A RESEARCH ON THE POTENTIAL OF LOCAL NATURAL FIBER TO PRODUCE HANDMADE PAPERS FOR DRAWING, PAINTING AND PRINTMAKING

By

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Table of Contents

List of Tables

List of Figures

SATU KAJIAN TERHADAP POTENSI SERAT SEMULAJADI TEMPATAN UNTUK MENGHASILKAN KERTAS BUATAN TANGAN UNTUK KEGUNAAN LUKISAN, CATAN DAN SENI CETAKAN

ABSTRAK

Kertas dibuat daripada bahan mentah yang telah ditumbuk dan dihancurkan menjadi gentian halus. Seterusnya gantian ini dicampur dengan air dan dibentuk menjadi kepingan atau helaian di atas permukaan skrin yang menapis kandungan air dari gentian berkenaan. Gentian halus yang telah dinyah ini akan berpaut dan membentuk sehelai kertas apabila ditekan dan dikeringkan. Bahan-bahan mentah yang boleh digunakan untuk menghasilkan gentian tersebut adalah dari sumber tumbuh-tumbuhan seperti tumbuhan basta, kulit kayu dan jenis-jenis rerumput.

Pemodenan pembuatan kertas menggalakkan pengeluaran kertas secara besar-besaran menggunakan pulpa kayu. Penciptaan mesin pulpa telah menamatkan penggunaan kain pulpa dan serat tumbuhan yang telah diamalkan dalam pembuatan kertas selama 2000 tahun sebelumnya. Perubahan ini memulakan era baru bagi pengeluaran kertas. Hampir semua kertas hari ini adalah dibuat daripada pulpa kayu. Walau bagaimanapun, kertas yang dihaslikan secara industri moden menggunakan pulpa kayu tidak sesuai digunakan untuk karya seni. Ini kerana kertas perindustrian mempunyai kandungan asid yang tinggi akibat pemprosesan pulpa kayu. Kertas berasid perlu dielakkan penggunaannya oleh pelukis kerana kertas berasid bertukar menjadi kuning dengan cepat dan boleh mempengaruhi secara negatif nilai ketahanan dan aspek estetika karya seni. Oleh itu, kertas untuk tujuan seni lukisan, seni cetak dan seni catan masih bergantung secara dasarnya kepada proses kertas buatan tangan.

Kajian ini menyelidik potensi gentian asli tempatan untuk menghasilkan kertas buatan tangan yang khusus bagi tujuan untuk seni lukisan, catan dan seni cetakan. Ia bertujuan untuk memajukan lagi penyelidikan berkenaan kertas buatan tangan yang sedia ada di pusat pengajian Seni USM ke arah aplikasi khusus bidang ini untuk menghasilkan kertas buatan tangan yang dikhaskan untuk kegunaan seni tampak. Dalam kajian ini kertas berkenaan dihasilkan daripada gentian asli yang diperolehi daripada tumbuhan pisang, kantan dan mengkirai. Kertas buatan tangan ini kemudiannya melalui ujian makmal dan juga dinilai oleh beberapa seniman terkenal di Malaysia untuk mengenal pasti kualiti dan potensi kertas-kertas berkenaan.

A RESEARCH ON THE POTENTIAL OF LOCAL NATURAL FIBER TO PRODUCE HANDMADE PAPERS FOR DRAWING, PAINTING AND PRINTMAKING

ABSTRACT

Paper is made of a raw material that has been beaten and broken down into tiny fibres, mixed with water and formed into sheets on a screen surface that catches the fibres as the water drains through it. The individual fibres interlock and form a sheet of paper when pressed and dried. The raw materials producing such fibres include the bast plants, tree bark, stalks of grasses, and other vegetation.

The modernization of papermaking made it possible for mass-production of paper using pulped woods. The invention of pulping machine would end the nearly 2000-year use of pulped rags and plant fibres, and start a new era for the production of newsprint. Eventually almost all paper that we know today is made out of pulped wood. However, industrialized papers made from wood pulp are not suitable to be used for artworks. This is because industrialized papers have high acid content due to the processing of the wood pulp. Acidic papers must be avoided at all cost by artists because these papers turn yellow quickly in time, negatively affecting the durability and aesthetic value of the art work. Therefore, rather than relying on the industrial process of papermaking the production of art papers that is used for drawing, printmaking and painting remains heavily based on the handmade process.

This research investigated the potential of natural fibres available locally to produce specialized hand-made art papers for drawing and painting. It intended to further develop the existing research on hand-made papers at the USM School of Arts towards a specific application to produce hand-made papers specifically tailored for artistic use. Papers were made from natural fibres obtained from banana, *kantan* and *mengkirai* for artistic purposes. The handmade papers were then evaluated through performing laboratory tests and assessed by several well-known Malaysian artists to compare their performance against commercial papers.

Chapter 1: Introduction

Introduction

This research examines the potentials of local plant fibres to make handmade paper for drawing and painting. Generally, paper is made from bast plant fibres that have been beaten and broken down into tiny fibres, mixed with water and formed into sheets on a screen surface that catches the fibres as the water drains out. When the individual fibres are pressed and dried, they interlock and form a sheet of paper. The raw materials applied for producing such fibres include the bast plants, tree bark, stalks of grasses, and other vegetation. Traditionally, Chinese papermakers used to apply almost all kinds of plants known to modern paper industry. Earliest historical record of papermaking goes back to China in 105 A.D. It then spread to Japan by 615 A.D. Chinese papermaking techniques and processes were introduced to the Middle East during the time of the Islamic empire in the 8th century. This passed the way for the papermaking to go to Europe, where it was modernized and industrialized in the 18th century.

The modernization of papermaking made it possible for mass-production of paper using pulped woods. The invention of pulping machine would end the nearly 2000-year use of pulped rags and plant fibres. This initiated the production of newsprint. Eventually, almost all papers known today are made out of pulped wood. However, industrialized papers made from wood pulp are not suitable to be used for artworks. This is due to high level of acid in industrialized papers, as a result of processing the wood pulp. Acidic papers must be avoided at all cost by artists

because these papers turn yellow quickly in time, negatively affecting the durability and aesthetic value of the art work (Fig 1.1- 1.2).

Figure 1. 1: Muzium Tuanku Fauziah[1]

Figure 1. 2: Detail of figure 1.1

Figure 1. 3: Penang State Gallery[2]

Figure 1. 4: Detail of figure 1.3

[1] Artist: Jaini Salleh, Title: Pena Revolusi Budaya, Medium: Lino Print, Size: 18 x 27 Inches, Year: 1979

[2] Artist: Tan Chiang Kiong, Title: Lotus, Medium: Watercolour, Size: 55 x 54 cm, Year: 1996

This research investigates the potential of natural fibres from native plants (banana, *kantan* and *mengkirai*) to produce specialized hand-made fine art papers for drawing, painting and printmaking. Preliminary findings indicate that the bast fibres from local plants have enough elasticity, flexibility, and tensile strength for making hand-made art papers. Papers made from local natural fibres in this research are highly responsive to both wet and dry mediums. They produce a wide range of line qualities using pencil, charcoal, acrylic, and ink. They also allow for excellent tonal variations and are versatile for executing different mark-making techniques. Overall, this study aims to develop the existing research on hand-made paper at the School of Arts, USM, in order to produce hand-made papers specifically tailored for artistic use.

Research Background

The Fine Art department at the USM School of the Arts is the only department in Malaysia that has papermaking research facility. The present research essentially builds from papermaking researches at the USM School of the Arts on local plant fibre. Some of the previous investigations involving local plants include one entitled 'Papermaking from Selected Malaysian Fibres: An Investigation of Its Artistic Potential Through the Creation of Original Paper Artworks', conducted by Dr. Chew Teng Beng in Universiti Sains Malaysia (USM) in 1983. There has also been another research by Chew Teng Beng (1984) in Universiti Sins Malaysia, on local plants such as banana, pandanus and pine apple fibres to produce fine art papers[1]. And later in 1997, at Universiti Sins Malaysia, researchers produced pulp from banana stem for

[1] Papermaking From Selected Malaysian Fibers: An Investigation of Its Artistic Potential Through Creation of Original Paper Artworks

making banana fibre-based products such as paper, flour, etc[1]. In this regard, Mr. Adnan Mat has lead and developed researches on handmade papers from banana trunk in the School of the Arts at USM in 2009. He made banana papers for printmaking and producing handicrafts. He collaborated with his project team members that include Prof. Madya Baharin Azhari (school of Industrial Technology), Dr. Mazlan Ibrahim (School of Industrial Technology), and Prof. Omar bin Bidin (School of the Arts) . Furthermore, another research entitled 'Going Bananas: A lesson in sustainability' conducted by Universiti Sains Malaysia in 2007, indicated that the expired stem of banana is an excellent source of pulp to make paper due to its high content of bast fibres. Another research has been done by Dr. Leh Cheu Peng, in the School of Industrial Technology in USM, during 2006 to 2008, entitled 'The Production of High Quality Pulps and Papers by Using Environmentally Compatible Chlorine-Free Bleaching Sequences'. While the latter's research is not directly related to the current study, it still involves papers and tried to use some safe chemical during bleaching process. Moreover, at the same school, Ms. Asmahaida Binti Mohamad Noor, has worked on banana's pseudo-stem through a research entitled 'Outer Periphery of Banana (*Musa paradisaca var abu*) Pseudo-Stem Sheath PLY's Properties' in 2012.

While papermaking researches at USM has been steadily developed as indicated above, none of the researches has delved into investigating the use of local plant fibres to produce fine art papers for drawing and painting, which is the subject of the present thesis.

[1] Going Banana

Definition of Paper

Apart from papermaking research/activities in local context, this research relies heavily on a more general and global development of papermaking. Merriam-Webster defines paper as "a substance made in the form of thin sheets or leaves from rags, straw, bark, wood or other fibrous material, for various uses." More specifically, paper may be made from pounded, bruised, or shredded cellulose-fibered material, including linen or cotton rags, straw, bark, wood, and almost all the living plants on this good earth (Heller, 1978).

Many substances were used as writing surfaces before paper was developed. As early as the 14th century, the Chinese inscribed marks on bones. In Egypt and some other countries, hieroglyphs were carved in monuments of stone and written on papyrus. Before the invention of paper, writing in China was done on bamboo strips or pieces of silk. Native plants were used to make paper in many countries such as China, Japan, Korea, Thailand, Nepal, India, and etc. (Hiebert, 2000).

Earliest historical record of papermaking goes back to China in 105 A.D., followed by Japan at 615 A.D. (*Ibid*.). Around 610 AD, China, Korea and Japan were among the first countries which exported art of papermaking (Holik, 2006; Mahdavi, 2003). Around 750 A.D. some Chinese paper makers were captured by the Turks during the battle at Samarkand[1] (Chew, 2011; Hibert, 2000). Consequently, papermaking techniques and technology became transplanted into the Islamic

[1] Samarkand is the second-largest city in Uzbekistan. This city's position is in central on the Silk Road between China and the West.

empire. Then, the knowledge of paper making was spread through Arabic people during their military campaigns in the North of Africa and the South of Europe, reaching towards Egypt and North Africa. Under the Islamic empire the process of papermaking was refined and machinery was designed to manufacture papers in bulk. This turned papermaking from an art into a major industry. Paper manufacturing began in Baghdad under the supervision of the Grand Vizier Ja'far ibn Yahiya[1] , who invented a method to make a thicker sheet of paper. The earliest references to paper mills come from the medieval Islamic world, where they were first noted in the 9th century by Arabic geographers in Damascus (Holik, 2006; Mahdavi, 2003).

Papermaking was diffused across the Islamic world, reaching North Africa and then further west into Europe via Spain (Bloom, 1999). In 1144, the first paper was made in Europe in Xativa (near Valencia) in Spain. Around the same time, papermaking reached Italy. A paper mill in Fabriano (near Ascona) in Italy existed in 1276, which still exists nowadays. Around the time, Italians invented sizing paper with animal glue. The Germans had their first paper mill in 1389, followed by the rest of Europe at the end of the 15th century. In Belgium the first paper production was in Huy (Hoei) in 1405, while the first paper production in Holland occurred only in 1586 in Dordrecht (Staff-Sacilotto, 1978).

[1] Vizier Ja'far ibn Yahiya (767-803), was a member of Barmakids Family, and also Harun al-Rasid's, Abassid Caliph's minister. He got credit from caliph to open a paper mill in Baghdad.

Papermaking was then modernized and industrialized in Europe. Nicholas Louis Robert[1] produced the first papermaking machine in France in 1798, which was perfected in England by the Foudrinier brothers in the early 1800's (Hiebert, 2000). Before the invention of the Fourdrinier machine, paper had to be produced in single sheets. The fourdriner machine made it possible for paper to be mass-produced in a continuous rolls rather than individual sheets. These machines were very large, up to 500 feet (~150 m) in length, producing a sheet 400 inches (~10 m) wide, and operating at the speed of over 60 mph (100 km/h). In 1844, both Canadian inventor Charles Fenerty and German inventor F.G. Keller had invented the machine and process for pulping wood for the use in papermaking. This ended the nearly 2000-year use of pulped rags and started a new era for the production of newsprint and eventually almost all paper out of pulped wood (Burger, 2007).

The papers based on wood pulp are mainly produced for newspaper and computer paper. However, they are not suitable to be used for artworks. Their stability and permanence did not seem to match those of better-grade rag papers. These papers turn yellow quickly chemical treatments using acid sulphite (PH around 2) and don't have the durability and aesthetic value required for art works. These have acid content due to the processing of wood pulp (Mayer, 2000; Turner & Skiöld, 1983; Woods, 2001).

[1] Nicholas Louis Robert Around (1761-1828), was a French mechanical engineer, who was invented Papermaking Machine. His invention became the core of the Next (Fourdrinier) machine, and the basis for modern papermaking.

The Significance of Paper as a Surface

Paper has been used as the ground for drawing and painting since ancient time. The surface of paper is the most important foundation for drawing and printmaking (Thompson, 1992). Paper is used every day for thousands of purposes. Handmade paper, especially, is one of the artists' and printmakers' major raw materials and the cheapest and most easily available material to use for many.

Although the principal role of paper is simply to act as a medium to support and hold together the printed, painted, written or drawn image, it has other functions, too. Paper sets the limits as to how accurate a printing job can be and how a work is viewed, as the shade and texture of a sheet adds to the impression made by the final work. Hence, the selection of paper is of utmost importance.

The most important factor in papermaking is the quality of art materials. For example, higher quality papers are much more responsive to ink and pigment as well as to the artist's touch. The type of paper used, ink absorbency, diffusion directions, and diffusion patterns vary based on the fibre's type of materials and fabrication. Paper does not only function as mere support for drawing and painting, but is also considered as an integral creative element in art work. Therefore, it determines the final result of the artwork, while affecting the artist's engagement with the drawing or painting during the process of making (Albert &Wolf, 1991).

Problem Statement

Wood pulp is the main source of producing modern industrial papers such as newspaper, and computer paper. It would be bleached in a sulphite or peroxide

solution in order to clarify the natural dark tint of wooden pulp and produce light tinted paper. Since industrialized papers have high acid and lignin[1] content, they are not suitable for artistic use, and turn yellow in time, thus negatively affecting the durability and aesthetic value of the art work. Hence, in the production of fine art papers, the use of wood pulps is avoided and replaced with rags and plant fibres. Furthermore, the use of wood pulp will increase the production cost of fine art papers because it will require more extensive chemical treatment (Woods, 2001). Moreover, recycling can assist in the reduction of the amount of forests being harvested. The cost of collection and reproduction, coupled with the continuous deterioration in quality of recycled fibre, means that it can only be recycled a handful of times and then only be applied into inferior products. Hence, there is a need for a sustainable solution for the use of a renewable source of fibre such as banana/*kantan* stems and *mengkirai* bark (Adnan Mat, 2010).

The time required for producing paper through natural fibres is shorter than papermaking through wood. This is due to the different processes to apply chemicals for bleaching in case of the latter. Moreover, the cost for raw materials (in this case banana/*kantan*/*mengkirai* fibres) would be significantly lower. The production costs for banana, *kantan* and *mengkirai* papers are esteemed to be less than one-fifth of the costs for traditional pulp paper, and the required capital investment would be just 3% of those required for pulp paper production (*Ibid.*).

Given the above, the current study aims to investigate the potential of natural fibres obtained from banana, *kantan* and *mengkirai* plants to be used for making

[1] Lignin is binds cellulose fibres together. It's approximately up to 30% of the wood pulp's bulk. Lignin can repels water, because of clumping in paper pulp during manufacture, and it would be acidic and turns yellow or brown with age.

handmade art papers which are available in the tropical region of Penang, at the northern part of the Malaysian Peninsula located in the equatorial region of Southeast Asia

Objectives of the Study

According to the outlined problems of modern papers made of wood pulp and their lack of durability and aesthetic value, this study was set out provide a solution by using natural fibres which can be found in Malaysian local plants to provide a ground for producing handmade art papers with lower cost, yet higher quality. Since Malaysia is located in the equatorial Southeast Asia, it has a hot, humid, and tropical climate, and rich rain forests. Due to the type of atmosphere of the region, many types of plants grow in equatorial rainforests. Over 20,000 species of plants can be found in Malaysia, most of which are rich sources of bast fibres (Moore & Garratt, 2008) that are well-suited for papermaking. Bast plants have strong woody fibres obtained especially from the phloem (the inner bark or the skin) of various plants. They support the conductive cells of phloem and provide strength to stem. Therefore, this research aims to make handmade art papers using natural fibres obtained from banana, *kantan* and *mengkirai* plants, which are available in the tropical region of Penang, and evaluate their suitability for various art mediums.

Since there is no significant previous study which has used these plants as potential raw materials for making fine art papers in Malaysia, they were selected for the current study. Overall, the objectives for this research are as the following:

1) To identify the potentials of selected local natural fibres to make fine art papers
2) To review the process of hand-made papermaking pertaining to local plant fibres
3) To produce fine art papers suitable for drawing and painting using local plant fibres

Research Questions

In line with the objectives of this study, the following research questions were formed:

1) Do the selected local natural fibres (banana, *kantan* and *mengkirai*) have the potentials to be used for art papers?
2) What is the process of handmade papermaking involved?
3) Are they produced handmade fine art papers suitable for drawing and painting?

Scope and Limitations

The scope of this research is focused on investigating the potentials of local natural fibres available in Penang, in making art papers. Fibres from banana, *kantan* and *mengkirai* plants are chosen for this research because they are rich source of cellulose. Cellulose fibres are largely used for papermaking. Apart from cellulose content, the selected fibres for papermaking are chosen for their specific qualities, including strength, softness, flexibility, texture, natural colour, and absorbency.

Furthermore, these three plants are highly available because they grow easily in tropical South East Asia. Moreover, the papers produced from banana, *kantan* and *mengkirai* are mostly suitable for dry and wet drawing and painting medium.

The scope of this study is limited to only three types of local plants, namely banana, *kantan* and *mengkirai*. Besides, these plants might not grow with the same quality in other regions or habitats. Hence, the findings of this study might be limited to the context and certain quality of the local plants applied in the research.

Finally, three kinds of banana/*kantan*/*mengkirai* papers were made in this research. (1) Pure *banana*/*kantan*/*mengkirai* pulp, (2) 70% banana/*kantan*/*mengkirai* pulp mixed with 30% recycle paper's pulp, and (3) 70% banana/*kantan*/*mengkirai* pulp mixed with 30% calcium carbonate. These plants were chosen due to their characteristics which make them suitable for paper making. All of these plants are rich in fibre and have high-tensile fibre structure which makes them a good choice for papermaking. Additionally, they are largely available in South-East Asia and rapidly grow again after being harvested. Besides, the *mengkirai* plant is poisenous d applying it in papermaking provides the potential of using the plant for helpful an .applications

Notes on the Fibers Explored in this Research

For this study, banana, *kantan*, and *mengkirai* have been chosen. All these plants are natural local plants which are available in Penang, Malaysia. Since Malaysia is a tropical country, it is rich in high cellulose natural plants, which have the potential to be used for papermaking. For the current research, the selected plants (banana, *kantan*, and *mengkirai*) were identified after discussion and consultation

with experts and pioneers in papermaking in Malaysia and field supervisor for the study. Furthermore, these plants are easily available as they grow up quickly after harvesting. They are rich sources of bast fibres, and have a high tensile straight. Furthermore, banana pseudo-stem has been studied in the pulp and papermaking industry (Asmahaiza, 2012). Guha (1960) studied the Kraft pulping process of banana pseudo-stem and determined the chemical compositions of banana pseudo-stem (Li et al., 2012; cited by Asmahaiza, 2012). While information on banana and *mengkirai*'s fibre's chemical composition are available, there is a dearth of existing information about the *kantan*.

Banana and *kantan* have been used for papermaking through handmade papermaker. However, *mengkirai* hasn't been used earlier to make paper. Overall, this study is among the first of its kind to use the above mentioned three plants to produce fine art papers.

Banana

Banana (Musa Acuminata x Balbisiana Colla, commonly known in Malaysia as "*Pisang Awak*") is a kind of herbaceous flowering plant with underground rhizomes which produce tall pseudo stems with very large leaves (Mason, 1979). They are generally smaller than the commercial bananas. Different kinds of banana are grown abundantly in South and Southeast Asia including Malaysia, Indonesia, New Guinea, China, and the Philippines. Banana is grown from crown. On average, banana plants reach a height of 6 to 7 meters, while the leaves become around 2.7 meters long and 60 cm wide. In Southeast Asia, all the parts of banana's plant are used, such as stem, leaf and fruit (Figure 1.5- 1.6). Since the pseudo-stem of banana fibre has high

specific strength and lower strain at break, thus banana is an excellent source of pulp for papermaking (Mohapatra et al., 2010; cited by Asmahaiza, 2012). The fibres in banana stem have enough elasticity, flexibility, and tensile strength for making hand-made art papers (Figure 1.5-1.6). Banana trunks are considered as wastes after the fruits are harvested and are usually left to rot in field (Adnan Mat, 2010; Ploetz, etal. 2007; Warren, 1996).

A recent research conducted at School of the Arts in Universiti Sains Malaysia (USM) successfully turned the banana trunk waste into useful handmade papers

Figure 1. 5: Banana tree

Figure 1. 6: Banana stems

Kantan

Torch ginger (Etlingera Elatior), or *kantan* as it is known locally, is a flowering plant which grows wildly. Torch ginger is a tropical flowering plant. Both leaf and flower stalks emerge separately from underground tubers. This ornamental plant is native to some parts of Southeast Asia such as Malaysia and Indonesia. It has a green, hairless leaves, which are up to 5 meters long (Warren, 1996). The height of

Torch-ginger tree reaches up to 1.5m and green-stalk flowers emerge from fleshy underground rhizomes. The *kantan* stalk is a rich source of cellulose and bast fiber which has enough elasticity, flexibility and tensile strength to make papers (Ibid.) (Fig 1.7- 1.8). A *kantan* plant grows quickly. Besides, it doesn't have fruit, so, it can be cut and used for papermaking anytime. Hence, it is an appropriate plant to be used for paper making in the current study (Wong, 2008).

Figure 1. 7: Kantan plants

Figure 1. 8: Kantan stalks

Mengkirai

Mengkirai (Trema Orientalis) is a kind of evergreen local plant which grows in Tropical areas, such as tropical East Africa, Madagascar, Pakistan, India, and Southern China to New Guinea, Australia, Indonesia and Malaysia. It is called *mengkirai* in Malaysia, and has some other common names such as "*Native Peach"* and "*Poison Peach"*. The *mengkirai* is a medium-sized tree that grows well in rainforests (Figure 1.9). The height of small *mengkirai* tree reaches up to 8 meters and the diameter of the stem is around 15 cm. The plant produces canopy quickly

which can be lifted by trimming the lower branches. It has very small greenish flowers and small black fruits. Poison peach leaves are reported to be toxic. Nonetheless, fruits and leaves are eaten by local birds and caterpillars. Since its smooth and greyish bark is rich in cellulose, it gives the fibre good flexibility, strength and texture, and makes it suitable for making art papers (Figures 1.9-1.10-1.11) (Jahan & Mun, 2003; Comprehensive information can be found at: http://www.saveourwaterwaysnow.com.au/01_cms/details_pop.asp?ID=334).

Figure 1. 9: Mengkirai tree

Figure 1. 10: Menkirai (Complete) bark

Figure 1. 11: Menkirai (Internal) bark

Thesis Structure

While *chapter 1* provided an introduction to this research by explaining the objectives of the research, its significance and limitations, *chapter 2* will review the literature with regards to papermaking and provide the foundation for this research. *Chapter 3* presents the necessary information on how to select the suitable paper for particular artworks by explaining the types and characteristics of fine art papers for drawing and painting. *Chapter 4* explains the key components of plants required for papermaking and illustrates the three plant fibres, namely Banana, *kantan*, and *mengkirai*, applied for making handmade papers in this study. Additionally, the results of several tests indicating chemical composition of some of these fibres were mentioned.

Chapter 5 explains the general method for making papers, followed by the method applied in this research for papermaking. Moreover, the procedure for some quality tests undertaken in the current study was illustrated. *Chapter 6* explains the results of the research obtained from the quality tests at Industrial Technology Laboratory. Additionally, *chapter 7* presents the empirical results obtained from the surveyed artists. Lastly, *chapter 8* recapitulates the study and explains its key findings, contributions and potential areas for future research.

Significance of the Study

The production of high quality local art papers will have significant impact on national artistic life. Since all of the local art shops sell only imported art papers, artists and art students are highly dependent on using imported papers, which are often very expensive. Since Malaysia has the potential plants to produce handmade art papers, the findings of this research have significant practical contributions to the local artists and art students to apply plants as the main source for producing art papers in the country. Besides, it goes without saying that this research has an excellent potential for commercialization, providing cheaper yet high-quality alternatives for local artists and art students. Hence, it enables them to be more self-sustaining by reducing their reliance on expensive imported art papers. Furtheremore, using banana plant for papermaking upon harvesting, brings the friendly recycle of the -in an eco remaining of the plant into the process and results mentioned plants fosters the application of local -plant. Overall, applying the above .plants in a green production and enhances the sustainability of local plantation

It is also expected that this research shall bear a promising future in the enhancement of human capital and commercial potential for Malaysia. These aspects of handmade papers have been amply proven in Thailand, India and Nepal where careful coordination of handmade paper activities are turned into a communal industry that resulted in economic empowerment for the rural citizens (Biggs, 2005; Ganguly, 2004; Poudyal, 2004). Indeed, the present research may embrace similar aspiration by disseminating the knowledge on the value of recycled fibres to local communities.

Chapter 2: Review of Literature

Introduction

This chapter reviews a series of preliminary studies on paper, papermaking history, handmade papermaking techniques and methods. It provides insights about the history, materials, and machineries of papermaking from its early history to the modern time.

Early History of Paper Making (China, Japan, and Arab Countries)

Before invention of paper, in the ancient times, numerous materials such as stones, clay tiles, bones, metals, skins, leaves of certain plants, waxed wooden tablets, linen and silk fabrics were used for writing and drawings. However, tablets were the most common ones among the antecedents of paper. The marks on the tablets could not be reversed, because those marks were made by awl on the tablets and there was no way to correct the writing.

Clay and wax tablets were more practical for writing because their surfaces were more malleable, and they occupied less space. Tablets made of fresh clay were used in Mesopotamia. In London's British Museum, for example, there are more than 20000 clay tablets from the library at Nineveh constructed by Ashurbanipal from the 7^{th} century BC. Wax tablets were used in classical Greek and Roman cultures, and continued to be used until the Middle Ages. These tablets were composed of wooden or metal sheets covered with a layer of wax on which to write. The Romans referred to these as *tabula* or *tabella*. The wax tablets were written on with a pointed metal

awl (*Stilus*), the other end of which was either flat or spherical and could be used as eraser to make correction. When a document included more than one tabula, it formed a *tabuladipticha*, *triptica*, or *polipticha*, depending on the number of tablets. Metal plates made of bronze or lead were other surfaces for writing. Although complicated to write on, metal plates proved to be extremely stable and have consequently survived since the days of ancient Rome. Stone and bronze slabs called steles are some of the largest and heaviest historical pieces bearing inscriptions. As civilization evolved, there was an obvious need for a lighter material that could be easily stored and transported. As a result, three fibrous materials with similar characteristics were developed independently in three locations around the globe: papyrus in the Mediterranean, pre-Columbian paper in America, and paper in the Far East (Asuncion, 2003, p. 10; Munsell, 1980; Studley, 1977).

The Egyptian used Papyrus as early as 3200 B.C. Its use lasted until the paper production began to replace papyrus. Papyrus is a plant which grows on the banks of rivers particularly the Nile. Its pretties of papyrus allow its leaves to be worked to form continuous, broad, smooth surfaces that are very similar to paper. Layers of leaves were placed parallel to one another at the right angles before being beaten to release a natural liquid that bound them together in a single sheet. Normally, sheets of papyrus measured about 12 to 20 inches long and 12 inches wide (30.5 to 50.8cm x 30.5cm). They were rolled up or kept flat in a volume. Because of the flexibility of papyrus, a long strip of joined pages could be rolled scroll. Some scrolls were as long as 20 to 40 yards (18 to 36m). To prepare the papyrus, its surface was polished using marble or agate. A quill called a *calamus* (reed), cut in the shape of a function pen, was used for writing on it. Later, this tool was used on parchment, and quills made

from bird feathers were used in Christendom (Asuncion, 2003, p. 11; Munsell, 1980; Studley, 1977).

By the end of the 4th century, parchment became popular and a bound codex format was used for writing. The nomadic populations of Asia Minor were the first to use parchment, and documentary evidence is available of this fact from the ancient Greek city of Pergamum from the years 258 to 197 B.C. The skins used were mainly from domestic animals such as calves, sheep and goats, although it could be from other animals too. Parchments quickly passed into widespread use and as a result, the library in Pergamum accumulated more than 200,000 volumes. Persian and Greek kings used parchment for writing laws and answers from the oracles. The Roman philosopher and statesman Cicero (106 to 43B.C.) claimed that the Greek poet Homer wrote *the Iliad* on parchment (Asuncion, 2003; Hiebert, 2000; Munsell, 1980; Place & Lane, 1965; Studley, 1977).

One variety of parchment was *vitela*, which yielded the finest and lightest type of parchment. It was prepared by removing the flesh and fat from animal skin using a scraper before soaking, drying, rubbing with plaster, and smoothing it. Until the 13thcentury, parchment sheets were usually made in monasteries. As making parchment became more widespread, guilds were organized. For a long time, parchment competed strongly with papyrus. The fact that parchment was more expensive than papyrus did not hinder its growth at that time, because its superior durability and functionality overcame this obstacle. The Latin name given to parchment over its long development period was *pergamena*. As with papyrus, the writing implement was the *calamus*. Scrolls are the oldest parchment documents and by the 5th century, both sides of the sheet were written on. Since parchment was

made from animal skins, it was difficult to produce the supply needed for libraries and other users. As a result, the parchment was recycled by washing and scraping. Today, ultraviolet rays are used to read the content of the original codices that were obscured by the cleaning and re-using of the parchment (Asuncion, 2003, p. 12).

The Central American Mayas discovered that bark fabrics used to make clothing could also be used for writing. These sheets were more durable than Egyptian papyrus because of their heavy texture. This paper was made of a tree in ficus family. The bark was removed in a single strip, left to soak for several days, and beaten on a flat trunk with another piece of wood until it became finely textured and elastic. This process can be used to make strip of soft, thin, malleable paper up to 18 feet (5.4m) long by 28 inches (71cm) wide. When Hemando Cortes (the Spanish explorer who conquered Aztec Mexico) arrived in Tenochtitlan (the ancient Aztec capital), he found pleated accordion books made from this paper. This paper was given to the Aztec rulers as a tribute and was also used in rituals. A similar paper made of bark is called *amate* which is still made today by descendants of the Aztecs, the Otomi Indians of San Pablito, Mexico. *Amate* paper, like its predecessor, is also made from the inner bark of a tree in the ficus family. In the *nahuatl* language, this tree is called *amacuahuitl* (tree) or *hunn* (skin of the earth). These trees grow throughout Mexico and South America. The most common variety is the *xonote*. The best known, the red *xonote*, is the most widely known variety, and yields a brown paper. The mulberry *xonote* produces a higher grade of marbled paper with ochre veins. Other varieties of this tree produce more colours. The Otomi Indians have been making *amate* the same way for over 500 years. It is used for religious and popular ceremonies and is exported in small amounts. The *amate* paper of the Otomi is made like the first pre-Columbian papers, with a slight variation in the process.

After removing the bark of the *xonote* tree and allowing it to dry in the sun for two days, the strips is baked in limestone and ashes for several hours. When the fibres of the bark reach the point that they can be pulled apart by hand, the bark is removed to cool before being washed with plenty of water. At the end of the process, the fibres are wrung out in preparation for making a sheet of paper. The fibres are arranged cross-wised. Then they are beaten with a rectangular piece of volcanic rock called a *moindo* or *mointo*, which is periodically moistened. As this is done, the fibres mesh to form a smooth, stable sheet that is placed in the sun to dry (Asuncion, 2003, p. 13).

Before the invention of paper by T'si Lun, a Chinese general named Moung-Tian discovered Egyptian papyrus. He directed his artisans to look for a similar plant species in China, but none of the plants produced the desired effect. A technique that influenced the invention of paper was discovered by a Chinese man, named Han Hsin (247 to 195 B.C.), who made a kind of felt from silk. He used the remains of coarse spun silk found in drums used for washing and bleaching the material, and placed it as filling between two layers of silk to make a kind of batting used to make shelters. Tablets discovered in the vicinity of the Gobi Desert from 100 B.C. contained this silk with texts written using brush and lacquer-based paint. Evidence shows that the invention of paper took place a few hundred years earlier than the date attributed to T'si Lun (Koretsky, 2009; Bloom, 1999; Hubbe & Bowden, 2009). Many attempts had been done by numerous people to produce a new substance to be used for writing purposes. Finally, T'sai-Lun, a Chinese court official, conceived the idea of making paper. And also, T'sai-Lun was even defined as the god of papermakers and succeeded in creating the first paper in history by mixing plant

fibres extracted from rags, fishing nets, mulberry-tree bark, nettle, and hemp. Furthermore, apart from mulberry and hemp, very early Chinese papers were made of jute, flax, ramie, rattan and bamboo. To make these papers, the plant fibres were softened in lime water and left to ferment before they were crushed and ground to pulp using hand mortars. The resulting paste was mixed with water. Then, a strainer made of bamboo fibres or clothes was submerged in the mixture to gather the amount of pulp needed to make a sheet of paper. Next, the strainer was hung on the walls of an oven to dry in the sun. Once the sheet was dried, it was peeled off the strainer and burnished with a smooth stone. To water pool the pages, they were coated with solutions made from an algae or plant juices. Due to these discoveries, T'sai-Lun set up the first paper factory in history in Mongolian Turkistan (Asuncion, 2003; Hiebert, 2000 ;Library of Congress, 1968).

T'sai-Lun worked during the Han dynasty in A.D.105. By building on experiments done with silk over 300 years ago, he devised the simplest and best method for producing a sheet of paper. Thus, the first paper in history, which was an important advancement for humankind, was born (Asuncion, 2003). In Xian, China, paper dating from 200 BCE was discovered. Paper of the same age has been located along the Silk Road. It is worth keeping in mind that all of these discoveries were made in desert climates, which provided at least a small chance for the paper specimens to survive and be discovered so many years later. One of the earliest archaeologists looking for early examples of Chinese paper was Aurel Stein, who found papers of Buddhist texts at Niya in Turkestan in 1900 the papers dated back to the 2nd and 3rd centuries (Clapperton, 1934; Hunter, 1978; Hubbe & Bowden, 2009). Indeed, one of the main uses of the early papers produced in China was to help