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Application and development of products from Yellow Millettia Wood Leaf

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The purpose of this research is to study the paper production process, paper test, paper assessment satisfaction, and the development of a multi-purpose shelf prototype from yellow Millettia wood leaf paper. The results showed that after the pulp boiling process, which comprises 30 kilograms of full-grown leaves from the yellow Millettia wood, the pulp would acquire a weight of approximately 8-10 kgs. The physical property test assessed 100 per cent yellow Millettia wood leaf paper, yellow Millettia wood leaf paper mixed with banana plants at a ratio of 50:50 per cent, and yellow Millettia wood leaf paper mixed with a ratio of 50:50 per cent pineapple leaves. The burst strength was equal to 75.00, 76.60, and 70.60 k.Pa, respectively. The tear resistance values were equal to 471, 1,640, and 706 mN, respectively. The basis weight values are 36.40, 30.00, and 21.50 g/m^2, respectively. When photographing with stereo microscopes at 10, 15, 20, and 30-times magnification, the texture of all three types of paper is rough. Comparing the satisfactions of 250 product design and development students with the paper, it was found that their satisfactions with the three types of yellow Millettia wood leaf paper were statistically significant and different ($p<0.05$).

Keywords: *Development, Prototype product, Paper, Yellow millettia wood, Leaf.*

INTRODUCTION

At present, the production of handmade paper in Thailand (Thai handicrafts products) is widespread. There is ongoing research and development to use waste materials to produce paper, including from pineapple leaves, mulberry trees, coconut spathe, banana trees, elephant dung, rice straw, and so on. From the studies, it was revealed that handmade paper has distinctive features, including toughness, durability, and being able to twist or bend easily without damage. They also have their own identity with smooth skin. Thailand has many

agricultural waste materials that can provide fibre and that are suitable for paper production. However, the production of the paper is only for use in folk handicrafts. There is no effective process development in producing the paper for other purposes. However, to produce paper, the number of raw materials should be sufficient (Alexander & Alexander, 1997; Topoonyanont et al., 2001; Anunvrapong et al., 2017a) and they should be easily found locally. In this research, the leaf of yellow Millettia wood (*Millettia leucantha* Kurz), a tree of the Rajamangala University of Technology Krungthep, was studied.

The benefits of creating prototype products can help support the verifying and proofing of the expected concepts, whether the designed products are effective in terms of the product appearance or materials used in the production. The prototype product is a tool for investigating the consumers' experience in the usage of the product. When designers touch and experience the products, they may understand the product properties. Moreover, the prototype products also help the designer to communicate clearly with customers about new products. This is evident because to show three-dimensional products to customers, it can help them to understand the products. Furthermore, by producing the prototype products, it helps to reduce the risk of errors that may occur when the product is manufactured into a real product. Furthermore, the prototype products allow the designer to realise the various usage restrictions of the products (Ankarbranth & Martenson, 2013).

According to the mentioned reasons and qualifications of the handmade paper, the researcher assumed that the yellow Millettia wood leaf is particularly suitable for producing handmade paper, as well as creating a prototype product. It can be studied and developed to be used as a prototype product, which has its own identity that can represent the identity of the Rajamangala University of Technology Krungthep (Sopheaktra, 2008; Kurokawa et al., 2010). In addition, this study can respond to the government campaign that has been promoting the production of 'One Tambon One Product' (OTOP) for export (Koomsalud, 2018).

According to the above statements, the researcher has developed several new products. Therefore, the prototype products' multi-purpose shelves made from yellow Millettia wood leaf paper were produced for a pilot study, which focussed on adding more value, promoting unique identity, and strengthening the confidence of product creators.

RESEARCH METHOD

This research is divided into five steps, as follows:

1. Study the process of producing yellow Millettia wood leaf paper by hand, including the preparing, pulping, and stock preparing of raw materials; and producing three types of paper from the yellow Millettia wood leaves:
    a. 100 per cent yellow Millettia wood leaf paper.

b. Yellow Millettia wood leaf paper mixed with banana plants at a ratio of 50:50 per cent.
c. Yellow Millettia wood leaf paper mixed with pineapple leaves at a ratio of 50:50 per cent.

2. Conduct physical property testing of the three types of yellow Millettia wood leaf paper, in the following ways:
   a. Burst strength test, measured in kilopascal (kPa), and tested in accordance with ISO 2758 (2014) of paperboard. The test tool is the Mullen tester.
   b. Tear resistance test, measured in milligrams (milinewton, mN), and tested in accordance with ISO 1974 (2012) of paperboard. The instrument used for testing is also the Mullen tester.
   c. Basis weight test, measured in grams per square metre (g/m^2), and tested in accordance with ISO 536 (2012) of paperboard. The test instruments are analytical balance and a stereo microscope camera with 10-, 15-, 20-, and 30-times magnification.

3. Conduct an assessment of the three types of yellow Millettia wood leaf paper. Two-hundred and fifty students from five branches in the faculty of Product Design and Development, Rajamangala University of Technology Krungthep were selected to participate using a cluster random sampling method. There were 50 students from each branch, including Industrial Product Design, Crafts Technology, Printing Technology, Thai Wisdom Product Development, and Textile and Fashion Design. The instruments used in the study were satisfaction assessment questionnaires (satisfaction scales), with five levels according to Likert's method (James & Perla, 2007; Boone & Boone, 2012). The statistical analysis used the Statistical Package for the Social Sciences (SPSS) program by testing the F-test and comparing the mean with the least significant difference (LSD) method at the 95 per cent confidence level ($p<0.05$).

4. Conduct the development of a prototype product from yellow Millettia wood leaf paper by creating three types of three-dimensional (3D) sketches. Subsequently, evaluate them to find the most suitable 3D sketch by using three experts. The research instruments employed are in-depth interviews by using open-ended questions (Kvale, 1996).

5. Create a multi-purpose shelf prototype product from 3D sketches that have been evaluated by the experts. The satisfaction with the prototype product was assessed by students from the five aforementioned branches of the University. The stratified random sampling method was applied in this step (Palys, 2008; Teddie & Yu, 2007). The tools used in the study were satisfaction assessment questionnaires or satisfaction scales. The statistics used were mean, percentage (%), standard deviation (SD.), chi-square test,

and F-test using one-way Analysis of Variance (ANOVA). To compare the average, the Duncan's multiple range test (DMRT) method was used at a 95 per cent confidence level ($p<0.05$) (Verma & Abdel-Salam, 2019). To analyse the statistics by using the SPSS program, the questionnaire is a quality ranking questionnaire based upon five rating scales using the Likert's method.

RESULTS AND DISCUSSION

Step 1: Study the Production Processes of Yellow Millettia Wood Leaf Paper

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Source yellow Millettia wood leaves: surveyed and collected yellow Millettia wood leaves from the Nong Bua Daeng District, Chaiyaphum Province, Thailand.

Raw materials selection: collected 30 kilograms (kgs) of full-grown leaves from the mature yellow Millettia wood tree. Fresh yellow Millettia wood leaves are more suitable than dry leaves because the dry leaves take time in boiling in order to get fiber longer than fresh leaves.

Materials and equipment in yellow Millettia wood leaf paper production: the materials and equipment for making yellow Millettia wood leaf paper is easily found in the locality that local people can produce by themselves. There are two chemicals used in the production process: caustic soda, and chlorine.

Raw materials preparation: thirty kgs of yellow Millettia wood leaves was used each time to produce the yellow Millettia wood leaf paper. During the preparation step, the yellow Millettia wood leaves were cut or chopped into small pieces approximately 10–12 centimetres cm long.

Processes in producing yellow Millettia wood leaf paper: the processes of paper production are as follows:

a. Boil the chopped yellow Millettia wood leaves. Add two to three kgs of caustic soda. The amount of caustic soda depends on how much the leaves are boiled. In the case of fresh yellow Millettia wood leaves, the amount of caustic soda used is less than the dry leaves. It takes four to five hours to boil the yellow Millettia wood leaves. The leaves can be boiled until they become putrid and darker. Subsequently, the fibres begin to separate from the flesh. To make the leaves crumble throughout the pan, during boiling, the leaves must be stirred by a stirring paddle to turn the leaves up and down.

b. Cool down the leaves after boiling. Scoop out the boiled leaves and put them in a fine-mesh nylon bag. Afterwards, separate the fibres from the leaves by tramping. During this process, clean water will be sprayed onto the leaves to wash away the caustic soda

from the leaf fibres. They can be washed until the washing water is clear. Subsequently, the clean leaf fibres are ready for the next steps.

c. Transmit the dark-coloured leaf fibres that have been washed to the basin. The next step is to bleach with chlorine. The ratio used is one kg of chlorine mixed with 30 litres of water. Soak for two to three hours. Afterwards, use hands (wearing rubber gloves) to squeeze the fibres. Exclude the leaves that are not rotted to produce the fine quality fibres with a milky white colour.

d. Re-scoop the leaf fibres into fine nylon mesh bags to clear the chlorine from the fibres. Subsequently, the fibres are ready to produce paper with soft white colour.

e. Put the leaf pulp into the pulp blender, which should be spinning with an electric motor. The quality of the paper depends upon the delicacy of the leaf fibre that can be used for a greater variety of purposes.

f. Transfer the leaf fibre into the tray with clean water. Stir the leaf pulp to spread out evenly by hand. Subsequently, dip the sieve (frame) into the tray to take out the leaf pulp. The leaf pulp must be distributed evenly and smoothly on the sieve while lifting it up from the water. Afterwards, dry the sieve with the leaf pulp under the sun for one day. When the paper is dry, slowly remove the paper from the sieve. After this process, 20 kgs of the leaf pulp produces approximately 50 sheets of paper. To produce the three types of paper, the procedures are similar to the steps mentioned above (see Figure 1 below).

g. The production of paper from yellow Millettia wood leaves is similar to the production of mulberry paper (Charoenwichianchai, 2008), paper from tamarind leaves (Kusolsong & Koonkaew, 2013), paper from pineapple leaves (Anunvrapong, 2015), paper from Bagasse (Wangtan & Inchan, 2017), paper from elephant feces (Srikotaphet et al., 2017), and paper from rice straw (Khampan et al., 2017). They are traditional methods in producing papers without any complicated steps. Moreover, the materials and equipment in producing are also readily available in the local area.

Figure 1. Production Processes: A) boil the pulp to produce 100 per cent yellow Millettia wood leaf paper; B) yellow Millettia wood leaves mixed with banana plants at a ratio of 50:50; C) yellow Millettia wood leaves mixed with pineapple leaves at a ratio of 50:50; and D) lift the boiled pulp with a sieve.

Step 2: Conduct Physical Property Testing of the Three Types of Paper

Burst strength: it was found that all three types of paper have burst strength values of 75.00, 76.60, and 70.60 k.Pa, respectively. The leaf paper mixed with banana tree at a ratio of 50:50 per cent had the highest burst strength value. The burst strength refers to the ability of the paper to resist the pressure exerted upon the test sheets at a constant rate until the test sheet is torn. The burst strength value depends on the type, proportion, fibre preparation, and fibre additives in the paper sheets. In addition, the burst strength is an important property in products that experience internal pressure when coming out from a packaging box. The researcher considered that the paper product had a suitable penetration resistance for practical usability. Therefore, it is necessary to use a paper with a high burst strength due to the impact strength between the products and the box. The high burst strength paper indicates the ability to support the weight of products packed in boxes while they are being transported (Phatpun et al., 2014). Consistent with the study report of Ritthisorn (2013), who studied the production of paper from banana pulp using biological methods (the lignin fungus), it was found that the banana paper had a proper burst strength, which was suitable for practical uses.

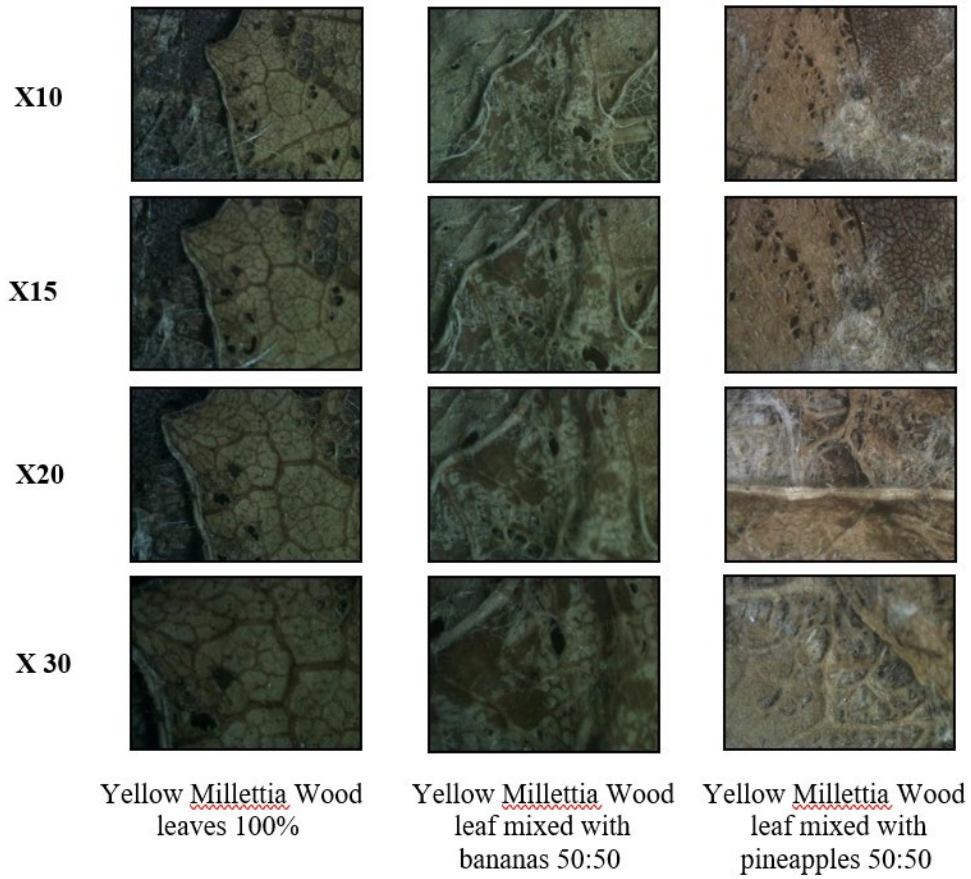
Tear resistance: from the study, it was found that all three types of paper had the tearing strength values of 471, 1640, and 706 mN, respectively. The leaf paper mixed with banana tree at a ratio of 50:50 per cent had the highest tearing strength value. The tearing strength value refers to the attribute of a paper that is tear resistant. The paper types which require testing of

the tearing strength are bag, printing, and writing paper (Pungrasmi & Hansuebsia, 1994; Somkeawwwaan, 2014). This finding related to the study report of Tangtaweewipat and Supapronhaemin (2013), who conducted the research on paper production from the waste of corn after harvesting. The results revealed that the paper from the waste of corns has a high tear resistance, which is suitable to be used as wrapping paper and single layer bags. Furthermore, it was also found that the paper can be used in art works, drawing, printing, and copying. Additionally, there is a result from the research of Areewong and Nakkarmtong (2012), who found that the production of paper from rice straw by using biological methods combined with a soda process produced paper with a high tear resistance value.

Basis weight: it was found that all three types of paper had a basis weight of 36.40, 30.00, and 21.50 g/m^2, respectively. The 100 per cent yellow Millettia wood leaf paper had the highest standard weight. Paper, in general, has a basis weight from 35–225 g/m^2. The paper that is produced at a level higher than 225 g/m^2 is always considered as a cover paper (Areewong & Nakkarmtong, 2012). The basis weight means the weight per area. Basis weights are related to the physical properties of paper, especially the strength of the paper. Although the basis weight does not relate to the paper property directly, it has a great effect on other properties. For example, the strength of the paper increases when the basis weight increases, which can be used in classifying the paper quality (Somkeawwwaan, 2014). This is consistent with the study from Leupong et al. (2017) who studied the production of paper from water hyacinth and agricultural waste. It was found that by using 70 per cent water hyacinth, ten per cent pineapple leaves, and 20 per cent leaf sheath of banana tree achieved paper with a basis weight of 183±5 g/m^2, which was suitable to be used in producing box paper for packaging purposes. Furthermore, the results reflect a study report by Khampan et al. (2017), who conducted a research on producing paper from rice straw and from agricultural wastes. It was found that the paper had the basis weight of 81.11 g/m^2.

Testing of physical properties: it is a test of external changes that can be observed, and the weight-light and width-length can be tested. The paper properties depend on the amount and substance in the materials. From this study, it was found that every type of yellow Millettia wood leaf paper was heavier than the normal paper that is currently used. Furthermore, when looking with only the naked eye, the colour of the 100 per cent yellow Millettia wood leaf paper is darker, followed by the 50:50 per cent yellow Millettia wood leaf mixed with banana tree paper, and the 50:50 per cent yellow Millettia wood leaf mixed with pineapple leaf paper, respectively. Moreover, when photographing the yellow Millettia wood leaf paper with the stereo microscope at 10-, 15-, 20-, and 30-times magnification, it was found that all three types of paper have a rough texture and show the specific characteristics according to the type of paper produced (see Figure 2 below).

Figure 2. The physical properties of the produced yellow Millettia wood leaf paper photographed by a stereo microscope at 10-, 15-, 20-, and 30-times magnification.



Step 3: Satisfaction Assessment of Yellow Millettia Wood Leaf Paper

The demographic information of the sample groups was obtained as follows, which collectively comprise 250 students from within the Product Design and Development Faculty at Rajamangala University of Technology Krungthep. In terms of gender, there were 96 (38.4 per cent) males, and 154 (61.6 per cent) females. The students were aged 18, 19, 20, 21, and over 22 years, which equated to 19 (7.6 per cent), 43 (17.2 per cent), 77 (30.8 per cent), 70 (28 per cent), and 41 (16.4 per cent), respectively. They were studying in the first, second, third, and fourth year levels, equating to 23 (9.2 per cent), 83 (33.2 per cent), 80 (32.0 per cent), and 64 (25.6 per cent), respectively. The male students were satisfied with the 100 per cent yellow Millettia wood leaf paper at 3.45±0.70, the leaf paper mixed with banana plants at a ratio of 50:50 per cent at 3.43±0.67, and the leaf paper mixed with pineapple leaves at a ratio of 50:50 per cent at 3.63±0.68. The female students were satisfied with the 100 per cent yellow Millettia wood leaf paper at 3.62±0.56, the leaf paper mixed with banana plants at a ratio of 50:50 per cent at 3.61±0.56, and the leaf paper mixed with pineapple leaves at a ratio of 50:50 per cent at

3.71±0.54, respectively. In conclusion, both male and female students were highly satisfied with the three types of papers.

The assessments of satisfaction of the 100 per cent yellow Millettia wood leaf paper was divided according to the following aspects. Satisfaction at a highest level was the aspect of natural color. Satisfaction at a high level were the beautiful pattern, the value of material, the paper thickness, the general property, the exotic texture, the mold formation prevention, handicraft jobs, packaging jobs, visual work job, decorative jobs and the paper utilization aspect. Satisfaction at a medium level including the tenderness, the variety of paper application, the aspect of paper flexibility, the paper toughness, the paper beauty with a contaminated substance, the uniqueness and wickerwork jobs, respectively.

In terms of the usability satisfaction of the 50:50 yellow Millettia wood leaf and banana plant paper was divided according to the following aspects. Most of the satisfaction assessments were at a high level, it is as follows the tenderness, the beautiful pattern, the aspect of natural colour, the value of material, the paper thickness, the variety of paper application, the general property, the exotic texture, the paper toughness, the paper beauty with a contaminated substance, the mold formation prevention, the uniqueness, handicraft jobs, wickerwork jobs, packaging jobs, visual work job, decorative jobs and the paper utilization aspect. Satisfaction at a medium level was the aspect of paper flexibility.

Lastly, in terms of the usability satisfaction of the 50:50 yellow Millettia wood leaf and pineapplee leaves paper was divided according to the following aspects. For this kind of paper, satisfaction is also high level. Which consists of the tenderness, the beautiful pattern, the aspect of natural colour, the value of material, the variety of paper application, the general property satisfaction, the exotic texture, the paper beauty with a contaminated substance, the mold formation prevention, the uniqueness, handicraft jobs, wickerwork jobs, packaging jobs, visual work job, decorative jobs, the paper utilisation aspect. Satisfaction at a medium level including the paper thickness, the aspect of paper flexibility and the paper toughness. (see Table 1).

Table 1: The Averages of the Satisfaction Assessments for the Three Types of Paper

Information	100% yellow Millettia wood leaf	50:50 yellow Millettia wood leaf mixed with banana tree	50:50 yellow Millettia wood leaf mixed with pineapple leaves
Tenderness	3.30±1.03	3.84±0.81	3.78±0.88
Beautiful pattern	3.79±0.96	3.77±0.90	3.86±0.89
Natural colour	4.31±0.74	4.02±0.78	3.91±0.90
Material value	4.07±0.87	3.88±0.78	3.80±0.86
Thickness	3.89±0.91	3.74±0.85	3.34±1.02
Variety of applications	3.34±1.13	3.67±0.98	3.62±0.96
General properties	3.78±0.61	3.82±0.56	3.72±0.64
Exotic texture	4.10±0.81	3.93±0.78	3.92±0.86
Flexibility	2.89±1.21	3.40±1.02	3.32±1.07
Toughness	2.96±1.12	3.44±0.93	3.39±1.01
Paper beauty with a contaminated substance	3.45±1.08	3.63±0.98	3.68±0.99
Mold formation prevention	3.29±1.06	3.34±1.03	3.38±1.06
Uniqueness	3.34±0.78	3.55±0.67	3.54±0.74
Handicraft jobs	3.58±1.11	3.86±0.87	3.84±0.94
Wickerwork jobs	3.16±1.06	3.50±0.98	3.53±1.01
Packaging jobs	3.44±1.10	3.66±1.02	3.73±1.01
Visual work jobs	3.49±1.04	3.64±0.97	3.70±1.01
Decorative jobs	4.05±1.01	4.02±0.91	4.13±0.86
Utilisation	3.54±0.78	3.74±0.67	3.79±0.71
Overall satisfaction of 100% yellow Millettia wood leaf	3.55±0.62	-	-
Overall satisfaction of 50:50% yellow Millettia wood leaf paper mixed with banana tree	-	3.54±0.61	-
Overall satisfaction of 50:50% yellow Millettia wood leaf mixed with pineapple leaves	-	-	3.68±0.60

Note: Satisfaction level 5.00-4.21 highest, 4.20-3.81 high, 3.80-2.61 medium, 2.60-1.81 low and 1.80-1.00 lowest.

Moreover, it was found that the satisfaction of the 250 students from the Design and Product Development Faculty with the three types of yellow Millettia wood leaf paper was statistically significant different ($p<0.05$) (see Table 2).

Table 2: A Comparative Analysis of Students' Satisfaction Assessments of the Three Types of Paper

Paper Types	df	Sum of squares	Mean squares	F	Significant
Overall properties of the three types of paper:					
Between groups	4	179.925	4.481	17.440	<0.05*
Within the groups	245	62.953	257		
Total	249	80.878			
100% yellow Millettia wood leaf paper:					
Between groups	4	18.149	4.537	13.896	<0.05*
Within the groups	245	79.994	0.327		
Total	249	98.143			
50:50 yellow Millettia wood leaves mixed with banana tree:					
Between groups	4	16.474	4.119	12.857	<0.05*
Within the groups	245	78.484	0.320		
Total	249	94.958			
50:50 yellow Millettia wood leaves mixed with pineapple leaves:					
Between groups	4	20.661	5.165	18.278	<0.05*
Within the groups	245	69.238	0.283		
Total	249	89.899			

Note: *there are statistically significant differences ($p<0.05$) at the 95 per cent confidence level.

When comparing the satisfaction levels of the students in the Product Design and Development Faculty with all three types of paper, it was found that there were statistically significant differences ($p<0.05$) (see Table 3).

Table 3: A Comparative Analysis of Students' Satisfaction Assessments in the Three Types of Paper

Paper Type	Related Fields of Product Design and Development				
	Industrial Product Design	**Crafts Technology**	**Printing Technology**	**Thai Wisdom Product Development**	**Textile and Fashion Design**
- Three types of paper	3.299[a]	3.882[b]	3.183[a]	3.684[b]	3.743[b]
100% yellow Millettia wood leaf paper	3.269[a]	3.840[b]	3.205[a]	3.697[b]	3.721[b]
50:50 Yellow Millettia wood leaf paper mixed with banana tree	3.539[b]	3.074[d]	3.224[a]	3.757[c]	3.837[c]
50:50 Yellow Millettia wood leaf paper mixed with pineapple leaves	3.369[a]	3.932[b]	3.204[a]	3.737[b]	3.739[b]

Note: the letters that are on different horizontal averages show a statistically significant difference ($p<0.05$) at the 95 per cent confidence level.

In terms of the students' satisfaction with the 100 per cent yellow Millettia wood leaf paper, it was found that there were significant differences ($p<0.05$) between the Thai Wisdom Product Development and Industrial Product Design branches, and the Thai Wisdom Product Development and Printing Technology branches. In the aspect of students' satisfaction with the yellow Millettia wood leaf paper mixed with pineapple leaves at a ratio of 50:50 per cent, there was a statistically significant difference ($p<0.05$) when comparing the satisfaction between the Thai Wisdom Product Development branch with the Industrial Product Design branch, the Thai Wisdom Product Development branch with the Textile and Fashion Design branch, and the Thai Wisdom Product Development branch with the Printing Technology branch (see Table 4).

Table 4: The Students' Satisfaction Assessments of the Three Types of Paper

Paper type	Comparison branches		Average difference	Significant
100% yellow Millettia wood leaf paper	Thai Wisdom Product Development	Industrial Product Design	0.385	<0.05*
		Textile and Fashion Design	-0.058	>0.05^{ns}
		Crafts Technology	-0.197	>0.05^{ns}
		Printing Technology	0.501	<0.05*
50:50 yellow Millettia wood leaves mixed with banana tree	Thai Wisdom Product Development	Industrial Product Design	0.428	<0.05*
		Textile and Fashion Design	-0.014	>0.05^{ns}
		Crafts Technology	-0.142	>0.05^{ns}
		Printing Technology	0.492	<0.05*
50:50 yellow Millettia wood leaves mixed with pineapple leaves	Thai Wisdom Product Development	Industrial Product Design	0.297	<0.05*
		Textile and Fashion Design	0.079	<0.05*
		Crafts Technology	-0.237	>0.05ns
		Printing Technology	0.612	<0.05*

Note: *there are statistically significant differences ($p<0.05$) at the 95 per cent confidence level and 'ns' have no statistically significant differences.

The students from the Product Design and Development Faculty had various needs and intentions for the use of the three types of paper. They wanted to use the three types of yellow Millettia wood leaf paper to make various products, such as multi-purpose shelves, notebooks, cards, paper, artificial flowers, gift boxes, paper bags, papier-mache products, two- and three-dimensional reliefs, mobiles, envelopes, and more (see Table 5).

These student needs were consistent with the study report of Charoenwichianchai (2008), who assessed the needs in products developed from mulberry paper, pineapple paper, and Flacourtia rukam paper. The results showed that the manufacturers, and those who are interested in the products, wanted products that are produced as wall-mounted objects with floral print patterns followed by scenery patterns. They also wanted a picture frame with floral print patterns followed by creative patterns, as well as notebooks with floral print patterns followed by creative patterns, and boxes with floral print patterns followed by creative patterns. This study also conformed to the research from Kusolsong and Koonkaew (2013), who revealed that the trainees in tamarind leaf paper production projects needed to develop notebooks, boxes, lamps, and mobiles from tamarind leaf paper. Moreover, this study is related to the research of Srikotaphet et al. (2017), who explored the use of elephant manure in the Surin Province to produce paper and develop sets of papier-mache elephants as souvenirs.

Table 5: A Students' Needs Analysis of the Three Types of Paper

Product Types	Product Type Selection	
	Number of students (repeat)	Percentage
Multipurpose shelf	140	19.4
Notebook	98	13.6
Paper card	87	12.1
Artificial Flowers	79	11
Gift box	71	9.9
Paper bag	64	8.9
Papier-mache	55	7.6
two-dimensional relief	54	7.5
three-dimensional relief	49	6.8
Envelope	21	2.9
Mobile	2	0.3
Others		
Total number of students	**720**	**100**

Step 4: 3D Sketching Development and Expert Evaluation

To develop a 3D sketching of multi-purpose shelf prototype products, the experts chose the 3D sketching type two (see Figure 3) because it was suitable to be used as a multi-purpose storage shelf prototype. The experts explained that the second type of shelves mixed Thai and modern styles with a unique design. It represented a contemporary design that can be used for various purposes. In addition, they recommended that the prototype should be adjusted in terms of the size to make it look more beautiful. The result related to the studies from Kusolsong and Koonkaew (2013), Anunvrapong et al. (2016a), Anunvrapong et al. (2016b), Anunvrapong et al. (2017b), Anunvrapong et al. (2017c), and Srikotaphet et al. (2017).

Figure 3. 3D sketch of a multi-purpose storage prototype products which were proposed to the experts for evaluation.

Pattern 1 Pattern 2 Pattern 3

Development of the Multi-purpose Shelf Prototype and Satisfaction Assessment

To create a multipurpose shelf prototype product, the researcher selected yellow Millettia wood leaf paper mixed with pineapple leaf at a ratio of 50:50 per cent, which had been evaluated as the most suitable paper type based on the fairness texture.

Creating a Multi-purpose Shelf Prototype Product

Product box:

a. Take the pattern mold to lay on the wood and mark the line clearly. Subsequently, cut the wood to the specified patterns.
b. Bring together the components of the wood pieces that were cut into the specified forms to assemble the specified structures. Afterwards, stick the components to each other (the product box, drawers, and squirrel house) with ready-made glue.

Squirrel body:

a. Tear the yellow Millettia wood leaf paper into small pieces to obtain the desired yellow Millettia wood leaf pulp.
b. Pour the resin into a glass containing yellow Millettia wood leaf pulp and mix them together.
c. Pour the yellow Millettia wood leaf pulp mixed with resin into the pre-made molds. Allow it to dry at room temperature until the work piece has hardened.
d. Take the work piece (squirrel) from the mold, and then put the work pieces together with the product box.
e. Finally, spray varnish onto the work piece thoroughly, letting it dry at room temperature (see Figure 4).

Figure 4. Assembled multipurpose shelf prototype products.

The Assessment of Multi-purpose Shelf Products

According to the student's satisfaction assessment, it was found that females had higher levels of satisfaction than males. All level of college having the highest level of satisfaction Moreover, in terms of the five branches — Thai Wisdom Product Development students have the highest level of satisfaction. Students in the fields of Industrial Product Design, Textile and Fashion Design, Printing Technology, and Crafts Technology were high satisfied level, respectively.

In terms of the product structure, the students were satisfied with the durability, neatness of products, suitability of materials, novelty of production techniques, suitable modern styles, and the balance of product proportions. The overall satisfaction in the product structure was highest. From the designing aspect, the students were satisfied with the appropriate and contemporary format. The squirrel clearly represents the Rajamangala University of Technology Krungthep; the colour of the product is appropriate, the texture of the product is appropriate, and the pattern of the paper clearly reflects the yellow Millettia wood leaf. Furthermore, the prototype products can be extended to other types of products. The overall satisfaction was high. In terms of beauty, the students were satisfied with the distinctive identity of yellow Millettia wood leaves, beautiful patterns, clear functions, uniqueness, complete details, and the beauty of the overall composition of the product. The overall satisfaction was high. For the functional aspects, the students accepted that the products are suitable for home decorations, use in offices, souvenirs, and multi-function products, and are easy to use and movable products. The overall satisfaction was highest. Furthermore, in the marketing aspect, the students commented that the product can serve for real needs, can be distributed, is suitable for people of all ages, and can be a

souvenir representing the Rajamangala University of Technology Krungthep. The overall satisfaction in this aspect was high.

To compare the satisfaction of the students within the Product Design and Development faculty (250 students), it was found that the students within the five branches difference were statistically significant at the 0.05 level ($p<0.05$) (see Table 6).

Table 6: Comparison of the Average Satisfaction of Students with the Multi-purpose Shelf Prototype Products

The product from yellow Millettia wood leaf paper	Faculty Branch				
	Industrial Product Design	Crafts Technology	Printing Technology	Thai Wisdom Product Development	Textile and Fashion Design
Prototype products	4.480^{ab}	4.240^{bc}	4.200^{c}	4.580^{a}	4.140^{c}

Note: letters that are on different horizontal averages show that there is a statistically significant difference ($p<0.05$) at the 95 per cent confidence level.

Comparing the satisfaction of students within the Product Design and Development Faculty's five branches, the results showed that the satisfaction in product structure and product beauty were statistically significant and different ($p<0.05$). Moreover, there was no statistically significant difference in the marketing aspect (see Table 7).

Table 7: The Average Comparison of Students' Satisfaction in Aspects of Structure, Beauty, and Marketing

Products	Student Branches				
	Industrial Product Design	Crafts Technology	Printing Technology	Thai Wisdom Product Development	Textile and Fashion Design
Structural	4.233^{ab}	4.130^{a}	4.196^{a}	4.393^{b}	4.233^{ab}
Beauty	4.160^{a}	4.086^{a}	4.179^{a}	4.442^{b}	4.069^{a}
Marketing	4.256^{a}	4.049^{a}	4.082^{a}	4.469^{a}	4.183^{a}

Note: letters that are on different horizontal averages show that there is a statistically significant difference ($p<0.05$) at the 95 per cent confidence level.

The overall satisfaction assessment of the students from the five branches was at the 'high level' (3.41–4.20). This related to the study of Boonyaruthukalin et al. (2002), who found that the satisfaction in products made from different kinds of rice straw paper was at a high level. Furthermore, Charoenwichianchai (2008) studied products developed from mulberry paper, pineapple paper, and Calabura paper to develop new product patterns for a particular

community. The satisfaction assessment was at a high level. Moreover, there was a research study conducted by Kusolsong and Koonkaew (2013), who studied the contexts and attitudes of tourists in an effort to develop ten types of souvenir products made from tamarind leaf paper. The satisfaction in the products was also at a high level. Wangtan and Inchan (2017) also developed paper products from bagasse. They mentioned that the paper can be used as a material in developing products. They were satisfied the most with a box product made from bagasse. Furthermore, there was a research study from Srikotaphet et al. (2017), who developed elephant dung paper products. The products from elephant dung were suitable to become souvenirs, which could be sold in the local market places.

The 250 students were asked, "Can this product be sold?". Two hundred and ninety-one students (87.6 per cent) accepted that the products could be sold. There were 30 students (12 per cent) who were uncertain if they could be sold or not. There was only one student (0.4 per cent) who mentioned that the products cannot be sold. If analysing the students' responses according to the branches, a majority of the Industrial Product Design students agreed that the products could be sold (45 students) while a minority was uncertain (5 students); a majority of the Crafts Technology students accepted that the products could be sold (41 students) compred to a minority who were uncertain (9 students); a majority of students from the Printing Technology branch believed that the products could be sold (40 students) with a minority who were uncertain (10 students); almost all students from the Thai Wisdom Product Development branch agreed that the products could be sold (49 students), with only one student remaining uncertain; and a majority of students from Textile and Fashion Design responded that the products can be sold (44 students), while a minority were uncertain (5 students) or believed they cannot be sold (1 student).

To answer the question, "How much should the products be sold for?", the students responded that they should be sold at 1,001–1,500; 1,501–2,000; 2,001–2,500 or 2,501–3,000 baht, which was equated to the number of students as follows: 130 (52 per cent), 78 (31.2 per cent), 34 (13.6 per cent), and eight (3.2 per cent), respectively. If analysing according to the students' branches, in Industrial Product Design it was found that the 33 students believed they should be sold at 1,001–1,500 baht, 14 students said 1,501–2,000 baht, three students said 2,001–2,500 baht, and no one believed they should be sold at 2,501–3,000 baht. Meanwhile, in Crafts Technology, 28 students believed they should be sold at 1,001–1,500 baht, 14 students said 1,501–2,000 baht, five students said 2,001–2,500 baht, and three students said at 2,501–3,000 baht. In Printing Technology, 27 students believed they should be sold at 1,001–1,500 baht, 15 students said 1,501–2,000 baht, eight students said 2,001–2,500 baht, and no one believed they should be sold at 2,501–3,000 baht. Within the Thai Wisdom Product Development branch, 11 students believed they should be sold at 1,001–1,500 baht, 17 students said 1,501–2,000 baht, 17 students said 2,001–2,500 baht, and five students said at 2,501–3,000 baht. Lastly, among Textile and Fashion Design students, 31 students believed they should be sold at 1,001–1,500

baht, 18 students said 1,501–2,000 baht, one student said 2,001–2,500 baht, and no one believed they should be sold at 2,501–3,000 baht.

When using a Chi-square statistics test to analyse the answers to the question, "Can the prototype product be sold?", all students' answers were not significantly different. For the responses to the question, "How much should the product be sold for?", the answers from all students were statistically significant and different ($p<0.05$). However, the results were not statistically significant and different when the genders were analysed (Tables 8 and 9).

Table 8: The Chi-square Statistics Test According to Pricing the Product

Selling Price (Baht)	Branches					Total
	Industrial Product Design	Crafts Technology	Printing Technology	Thai Wisdom Product Development	Textile and Fashion Design	
1,001–1,500	33^{a}	28^{a}	27^{a}	11^{b}	31^{a}	130
1,501–2,000	14^{a}	14^{a}	15^{a}	17^{a}	18^{a}	78
2,001–2,500	3^{ab}	5^{ab}	8^{b}	17^{c}	1^{a}	34
2,501–3,000	0^{a}	3^{ab}	0^{a}	5^{b}	0^{a}	8
Total	50	50	50	50	50	250

Table 9: The Chi-square Statistics Test According to Pricing the Product

Selling price (Baht)	College Years				Total
	Year 1	Year 2	Year 3	Year 4	
1,001–1,500	22^{a}	22^{a}	25^{a}	61^{a}	130
1,501–2,000	9^{a}	20^{a}	13^{a}	36^{a}	78
2,001–2,500	14^{a}	7^{b}	3^{c}	10^{b}	34
2,501–3,000	0^{a}	4^{a}	0^{a}	4^{a}	8
Total	45	53	41	111	250

Note: the letters that are written on different horizontal numbers show that there is a statistically significant difference ($p<0.05$) at the 95 per cent confidence level.

RESEARCH SUGGESTIONS

1. There should be the development of colours, sizes, thickness, and patterns of yellow Millettia wood leaf paper, which can be created as contemporary multi-purpose storage racks.

2. Yellow Millettia wood leaf paper should be developed as appliances, souvenirs, and other home decorations to enhance the community handicrafts industry.

3. Further research should study other kinds of leaves that can represent the community identity, just as the development of the yellow Millettia wood leaf was used in this study.

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