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Hand Properties of Woven Fabric Treated with Commercial Softeners

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Abstract

This study was carried out to determine the hand properties of cotton woven fabric treated with three different brands of commercial softeners and to identify the stiffness relationship between objective and subjective assessment. The hand properties refer to the impression feels when the fabric is touched, squeezed, rubbed or otherwise handled. The cotton woven fabric was categorized into light to medium weight and medium to heavy weight type. Three different brands of softener; Brand A, Brand B and Brand C were used, and the fabric samples were washed by using top load home washing machine for 48 minutes in each cycle with the detergent and softener added into the washing machine dispenser drawer following the instruction label on the softener's bottle. After washing process was done, the samples were evaluated objectively by their stiffness and panel experts did subjective assessment on the samples by investigating three attributes namely stiffness, softness, smoothness. The results obtained from objective and subjective evaluation were then analysed using Two-way ANOVA and Kruskal Wallis test respectively.

Keywords: softener, cotton, home laundry, subjective evaluation, hand properties

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Introduction

Hand properties refer to the impression feel when the fabric is touched, squeezed, rubbed or otherwise handled (Hoffman & Beste, 1951). Fabric hand also brings the means of the feel of the material and it is expressed in terms of stiffness, limpness, hardness, fullness, roughness and smoothness (Jinlian, 2008). According to Jang and Yeh (1993), fabric hand and the lost physical properties during home laundering process can be improved by the chemical softening agent. Chemical softening agent can be defined as an auxiliary that results in an alternating in hand and causing the fabrics being more pleasing to touch (Mauinson, 1974). It is applied on textile materials especially during home laundering, and is the most important global textile finishing chemicals in terms of value and amount (Choudhury, 2017). Simpson and Silvernale (1976) studied on the effect of fabric softener through fabric hand, static electricity and odour which showed that rinse cycle softener yielded the best performance in hand compared to the dryer spray. However, rinse cycle softener treatment has a significant impact on the absorbency, air permeability and wicking ability, and causes a negative impact on the fabric performances of cotton and polyester fabrics (Rathinamoorthy, 2019). There was also a study to explore the feasibility of applying softener and wetting agent during flame-retardant treatment of cotton fabrics. The result showed that softener addition could improve fabric hand and mechanical properties such as tensile,

shearing, bending and compression (Tang *et al.*, 2017; Kan and Lau, 2018). With respect to domestic laundering without softener as carried out by Ramli (2017), she concluded that repeated number of laundering cycles does not give much influence towards hand properties of woven cotton, polyester and silk fabric.

Over the years, the hand properties of textiles have been assessed by both objective and subjective methods, or also known as instrumental evaluation and sensory evaluation respectively (Wang *et al.*, 2014). Instrumental evaluation, such as the KES system, could provide quantitative specifications of fabric handle as well as other physical properties. Sensory evaluation on the other hand is widely used for the sensorial properties of textile products which is based on the personal perception and is affected by the evaluator's own experience and background (Wang *et al.*, 2014). In this evaluation according to Valatkienė and Strazdienė (2006), panel expert would assess the fabric through attributes such as smoothness, hardness, flexibility, roughness, stretchability, resiliency, stiffness and softness. They found that more number of trainings given to the panel experts would give more significant results towards subjective evaluation. As mentioned by Ramli (2017), there was not much significant relationship shown between objective and subjective evaluation of repeated number of home laundering on the sensory properties of cotton, polyester and silk. In other research by Broega *et al.* (2010), they studied the relationship between wool fabric pulling force through pins and the subjective assessment of fabric handle of light weight wool fabrics. The correlation analysis showed very good agreement between the fabric pulling force and subjective hand rating.

In the current study, three attributes evaluated are stiffness, softness and smoothness, while the bending length is investigated for objective evaluation. This study is conducted since customers usually lack of information on the effectiveness of softener and they just buy their softener based on the live popularity of the brand without knowing whether the price is worth with the performance offered. It is an effort to determine the effectiveness of commercial softeners available on the rack and to check whether subjective and objective evaluation are aligned in giving right information to consumer from the standard of the product by identifying the relationship between them. It may help to provide the knowledge for the customer to make an informed choice of how to care for their textile product. Hence, the purpose of the study is to determine the hand properties of cotton woven fabric treated with three brands of commercial softeners through subjective and objective evaluation.

Method

Materials

This study was performed on cotton woven fabric with two different weight; 97.57g/m^2 for light to medium weight and 163.20g/m^2 for medium to heavy weight category. The fabric softeners selected were from three different brands and of different price range; Brand A (RM4.45), Brand B (RM2.00) and Brand C (RM1.50) for 500ml each.

Physical Properties

i. Weight

Five numbers of specimens were taken randomly from the full width of fabric by using circular weight per metre^2 cutter and weighed by using analytical balance. The sample placed on the analytical balance and the weight recorded. These steps were repeated for another four samples. Then, the average weight of the 100% cotton fabric was calculated and multiplied by 100 to get the weight per meter in gsm. The standard method used in this test is ASTM D 3779-1996.

ii. Density

Five samples were prepared at random places on the fabric for 1 inch² according to MS ISO 7211/2 - 2003. The samples were unravelled and the number of warp and weft were separately counted from each sample using counting glass.

iii. Thickness

The thickness of fabric samples was determined by placing the fabrics on the anvil of the thickness gauge and lowering the presser on to the fabric following standard method ASTM D 3776-96/2002. Ten readings of thickness were required at random places of the fabric.

Preparation of Sample

i. Sample Specification

Table 1 shows the fabric sample specification according to the type of softeners used. The woven cotton fabric was cut into 24 samples of 30 × 30 cm in size. All the samples were distributed into four groups according to the type of softeners used; A, B, C and X.

Table 1: Fabric Sample Preparation

Sample No.	Softener Brand	Weight (g/m^2)	Sample Name
1 **2** **3**	Brand A	Light to medium (97.57)	A
4 **5** **6**	Brand B		B
7 **8** **9**	Brand C		C
10 **11** **12**	Without softener		X
13 **14** **15**	Brand A	Medium to heavy (163.20)	A*
16 **17** **18**	Brand B		B*
19 **20** **21**	Brand C		C*
22 **23** **24**	Without softener		X*

ii. Home Laundering Process

Table 2 shows the washing machine setting for the laundering process. Five kilograms of garments including the samples were washed by using 7kg top load Samsung washing machine. The detergent and

amount of softener added into the washing machine dispenser drawer were following the instruction label on the back of bottle. The washing machine door was closed and the drain pipe was hung up. The water tap turned on and the desired programme was chosen.

Table 2: Laundry Setting

Washing Setting		
Brand		Samsung
Type		Top load
Time		48 minutes
Weight of load		5 kg
Volume of softener	A	37 ml
	B	37 ml
	C	35 ml
Detergent		52 g

Objective Evaluation

Stiffness is one of the most widely used parameters to judge bending rigidity and fabric handling. It is the feel or texture of the fabric and it assesses fabric drape and handle related to weight and thickness. When the reading of bending length is high, the fabric will become more stiff and poor draping quality. Figure 1 shows fabric Stiffness Tester operated with standard method ASTM D 1388-96/2002.

Figure 1: Stiffness Tester

Subjective Evaluation

Judge panels consisting of ten panel experts were chosen for fabric hand subjective evaluation. The judges were trained individually to use the prescribed techniques (Valatkienė and Strazdienė, 2006; Ramli, 2017). The panels were also provided with explanatory and visual information on how to assess these features.

i. Stiffness

Stiffness is the tendency of the fabric keep standing without any support. Figure 2 shows how the sample was taken in to the palm, then clenched and unclenched for three times.

Figure 2: Evaluation method for stiffness

ii. Smoothness

Smoothness can be defined as the surface of a smooth fabric that offer little resistance to slipping when rubbed. As displayed in Figure 3, this attribute was assessed by taken the sample between two fingers of both hands and being pulled by one hand so that it would slide between two fingers.

Figure 3: Evaluation method for smoothness

iii. Softness

Softness refers to the resistance or non-resistance to compression or bending. It is evaluated by holding the sample between two fingers in one hand and swept from top to bottom with the palm of the other hand as shown in Figure 4.

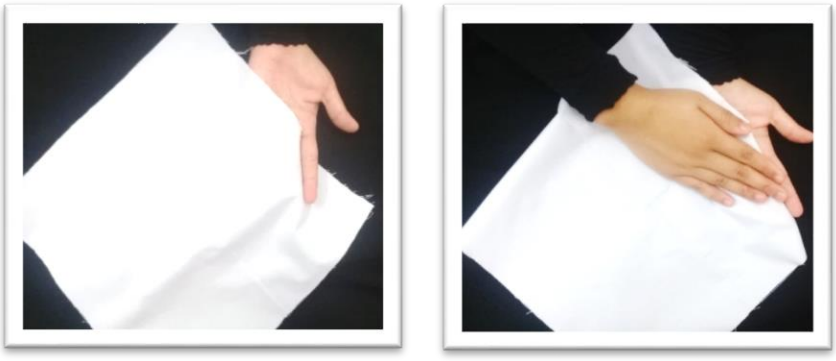

Figure 4: Evaluation method for softness

Table 3 shows the example of subjective evaluation form that was given to the judge panels. 1 is for the worst rating and 5 is the best rating.

Table 3: Subjective Evaluation Form

Sample	Subjective	1		2		3		4		5	
	Stiffness	very stiff		stiff		soft		limp		very limp	
	Softness	very rough		rough		medium		soft		very soft	
	Smoothness	very hard		hard		medium		smooth		very smooth	

Results and Discussion

Physical properties of fabric

Cotton woven fabrics were tested for their physical properties before laundering process, which are weight, density and thickness. Table 4 below shows the results recorded, with the weight for light to medium fabric is 97.57g/m^2 and the thickness is 0.20mm, while the weight and thickness for medium to heavy is 163.20g/m^2 and 0.28mm respectively.

Table 4: Physical Properties of Fabric

Physical Properties		Fabric	
		Light to medium	Medium to heavy
Density	epi	103	112
	ppi	68	68
Weight	g/m^2	97.57	163.20
Thickness	mm	0.20	0.28

Fabric hand properties

In this study, stiffness test was done to measure the bending length of the fabric. For subjective evaluation, three attributes were evaluated which are softness, smoothness and stiffness. All the recorded data are shown in Table 5.

Table 5: Bending Length and Subjective Evaluation

Sample	Weight (g/m^2)	Bending Length (cms)		Human rating (1-5)		
		Warp	Weft	Stiffness	Softness	Smoothness
A	97.57	0.96	0.52	2	3	3
B		1.03	0.78	2	3	2
C		1.42	0.73	2	2	2
X		1.25	0.69	2	3	3
A*	163.20	0.84	0.59	2	4	3
B*		0.73	0.59	3	3	4
C*		0.89	0.57	3	5	3
X*		1.05	0.68	3	2	3

Objective evaluation

Figure 5a and 5b show the results of bending length for the test samples. Among the entire samples in warp direction, Sample B* is the least stiff since it has the lowest reading with 0.73 cms, while the stiffest is Sample C with 1.42 cms. For weft direction, the sample with the lowest reading is Sample A and the highest is Sample B with 0.52 cms and 0.78 cms respectively.

From the data presented, warp direction for all samples are stiffer as compared to the weft direction. This is due to the high number of warp yarns in the fabric structure that makes them more rigid and difficult to bend (Yüksekkaya *et al.*, 2008).

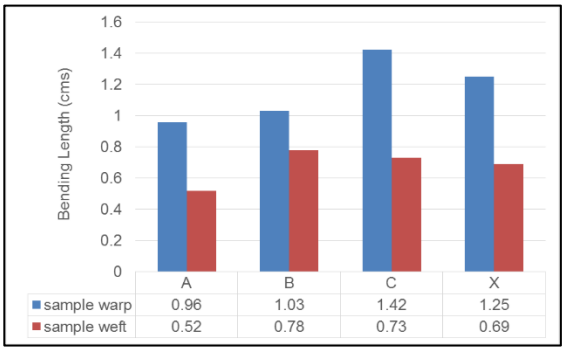

Figure 5a: Bending Length for Light to Medium Weight Fabric

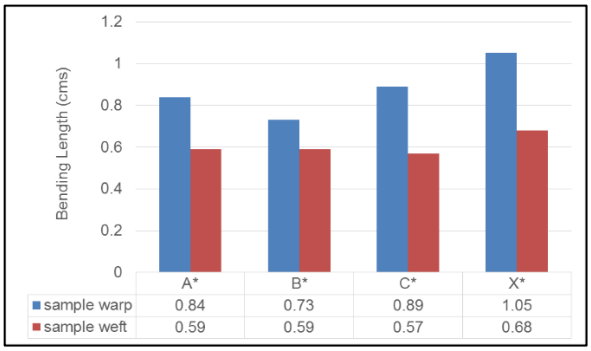

Figure 5b: Bending Length for Medium to Heavy Weight Fabric

The results have been statistically evaluated by using Analysis of Variance (ANOVA). Table 6 shows the result of the 2-way ANOVA analysis that examined the effect of brand and weight on warp and weft sample. The significance level of the statistical analysis conducted in this study was set at 0.05. The p-value obtained with less than 0.05 indicates that there are statistically significant different in brands or weights or the interaction towards warp and weft sample. There was statistically significant interaction between the effects of brands and weight of fabric on warp sample, F (3, 16) = 3.473, p = 0.041. However, there is no significant interaction on the weft sample since the p = 0.597 is greater than 0.05.

Table 6: Statistical Analysis for Bending Length in Warp and Weft Direction

Source	Sum of Squares		df		Mean Square		F		Sig.	
Sample	warp	weft	warp	weft	warp	weft	warp	weft	Warp	Weft
Brand	0.257	0.069	3	3	0.086	0.023	3.274	0.510	0.049	0.681
Weight	0.821	0.099	1	1	0.821	0.099	31.401	2.203	0.000	0.157
Brand*weight	**0.273**	**0.087**	**3**	**3**	**0.091**	**0.029**	**3.473**	**0.646**	**0.041**	**0.597**
Error	0.419	0.718	16	16	0.026	0.045				
Total	1.769	0.972	23	23						

Subjective Evaluation

Based on Figure 6a and 6b, three samples that present the best rating for stiffness attribute are Sample B*, C* and X* which were from medium to heavy weight category with rating 3. Sample A, A*, B, C and X exhibit poor rating for stiffness with rating 2. For smoothness attribute, Sample B* again shows the best rating which is 4 and sample B and C* have poor rating which is 2. It is found that the best rating for softness attribute belongs to medium to heavy weight fabric treated with Brand C (rating 5), and the poorest is for light to medium weight fabric which was treated with Brand C and medium to heavy weight without softener.

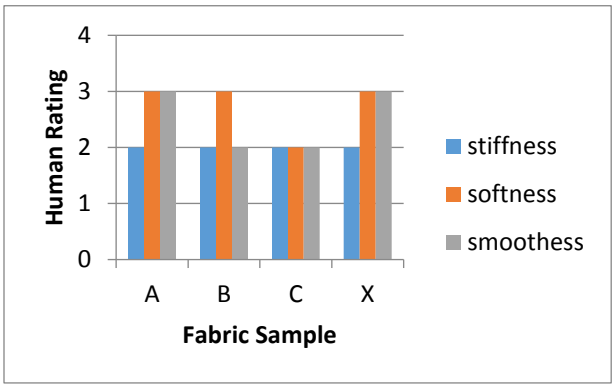

Figure 6a: Rating of Stiffness, Smoothness and Softness for Light to Medium Weight Fabric

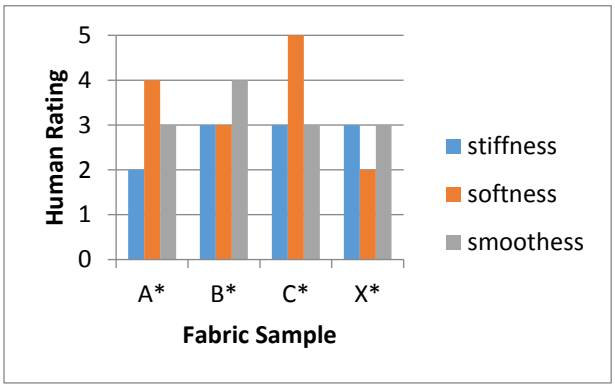

Figure 6b: Rating of Stiffness, Smoothness and Softness for Medium to Heavy Weight Fabric

Softeners give a better effect towards heavier sample since the density of the fabric is higher than the lighter fabric. Higher in fabric density means that the fabric has more number of warp and weft yarns, so they can adsorb more softener and make them better in fabric hand. Softener did not give too much effect on medium to light weight fabric as the potential to absorb softener is low.

Statistical tool, Kruskall-Wallis test was used to compare the human rating on smoothness, stiffness and softness across different brand of softeners used in this study. As presented in Table 7 and Table 8, all the three attributes are greater than 0.05 for different weight of fabric. This result indicates that all brands of softeners gave same effects towards stiffness, smoothness and softness attributes from human perspective.

Table 7: Chi-Square test for Subjective Hand Properties of Light to Medium Weight Fabric

	Smoothness	**Stiffness**	**Softness**
Pearson Chi-Square	6.500	2.333	6.600
Df	3	3	3
Sig.	0.09	0.506	0.086

Table 8: Chi-Square test for Subjective Hand Properties of Medium to Heavy Weight Fabric

	Smoothness	**Stiffness**	**Softness**
Chi-Square	4.760	3.286	6.400
Df	3	3	3
Sig.	0.190	0.350	0.094

Relationship between Subjective and Objective Evaluation

Spearman's rank order correlation is a nonparametric technique that measures the strength and direction of relationship between two variables measured on at least an ordinal scale. The closer the correlation to ± 1 the more closely the two variables are related. The two variables used in this study were the bending length reading for objective evaluation and stiffness attribute from human rating. Based on Table 10, the bending length of warp shows negative moderate correlation (r = -0.407)) with the subjective assessment, while weft have negative weak direction. The weak relationships make it difficult to relate that human assessment is almost accurate to the result from the machine. Hence, the hand properties of fabric cannot be determined by depending on the subjective evaluation alone unless there is strong relationship between the two methods of assessments. In addition, only one aspect of hand properties was tested objectively, whereas three features were measured subjectively.

Table 10: Spearman's Rank Order Correlation Coefficient on Stiffness

	Warp	**Weft**
Spearman's Rho	-0.407	-0.053

Figure 7a and 7b present the correlation between subjective and objective evaluation in warp and weft direction.

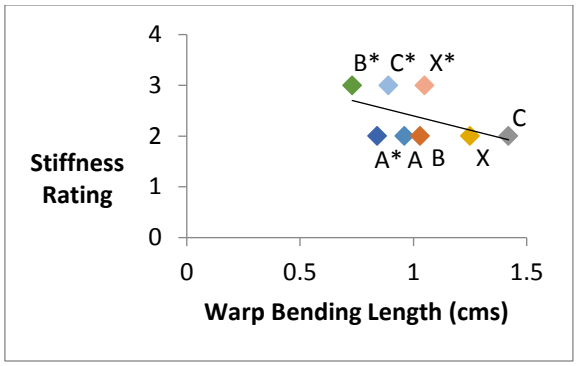

Figure 7a: Relationship between Subjective and Objective Evaluation for Warp Direction

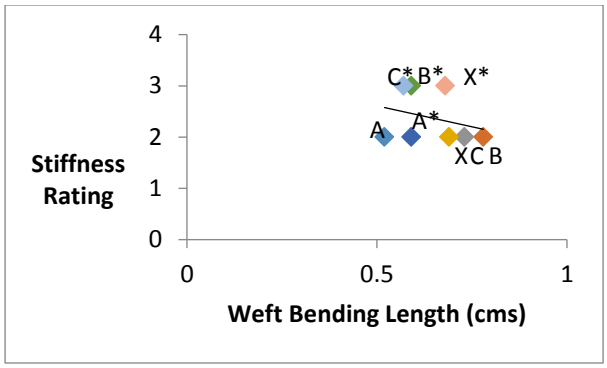

Figure 7b: Relationship between Subjective and Objective Evaluation for Weft Direction

Conclusion

In conclusion, softener is a chemical softening agent that improves the hand properties of the fabric. The results from objective testing show that the samples in warp direction for both light to medium and medium to heavy fabric are stiffer than weft direction due to the number of yarns in warp direction which is higher, making it difficult to bend. The best brand of softener for light to medium weight fabric is Brand A since it has the best result for objective testing, but the excellent rating for both subjective and objective testing for medium to heavy weight sample was obtained by Brand C softener. It shows that the more expensive brand of softener does not necessarily offer better hand properties. From the data gained for subjective and objective evaluation on the stiffness quality, it displays the similar information but the relationship between these two evaluations is still considered as weak negative relationship. Hence, the hand properties of fabric cannot be determined by solely depending on the subjective evaluation unless there is strong relationship between the two methods of assessments.

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