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Production of Tray from Cocoa husk fiber

Key word : packaging, cocoa husk fiber.

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Abstract

Cocoa husk is comprised of 82.77% water (on wet basis), fiber, lignin, cellulose and hemicellulose, was 26.12, 11.74, 23.13 and 6.40% (d.w.b.) respectively. The condition most suitable to separate the shell from the cocoa husk was found to be soaking the fresh husk in 30% sodium hydroxide solution at room temperature for about 6-7 h. The husk was then placed in 20% sodium hydroxide solution at 121°C with a pressure of 15 psi. for 30 min. After this step, the fiber was brown and comprised of 62.19% cellulose and 27.08% lignin (d.w.b). The next step was to bleach this fiber with 15% hydrogen peroxide solution at 75°C for 2 hr. The result was that the fiber turned white-yellow. The bleached fiber color in terms of L, a and b was 75.427, -3.320 and 17.707 respectively. The water holding capacity was 2.08 g water per g fiber. The fiber then was mixed with tapioca starch, modified tapioca starch, water and binders such as carboxymethylcellulose, hydroxypropylmethylcellulose and microcrystallinecellulose. The mixture was pressed in a mould which was heated up to 120°C at a pressure of 8,000 psi. for 5 min and 0 psi. for 15 min. The physical properties of the trays, namely, bending strength, compression strength and water absorption, determined that trays from a mixture of fiber, modified tapioca starch, water and 10% carboxymethylcellulose were the strongest and most suitable for use as packaging. Pieces of sliced guava were packed in a tray, wrapped with plastic film and stored at 8-10°C for 10 days. It was found that the guava was lighter, had drier skin and browning had occured because of a loss of water from transpiration and absorption by the tray. The tray was heavier, had softened and had lost shape, due to its absorption of water from the fruit.

Introduction

Packaging, particularly plastics, has come into wide use throughout the world. With increased application, the disposal of waste plastics has become a serious problems. Therefore, the development of biodegradable packaging has recently been undertaken.

Biodegradable packaging made from 60-80% wood fiber, 20-40% synthetic fiber, 10-15% China clay and 12-% cationic dispersed resin has been reported[1]. Foam has been made by mixing modified cornstarch and triethylenediamine, triethanolamine, silicone polyoxyalkylene, dibutyltin dilaurate, fluorotrichloromethane, polymeric isocyanate, fiber and water[2].

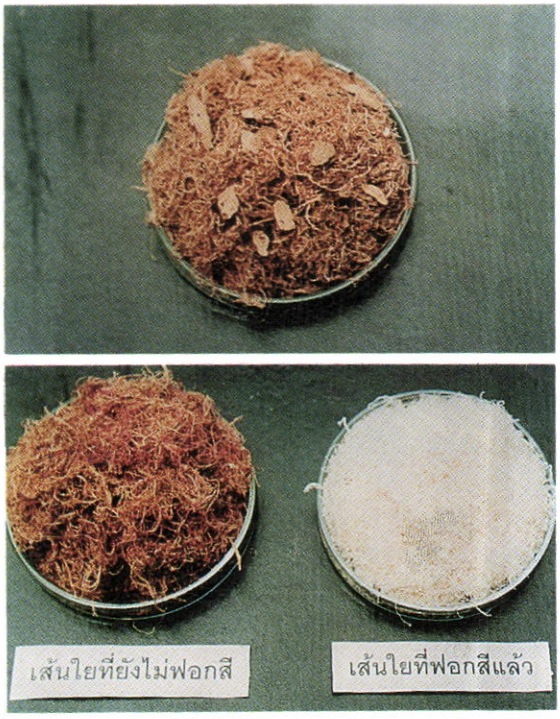
Cocoa (*Theobroma cocoa L.*) is one of the main crops in Southern Thailand. Cocoa husk, about 70% of the fruit is the by product from the production of dried cocoa bean. The cocoa husk has been used as fertilizer and animal feed.

The objectives of this project were to study the production of biodegradable tray made from modified tapioca starch and fiber from cocoa husk.

Materials and Methods

Material Preparation

Cocoa husk was washed and cut lengthwise into 2 in wide strips.



Extraction and Bleaching of the Fiber

Following the material preparation step, the cocoa husks were then soaked in 20, 30 and 40% (by weight) of NaOH solution. The husks were examined for shell separation every 15 min. The soaking step will be stopped when the shell can easily be separated from the husk.

The cocoa husks without shell were boiled in 20% (by weight) of NaOH solution at 121° C, 15 psi for 30 min. The mixture was filtered through a 16 mesh screen. The fiber was separated by hand in the running water.

The fiber was dried in tray drier. The fibrous product was analysed for cellulose by the Van Soest and Wine method[3].

The fiber obtained from the extraction step was bleached by adding H_2O_2 concentration of 10, 15 and 20% (by weight). The pH of the mixture was adjusted to 10 - 10.5. Boiling the mixture at 75° C for 2 h. At the completion of bleaching, the mixture was filtered through a 40 mesh screen. The fiber was then washed with distilled water and dried to a moisture content of 10-15%. The colour of dried fiber was determined in term of L, a and b.

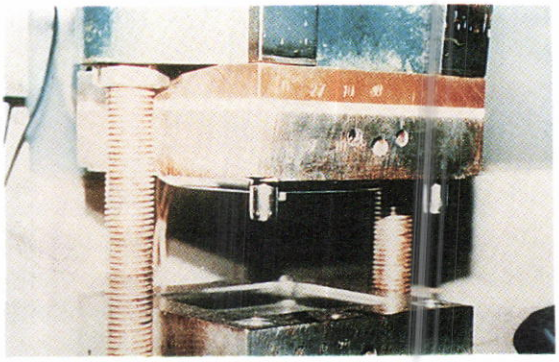
Making the Tray

The tray was made by using native tapioca starch or modified tapioca starch mixed with binders which were carboxymethylcellulose (CMC), hydroxypropylmethylcellulose (HPMC) and microcrystalline cellulose (MCC) and the cocoa husk fiber.

The mixture of starch, binder, fiber and water was mixed for 6-10 min to form a dough. The dough was spread into 3 x 3 in. shape. The dough was then placed on the base plate of the mould which was heated to 115-120° C. The base plate was lifted up to fully engage the male die by hydraulics at 8000 psi. This position was maintained for 5 min and then the pressure was released to 0 psi. and held for another 15 min. The tray was removed from the mould, cooled and trimmed. The weight and thickness (at five points) of the tray were measured.

Determination of Phypical Properties of the Tray

Water absorption of the tray was determined by



ASTM D570 method[4], The bending strength and compression strength of the tray were measured by Thai Packaging Institute methods[5].

Application of the Tray

Pieces of sliced guava were packed in the tray, both were wrapped together with plastic film. and stored at 8-10 °C for 10 days. The weight and physical changes of the guava and tray were examined every two days through to the end of the storage period.

Results and Discussion

Extraction and Bleaching of the Fiber

The results of chemical analyses of cocoa husk as raw material are shown in Table 1.

Table 1 Chemical properties of cocoa husk

Composition	%*
Moisture	82.77 ± 0.56
Ash (d.w.b.)	8.85 ± 0.14
Fiber (d.w.b.)	26.12 ± 0.08
Lignin (d.w.b.)	11.74 ± 0.95
Cellulose (d.w.b.)	23.13 ± 0.32
Hemicellulose (d.w.b.)	6.40

*Mean of 3 replications ± standard deviation.

From Table 1, cocoa husk is composed mainly of water (82.77%). The fiber, lignin, cellulose and hemicellulose content was 26.12%, 11.74%,23.13% and 6.40% (d.w.b.) respectively.

Table 2 Soaking time of cocoa husk in NaOH for separating shell

NaOH Concentration % (by weight)	Soaking time h.
20	11-12
30	6-7
40	6-6.5

Separating the shell from the cocoa husk using different concentrations of NaOH are shown in Table 2. It was found that the optimum condition for separating the shell was carried out at 30% NaOH for 6-7 h. After the extraction of the fiber with 20% NaOH at 121° C 15 psi for 30 min, the colour of fiber was brown and composed of 62.19% cellulose and 27.08% lignin (d.w.b.). The colour characteristic of the fiber after the bleaching step is shown in Table 3. It was found that the optimum condition for bleaching was using 15% H_2O_2.

Making the Tray

The cocoa husk fiber was mixed with native tapioca starch, modified tapioca starch, water, and binders (CMC, HPMC, MCC). The mixture was placed in a mould heated to 115-120° C at 8000 psi for 5 min and 0 psi for 15 min. It was found that the tray with fiber is stiffers when compared to the tray without fiber (control sample) (Fig. 1) The moisture content, weight and thickness of the tray are shown in Table 4.

Table 3 Hunter colour characterestics of fiber after bleaching step*

H_2O_2 Concentration % (by weight)	L	a	b
10	74.53 ± 0.25^{b}	-2.41 ± 0.59^{b}	15.88 ± 0.76^{b}
15	75.43 ± 0.28^{a}	$-3-32 \pm 0.18^{a}$	17.71 ± 1.19^{a}
20	73.45 ± 0.85^{b}	-2.88 ± 0.10^{ab}	16.33 ± 0.35^{ab}

*Values with the same letter within the same column are nor significantly different ($P > 0.05$)

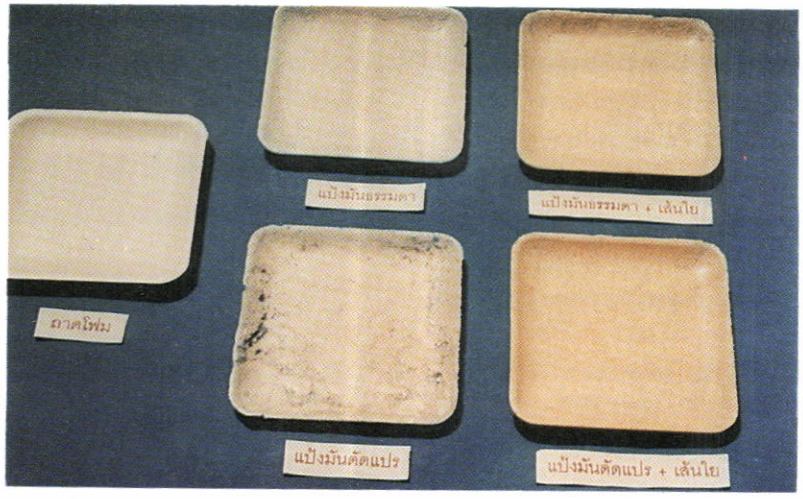


Fig. 1 Tray produced from cocoa husk fiber and native tapioca starch and modified starch.

Table 4 Moisture content, Weight and Thickness of tray made from cocoa husk fiber and tapioca starch.

Samples	Moisture content %	Weight g.	Thickness cm.
A	4.22	18.87	0.34
B	3.84	20.05	0.30
B + CMC 5%	5.28	26.01	0.27
B + CMC 10%	5.59	26.67	0.28
B + HPMC 5%	3.57	17.19	0.32
B + HPMC 10%	3.82	19.26	0.33
B + MCC 5%	3.94	20.12	0.33
B + MCC 10%	6.46	20.34	0.33
C	6.40	10.00	0.42
D	4.62	14.48	0.37
D + CMC 5%	5.81	18.78	0.36
C + CMC 10%	5.84	20.49	0.36
D + HPMC 5%	3.58	12.44	0.38
D + HPMC 10%	3.58	14.88	0.38
D + MCC 5%	4.68	13.28	0.38
C + MCC 10%	5.00	15.00	0.39

Remark : A = modified starch + water B = modified starch + fiber + water
C = native starch + water D = native starch + fiber + water

It was also found that the physical properties of the tray especially, bending strength, compression strength and water absorption were effected by the type of starch and binders as shown in Table 5. The tray made from modified starch and fiber had a higher bending strength and compression strength than tray made from native starch and fiber while amount of water absorption decreased. The tray added 10% CMC had higher bending and compression strength when compared to other binders.

Application of the Tray

The tray was packed with pieces of fresh guava and wrapped with plastic film. The package was stored at 8-10 °C for 10 day. It was found that the weight of the guava decreased while the weight of tray increased. The guava became brown and had a dry appearance. The tray became soften and lost its shape due to its absorption water from the guava as shown in Fig. 2.

Table 5 Physical properties of tray made from cocoa husk fiber and starch

Samples	Bending strength Kg/cm^2	Compression strength Kg/cm^2	Water absorption g/cm^2
A	1.344^{cd}	3.010^{cd}	0.049^{bcde}
B	2.457^{a}	3.151^{bc}	0.035^{cde}
B + CMC 5%	2.618^{a}	2.966^{cde}	0.052^{bcd}
B + CMC 10%	2.842^{a}	3.811^{a}	0.043^{cde}
B + HPMC 5%	0.907^{d}	1.750^{ghij}	0.090^{a}
B + HPMC 10%	0.866^{d}	1.104^{kl}	0.080^{a}
B + MCC 5%	1.891^{b}	2.168^{fg}	0.026^{e}
B + MCC 10%	1.635^{bc}	2.548^{cdef}	0.028^{e}
C	1.051^{cd}	1.066^{kl}	0.048^{bcde}
D	1.193^{cd}	1.940^{ghi}	0.043^{cde}
D + CMC 5%	1.149^{cd}	2.041^{fgh}	0.043^{cde}
D + CMC 10%	1.098^{d}	3.640^{ab}	0.071^{ab}
D + HPMC 5%	0.888^{d}	0.983^{l}	0.053^{bc}
D + HPMC 10%	0.875^{d}	0.985^{l}	0.086^{a}
D + MCC 5%	1.092^{d}	1.646^{ghijk}	0.036^{cde}
D + MCC 10%	1.324^{cd}	1.226^{jkl}	0.033^{cde}

Remark : Values with the same letter within the same column are not significantly different ($P > 0.05$)

A = modified starch + water B = modified starch + fiber + water

C = native starch + water D = native starch + fiber + water

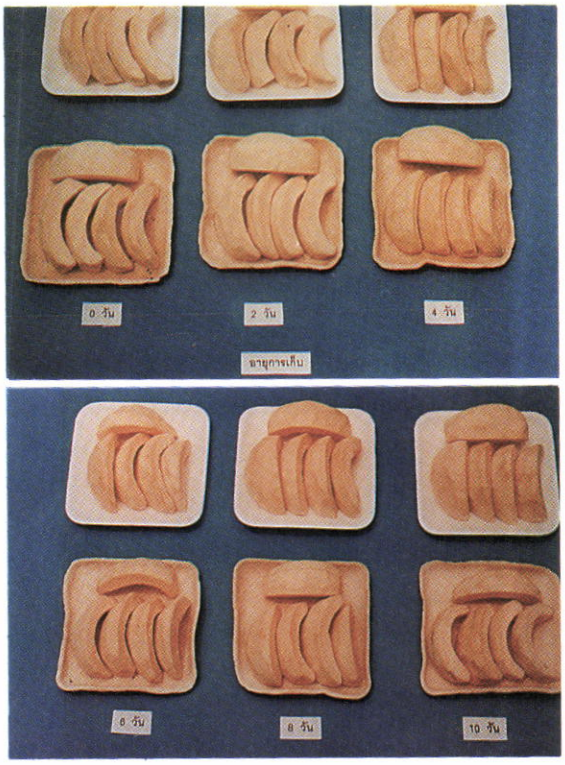


Fig.5 Appearance of tray packed with guava stored at 8-10° C for 10 days

Conclussion

Cocoa husk contains mainly water (82.77%) and fiber (26.12%). The optimum condition for extracting the fiber was soaking the cocoa husk in 30% NaOH for 6-7 h. and then extracting by 20% NaOH at 121° C, 15 psi for 30 min. The fiber was bleached with 15% H_2O_2 at pH 10.5.

The trays were prepared by mixing the native and modified tapioca starch and fiber, water and binders (CMC, HPMC, MCC). The trays obtained from the experiments showed that trays made from modified starch had higher bending and compression strength while maintaining lower rate of water absorption. The bending and compression strength of the tray were also effectecd by the type and amount of binder added. The 10% CMC binder gave higher bending and compression strength.

When the tray was packed with pieces of fresh guava and stored at 8-10° C for 10 days, it was found that the weight of guava decreased while the weight of the tray increased. The colour of guava became brown and drier in appearance. The tray became soft and lost its shape.

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