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STUDY ON PROPERTY OF BIODEGRADABLE PACKAGING FROM WATER HYACINTH FIBERS

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Abstract

The purpose of this research is to produce alternative ware made from natural materials which are naturally degradable for natural conservation without environmental destruction, and also to study variables affecting forming and mechanical property of the ware made from natural materials. The generally available water hyacinth is the main raw material in fiber production, and cassava starch is used as binder. In preparation of raw material mixture used in testing, the ratio of mixture between water hyacinth fiber and binder for 4 specimens consisting of 40:60, 45:55, 50:50 and 55:45 by weight was applied. The length of water hyacinth fiber used in testing was 5 mm. Hot compression process method was applied in forming whereas heat used testing was 110 °C 130 °C and 150 °C, respectively at constant pressure of 6 bar, and 20 minutes was taken in compression. The testing result indicated that the ware was compressed into wide opening bowl I in the size of Bowl Opening: Bowl Bottom: Height: Thickness for 140:90:25:2 mm, respectively. The appropriate ratio between water hyacinth and binder was 40 : 60 by weight, using 150 °C of temperature in forming ware in forming ware and having 0.83 g/cm^3 of density, 141.66% of % water absorption, 54.80 MPa of Tensile Strain Test, 3.24 MPa of Flexural Strength Test. The ware derived from this testing has been appropriate for containing dried foods.

Keywords: Hot compression process, Natural materials, Water hyacinth.

1. Introduction

The severity of today's toxic environmental problem has been increasingly multiplied every day whether being water or air pollution that has substantially Affected ecosystem and living and resulted in bad effect toward living condition of human. The significant cause has been the problem from overabundant solid wastes based on increasing number of populations. According to Thanawadee [1] and National Innovation Agency [2], plastic or plastic made food ware, foam cup or box have been the products as the major causes due to ease of use.

Siracusa et al. [3] and Kirwan et al. [4] commented that, in manufacturers, users of plastics and every consumer represent an awareness of the environment and the importance of finding a greener solution to without users of plastic packaging. In Thailand, the volume of wastes in type of foam and plastic has been high over than several million tons per year. These foams and plastics must take long decades for degradation. Therefore, these have resulted in pollution, numerous negative effects and problems in wide areas. According to the aforesaid occurred problems, the alternative ware which is made from natural material and similar to foam and plastic ware have been developed and improved for use as substitute of foam made product and plastic made product. The materials which are available and abundant in the community such as products from cassava fiber, pineapple fiber, leaf sheaf fiber of banana tree, water hyacinth fibre, etc., have been used [5-10].

In addition, ware forming machine for ware that uses natural materials has been developed and improved into various designs for extensive use [11-13]. As aforesaid, this research aims at development of alternative degradable ware made from natural materials [14, 15] for natural conservation without environmental destruction. Water hyacinth fibers were mainly used under hot compression process method to acquire actual usable ware. Apart from utilization of natural materials, it has also contributed to weed elimination, waste disposal abatement and environmental conservation of Thailand in the future.

2. Material and method

2.1. Materials and equipment used in experiment

Ware forming machine for ware from natural materials used in ware forming testing, is functioned by pneumatic system. Electric system is used in functional mechanism control system through functional control unit. The overall components are shown in Fig. 1.

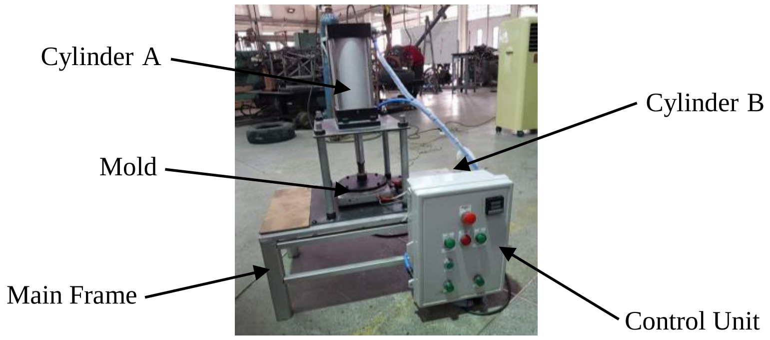

Fig. 1. Components of ware forming machine.

The used mold fixes the compressed ware to have the appearance of wide opening bowl in not more than 140 mm of blow opening size, not more than 90 mm of bowl bottom size, not more than 25 mm of height and 2 mm of thickness. Liamphipat [16] explained that, the mold is a semi-positive mold using Aluminium Grade 6063 material as shown in Fig. 2.

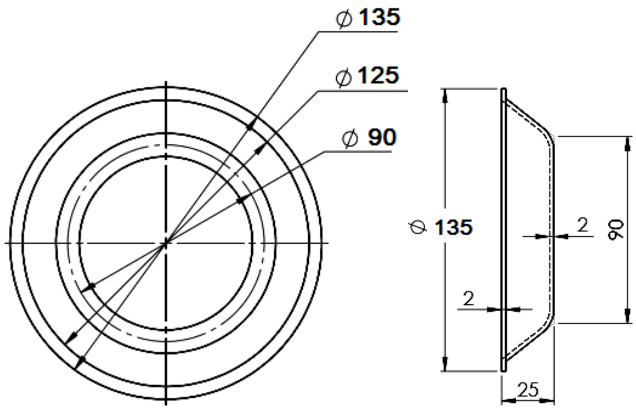

Fig. 2. Size of ware (Unit: mm).

The main materials used for testing consist of water hyacinth fiber, non-modified cassava starch, plain water, fine blender, filter cloth, digital weighing machine, and air compressor. Water hyacinth fibers are prepared starting from cutting roots and leafs of fresh water hyacinth to have stalk remained only, washing with clean water, and then slicing fresh water hyacinth into small pieces in approximate size for 5 mm After that, water hyacinth is blended to be fine with fine blender and when blending is completed, they are dried with sun exposure as shown in Fig. 3 In preparing binder, cassava starch is mixed with plain water (Cassava Starch: Water is 500 g : 3000 cc.) and then boiled using low fire until starch is boiled. The sun-exposed water hyacinth is mixed with binder in the ratio as specified in Table 1, made into round sheet in the size of 13 cm diameter and 5 mm thickness, exposed to sun in open air area in both sides for 5-6 hours period as shown in Fig. 4.

Fig. 3. Fresh and sun-exposed water hyacinth fibers.

Fig. 4. Water hyacinth fiber sheet.

2.2. Testing method

2.2.1. Testing procedure

The research procedure in producing biodegradable ware from water hyacinth fibers is classified into 3 parts, consisting of finding appropriate variables of ware compression with testing method, then testing the said variables to measure properties, and passing ware compression process for actual use in final part. The test is conducted by hot compression process method using testing 110 °C, 130 °C and 150 °C of heat, respectively, at 6 bar of constant pressure for 20 minutes in compression. After that, wares are taken to measure its mechanical and physical properties to find appropriate variables for use in ware production. Functional Process and Procedure Diagram is shown in Fig. 5. The ratio between water hyacinth fiber and binder and temperature used in testing is in Table 1.

Table 1. Ratio between water hyacinth fiber, binder and temperature used in compression.

Temperature for test, °C	Specimens	% Fiber (By weight)	% Binder (By weight)
110	Case 1	40	60
	Case 2	45	55
	Case 3	50	50
	Case 4	55	45
130	Case 5	40	60
	Case 6	45	55
	Case 7	50	50
	Case 8	55	45
150	Case 9	40	60
	Case 10	45	55
	Case 11	50	50
	Case 12	55	45

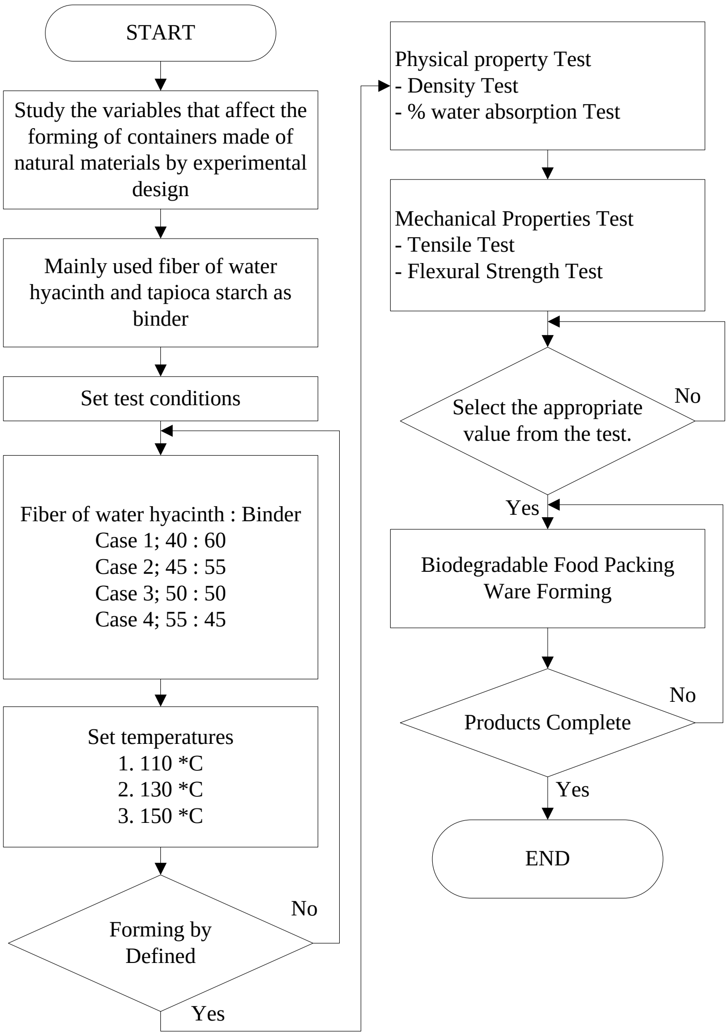

Fig. 5. Functional diagram of ware forming machine.

2.2.2. Density test

Based on studies by Lewthiasong and Chitsonboon [17], density test is the measurement of mass per volume of test piece. Test piece is cut into the size of width: length: thickness for 4: 6: 2 cm and then measured for volume, weighed and recorded acquired weight values. The test is repeated for 3 times and average is measured from acquired weight values. Density value of test pieces can be calculated from Eq. (1).

$$\rho = \frac{m}{V} \quad (1)$$

2.2.3. % water absorption test

Test piece is tested to measure % Water Absorption applying ABNT NM ISO535 Standard [17]. Test piece is cut into the size of width : length : thickness for 4 : 6 :

2 cm, weighed before immersing in water (m_1), immersed in plain water at room temperature for 60 seconds period, and then weighed after immersing in water (m_2). The varying weight values of test piece are weighed both before and after immersing in water. The test is repeated for 3 times and average is measured from acquired weight values. % Water Absorption is calculated from Eq. (2).

$$\%\ \text{water absorption} = \frac{(m_2 - m_1)}{m_1} \times 100 \tag{2}$$

2.2.4. Tensile test

Tensile Test applies ASTM D638 Standard [17] using Multipurpose INSTRON Tester with 10 kN of Load cell. Test piece is cut into dumbbell in the size of gauge length : width : thickness for 5 : 1 : 0.3 cm and taken for testing by intensifying tensile on test piece until test piece is separated with constant tensile rate (test speed) at 0.5 mm/sec. and then the result is recorded. Test is repeated for 3 times and average is measured from acquired values. Stress, strain and elasticity modulus values of test piece are calculated from Eq. (3), Eq. (4) and Eq. (5).

$$\sigma = \frac{F}{A} \tag{3}$$

$$\varepsilon = \frac{\Delta L}{L_o} \tag{4}$$

$$E = \frac{\sigma}{\varepsilon} \tag{5}$$

2.2.5. Flexural strength test

Flexural Strength Test is conducted in the way of three point bending [17]. Test piece is cut into the size of width: length: thickness for 8: 3: 0.3 cm. In testing state, distance between two points of supporting platform of test piece is 5 cm and the center of test piece is forced. Weight is increased until test piece is broken. Test is repeated for 3 times and then average is measured. Flexural value is calculated from Eq. (6).

$$\delta = \frac{3F_f L}{2Bh^2} \tag{6}$$

3. Results and Discussion

3.1. Functional testing result of ware forming machine

Ware forming test was conducted by ware forming machine for natural resources made ware. The machine can function in accordance with the designed procedure. Testing result of ware compression shows in Fig. 6 and ware acquired from forming can be used to contain foods as shown in Fig. 7.

The finding from testing indicated that at the ratio between water hyacinth fiber and binder for 40 : 60, the temperature used in forming ware was 150 °C (Case 9) and ware with strength, smooth and even surface, attractive shape different from other specimens which were somewhat shapeless, soft or easily cracked, was produced.

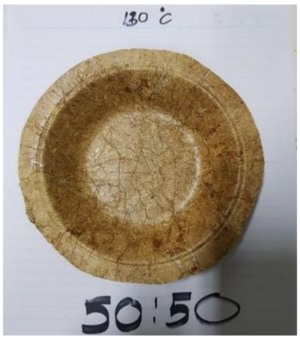

Fig. 6. Shows forming of water hyacinth ware.

(a) Dried food

(b) Wet food

Fig. 7. Water hyacinth ware contains food.

3.2. Testing result of density measurement

From Fig. 8, it shows relation between density value and fiber content of water hyacinth. The finding indicated that density value of ware varied directly with % By weight of fiber and density value of ware varied inversely with Temperature for test whereas in 55% for % By weight of fiber at 110 °C of Temperature for test, maximum density was 1.52 g/cm^3 since it was the maximum water hyacinth contained mixture, and at 40% for % By weight of fiber at 150 °C of Temperature for test, minimum density was 0.83 g/cm^3 since it was the minimum water hyacinth contained mixture.

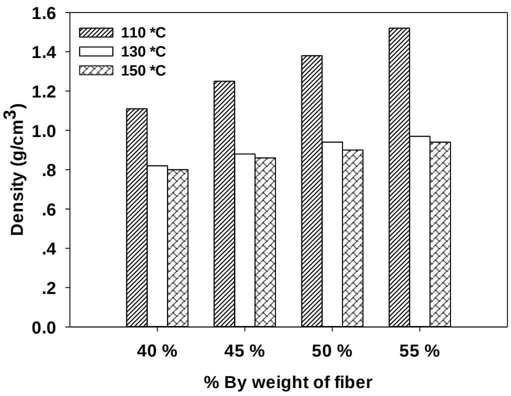

Fig. 8. Relation between density and fiber content of mixture.

3.3. Testing result of % water absorption measurement

From Fig. 9, it shows relation between % water absorption value and fiber content of mixture. The finding indicated that % water absorption varied directly with % By weight of fiber and Temperature for test whereas in 55% for % By weight of fiber at 150 °C of Temperature for test, maximum % water absorption was 164.70% and in 40% for % By weight of fiber at 110 °C of Temperature for test, minimum % water absorption was 81.25%.

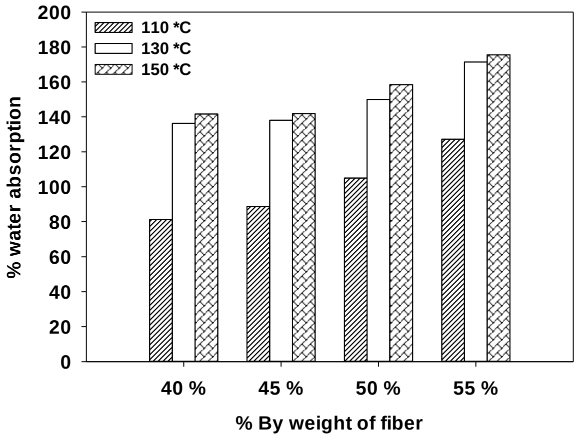

Fig. 9. Relation between % water absorption and fiber content of mixture.

3.4. Result of tensile strength test

From Fig. 10, it shows relationship between tensile strength value and fiber content of mixture). The finding indicated that at 50% for % By weight of fiber and at 150 °C of temperature for test, maximum tensile strength was 63.73 MP since it was the many water hyacinth fiber-contained mixture and at 40% for % By weight of fiber at 110 °C of Temperature for test, minimum tensile strength was 19.90 MPa since it was the minimum water hyacinth fiber-contained mixture.

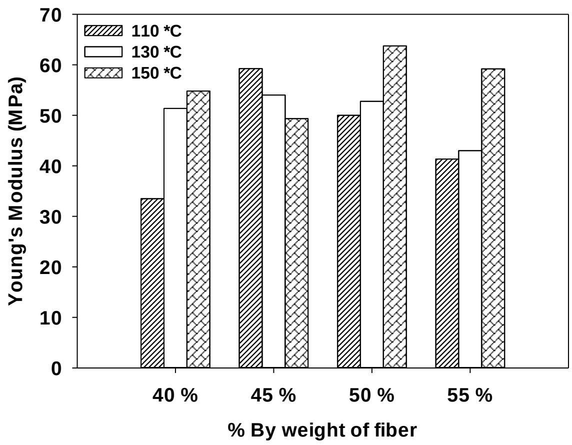

Fig. 10. Relation between tensile strength and fiber content of mixture.

3.5. Result of flexural strength test

From Fig. 11 shows relation between flexural strength and fiber content of mixture. The finding indicated that flexural strength value of ware was similar to every % By weight of fiber at the same Temperature for test, and flexural strength value of ware varied directly with Temperature for test whereas in 40% for % By weight of fiber at 150 °C of Temperature for test, maximum flexural strength was 3.24 MPa, and at 55% for % By weight of fiber at 110 °C of Temperature for test, minimum flexural strength was 1.22 MPa.

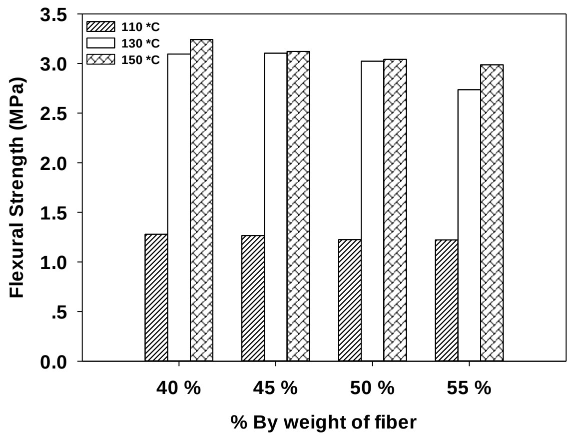

Fig. 11. Relation between flexural strength and fiber content of mixture.

4. Conclusions

The purpose of this study is to produce alternative ware made from natural materials which are naturally degradable as substitute of plastic and foam made products for natural conservation without environmental destruction, and to study variables affecting forming and mechanical property of the ware made from natural materials. This research is an experimental research. Water hyacinth was selected as main material in fiber production and cassava starch was used as binder. Hot compression process method was applied in forming at 6 bar of constant pressure and 20 minutes were taken in compression. The tests were conducted under determined conditions. After that, they were taken for testing and measuring mechanical and physical properties of the ware in order to find the appropriate variables used for ware production. The testing result indicated that the size of the ware which was compressed into wide opening bowl in the size of Bowl Opening: Bowl Bottom: Height: Thickness was 140:90:25:2 mm, respectively. The most appropriate ratio between water hyacinth and binder was 40:60 by weight, using 150 °C of temperature in forming ware and having 0.83 g/cm^3 for density, 141.66% for % water absorption, 54.80 MPa for Tensile Strain Test, 3.24 MPa for Flexural Strength Test. The ware derived from this developed and tested is suitable for the use of relatively dry foods such as snack foods, grilled foods, roasted food or fire. (No oil) and is not suitable for liquid foods. In the future, it will increase test production methods at different pressure conditions, biodegradation, morphology (using SEM) and surface chemistry (using FTIR) analysis of raw material. The ingredients have to be improved and developed to have the better liquid filling qualities.

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Nomenclatures

A	Cross Sectional Area, m^2
B	Width, m
E	Young's Modulus, MPa
F	Force Applied, N
F_f	Force at the fracture point, N
h	Thickness, m
L_o	gauge length, m
L	Length of the support span, m
m	mass, g
m_1	Weight of oven - dried sample, g
m_2	Wright of saturated surface - dried sample, g
V	Volume, cm^3

Greek Symbols

ΔL	Stretched length, m
δ	Flexural Strength, MPa
ε	Strain
ρ	Density, g/cm^3
σ	Stress, N/m^2

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