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Effect of Enzymatic Treatment on the Mechanical Properties of Pineapple Leaf Fibre

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Abstract: Pineapple leaves which are agricultural wastes can be used as textile products. Pineapple leaf fibre has excellent properties such as high strength and modulus. Pineapple leaf fibres need to be used as textile products. One method used is treatment with enzyme. In this study an investigation of enzyme treatments for pineapple leaf fibre was analyzed. The test was carried out by applying the enzyme xylanase and pectinase enzyme to pineapple leaf fibres with and without alkaline. After the application of the enzyme, weight reduction, fibre morphology, fineness and sorbtion time of pineapple leaf fibres were sought. The results showed that the use of enzyme affected to the weight reduction, fineness and sorbtion ability.

Keywords: Pineapple leaf fibre; Xylanase enzyme; Pektinase enzyme

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1. Introduction

Pineapple fibre is a natural extracted from pineapple plant leaves. The pineapple plant is mostly cultivated in tropic and sub-tropic countries. Pineapple plant farming has an important role in tropical and sub-tropical countries agriculture and it is mostly cultivated for its fruit. Tons of pineapple leaves are left as agrowaste material since the majority of pineapple extracts are extracted from waste pinapple plant leaves [1].

At the present, waste treatment is in the spotlight in the world. One way to minimize the formation of waste leaf pineapple is to use pineapple leaf fibres to become textile materials. Pineapple fibre has excellent properties such as high strength and modulus. Highly amount of cellulose (70-82% based on weight of fibres) and 16-22.2% hemicellulose, 5-13% lignin, 2.5-3.5% wax and others [1].

Nowadays, natural fibre reinforced composites have had great interest due to the cost saving, improvement of the productivity improvement and the mechanical product [2]. Pineapple leaf fibre is one of the natural fibres. The major problem is natural fibrous as a reinforced material is improper contact with adherent surface and polymer material. Thus the improved interface quality of composites is commonly treated by treating surfaces of fibres with suitable methods such as chemical modifiers, coupling agents and compatibilizer agents. The use of enzyme technology has been increased substantially in the natural fibre processing [2].

Previous research has examined the effect of xylanase enzymes on the mechanical properties of corn husk [3] and application of cellulase and laccase to pineapple leaf fibres [4]. In this study, alkalineand enzyme treatments were used. This study aims to investigate the effect of enzymatic treatment on the mechanical properties of pineapple leaf fibre. The enzyme used are xylanase and pectinase. Enzymes have been used in processing fibre sources such as flax and hemp. At present, fibre liberation is affected by retting i.e., the removal of binding material present in plant tissues using enzymes produced in situ by microorganisms. Pectinases are believed to play the main role in this process, however, xylanases may also be involved [5]. Xilanase enzyme breaks the covalent bond between lignin and cellulose and depolimerize hemicellulose in the fibre [3].

2. Materials and Methods

2.1 Materials

Pineapple leaf fibres were used is a comercial pineapple leaf fibre called Alfibre. The age of the fibres since it planted is 1,5 years old, however, as long as the pineapple leaves reaches above 60 cm, it can be used as fibre. Xylanase enzyme obtained from BPPT Research and Development. Pectinase enzyme used is a comercial pectinase. Sodium hydroxide (NaOH) and Acetic Acid (CH_3COOH) is a technical grade supplies from CV Sofyan Jaya.

2.2 Methods

Method used in this experiment is based on Yilmaz experiment with corn husk. A portion of pineapple leaf fibre was alkalized with NaOH. Pineapple leaf fibre were subjected to alkalization treatment at a NaOH concentration of 7,5 g/L for 20 min under boiling temperature in distilled water. The alkalization treatment was carried out at 1:20 liquor ratio. Alkalization was followed by rinsing several times, one with hot water, neutralizing with 10% acetic acid solution, rinsing and drying under ambient conditions.

Xylanase Enzyme treatment was carried out in beaker glass at 70oC, pH 9 with liqour ratio 1:20 in distilled water. Pectinase Enzyme treatment was carried out in beaker glass at 70oC, pH 7 with liqour ratio 1:20 in distilled water. Duration of each enzyme treatment is one hour. Enzyme consentration was calculated based on the percentage ratio enzyme mass to the fibre mass [3]. Enzyme consentration used is 1% based on fibre weight.

After enzyme treatments, morphological structure, weight reduction, tenacity, fineness and sorbtion time of treated pineapple leaf fibre were evaluated. Morphological structure was measured using microscope with 40x magnification. Weight reduction was measured by measuring the untreated pineapple leaf fibre mass and then its mass after treated. The weight reduction was

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calculated with the percent of weight. Tenacity of the fibres was measured based on SNI 08-1112-1989. Fineness of the fibres was measured based on SNI 08-1111-1989. Sorbtion time was measured by water drop test.

3. Results

The effect of treatments on physical and mechanical characteristics of pineapple leaf fibre have been investigated. The weight reduction, tenacity and wet sorption ability are shown in table 1.

Table 1. weight reduction, tensile properties and wet ability of treated pineapple leaf fibres

	Weight reduction (%)	Tenacity (g/tex)	Fibre fineness (tex)	Sorption time (s)
Neat	-	21.4	3.99	5.28
Pretreatment	24,2180	13.73	2.64	1.67
Pretreatment + xylanase 1%	33,7496	11.21	1.97	1.75
Pretreatment + pectinase 1%	28,1453	10.74	2.64	1.51
Xylanase 1%	9, 7728	21.08	2.83	4.91
Pectinase 1%	9,1542	20.16	3.38	2.39

3.1 Morphological Structure

Morphological structure of each treatment with 40x magnification indicates that there is no significant different between plain pineapple leaf fibre, alkaline treatment pineapple leaf fibre and enzyme treatment pineapple leaf fibre. Morphological structure consists of longitudinal section and cross section. Figure 1 shows the longitudinal section of pineapple leaf fibre while figure 2 shows the cross section of pineapple leaf fibre.

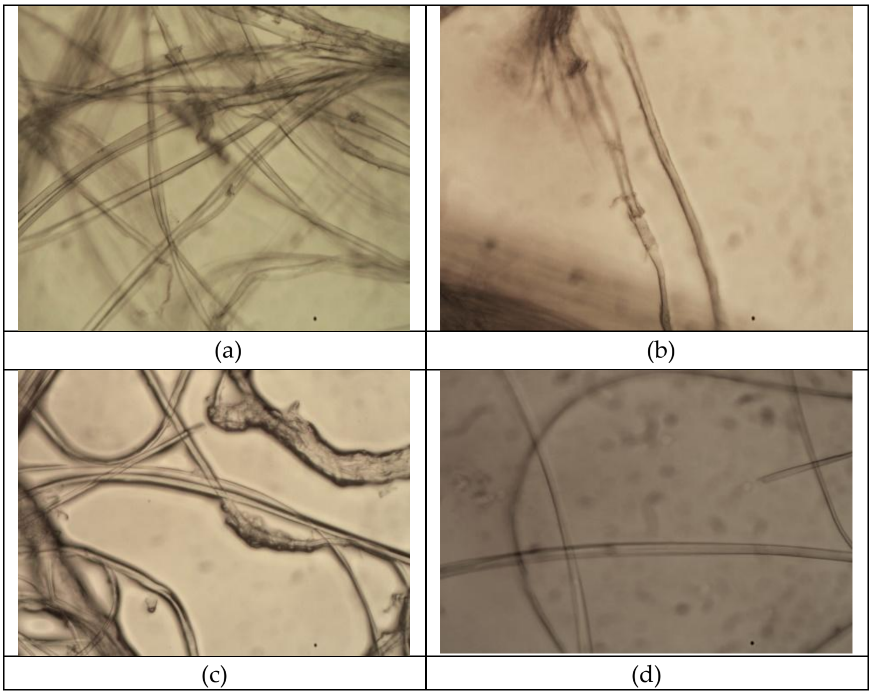

Figure 1. longitudinal section of pineapple leaf fibre. (a) Non treatment (b) NaOH treatment (c) Xylanase treatment (d) Pectinase treatment

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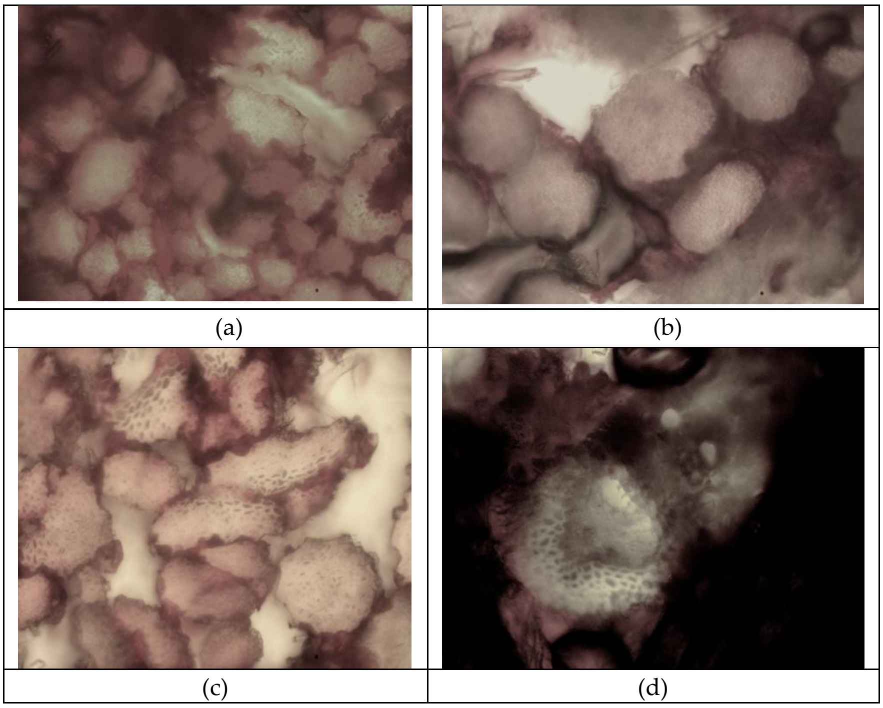

Figure 2. cross section of pineapple leaf fibre. (a) Non treatment (b) NaOH treatment (c) Xylanase treatment (d) Pectinase treatment

3.2 Weight Reduction

From table 1, it can be seen that there was a weight reduction after the pineapple leaf fibres were treated. Alkaline treatment shows a greater reduction than only treatment with enzymes. Large weight reduction occurs in the treatment of a combination of alkaline treatment and enzyme treatment. Either with xylanase enzyme or pectinase enzyme shows significant result in weight reduction when it is combined with NaOH. This result illustrates that although alkaline use cannot be replaced by the use of enzymes, alkaline use can be reduced.

3.3 Tenacity

Based on table 1, it can be seen that the treatment carried out on pineapple leaf fibres reduces the tenacity of pineapple leaf fibres. The biggest tenacity reduction is found in pineapple leaf fibres treated by NaOH and enzyme. The smallest tenacity reduction is found in pineapple leaf fibres treated only with enzymes.

3.4 Fibres Fineness

Based on the table 1, it can be identified that the treatment carried out on pineapple leaf fibres increase the fineness of the fibres. The finest fibres is found in pineapple leaf fibre treated by NaOH and xylanase enzyme. It is related with the weight reduction since it influence the fibres fineness.

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3.5 Sorption Time

Based on table 1, it can be seen that the treatment carried out on pineapple leaf fibres improves sorption time on pineapple leaf fibres. The fastest sorption time is found in the treatment of pineapple leaf fibres with a combination of NaOH and xylanase enzymes.

4. Discussion

In this study, alkaline treatment and enzymes were carried out on pineapple leaf fibres. Tests include morphology structure, weight reduction, tenacity, fineness and sorption time.

Alkaline treatment was used to achieve good results because alkaline can remove waxes and other non cellulosic compound [2]. Xylanase enzyme breaks the covalent bond between lignin and cellulose and depolymerize hemicelulose in the fibre. Depolymerize hemicelulose and separated lignin are removed during washing [6]. Pectinase enzyme can be degrading the pectin in the middle lamella and the prymary cell wall of higher plants [7].

On the observation of the morphology structure a 40x magnification was used using a microscope. The use of SEM (Scanning Electron Microscope) will be able to clarify the desired results.

Weight reduction in pineapple leaf fibers treated with NaOH and enzymes occurs because alkaline treatment with NaOH remove impurities in non-cellulose substances and waxes. xylanase enzymes depolymerize hemicellulose while the pectinase enzyme trade the potential located in the middle lamella and the primary cell wall of higher plants. The degradated substance then removed during washing so it make weight reduction occur.

Alkaline and enzyme treatment have an effect on tenacity, fineness and sorption time of the fibers. This is due to the breakdown of bonds by both the alkaline and the xylanase and pectinase enzymes. Alkalinecan degrade lignin in the cellulosic fiber structure, the enzyme xylanase depolymerizes hemicellulose and the pectinase enzyme degrades pectin. Breaking the bond makes the handle softer and the tenacity will decrease.

The enzyme works both the xylanase enzyme and the pectinase enzyme in line with the alkaline treatment. This means that the use of NaOH as an alkaline treatment can be reduced by using enzymes, both xylanase and pectinase enzymes. Enzyme treatment increases fibre sorption time because xylanase enzyme degrades xylan which binds lignin and other than cellulose (lignin and hemicellulose) therefore the sorption time of fibre is improved.

5. Conclusions

Treatment of pineapple leaf fibres using alkalineand enzymes influences weight reduction, tenacity, fineness and time sorbtion. The highest weight reduction was found in the treatment of

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NaOH and xylanase. The lowest tenacity is found in the treatment of NaOH and enzymes, while the fastest sorbtion ability is found in the treatment of NaOH and enzymes.

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