Prototypes of innovative and creative products from laboratory of forest products technology

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Abstract. Three types of prototypes of innovative and creative products have been made in Laboratory of Forest Products Technology, Faculty of Forestry, Universitas Sumatera Utara. According to the origin of raw material, the products are consisted of recycle paper, natural dye, and plastics waste. Production methods were as follows: recycle paper was produced using used paper with addition thermoplastic adhesive. Natural dyes derived from plants and they were applied mainly into fabrics using eco-print technique. Plastics waste originated from beverages bottles and packaging were mixed with wood and converted into eco-friendly souvenir. Results of this study: recycle paper can be used as book cover, campaign media, eco-print media and egg tray. Natural dyes in conjunction with eco-printing technique have been patterned not only on fabrics but also onto paper, wood, leather and ceramics become décor paper, stationary, women and seminar needs and mugs, respectively. Mixture of plastics waste and wood become eco-friendly souvenirs in various composition and shape. Limited and simply testing were carried out and discussed. Advance examination is still needed to assess the quality of the products. Determination of packaging, pricing and market sharing of these various innovative and creative products should be also studied further.

1. Introduction

Laboratory or simply lab is a place offering an environment that encourages creativity and practice of problem solving, and supports students to adopt technology and engineering as a single mindset [1]. The core idea behind a lab is to provoke, stimulate and motivate students and young researchers to actively use their intellectual and creative potentials to generate innovative ideas. In this context, making prototype of innovative and creative products derived from lab’s work is very important. Prototyping is a valuable tool in activity of new product development processes. The objective of prototyping is either to explore new opportunities or enhance existing solutions [2].

Lab of Forest Products Technology in our university has been officially named by Rector Decree No. 811/UN5.1.R/SK/SPB/2018 even though history of its establishment was started in 2001 when Study Program of Forest Products Technology was officially opened in Universitas Sumatera Utara (USU). In 2019, this lab has been applied tariff for lab service and testing through Rector Decree No.1863/UN5.1.R/SK/PS/2019 because the equipment and its facility were possibly to do lab’s work [3] including making prototype.

Starting from 2019, one of community service programs, called of PPUPIK, has been collaborated with this lab. PPUPIK is abbreviation from “Program Pengembangan Usaha Produk Intelektual Kampus” or Business Development Program from Intellectual Products of Campus. For the first year
round, development of eco-printing on recycle paper and fabrics for seminar kits needs was carried out [4]. Because of covid-19 pandemic, second year round (2020) of this program emphasized making prototypes of intellectual products from this lab.

In this contribution, three prototypes of innovative and creative intellectual products matched with the theme of this conference, namely recycle paper, natural dye, and eco-friendly souvenir were presented and discussed.

2. Materials and methods

Generally, materials used in this study were waste derived from our daily activity or nature. For making recycle paper, several types of used paper were utilized such as newspaper, office paper, and packaging paper. For producing natural dye, some partitions of specific plants were used such as bark, leaves, and flower. For generating composite plastics, different type of plastics litter originated from beverage, packaging or shampoo bottles were utilized. Following is description procedures of each product production.

2.1. Recycle paper

In order to make recycle paper, used paper was converted into pulp. Pulp was obtained by soaking the used paper in water in certain periods and then defibrillating using a blender. Separation between fiber and water was done using screen with various mesh size depended on final target of recycle paper, for instances as décor paper, fancy paper, or just sketch paper. Mixing with adhesive, hereafter starch based glue or thermoplastics resin like PVAc (polyvinyl acetate), was conducted subsequently after screening. A furnish consisting of a mixture of pulp and adhesive and sometimes with addition of filler with different ratio was used as a raw material for making specific products, such as book cover, campaign media, eco-print media and egg-tray. Further study of these particular products has been conducted by [5] and [6], both are our students. [5] made prototype of recycle paper from used paper for eco-printing media while [6] made prototype of egg-tray from mixed used paper.

Examination of the quality of the recycle paper was conducted by a small sample observation under a photo-microscope in certain magnification. A small specimen was prepared by tearing the surface of the recycle paper. Result of the observation then was captured in certain magnification and the scale was put in the image.

2.2. Natural dyes

Natural dyes here could able to colour either whole part of the object or only making pattern on specific part of the object. For the first, brown colour can be obtained from mangrove bark or plants whose have high tannin content such akasia (Acacia mangium) and tea (Camellia sinensis). Blue colour can be obtained from telang (Clitoria ternatea) flower, and green colour can be obtained from suji (Dracaena angustifolia) leaves. For the second, pattern of leaves or flower can be obtained from specific plants such as jati (Tectona grandis) and belimbing wuluh (Averrhoa bilimbi) leaves and gerbera/herbras (Gerbera jamesonii) flower using eco-printing technique.

Natural dyes in conjunction with eco-printing technique have been patterned not only on fabrics but also onto paper, wood, leather and ceramics become décor paper, stationary, women and seminar needs and ceramic mugs, respectively. Methods for obtaining these patterns used steam or hit/beat/pound technique. In this second year program, prototyping of these products have been carried out. Further studies about natural dyes in conjunction with eco-printing technique have been also conducted by our students, namely [7] and [8]. [7] utilized tannin from A. mangium for colour binding in natural dyes while [8] analyzed the differences leaves pattern in different media such as silk cloth and linen paper.

Preliminary evaluation on application of natural dye in this study was using image analysis. Image analysis was consisted of three steps, namely scanning sample using a scanner, analysing the image using a free software image analysis (the freeware ImageJ can be downloaded in
http://rsbweb.nih.gov/ij/), transforming the image colour into value of RGB (red, green, blue) in number. Here quantifying colour resulted in eco-printing was possible.

2.3. Eco-friendly souvenirs

An innovative eco-friendly product has been produced in the form of wood plastics composite by our team, consisting of students and supervisors [9]. “Environmentally-friendly” have been claimed to this product because it would deteriorate after certain time buried in the soil even though the composition of the plastics was predominant. Recent publication about this product, termite was able to consume this thing [10]. Therefore in this study, a mixture of plastics majority and wood was converted into souvenirs. Various prototypes with different composition as well as shape of these products have been produced.

Presented here predominant HDPE (high density polyethylene) plastics derived from shampoo bottles were broken up using a blender as shown in Figure 1.

![Figure 1. Plastics waste with various colour and origin](image)

The resulted plastics particles were then mixed with wood sawdust with various weight ratios, namely 95:5, 90:10 and 85:15. Using high temperature, plastics will melt, encapsulate and cover wood sawdust. Because of souvenir is the final shape, performance will be considered as the quality.

3. Results and discussion

3.1. Recycle papers

Conventional or traditional method of converting used paper into pulp was applied. In other words, pulping process was carried out simply without any treatments. In order to make recycle paper with certain purposes, either adhesive or filler was added into the pulp. Figure 2 showed prototypes of recycle paper for different purposes such as book/ block-note cover, campaign media, eco-print media and egg-tray. All of these products carried a massage that recycle paper was environmentally friendly.

Generally, recycle paper showed lower brightness compare to that of original paper. This condition because ink containing in used paper was still exist. Research on deinking on used paper has been done by [11]. Result of this study stated that residual ink area and deinkability factors would affect to the quality of resulted pulp. In this study, deinking was intended not to apply because deinking process needed more chemicals. Products presented here were claimed as environmentally friendly, therefore minimizing or zero chemicals was suggested.
Results of observation under photo-microscope were presented in Figure 3. Comparison of morphology between recycles paper bonded by starch and that of by PVAc were exhibited.

Recycle paper bonded by starch showed less compact compare to that of bonded by PVAc. Starch adhesive was consisted of two important parts namely amylose and amylopectin which have had different characteristics [12]. Amylose has linear structure while amylopectin has branched structure which will influence in the final bonding characteristics of the recycle paper products. PVAc has had linear structure and rapid setting [13] therefore penetration into fibers among the recycle paper was faster thus its bonding property was tackier.

3.2. Natural dyes
Natural dyes in conjunction with eco-printing technique have been patterned not only on fabrics but also onto paper, wood, leather and ceramics become décor paper, stationary, women and seminar needs and mugs, respectively as shown in Figure 4.
Figure 4. Prototypes of eco-printing technique using natural dyes onto paper, wood, leather, and ceramics become décor paper (a), pencil box (b), leather for bag (c), and mugs (d), respectively.

These products have been produced commercially for seminar purposes (seminar kits, souvenirs, and display/exhibition) and they were sold even though their prices were not standard [10]. Therefore, further study for pricing is required. For continuing production or sustainability, packaging and marketing strategy of these products have been also carried out.

Figure 5 showed example for quality testing of eco-printing product using image analysis. Here, image control (a and b) and after application of alum (\(\text{Al}_2(\text{SO}_4)3.18\text{H}_2\text{O}\)) as a mordant (c and d) were used as the observation objects. Both control and treatment were conducted twice in order to observe the consistency.

Figure 5. Application of natural dye either whole (using tannin) or partly (using leaves) with and without mordant (alum) treatment. (a and b were control; c and d were treated ones).

Tannin resulted in brown colour while leaves resulted in both purple and green colours. Application of alum as mordant made sharpen the image. Indeed, alum has been used as a mordant in
traditional textiles by Indonesian people for centuries [14]. Results of image conversion into RGB number presented in Tables 1-4 proved that treatment of alum mordant made the images were brighter consistently. Comparison between Tables 1 and 2 showed inconsistent maximum value of RGB value. Fortunately after application of alum mordant, the RGB value showed optimum (Tables 3 and 4).

### Table 1. RGB value for control image (without alum mordant)

| Label          | Area | Mean   | SD      | Min | Max |
|----------------|------|--------|---------|-----|-----|
| Red            | 8947950 | 175.061 | 14.748  | 46  | 252 |
| Green          | 8947950 | 141.006 | 19.352  | 31  | 247 |
| Blue           | 8947950 | 127.326 | 20.646  | 26  | 254 |
| (R+G+B)/3      | 8947950 | 147.759 | 17.809  | 37  | 249 |
| 0.299R+0.587G+0.114B | 8947950 | 149.641 | 17.790  | 36  | 248 |

### Table 2. RGB value for second control image (without alum mordant)

| Label          | Area | Mean   | SD      | Min | Max |
|----------------|------|--------|---------|-----|-----|
| Red            | 8947950 | 172.013 | 18.175  | 50  | 255 |
| Green          | 8947950 | 141.123 | 24.157  | 35  | 255 |
| Blue           | 8947950 | 131.626 | 25.610  | 28  | 255 |
| (R+G+B)/3      | 8947950 | 148.181 | 21.914  | 40  | 255 |
| 0.299R+0.587G+0.114B | 8947950 | 149.242 | 22.088  | 41  | 255 |

### Table 3. RGB value for treatment image (with alum mordant)

| Label          | Area | Mean   | SD      | Min | Max |
|----------------|------|--------|---------|-----|-----|
| Red            | 8947950 | 157.347 | 34.463  | 44  | 255 |
| Green          | 8947950 | 112.360 | 40.807  | 19  | 255 |
| Blue           | 8947950 | 96.754  | 36.444  | 9   | 255 |
| (R+G+B)/3      | 8947950 | 122.159 | 36.415  | 30  | 255 |
| 0.299R+0.587G+0.114B | 8947950 | 124.043 | 37.873  | 28  | 255 |

### Table 4. RGB value for second treatment image (with alum mordant)

| Label          | Area | Mean   | SD      | Min | Max |
|----------------|------|--------|---------|-----|-----|
| Red            | 8947950 | 166.440 | 35.894  | 12  | 255 |
| Green          | 8947950 | 125.685 | 43.923  | 0   | 255 |
| Blue           | 8947950 | 108.788 | 40.038  | 2   | 255 |
| (R+G+B)/3      | 8947950 | 133.643 | 38.890  | 6   | 255 |
| 0.299R+0.587G+0.114B | 8947950 | 135.957 | 40.402  | 5   | 255 |

3.3. Eco-friendly souvenirs
Figure 6 showed performance of souvenir made of a mixture plastics waste and wood sawdust. More amount of wood sawdust added, the performance was worse. Performance was described as surface smoothness, compatibility between plastics and wood, and colour.

Even though raw materials of plastics showing different colour, final form of this souvenirs showed brown-dark colour as shown in Figure 6. The most influenced darkness could be attributed to the heat treatment and minor effect of extraction of the wood filler [15]; which then influenced the final colour of the wood plastics composite in the form of souvenir produced [10].
Figure 6. Souvenirs made of a mixture of plastics and wood sawdust with various ratios, (a) 95:5; (b) 90:10, and (c) 85:15

4. Conclusions

Three groups of prototypes of innovative and creative products have been produced at Laboratory of Forest Products Technology in our university, namely recycle paper, natural dyes, and eco-friendly souvenirs. Testings of the quality of these products have been also developed in order to quantify the standard. Further study should be also conducted to determine packaging, pricing and market sharing of these various innovative and creative products.

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