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Physical and Mechanical Properties of *Tenun Pahang* Fabrics using Alternative Yarns

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ABSTRACT

An investigation on the properties of Tenun Pahang fabric performances using alternative yarns was conducted. The studies were made in order to evaluate whether the Tenun Pahang fabric could be produced economically and at the same time maintain the fabric quality. Traditional Tenun Pahang fabric uses silk for both warp and weft. For this project, two alternative yarns were used which were bamboo and modal, which were a little lower in cost compared to silk. These yarns were woven with two variations, one with the yarns as weft only while maintaining the silk warp and the other with both warp and weft using the alternative yarns. Four (4) physical testings and three (3) mechanical testings conducted on the fabric samples. The fabric samples were evaluated including weight, thickness, thread density, crease recovery angle, stiffness and drapability. The results show that modal/silk and bamboo silk fabrics are comparable in terms of stiffness and drapability, hence they have the potential to replace 100% silk Tenun Pahang.

Keywords: *Tenun Pahang, modal, spun silk, bamboo, fabric properties*

INTRODUCTION

In Malaysia, *Tenun Pahang* seldom draws attraction compared to *songket* and *batik* fabrics. The young generation nowadays seems to be less interested in this kind of heritance. Normally, this art is appreciated by those who are really concerned with traditional costume and fashion [1].

Tenun Pahang is one of the famous legacies that belong to Malay ethnics and it is also well-known due to its beautiful arts that have motives, subject, colour, methods and instruments. These features have made these arts to stand until today [1]. Unfortunately, as time goes by, these arts are forgotten and it is possible that one day this art will be gone. *Tenun Pahang* needs to be exposed and commercialised so that it can turn out to be one of the heritages that represent the Pahang State [2].

Tenun Pahang fabric was believed to come from Sulawesi in 1669 which the port in the place named Makassar was invaded by the Dutch. This caused a migration of the local Bugis far from the country [3]. They finally landed in Pahang known then as Inderapura. *Tenun Pahang* was introduced by one of the Bugis chief named Keraing Aji that held a respected title of Tok Tuan. He was the one who introduced the hand-woven fabric woven on the Malay frame loom to the local folk in Pahang [4].

Tenun Pahang Diraja (Royal Pahang Weaving) or originally called *Tenun Pahang* (Pahang Weaving) is a woven fabric consists of decorative tapestry, motives and unique manufacturing techniques. This name is consistent with its high prestige and status because of the strong support given by the Pahang royal family, first by HRH Tengku Ampuan Meriam, and later extended by HRH Tengku Puan Pahang, Tunku Hajah Azizah. Tunku Hajah Azizah's concern on the heritage of *Tenun Pahang* has produced many new talents in the art of weaving with the opening of the *Institusi Tenun Pahang Diraja Tengku Ampuan Afzan* (Royal Weaving Institution of Pahang Tengku Ampuan Afzan) [5].

Tenun Pahang's prestige and status were lifted to an even higher level when it was officially recognised "royal" in 2006 to produce textiles that are more exclusive and special. *Tenun Pahang Diraja* which was originally the attire for the royals, chiefs and nobles now becomes a 'versatile' woven product of various design patterns while maintaining its traditional characteristics and made into *sampin, kain pasang*, clothes, products for corporate gifts, home furnishings and also accessories [6].

Tenun Pahang has been woven using silk since the beginning until today but lately, polyester is also used in *Tenun Pahang* especially for souvenir items. Silk is an expensive material and thus new material or alternative material is needed to lower the cost without compromising quality.

New technology in textile has made available fibres with better properties which were available to be explored. Bamboo yarn for example, has good durability, stability, tenacity, antibacterial and deodorizing in nature, incredibly hydroscopic which absorbing more water than other conventional fibres [7].

Other alternative yarn used in the project is modal fibre. With the modal fibre, the textile industry is being favoured with a new generation of cellulosic fibres, these being used in a wide woven fabrics sector with the best performance conditions due to their excellent properties, for example, their purity, high strength, either wet as in dry, their fines, their highly bright colour and also to their silky lustre and soft and pleasant touch [8].

There have been limited publications in the development of *Tenun Pahang* in terms of materials and techniques except the works at *Tenun Pahang* Centre which do some modification using handloom from Thailand and also introducing new designs such as *ikat*. Therefore, this project is intended to investigate some of the properties of *Tenun Pahang* fabric by using alternative yarns which are bamboo and modal in order to produce *Tenun Pahang* fabric with drape performances to the present yarns but at lower cost. It is also to establish a benchmark in terms of standard specifications and performance for *Tenun Pahang* using silk.

EXPERIMENTAL METHOD

Flow of process

Figure 1 shows the flow process of this project.

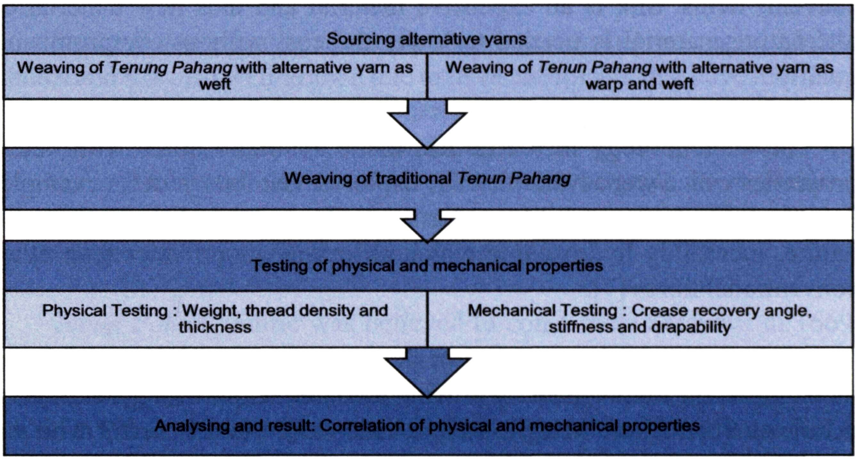


Figure 1: Project flow process

Sourcing Alternative Yarns

There are two (2) types of new yarns selected to weave the fabric in the project which are modal (2^{nd}) and bamboo yarn. The reasons to use the yarns are due to the advantages offered that had been mentioned earlier and also cheaper than silk. The yarn count are 23.6, 20 and 25 tex for silk, modal and bamboo respectively.

The *Tenun Pahang* fabric is woven at the Centre of Excellence for *Tenun Pahang Diraja* in Kampung Soi, Kuantan, Pahang which specialised in making Tenun Pahang fabric.

Weaving of samples was done in two phases. In the first phase, the *Tenun Pahang* fabric was woven by using alternative yarn in the weft only while the warp is silk. The second phase is where the *Tenun Pahang* fabric was woven with alternative yarn on both warp and weft.

Five (5) samples of fabric were woven which are 100% silk (S100), 100% bamboo (B100), 100% modal (M100), silk/bamboo (B/S) and silk/ modal. For 100% modal and 100% bamboo warp, the yarn has to be doubled to stand the friction and tension in order for it to be woven as warp.

Testing of Physical and Mechanical Properties

There are six (6) types of textile testing done on the Tenun Pahang fabrics, four (4) on physical properties and three (3) on mechanical properties which are:

Physical Properties

i. Weight

This test follows MS ISO 5084-2003 and ASTM D 3779-1996 standard. The standard cutter is used and the mass of the fabric is measured using weighing balance and recorded as g/cm^2.

ii. Thickness

This test follows ASTM D 3776-96/2002 standard. The thickness of the fabric is measured using thickness gauge equipment and recorded as mm.

iii. Thread Density

This test follows MS ISO 7211/2-2003. The density is counted by using counting glass equipment. It is the number of ends and picks per inch or per centimetre of a woven fabric. The counting is done with the help of pick counter.

Mechanical Properties

i. Stiffness

The stiffness of the fabric is tested to determine the bending length and flexural rigidity of the fabric. This test is done following the standard method of ASTM D 1388 – 96/2002. SDL Stiffness Tester is used to record the results.

ii. Drapability

The purpose of the test is to determine the drape coefficient of fabric. This test is done following the standard method of BS 5058 - 1997. The equipment that is used for drapability testing is Cusick Drape Tester.

iii. Crease Recovery Angle

The purpose of this test is to determine the crease recovery angle of the fabric. The equipment used is the SDL Crease Recovery Angle Tester. The test is conducted based on the AATCC 66 – 2003 standard method. ten samples of warp and ten samples of weft direction of 40 mm x 15 mm each are prepared. The test is repeated for the next 19 sample. Measurement is made face to face (F to F) and back to back (B to B).

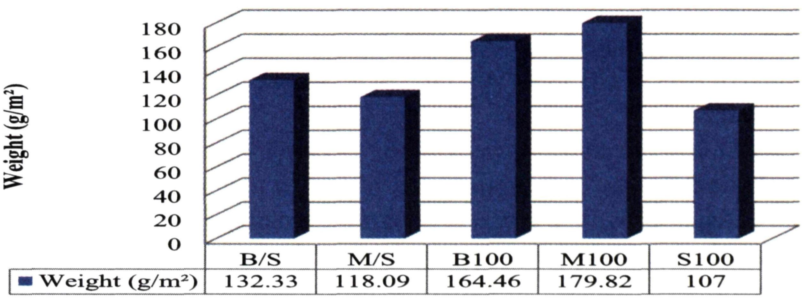
RESULT AND DISCUSSION

Physical Testing

i. Fabric Weight

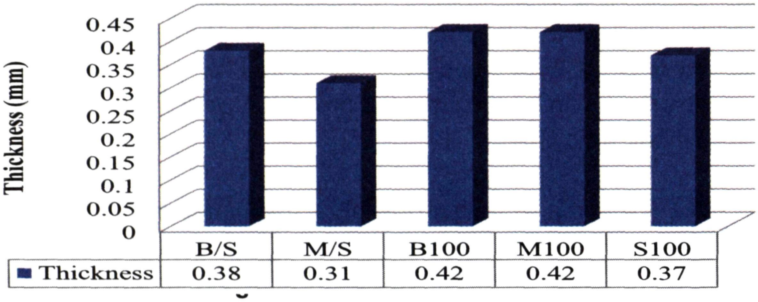
Figure 2 shows the weight of the *Tenun Pahang* fabrics using alternative yarns. The result shows that 100% modal fabric is the heaviest compared to others with 180 g/m² followed by 100% bamboo fabric weight of 164 g/m².

The lowest fabric weight is 100% silk fabric with 107 g/m² while bamboo/silk and modal/silk fabrics have a weight of 132 g/m² and 118 g/m² respectively. It was noted that 100% modal and 100% bamboo fabric are heavier because the warp yarns for both fabric was doubled to avoid yarn breakage during warping. Single yarns tend to untwist and break easily because there was no sizing applied to the warp on a hand woven material.



ii. Thickness

Figure 3 shows the result of fabric thickness for each of the fabric using alternative yarns. The result shows that all fabric had almost similar thickness, with again 100% modal and 100% bamboo was a little thicker due to the double warp yarns.



iii. Thread Density

Figure 4 shows the thread density of the *Tenun Pahang* fabrics using silk and alternative yarns. It shows that the thread density of the warp yarn is almost similar due to the same reed number used in weaving all fabrics. The thread density of the weft yarn of the three fabrics, bamboo/silk, modal/ silk and 100% silk are almost similar which are 70.8, 73 and 69 picks but 100% bamboo and 100% modal fabrics have thread thread density of 44 and 44 picks respectively which are lower than the silk warp fabrics, the doubling of the warp yarns had made the weft yarns to condense resulting the weft yarns to be low.

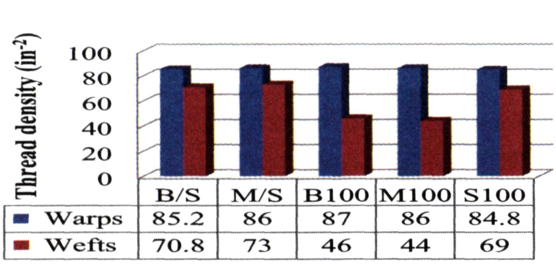


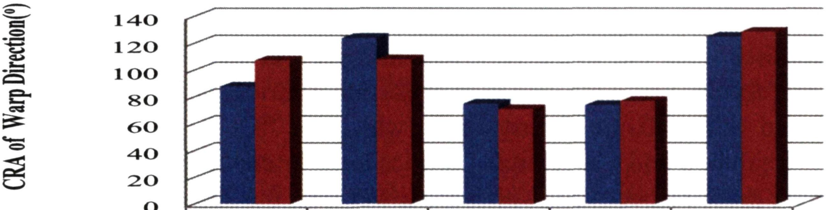
Figure 4: Fabric thread density

Mechanical Testing

i. Crease Recovery Angle (CRA)

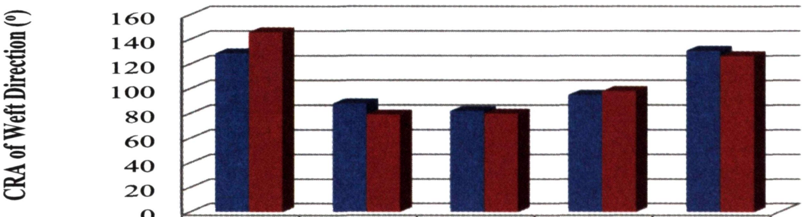
Figure 5 and Figure 6 show the crease recovery angle (CRA) of the Tenun Pahang fabrics using alternative yarns. The CRA in the warp direction show that 100% silk fabric has the highest angle with 125° - F to F and 128.8° - B to B followed by modal/silk, bamboo/silk, 100% modal and 100% bamboo with 124° - F to F and 108° - B to B, 87.8° - F to F and 107.4° - B to B, 74° F to F and 77° - B to B and 75° - F to F and 71° - B to B respectively. It can be seen that the best CRA of warp direction is 100% silk for having high CRA.

The CRA in the weft direction show that bamboo/silk and 100% silk gives the best CRA with (128.6° F to F and 145.8° - B to B) and (130.8° - F to F and 126.6° - B to B) followed by 100% modal, modal/silk and 100% bamboo with (95° F to F and 98o - B to B) (88° F to F and 79° - B to B) and (82° - F to F and 80° - B to B).



	B/S	M/S	B100	M100	S100
F - to - F	87.8	124	75	74	125
B - to - B	107.4	108	71	77	128.8

Figure 5: Fabric crease recovery angle (warp direction)

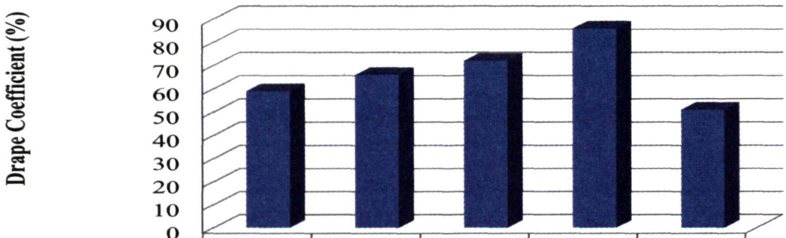


	B/S	M/S	B100	M100	S100
F - to - F	128.6	88	82	95	130.8
B - to - B	145.8	79	80	98	126.6

Figure 6: Fabric crease recovery angle (weft direction)

ii. Drapability

Figure 7 shows the drapability of *Tenun Pahang* fabrics using alternative yarns. From the graph, it shows that 100% silk fabric give the best drapability with 51% drape coefficient compared to others. Bamboo/silk fabric give good drapability followed by modal/silk with 59% and 66% respectively while 100% bamboo and 100% modal fabrics give poor drapability with 72% and 86% respectively. However, this could be to the doubling of the warp yarn for 100 % bamboo and 100% modal.



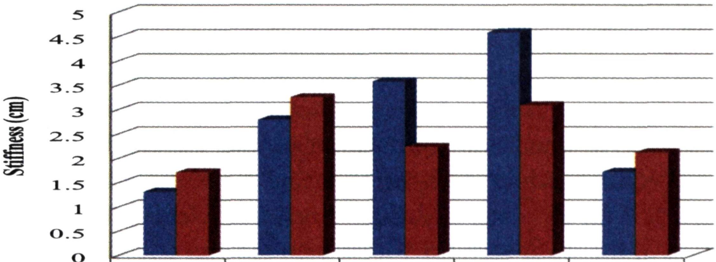
	B/S	M/S	B100	M100	S100
Drape Coefficient	59	66	72	86	51

Figure 7: Fabric drape coefficient

iii. Stiffness

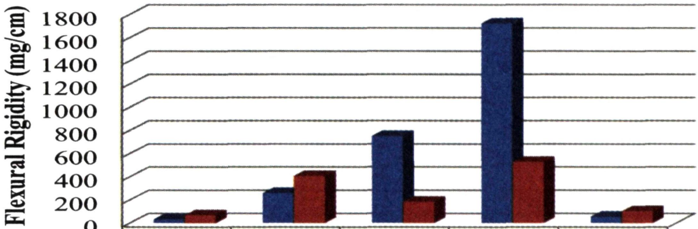
Figure 8 shows the stiffness of the *Tenun Pahang* fabrics. From the result, it shows that bamboo/silk has highest drape coefficient with 1.31 cm in warp and 1.71 cm in weft compared to other fabrics. The 100% modal fabric give the worst result with 4.58 cm in warp and 3.08 cm in weft compared to other fabric. The 100% bamboo and modal/silk give an average result with (2.79 cm in warp and 3.25 cm in weft) and (3.57 cm in warp and 2.23 cm weft) respectively.

Figure 9 shows the flexural rigidity of the *Tenun Pahang* fabrics. From the result, it shows that 100% modal fabric is the stiffest with 1722 mg/cm in warp way and 527 mg/cm in weft way compared to other fabrics. Bamboo/silk and 100% silk fabrics are the lowest value of flexural rigidity with 30 mg/cm (warp), 67 mg/cm (weft) and 55 mg/cm (warp) 102 mg/cm (weft) respectively compare to other fabrics. Modal/silk and 100% bamboo give 257 mg/cm (warp), 406 mg/cm (weft) and 100% silk give 751 mg/cm (warp) 183 mg/cm (weft).



	B/S	M/S	B100	M100	S100
Warp	1.31	2.79	3.57	4.58	1.72
Weft	1.71	3.25	2.23	3.08	2.12

Figure 8: Stiffness of the fabrics



	B/S	M/S	B100	M100	S100
Warp	30	257	751	1722	55
Weft	67	406	183	527	102

Figure 9: Flexural rigidity of the farics

Fabric Analysis

The relationships of drape properties with physical and mechanical properties of the fabrics are evaluated. The relationship between the mechanical properties of the fabrics are also analysed.

i. Relationship between the Drapability and the Thickness of the Fabric

Figure 10 shows the relationship between the drapability and the thickness of the fabric. The graph shows that the correlation between drapability and the thickness have a moderate relationship R-value of 0.50. Hence, it can be said that there is a moderate chance that higher thickness fabric to have higher drape coefficient.

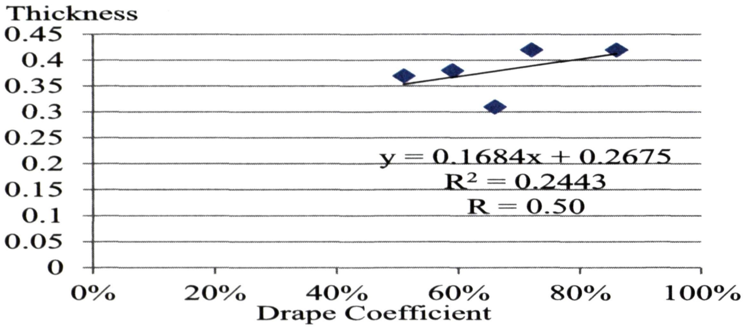


Figure 10: The relationship between the drapability and the thickness of the fabric

ii. Relationship between the Drapability and the Weight of the Fabric

Figure 11 shows the relationship between the drapability and the weight of the fabric. The graph shows that there is a strong relationship between drapability and the weight with R-value of 0.91. It can be concluded that drapability is influenced by the weight of the fabric. The heavier the fabric, the smaller the drape coefficient of the fabric.

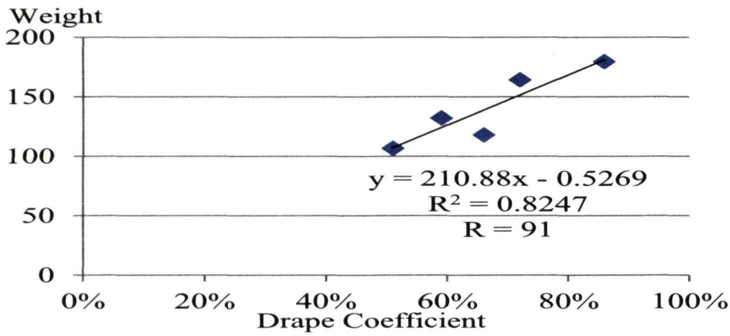


Figure 11: The relationship between the drapability and the weight of the fabric

iii. The Relationship between the Drapability and Thread Density of the Fabric

Figure 12 shows the relationship between the drapability and the thread density of the fabric. The graph shows that there is a strong relationship with coefficient R-value of 0.81. It can be concluded that the drapability is influenced by the thread density of the fabric. The higher the thread density of the fabric, the bigger the drape coefficient the fabric.

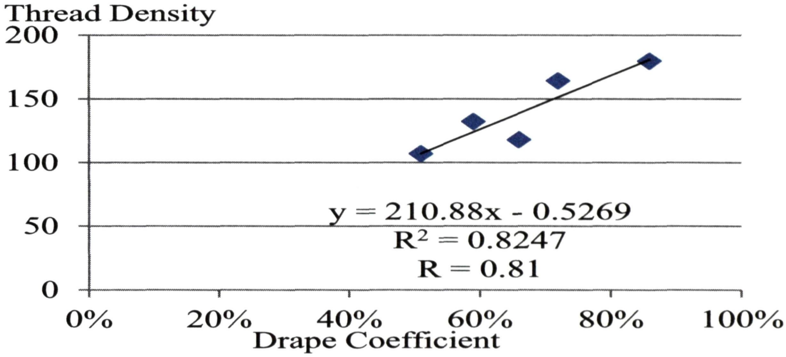


Figure12: The relationship between the drapability and the thread density of the fabric

iv. The Relationship Between Crease Angle Recovery and Stiffness of the Fabric

Figure 13 and Figure 14 show the relationship between the crease recovery angle and stiffness. It can be seen that the relationship between the two factors is strong which the R-value is 0.70 and 0.71. It can be concluded that the crease recovery angle is influenced by the stiffness of the fabric.

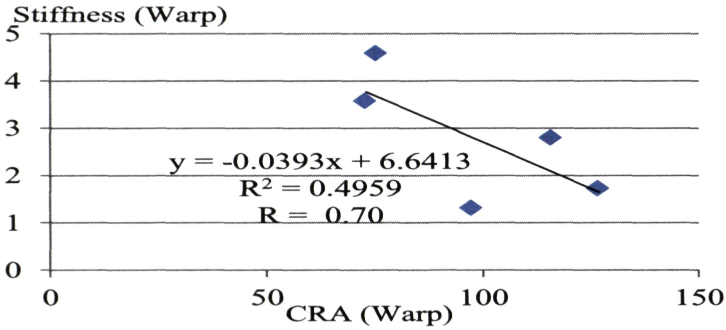


Figure 13: The relationship between the crease angle recovery (warp) and the stiffness of the fabric

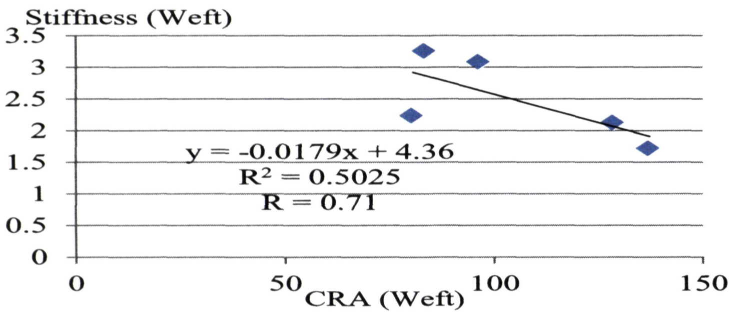


Figure 14: The relationship between the crease angle recovery (weft) and the stiffness of the fabric

v. The Relationship between the crease recovery angle ` and the drapability of the Fabric

Figure 15 and Figure 16 show the relationship between the crease recovery angle (wrap and weft repectively) and the drapability of the fabric. It can be seen that the relationship between the two factors is strong with the R-value of 0.82 for warp direction and 0.64 for weft direction. Therefore, crease recovery angle has some influence on the drapability of the fabric.

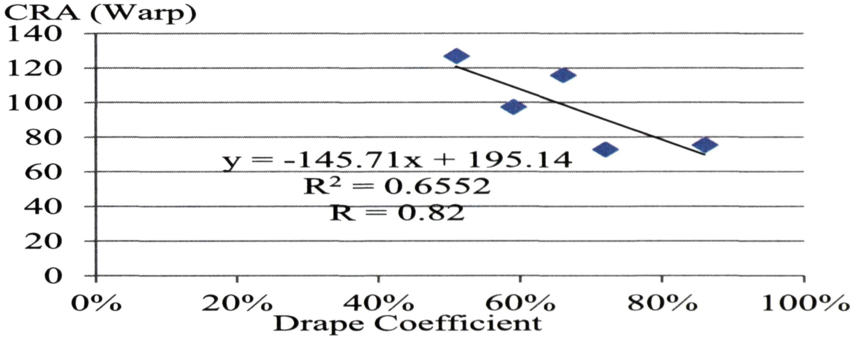


Figure 15: The relationship between the crease angle recovery (warp) and the drapability of the fabric

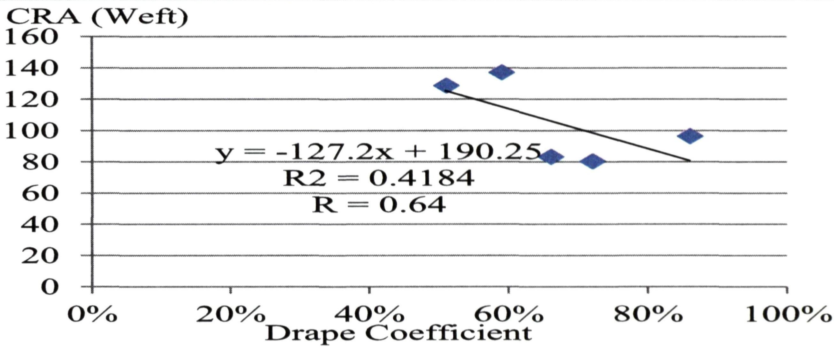


Figure 16: The relationship between the crease angle recovery (weft) and the drapability of the fabric

vi. The Relationship between the Flexural Rigidity and the Drapability of the Fabric

Figure 17 and Figure 18 show the relationship between the flexural rigidity (wrap and weft respectively) and the drapability of the fabric. It can be seen that the relationship between the two factors is strong with the R-value of 0.95 for warp direction and 0.81 for weft direction. Therefore, flexural rigidity has some influence on the drapability of the fabric.

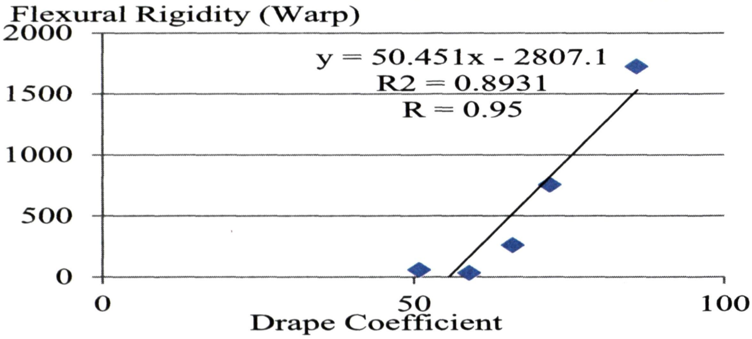


Figure 17: The relationship between the flexural rigidity (warp) and the drapability of the fabric

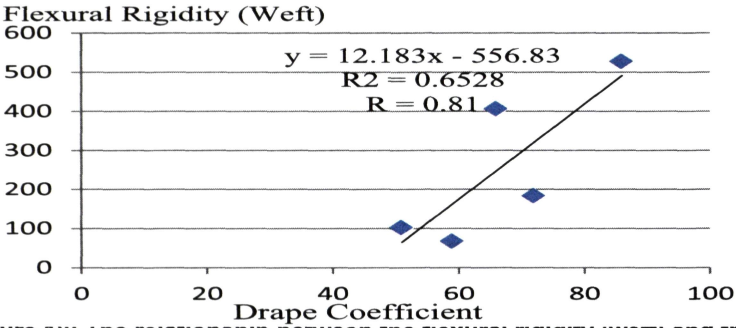


Figure 18: The relationship between the flexural rigidity (weft) and the drapability of the fabric

CONCLUSION

From the properties result, it can be concluded that in terms of drapability, silk and modal/silk fabric are comparable. In terms of stiffness, bamboo/silk shows the best result and 100% modal fabric shows poor performance. In term of crease angle recovery, bamboo/silk and silk shows the best result. Overall, modal/silk and bamboo/silk fabric has the potential to replace 100% silk in *Tenun Pahang,* but for 100% bamboo and 100% modal, finer warp is needed to get comparable properties with the silk yarn.

Drapability of the *Tenun Pahang* is affected by several factors. In terms of physical properties, it is found that thickness, weight and thread density affect the drapability. Mechanical properties such as stiffness, crease recovery angle and flexural rigidity correlate well with the drape coefficient.

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Tables should be included within the text where appropriate and must be numbered consecutively with Arabic numerals and have titles that precede the table. Similarly, all figures must be numbered and a detailed caption should be provided below each figure. Figures should be embedded within the text where appropriate. Glossy photographs when required should be scanned to a suitable resolution (1200 dpi), which enables quality reproduction.

References should be numbered in ascending order and cited within square brackets, e.g. [1], [3-5], in the main body of the text. References included at the end of the manuscript are to be in the order that they appear in the main body of text. Some entry samples are as follows:

[1] A. B. Author, 2000. *Title of Book*, ABC Press, Kuala Lumpur, Malaysia.

[2] C. D. Author and E. F. Author, 1999. Title of Paper, *Journal Name, Vol. 10*, pp. 32-45.

[3] G. H. Author, 2006. Title of the conference paper, in Proceedings of the 2000 IEEE International Symposium on Circuits and Systems, Geneva, Switzerland, pp. 100-105

Manuscripts submitted to the journal will be initially screened by the Chief Editor, to determine appropriateness. Only those manuscripts considered of a sufficiently high standard will proceed to undergo a double blind review.

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