International Journal of Agricultural Technology 2025 Vol. 21(2):545-554
DOI: https://doi.org/10.63369/ijat.2025.21.2.545-554
Available online http://www.ijat-aatsea.com
ISSN 2630-0192 (Online)

Forming packaging from durian husk fiber using modified starch and cassava starch

Khanitta, R.[1*], Waritchon, N.[1], Kunlaporn, P.[1], Suporn, S.[1] and Juthathip, N.[2]

[1]Faculty of Agricultural Technology, Rambhai Barni Rajabhat University, Thailand; [2]Faculty of Industrial Technology, Rambhai Barni Rajabhat University, Thailand.

Khanitta, R., Waritchon, N., Kunlaporn, P., Suporn, S. and Juthathip, N. (2025). Forming packaging from durian husk fiber using modified starch and cassava starch. International Journal of Agricultural Technology 21(2):545-554.

Abstract The formation of packaging from durian husk fibers using modified starch and cassava starch as binders through a heat baking process was analyzed for physical, chemical quality, and shelf life. The results showed that packaging made from durian husk fibers presented a good physical appearance, including strength, hardness, flexibility, and brightness. Packaging formed with cassava starch provided better oil, water resistance, and hardness than modified starch. The water and oil resistance values were 9.2-125.5 sec/ml and 25.8-85.8 sec/ml, respectively. The hardness of the packaging is 0.90-0.93 kg/cm^2. The chemical composition of the packaging is contained 7.83-7.94 % moisture and 1.42-4.55 % ash. The moisture content of the packaging increased after storage. A 35-day shelf-life revealed no significant difference in color value, with the L*-value decreased (67.96-68.57), the a*-value increasing (3.75-4.21), and the b*-value decreased (18.42-18.99) over time.

Keywords: Durian, Durian husk, Durian husk fiber, Packaging

Introduction

Durian is an important economic fruit in Thailand, which is highly popular for consumption both domestically and internationally. Currently, a problem that arises from its consumption and processing is the waste generated from the durian husk. The husk is a significant by-product and constitutes at least 30% of the total weight of a fruit. This makes it a significant disposal problem for responsible agencies and a negative impact on the environment. Therefore, this research aims to utilize durian husks for food packaging purposes, as they contain a high fiber content. In addition to polysaccharides content, the husk also contains up to 30% cellulose fiber, with the fibers diameter of approximately 100-150 micrometers. This makes it a key raw material for the preparation of carboxymethyl cellulose (CMC) (Waritchon *et al.*, 2021).

---

[*] **Corresponding Author:** Khanitta, R.; **Email:** khanitta.r@rbru.ac.th

Currently, the use of various food packaging materials, particularly plastics and foams, has been continuously increasing annually due to their convenience and low cost. However, these materials are highly durable in environmental conditions, difficult to decompose, and therefore contribute to environmental pollution. Researchers have been searched biodegradable agricultural materials as substitutes for these non-degradable substances. The component of these alternatives typically consists of mixtures of starch, water, and fibers from various plants. Soykeabkaew *et al*. (2004) reported that the addition of fibers from jute or hemp in cassava starch contributed to improve the flexibility of the packaging. Salgado *et al*. (2008) used 10-20% cellulose fibers in foam packaging formulations, which enhanced mechanical properties and helped to reduce moisture retention. Kaisangsri *et al*. (2012) reported the production of foam trays using cassava starch mixed with 30% kraft fibers and 4% chitosan. The properties of resulting foam trays are comparable to polystyrene foam.

In addition to natural fiber components, the inclusion of starch is relevant for packaging formation, as it plays an important role in binding the structure of the packaging, providing strength and appropriate packaging characteristics. Commonly used starch types include cassava starch, which consists of high molecular weight amylose and amylopectin. Cassava starch have various physical, chemical, physicochemical, pasting, and thermal properties that are beneficial for industrial applications. However, cassava starch has certain limitations when formed into food packaging, such as its high affinity for water, leading to high moisture sensitivity, low mechanical properties, and brittleness (Tadini, 2017). Therefore, modification of certain properties of the starch is necessary to achieve functionality suitable for food packaging (Nattha, 2019).

Modified starch is an alternative that can replace traditional packaging materials. Various methods of starch modification include the use of chemical acid treatment, oxidation using chemicals, plasma treatment in a gas environment, thermal treatment with moist heat, or the multiple methods, such as acid treatment with oxidation. However, a disadvantage of these processes is the need to control the heat generated during processing, as the gelatinization temperature of starch ranges between 65 to 70°C. Thus, the duration of the heat exposure is short, which may result in lower efficiency of the modified starch compared to other processes (Nattha, 2019). The differing properties of starch can affect the molding process and packaging properties. Therefore, the research project was to investigate the developing packaging from durian husk fibers by studying the effects of using modified starch and cassava starch on the chemical and physical properties of the forming packaging.

Materials and methods

Raw materials and chemicals

Monthong durian husk (*Durio zibethinus* Murr.) from Noen Sung Market, Mueang District, Chanthaburi. Cassava starch, wheat flour, modified cassava starch (FO71MS, Krugthepchemi Co., Ltd.), Sodium hydroxide, Hydrogen peroxide, Glycerol, Magnesium stearate, and Guar gum, (LR grade, Scientific and Chemical Co., Ltd.) were used.

Preparation of fibers from durian husk

The durian husk of the Monthong variety were subjected to a coarse shredding process using chopper. It was then boiled in a sodium hydroxide solution at a concentration of 18%, with a ratio of solution to dry fiber of 5:1, at a temperature of 100°C for 2 hours. The fiber of the durian husk was then thoroughly washed to remove any residual sodium hydroxide. Subsequently, the fiber was bleached with a 15% hydrogen peroxide solution at a solution to dry fiber ratio of 5:1, at 100°C for 2 hours, resulting in a significant increase in whiteness. The bleached fiber was then dried at a temperature of 60±5°C. The fiber was subsequently spread out to separate any clumps of fibers and stored in double-layer PE plastic bags at room temperature.

Molding equipment for packaging

The packaging molding equipment consist of a hot press forming machine that uses hydraulic power. The developed machine is capable of generating a maximum hydraulic pressure of 15 tons and is equipped with a heating system used in the molding process. The conditions for forming the packaging are set at temperature of 120-150°C for 1 hour at a pressure of 2 tons. The mold dimensions are 22x22x10 centimeters (Figure 1).

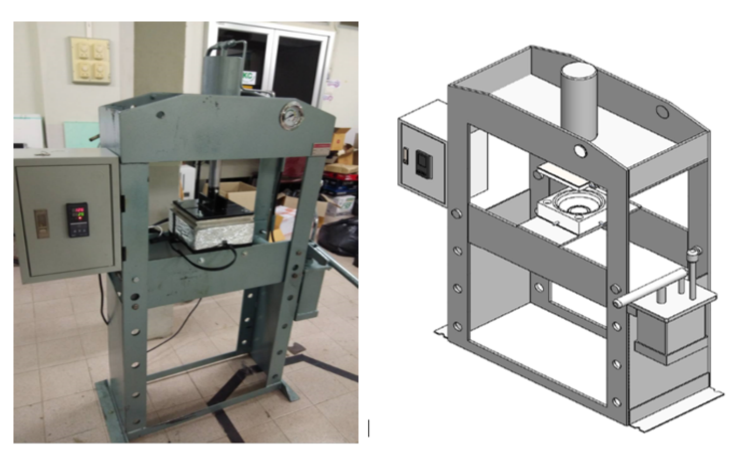

Figure 1. Prototype machine for forming packaging

Molding of packaging using modified starch and cassava starch

The molding process involves using 10-50% modified starch and cassava starch, based on the weight of durian husk fibers, mixed with other molding agents such as 4% magnesium stearate, 1.5% guar gum, 4% glycerol, and 10% wheat flour. All components are mixed together using a mixer for 5 minutes and then molded using a prototype forming machine. The packaging is dried in an oven at approximately 150°C for 5-10 minutes. Afterward, the packaging is stored at 27±2°C for 24 hours. The color quality of packaging is analyzed using a color meter (Konica Minolta, CR-400 series). The packaging properties, including water and oil resistance, hardness, and shelf life, are tested by storing the packaging at room temperature for 35 days. Moisture content, ash content (AOAC, 2000), and pH (pH meter).

Quality analysis

The quality of the molded packaging was analyzed based on physical characteristics such as appearance and hardness. Hardness was measured using a Hardness tester (Cat. Nos. 510-1) with a cone-shaped C-type intender. The measurement position was set by placing the intender perpendicular to the sample and pressing it down with consistent force. The hardness value was read from the scale and recorded in kilograms per square centimeter.

Water and oil resistance was measured using a modified method by Waritchon *et al.* (2022). The samples are placed on a metal stand, and 700 milliliters of water and oil was separately added to the sample. The time and the amount of water and oil that permeated the sample into the receiving packaging were recorded.

Experimental design

A Completely Randomized Design (CRD) with three replications was used for the experimental planning. The variance analysis of the experimental results is analyzed using ANOVA (Analysis of Variance), and the differences between the means were compared using Duncan's new multiple range test at a 95% confidence level.

Results

Physical properties of the packaging

The packaging was formed and tested for binding capability between the modified starch and cassava starch using a prototype machine. The packaging was stored at 27±2°C for 72 hours before being tested for water and oil resistance, as well as hardness, shown in Table 1. The result showed that packaging made with cassava starch exhibited better resistance to both water and oil permeability than those made with modified starch. An increase in the amount of starch improved the water and oil resistance. Packaging made with 40% modified starch and cassava starch provided the highest water resistance, with values of 125.5 and 127.2 sec/ml, respectively, and the highest oil resistance, with values of 85.0 and 85.8 sec/ml, respectively. These differences were statistically significant ($P \leq 0.05$) as compared to packaging made with 20% and 30% starch content.

Table 1. Water and oil resistance and hardness of the packaging made from durian husk fibers with modified starch and cassava starch

Modified starch (%)	Water permeation time (sec/ml)	Oil permeation time (sec/ml)	Hardness (kg/cm^2) ^{ns}
20	9.2 ± 10.23^a	25.0 ± 11.23^a	0.88 ± 1.10
30	105.7 ± 12.15^b	72.0 ± 9.51^b	0.90 ± 2.14
40	125.5 ± 15.18^c	85.0 ± 12.20^c	0.91 ± 1.53
Cassava starch (%)	**Water permeation time (sec/ml)**	**Oil permeation time (sec/ml)**	**Hardness (kg/cm^2) ^{ns}**
20	9.6 ± 12.50^a	25.8 ± 10.74^a	0.90 ± 3.21
30	115.3 ± 15.10^b	78.0 ± 11.50^b	0.90 ± 2.00
40	127.2 ± 18.35^c	85.8 ± 19.10^c	0.93 ± 2.26

Results are expressed as mean values± standard deviation. Different letter (a-c) in the same column indicates statistical difference ($p \leq 0.05$); ^{ns} Not significant.

However, the results indicated that packaging with higher amounts of both types of starch showed better water resistance than oil resistant. In contrast, packaging with lower starch content exhibited better oil resistance than water resistance. The hardness was not statistically significant difference (P>0.05) among the packaging, with hardness values ranging between 0.88 and 0.93 kg/cm². Based on these results, 40% starch content was selected for forming the packaging and analyzing their quality over a 35-day storage period. The packaging formed with modified starch and cassava starch are shown in Figure 2.

(A) Packaging formed with modifies starch

(B) Packaging formed with cassava starch

Figure 2. Molded packaging made from durian husk fibers with modified starch (A) and cassava starch (B)

Shelf life of packaging

The color values of the packaging) showed that the *L**-values ranged from 67.96 to 68.57, the *a**-values ranged from 3.75 to 4.49, and the *b**-values ranged from 17.88 to 19.19 (Table 2). There were no statistically significant differences (P>0.05) in the *L**, *a**, and *b**-values. However, the color of the packaging mixed with different material changes with the increased shelf life depends on various factors, such as light, oxygen, heat, and pH levels.

The analysis of moisture, ash content, and pH value after storing packaging for 0–35 days at room temperature is shown in Table 3. It was found that packaging made from both types of starch showed an increasing trend in moisture content as the storage time increased. After 35 days of storage, the highest moisture content was observed in the modified starch at 7.90%, with no significant statistical difference (P>0.05) compared to the 21 and 28-days storage periods. Similarly, packaging made from cassava starch showed the highest moisture content of 7.94% at 35 days, with no significant statistical difference

(P>0.05) compared to the 21 and 28-days storage periods. Regarding to ash content, packaging made from both types of starch showed a decreasing trend in ash content as the storage duration increased. The modified starch packaging had an initial ash content of 4.10% and decreased to 2.19% after 35 days. For the cassava starch packaging, the initial ash content was 4.55% and decreased to 1.44% after 35 days. In terms of pH values, all packaging showed no significant statistical difference (P>0.05), with pH values ranging from 7.93 to 7.94.

Table 2. Color value of packaging made from durian husk fibers containing modified starch and cassava starch at a storage period of 0-35 days

Shelf life (days)	**Color value**					
	Modified starch ^{ns}			Cassava starch ^{ns}		
	*L**	*a**	*b**	*L**	*a**	*b**
0	68.50±5.26	3.77±8.15	18.90±3.10	68.57±5.75	3.75±5.09	18.99±2.24
7	68.51±4.10	3.82±5.12	18.90±2.14	68.53±6.22	3.99±4.24	18.93±1.96
14	68.25±7.21	3.89±2.25	18.93±3.10	68.49±5.26	4.05±5.12	18.79±3.15
21	68.42±5.11	4.03±4.16	18.89±2.02	68.52±5.00	4.11±2.20	18.58±4.55
28	67.99±2.05	4.09±4.05	18.53±1.26	68.19±4.14	4.20±4.19	18.46±3.14
35	67.98±4.00	4.11±2.10	18.45±2.15	67.96±3.53	4.21±5.01	18.42±1.95

Results are expressed as mean values± standard deviation; ^{ns} Not significant.

Table 3. Chemical composition of packaging made from durian husk fibers containing modified starch and cassava starch at a storage period of 0-35 days

Shelf life (days)	**Modified starch**			**Cassava starch**		
	Moisture (%)	Ash (%)	pH^{ns}	Moisture (%)	Ash (%)	pH^{ns}
0	7.84±1.50^{a}	4.10±0.22^{b}	*7.85* ±0.15	7.83±1.51^{a}	4.55±0.23^{b}	*7.83* ±0.24
7	7.86±1.30^{a}	4.11±0.50^{b}	*7.84* ±0.23	7.84±1.23^{a}	4.19±0.50^{b}	*7.* 91±0.13
14	7.83±1.52^{a}	3.89±0.51^{b}	*7.91* ±0.74	7.82±1.50^{a}	3.89±0.34^{b}	*7.84* ±0.12
21	7.85±0.50^{ab}	2.51±0.26^{b}	*7.93* ±0.51	7.85±1.57^{ab}	4.15±0.15^{b}	*7.86* ±0.19
28	7.88±0.82^{ab}	2.16±0.12^{a}	*7.90* ±0.92	7.91±0.90^{b}	2.16±0.10^{a}	*7.94* ±0.21
35	7.90±0.90^{b}	2.19±0.24^{a}	*7.94* ±0.46	7.94±0.91^{b}	1.42±0.12^{a}	*7.93* ±0.22

Results are expressed as mean values± standard deviation. Different letter (a-c) in the same column indicates statistical difference ($p \leq 0.05$); ^{ns} Not significant.

Discussion

The main components of durian husk primarily consist of cellulose and hemicellulose, accounting for approximately 57.4% and 22%, respectively, along with 13.6% lignin and polysaccharide compounds. The fiber properties of durian husks are characterized by being stiff and inelastic, exhibiting mechanical properties similar to those of cotton and jute fibers, which can be used in the textile industry (Monteiro *et al*., 2016). Durian husk fibers that have been extracted and bleached are white to light brown. The color of the packaging ranges then from light to dark brown, due to residual components of the husk that were not fully extracted. In the development of packaging from durian husk fibers, a main ingredient is starch. Starch function similarly to an adhesive, allowing two surfaces to bond together. The films formed from starch showed specific properties that yield products with desired characteristics, such as plasticity, enhanced structural integrity, water solubility, moisture response, transparency, and gloss (Nattha, 2019). Research on the forming of packaging utilizing high hydraulic pressure and heating to temperature of 150°C showed that the formulation of additives significantly affects the quality of the final product. The effect of temperature and appropriate production method influence the distribution of starch granules, leading to uniform granule dispersion and complete gelatinization. The gelatinization process allows hydroxyl groups of starch to interact more effectively with other substances. After cooling, the amylose molecules rearrange via hydrogen bonding, forming a new three-dimensional network structure capable of retaining water while preventing further absorption. This results in increased viscosity (Waritchon *et al.,* 2022). Therefore, under condition of optimum starch content, the bonding between the starch gel and the fibers is enhanced, leading to a more robust structural strength. These adhesive properties, along with effective resistance to oil permeability, results in a final product with crumbly texture and high stability when baked. After drying, the incorporation of carboxylic groups enhances the expansion efficiency of the material, providing packaging that are lightweight with low density (Monteiro *et al.,* 2016).

Cassava starch has certain unstable properties. When heated, it forms a solution with high viscosity, but its viscosity decreases rapidly when subjected to continuous shear force and heat. This characteristic limit the application of native cassava starch, making its modification necessary to achieve improved properties. There are various methods for modifying starch to achieve desired properties, ensuring its stability under different processing conditions. However, some modification processes have limitations. For example, heat treatment requires careful control of temperature during the process since the gelatinization temperature of cassava starch is between 65 and 70°C. As a result, the duration of heat exposure in the process is brief, which may affect the efficiency of the modified starch. Additionally, there are difference between the properties of modified starch and unmodified starch. The hot paste of the modified starch has lower viscosity, lower retrogradation rate, higher gelatinization rate, and lower peak viscosity compared to the unmodified starch. The film made from modified starch is clearer and less susceptible to bacterial contamination (Wilasini, 2010). Although modified starch has better properties than unmodified cassava starch, the molding process for forming films requires high temperatures of up to 150°C and high pressures of up to 2 tons, which can reduce the effectiveness of the modified starch. In terms of storage stability, prolonged storage affects moisture absorption. This may partly result from the solubility of starch granules and the dissolution of plasticizers added to enhance cohesion and flexibility of the starch film. Most plasticizers are highly compatible with water (Rompothi *et al.*, 2017). Glycerol is a plasticizer that is highly compatible with water. Therefore, part of the dissolution of the cassava starch film may be due to the dissolution of glycerol. (Nattha, 2019). Nevertheless, the proportion of glycerol added before forming the film remains constant across different conditions, so the proportion of glycerol used in unmodified and modified cassava starch under various conditions does not differ.

Therefore, the selection of starch for this molding process, cassava starch has more advantages in terms of its resistance to oil and water penetration, as well as the hardness of the packaging. It also offers a cost benefit. However, changes in production conditions may result in different outcomes. This information serves as a basis for the development of durian husk fiber-based packaging for future application in the industrial.

Acknowledgements

We appreciate the financial support and research operations provided by Thailand Science Research and Innovation (TSRI) and Rambhai Barni Rajabhat University in 2023.

References

AOAC (2000). Official methods of analysis (20th ed.). The Association of Official Analytical Chemists. Arlington, Virginia.

Kaisangsri, N., Kerdchoechuen, O. and Laohakunjit, N. (2012). Biodegradable foam tray from cassava starch blended with natural fiber and chitosan. Industrial Crops and Products, 37:542-546.

Monteiro, S., Martins, J., Magalhães, F. D. and Carvalho, L. (2016). Low density wood-based particleboards bonded with foamable sour cassava starch: Preliminary studies. Polymers, 8:354.

Nattha, K. (2019). Preparation of oxidized cassava starch using solution plasma process for biodegradable film wrap application. (Master Thesis). Naresuan University, Thailand.

Rompothi, O., Pradipasena, P., Tananuwong, K., Somwangthanaroj, A. and Janjarasskul, T. (2017). Development of non-water soluble, ductile mung bean starch based edible film with oxygen barrier and heat sealability. Carbohydrate Polymers, 157:748-756.

Salgado, P. R., Schmidt, V. C., Molina Ortiz, S. E., Mauri, A. N. and Laurindo, J. B. (2008). Biodegradable foams based on cassava starch, sunflower proteins, and cellulose fibers obtained by a baking process. Journal of Food Engineering, 85:435-443.

Soykeabkaew, N., Supaphol, P. and Rujiravanit, R. (2004). Preparation and characterization of jute-and flax-reinforced starch-based composite foams. Carbohydrate Polymers, 58:53-63.

Tadini, C. C. (2017). Bio-based materials from traditional and nonconventional native and modified starches. In: Starch-based materials in food packaging processing, characterization and applications, Academic Press, pp.19-36.

Waritchon, N., Kunlaorn, P., Jiraporn, S., Komsan, M. and Pramoun, S. (2021). Development of packaging from durian rind fibers by bleached and unbleached fibers. Journal of Science and Technology Mahasarakham University, 40:422-429.

Waritchon, N., Kunlaporn, P. and Khanitta, R. (2022). The effect of modified starch as a binder on the molding of packaging material sheet from durian husk fiber. The 5th ARUCON conference "Krung Kao Rajabhat", Phranakhon Si Ayutthaya Rajabhat University, Ayutthaya, Thailand, 187 p.

Wilasini, K. (2010). Preparation and utilization of phosphate cross-linked starch. (Master Thesis). Thammasat University, Thailand.

(Received: 29 September 2024, Revised: 3 March 2025, Accepted: 10 March 2025)