps to minimize microbial deterioration and thereby, increase the shelf life of food.

Thus far, no any food packaging material has been produced with the incorporation cassava starch, lime waste and Aloe vera gel. This study aims to produce an edible film which can function as a food packaging material which helps to be a promising, eco-friendly, sustainable solution while simultaneously minimizing the usage of synthetic plastic food packaging material.

2.Materials and Methods

2.1 Materials

Cassava, was purchased at a local market in Kilinochchi, Sri Lanka. Used lime waste portion such as peel, pulp and mix of peel and pulp portions were obtained from the Juice bar at University of Jaffna. *Aloe vera* was obtained from the University of Jaffna premises. Food-grade glycerol was purchased at a local chemical store.

2.2 Methods

2.2.1 Preparation of Raw materials

Cassava Starch

Cassava tubers were washed and their outer peel was removed. Then, it was cut into small pieces and washed again. It was blended with water and squeezed through a muslin cloth to obtain cassava slurry which was left undisturbed in refrigerator for 12 hours duration and the top water was removed and starch sediment was cabinet dried at 60°C for 12 hours and grinded and sieved and cassava starch powder was obtained.

Lime waste flour

Different lime waste portions were cabinet dried at 60°C for 12 hours and grinded to obtain lime waste flour.

Aloe vera

It was washed and the *Aloe vera* was split horizontally and the inner colourless gel was extracted and grinded.

2.2.2 Preparation of Cassava starch films

Films were produced by solvent casting process. Table 01 shows the different treatments produced. 3% (w/v) Cassava starch and 1% (w/v) lime flour powder and 1% (w/v) glycerol and 10% (v/v) *Aloe vera* gel (only for few treatments) were dissolved in 100ml water while simultaneously homogenized at 90°C for 30minutes. Then the solution was allowed to cool to 50°C. Then it was poured in a petri dish and dried in a humidity chamber at 40°C at 55% RH for 24 hours. Once the films dried there were removed and stored in the desiccator for further analysis.

Table 1 Different edible film treatments

Ingredients	Treatment code					
	P1A0	**P2A0**	**P3A0**	**P1A1**	**P2A1**	**P3A1**
Cassava starch (g)	3.75	3.75	3.75	3.75	3.75	3.75
Lime flour(g)	1.25	1.25	1.25	1.25	1.25	1.25
Glycerol (g)	1	1	1	1	1	1
Distilled water (mL)	100	100	100	90	90	90
Aloe vera (mL)	-	-	-	10	10	10

2.2.3 Evaluation of Edible film

Film properties were measured by thickness, solubility, moisture content, migration test, Fourier Transfer Infrared Spectroscopy (FTIR), X-Ray Diffraction (XRD) and microscopic observations.

2.2.4 Statistical Analysis

The statistical analysis was conducted by Completely Randomized Model using Minitab software. General Linear Model was used to evaluate the significance among the treatments. Mean separation was done using Tukey's test ($\alpha = 0.05$). All the experiments were carried out in duplicates.

3. Results and Discussion

3.1 Preparation of Edible film

Raw materials were collected. Edible films were successfully developed by incorporating cassava starch, lime waste portion, glycerol and *Aloe vera* (only for particular treatments). The films were separated from the petri dish and physiochemical properties were evaluated.

3.2 Evaluation of physiochemical properties

3.2.1 Thickness measurement

Thickness of the edible films were measured by a digital vernier calliper at 6 different locations. The thickness of the films developed varied in between 0.17 ± 0.04 mm to 0.24 ± 0.05 mm. The edible film thickness measurement showed statistically insignificant results between the treatments ($p > 0.05$). Hence, neither the lime waste or Aloe vera cause variation in the thickness which may be caused due to casting volume and drying pattern.

3.2.2 Solubility test

Solubility of the films in water was measured. Solubility of the films varied between 21.07 ± 0.51% to 32.00 ± 0.89%. Solubility measurement shows a statistically significant results where P1 A0 (peel-based film without Aloe vera) shows less solubility in water whereas peel-based film made with Aloe vera shows higher solubility. Hence, Aloe vera tends to increase solubility in water.

3.2.3 Moisture content measurement

Moisture content measurement showed there is no significant difference among treatments. Hence, the raw materials such as Aloe vera and lime waste doesn't influence the moisture content of the film.

3.2.4 Migration test

Migration test was done using water as food simulant and quantified using Folin-Ciocalteu method. Test results varied from 2906.98 ± 4.65 mg GAE/kg to 7660.47 ± 4.65 mg GAE/kg. Migration of polyphenols in water as food simulant showed significant results. P1 A0 (Peel-based films without Aloe vera) showed highest migration while (P2 A1) pulp-based film with Aloe vera showed lowest migration. Variation may be due to initial load of polyphenols present in the raw materials which is desirable in case to reduce oxidation reactions by transferring polyphenols to the food.

3.2.5 Fourier Transfer Infrared Spectroscopy (FTIR)

FTIR spectra was done in ATR mode using Thermo Scientific – Nicolet iS10 spectroscopy. The spectra were done in the range of 550-4000cm^{-1} taking 32 scans with a resolution of 4 resolutions. FTIR spectra shows similar results in all the edible films where molecular functionality is at 3317, 2997, 1644 and 1558 cm^{-1} which are respectively due to the presence of hydrogen bond, C-H bond, C = N and C= C bonds in the film.

3.2.6 X-Ray Diffraction (XRD)

XRD characterization of the edible films were performed using a PANalytical X'Pert PRO diffractometer 47 with Cu Kα radiation (λ = 1.5406 Å) at 40 kV and 30 mA. Similar peaks could be observed in all edible film analysis with low crystalline nature.

3.2.7 Microscopic observation

The microscopic images were done using Nikon SMZ25 Stereo microscope at x400 magnification. Comparatively P1 A0 (peel-based film without Aloe vera) showed smooth, pale yellowish surface in comparison to the other treatments.

3.3 Conclusion

In summary, edible films incorporating cassava starch, lime-waste and Aloe vera was successfully developed. According to all the test results peel-based film without Aloe vera proves to be the most promising edible film with superior characteristics which has the potential to bea food packaging material and replace synthetic packaging and promote a sustainable, eco-friendly solution.

4.Reference

1. Piñeros-Hernandez, D., Medina-Jaramillo, C., López-Córdoba, A. and Goyanes, S. (2017). Edible cassava starch films carrying rosemary antioxidant extracts for potential use as active food packaging. *Food Hydrocolloids*, 63, pp.488–495. doi:https://doi.org/10.1016/j.foodhyd.2016.09.034.
2. Dash, K.K., Ali, N.A., Das, D. and Mohanta, D. (2019). Thorough evaluation of sweet potato starch and lemon-waste pectin based-edible films with nano-titania inclusions for food packaging applications. *International Journal of Biological Macromolecules*, 139, pp.449–458. doi:https://doi.org/10.1016/j.ijbiomac.2019.07.193.
3. Medina Jaramillo, C., Gutiérrez, T.J., Goyanes, S., Bernal, C. and Famá, L. (2016). Biodegradability and plasticizing effect of yerba mate extract on cassava starch edible films. *Carbohydrate Polymers*, 151, pp.150–159. doi:https://doi.org/10.1016/j.carbpol.2016.05.025.
4. Janowicz, M., Galus, S., Ciurzyńska, A. and Nowacka, M. (2023). The Potential of Edible Films, Sheets, and Coatings Based on Frusits and Vegetables in the Context of Sustainable Food Packaging Development. *Polymers*, [online] 15(21), p.4231. doi:https://doi.org/10.3390/polym15214231.