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EFFECT OF PICKS PER INCH ON ELONGATION, TENSILE AND TEARING STRENGTHS OF *ASO-OKE* PRODUCED ON NEO-TRADITIONAL AND MODIFIED FLOOR LOOMS

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ABSTRACT

Aso-Oke is the most famous indigenous woven fabric in Southwest Nigeria. This study evaluated the effect of picks per inch on elongation, tensile and tearing strengths of *Aso-Oke* produced on neo-traditional floor loom (TFL) and modified floor loom (MFL). This study adopted an experimental design. Ten samples of 2/2 matt woven fabrics were produced using 91 ends per inch (EPI), varied (2, 3, 5, 7, and 8) numbers of filling yarns (NFY), and 100% textured polyester yarn on TFL (TFL1-TFL5) and MFL (MFL1-MFL5). Fabric tensile, elongation, and tearing strength were tested. Data were analyzed using frequency counts, percentages, mean, standard deviation, independent t-test, and Principal Component Analysis (PCA). Results showed that Fabric MFL2 had the highest warp way tensile strength (50.04kgf), TFL3 (54.86kgf) in weft, and MFL3 (44.46kgf) showed significantly high breaking elongation in warp and weft ways corresponding to 64 picks per inch. Tearing strength was highest in fabrics TFL5 (46.51kgf) and TFL4 (53.34kgf) in warp and weft ways respectively. MFL3 tearing resistance was higher in both the warp and weft ways. T-test results revealed a significant ($p<0.05$) difference in Tearing Strength in weft way between MFL (29.34±8.56) and TFL (31.5±18.73; $p=0.01$) The correlation matrix showed moderately positive relationships ($r=0.50$), in Tensile 0.791 in weft way and Tearing Strength 0.962 in warp way; The study concluded that the *Aso-Oke* produced on TFL and MFL have excellent tensile, elongation, and tearing strength influenced by yarn type, density, thickness, and weave structure.

KEYWORDS: *Aso-Oke*, Woven, Fabric Tensile, Elongation, and Tearing

1. INTRODUCTION

According to Jahan (2017), woven fabric is the most versatile type of textile material for its construction. It is composed of fibres that can be derived from natural or artificial sources and can be woven into thick or thin sheets. Weaving and woven fabric *Aso-Oke* such as *Sanyan*, *Alaari*, or *Etu* signifies elegance, high social status and played a significant role in the economy of the Yoruba people of Southwest Nigeria (Makinde ***et al*.,** 2009; Asakitikpi, 2007). Without question, one of the most important aspects of a fabric is its mechanical properties. How woven fabric responds to applied stresses and deformation is what makes it mechanical (Kiron, 2022). Weaved fabrics' mechanical characteristics have always been important in determining their longevity and appropriateness for different uses. The type of fibre, the machine used, and the weave structure are a few factors that Jahan (2017) found to be crucial in determining the mechanical qualities of woven fabric.

Tensile, flexural, torsional, and fictional properties are the four general categories into which fabric's mechanical properties are divided. Behera and Hari's (2010a) study concentrated only on a few of the four properties, not all of which are equally important: tensile strength, burst strength, abrasion resistance, flexibility, stiffness, and elongation. These mechanical (Elongation, Tensile and Tearing strengths) properties are crucial for evaluating the performance and suitability of woven fabrics for various applications as these properties determine the fabric's strength, flexibility, and overall durability (Ziemele, *et al*., 2018).

Tensile strength refers to the maximum load a fabric can withstand before breaking while elongation measures the percentage increase in length before breaking (Behera and Hari, 2010b). *Aso-Oke* is known for its ability to resist stretching or breaking under tension. The mechanical strength of *Aso-Oke* comes from the fabrics tight weaving and weaving structure. This structure results in a dense textile that can withstand wear and tear and also makes it suitable for use in applications where strength and durability are required, such as for traditional clothing or ceremonial costumes (Jahan, 2017). Also, *Aso-Oke* is relatively resistant to tearing or puncturing, which enhances the ability to withstand daily wear and tear. *Aso-Oke* plain weave structure and yarn quality enhance its structural strength against easy bursting from external force.

Eryuruk and Kalaoglu, (2015) used two distinct weft yarns and three different weft densities to investigate the effect of weave construction on the tear strength of woven fabrics. For all weave types, they discovered that the most important factor affecting tearing strength is yarn density. According to Gadah (2012) fabric air permeability reduces as weft density rises; satin materials have the highest ripping strength and air permeability, while plain fabrics have the lowest. *Aso-Oke* can stretch to a certain degree before it reaches its breaking point. The elongation property of *Aso-Oke* makes it suitable for activities or designs that require stretching or pulling.

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Woven fabric end uses can be roughly divided into industrial, household and apparels. Fabrics projected for apparels have more emphasis on their appearance and handling characteristics such as lustre, smoothness or roughness, stiffness or limpness and draping qualities. In this research paper mainly focused on air permeability, tear strength and flexural rigidity were taken into consideration. In the present work observations are made by changing the pick density in the plain woven cotton fabric (Govardhana, *et al,* 2015). Though tear strength was taken into consideration, the primary emphasis of this study was on tensile strength and elongation. Changes in pick density in the plain woven indigenous fabric *AsoOke* produced on neo-traditional floor loom (TFL) and modified floor loom (MFL) were used to make observations.

The following research hypotheses stated in null form were tested:

Ho_1: There is no significant difference between the Elongation, Tensile and Tearing strengths properties of fabric samples from neo-traditional and modified floor looms.

Ho_2: There is no significant relationship between the Elongation, Tensile and Tearing strengths properties of woven indigenous fabrics on neo-traditional and modified floor looms.

2. MATERIAL AND EXPERIMENTAL PROCEDURE

The research adopted an experimental research design (Adetoro, 1997; Adogbo, and Ojo, 2003) and was carried out in Federal University of Agriculture, Abeokuta at the Departments of Home Science and Management Textile laboratory and Raw Material Testing and Research unit, Federal Institute of Industrial Research Oshodi (FIIRO) Lagos. Using ten samples of texturised polyester plain woven fabric with constant variables, the study concentrated on the indigenous woven fabrics known as *Aso-Oke*. Changing the pick density on both modified and neo-traditional floor looms allowed to examine the fabric qualities (Table 1).

Weaved fabrics from both modified and neo-traditional floor looms were evaluated for elongation, tensile, and tear strengths using standard tests ASTM-D-5034 and ASTM-D5587 with the Istoron Universal Materials Testing machine (X500, 25kN). A specimen measuring 100 mm (4.0 inches) in width is fastened to the centre of the tensile testing device, and force is applied until the specimen fractures. The data was analysed using both descriptive and inferential statistics, such as independent t Test and Pearson correlation.

Table 1: Details of Plain Fabrics Samples Produced

Sl. No	Weave Structure	Warp count (Denier)	Weft count (Denier)	EPI	PPI
MFL1	2 x 2 Matt	8.1	11.4	91	36
MFL2	2 x 2 Matt	8.1	16.5	91	38
MFL3	2 x 2 Matt	8.1	28.6	91	64
MFL4	2 x 2 Matt	8.1	36.5	91	89
MFL5	2 x 2 Matt	8.1	36.3	91	102
TFL1	2 x 2 Matt	10.8	11.4	91	36
TFL2	2 x 2 Matt	10.8	15.2	91	38
TFL3	2 x 2 Matt	10.8	28.4	91	64
TFL4	2 x 2 Matt	10.8	40.3	91	89
TFL5	2 x 2 Matt	10.8	40.0	91	142

Legend: EPI – Ends per Inch; PPI – Pick per Inch

The study focuses on the creation of woven fabric samples using various pick per inch (PPI) yarn plies and a constant warp ends per Inch (EPI) of 91. The ten indigenous woven fabric samples were created using both the neo-traditional floor loom (TFL) and the modified floor loom (MFL). The ten samples were plain. 2 x 2 matt weave constructed from varied plies of 100% texturized polyester yarn. Fabric samples MFL1 and TFL1, MFL2 and TFL2, MFL3 and TFL3, and MFL4 and TFL4 had 36, 38, 64, and 89 Picks per Inch (PPI), respectively, while samples MFL5 and TFL5 had 102 and 142 Picks per Inch (PPI).

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3. RESULTS OF THE STUDY

The ASTM-D-5034 standard test procedure evaluates fabric samples, table 2 revealed the relationship between pick per inch (PPI), tensile strength at break, and elongation percent at break.

Table 2: Fabric Tensile Strength and Elongation

Samples	PPI	Tensile Strength (kgf)		Elongation %	
		Warp	**Weft**	**Warp**	**Weft**
MFL1	36	39.59	27.27	29.77	19.76
MFL2	38	50.04	28.40	30.67	21.90
MFL3	64	36.90	44.46	33.93	32.62
MFL4	89	26.57	28.84	25.68	20.67
MFL5	102	36.38	44.90	31.42	21.69
TFL1	36	40.39	26.90	23.44	29.18
TFL2	38	43.28	24.98	21.84	19.39
TFL3	64	21.67	54.86	32.25	20.33
TFL4	89	37.59	30.38	28.87	21.02
TFL5	142	21.59	20.61	26.57	24.10

Figure 1 shows the average values for tensile strength of woven fabric samples produced on neo-traditional and modified floor looms. In the warp direction, fabric MFL2 (50.04 kgf) had the largest tensile strength, followed by TFL2 (43.28 kgf) and TFL1 (37.59 kgf). Tensile strength is stronger in the warp direction due to increased thread density. In the weft direction, fabric TFL3 (54.86 kgf) had the maximum tensile strength, followed by MFL5 (44.90 kgf) and MFL3 (44.46 kgf).

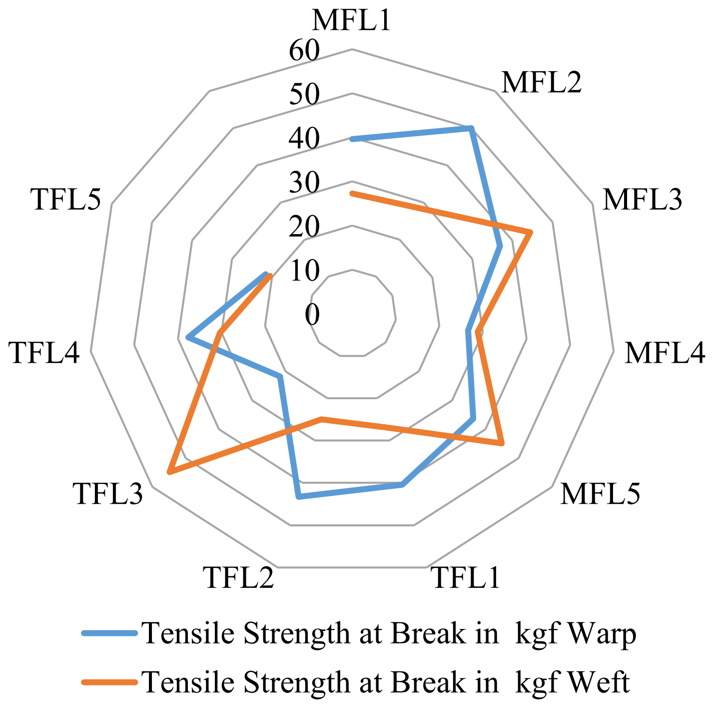

Figure 1: Fabric samples Tensile Strength at Break in kgf

Figure 2 on the average elongation % of fabric shows that MFL3 has a greater elongation % than other fabrics. Fabric elongation in the warp direction is more in the weft direction.

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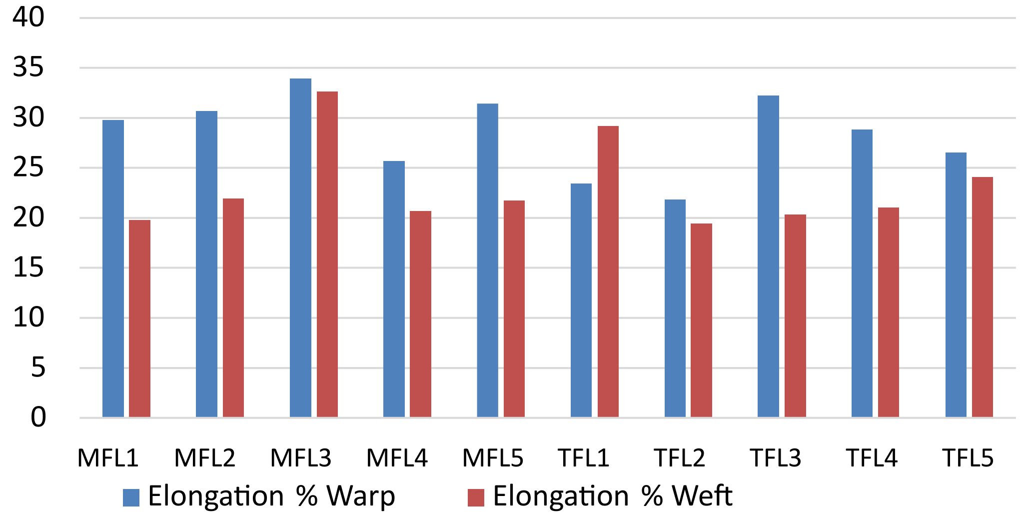

Figure 2: Fabric samples Elongation % in warp and weft directions

The force required under particular circumstances to rip a cloth in the weft or warp direction is known as the tearing strength. The effort required to expand a rip after it starts is measured using a testometric materials testing apparatus. In both the warp and weft directions, fabric samples made on traditional and modified floor looms are shown in Figure 3 with their mean tearing strength (tear force) values. Compared to other fabrics, the tearing strength of TFL5 (46.51, 50.26 kgf), TFL4 (40.25, 53.34 kgf), and MFL3 (30.96, 44.11 kgf) fabrics is higher. Nevertheless, less than 35.00 kgf is the warp and weft tearing strength in MFL1, MFL2, MFL4, MFL5, TFL1, TFL2, and TFL3 fabrics. The tensile properties of the individual fibres and yarns, as well as the yarn density, twist, and count, all affect the tearing resistance.

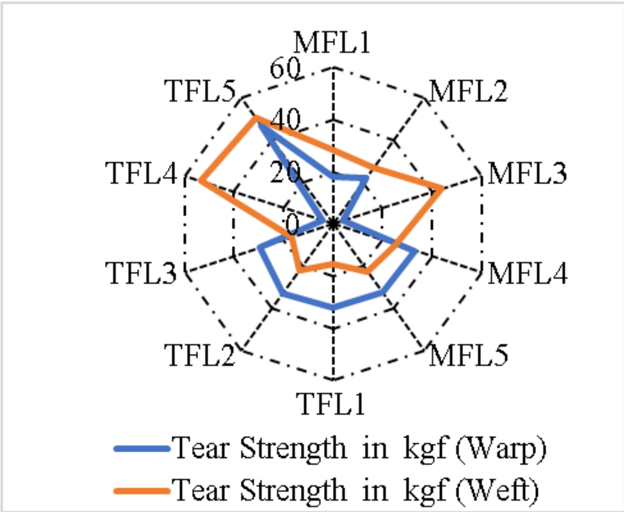

Figure 3: Mean Tear force of Fabrics from Modified and Neo-traditional floor looms

4. TEST OF HYPOTHESIS

The elongation, tensile, and tearing strengths of fabric samples from modified and neo-traditional floor looms are compared using an independent samples t-test, as shown in Table 3 results. Tensile strengths (TSE) in warp directions of fabrics from the Neo-traditional floor loom (M = 32.90, SD = 10.49) were significantly lower than those from the Modified floor loom (M = 37.90, SD = 8.39) t (8) = 0.831, p = 0.43). In the warp direction, the Modified floor loom's fabrics (M = 27.29, SD = 6.81) exhibited significantly reduced Tearing Strength (TrSE) compared to the Neo-traditional floor loom's fabrics (M = 36.26, SD = 6.99); t (8) = -2.06, p = 0.07. The Modified floor loom produced fabrics with a Tearing Strength (TrSP) in weft that was significantly lower than that of the Neo-traditional floor loom (M = 31.5, SD = 18.73), as indicated by t (8) = -0.23, p = 0.82.

Table 3: Independent t -Test of significant difference between Elongation, Tensile and Tearing strengths of fabrics from Traditional and Modified floor looms

Variables		Mean	Std. Dev.	F	df	t	*p*-value	Sig.
TSE	Modified floor loom	37.9	8.39	1.50	8	0.83	0.26	NS
	Neo-traditional floor loom	32.9	10.49					
TSP	Modified floor loom	34.77	9.06	0.13	8	0.44	0.73	NS
	Neo-traditional floor loom	31.55	13.5					
EPE	Modified floor loom	30.29	3.01	0.73	8	1.61	0.42	NS
	Neo-traditional floor loom	26.59	4.18					
EPP	Modified floor loom	23.33	5.27	0.15	8	0.18	0.71	NS
	Neo-traditional floor loom	22.8	3.98					
TrSE	Modified floor loom	27.29	6.81	0.01	8	-2.06	0.92	NS
	Neo-traditional floor loom	36.26	6.99					
TrSP	Modified floor loom	29.34	8.56	10.50	8	-0.23	0.01	S
	Neo-traditional floor loom	31.5	18.73					

Key:

TSE	Tensile Strength END	EPP	Elongation % END
TSP	Tensile Strength PICK	TrSE	Tear Strength END
EPE	Elongation % PICK	TrSP	Tear Strength PICK

Furthermore, t (8) = 1.16, p = 0.42 shows that the elongation percentage of fabrics produced on the Neo-traditional floor loom (M = 26.59, SD = 4.18) is significantly lower in the warp direction than that of fabrics generated on the Modified floor loom (M = 30.29, SD = 3.01).

There was a significant difference (Sig. 0.01) in the weft direction of the Tearing Strength (TrSP) between the fabrics from the Traditional and Modified floor looms, even though there was no significant variation in the Elongation, Tensile, and Tearing strengths of the fabrics. Therefore, it is believed that there has been no discernible difference in the elongation, tensile, and tearing strengths of fabrics produced on traditional and modified floor looms.

The linear correlation between Elongation, Tensile, and Tearing strengths of fabric from modified floor looms is perfectly correlated with itself, as shown in Table 4 and 5. The correlation matrix displays correlation coefficients between various properties related to fabrics made on modified floor looms. There is a substantial negative connection between TSE-MFL and TrSE-MFL, and TSE-MFL and TrSE-MFL (correlation coefficients: 0.703, and -0.740 respectively). Despite having correlations of 0.718 between EPP-MFL and EPE-MFL, there is a strong positive correlation 0.926 between TrSP-MFL and EPPMFL Additionally, there is a strong positive correlation between TSP-TFL and EPETFL (0.778); TrSE-TFL and TrSP-TFL have correlation coefficients of 0.917.

Table 4: Correlation Matrix of Fabric samples elongation, tensile, and tearing strengths from Modified floor loom

S/N		Mechanical Properties	TSE-MFL	TSP-MFL	EPE-MFL	EPP-MFL	TrSE-MFL	TrSP-MFL	FW-MFL
1		**TSE-MFL**	1						
2		**TSP-MFL**	-0.157	1					
3		**EPE-MFL**	0.501	0.693	1				
4		**EPP-MFL**	-0.001	0.655	0.718	1			
5		**TrSE-MFL**	-0.703	0.637	-0.058	0.351	1		
6		**TrSP-MFL**	0.041	0.385	0.628	0.926	0.069	1	

Key: MFL – Modified Floor Loom

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TRESEARCH

1	TSE	Tensile Strength END	4	EPP	Elongation % END
2	TSP	Tensile Strength PICK	5	TrSE	Tear Strength END
3	EPE	Elongation % PICK	6	TrSP	Tear Strength PICK

Table 5: Correlation Matrix of Fabric samples elongation, tensile, and tearing strengths from Neo-traditional floor loom

S/N	Mechanical Properties	TSE TFL	TSP TFL	EPE TFL	EPP TFL	TrSE TFL	TrSP TFL
1	TSE-TFL	1					
2	TSP-TFL	-0.44	1				
3	EPE-TFL	-0.720	0.778	1			
4	EPP-TFL	0.103	-0.360	-0.330	1		
5	TrSE-TFL	-0.300	-0.620	-0.010	0.063	1	
6	TrSP-TFL	-0.200	-0.440	0.191	-0.160	0.917	1

Key: TFL – Neo-traditional Floor Loom

1	TSE	Tensile Strength END	4	EPP	Elongation % END
2	TSP	Tensile Strength PICK	5	TrSE	Tear Strength END
3	EPE	Elongation % PICK	6	TrSP	Tear Strength PICK

The factor analysis scree plots indicated that there was a pattern of association in the elongation, tensile, and tearing strengths of fabrics produced on the neo-traditional and modified floor looms.

Table 6: Fabric Elongation, Tensile, and Tearing strengths from Neo-traditional and Modified floor looms – Rotated Component Matrix

S/N	Mechanical Properties	Component - Neo-traditional floor loom				Component - Modified floor loom			
		1	**2**	**3**	**4**	**1**	**2**	**3**	**4**
1	TSE	-.384	.639	.371	-.554	-.618	.376	-.477	.499
2	TSP	.373	.202	-.891	.163	.791	.374	.096	.474
3	EPE	.804	-.071	-.493	.324	.191	.833	-.112	.507
4	EPP	-.418	.302	.431	.740	.568	.773	-.255	-.124
5	TrSE	.344	-.590	.724	.100	.962	-.269	-.028	-.042
6	TrSP	.640	-.385	.660	-.080	.297	.878	-.141	-.347

Extraction Method: Principal Component Analysis

Key:

1	TSE	Tensile Strength END	4	EPP	Elongation % END
2	TSP	Tensile Strength PICK	5	TrSE	Tear Strength END
3	EPE	Elongation % PICK	6	TrSP	Tear Strength PICK

5. DISCUSSIONS

Matsudaira et al. 2009 and Zupin and Dimitrovski 2010 have both predetermined the mechanical properties of woven fabric, which are influenced by various physiognomies. These properties include yarn type, linear density, fabric sett or weave type, and cover factor. These factors directly impact the fabric's mechanical properties, such as tensile strength, elongation percent, tear resistance, and fabric stiffness, during weaving. Fabric density is determined by its sett, with denser textiles requiring heavier picks and ends per inch (PPI) and EPI. The fineness and twist of yarn affect fabric behavior.

Tensile strength, elongation, and tearing strength are essential for fabric performance and lifespan evaluation. Synthetic materials have superior tensile strength than natural fibers. Fine and long-staple fabric have higher tensile strength than coarse and short-staple fabric. If warp and weft counts are equal, fabric with more threads per square inch has higher tensile

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strength. Tearing strength, which is important for high-performance and commonplace materials such industrial settings, tents, worker jeans, sacks, bulletproof jackets, and stylish clothes, is the power needed to tear a fabric in the weft or warp direction under certain conditions. The force required to rip a single strip of cloth is measured by Testometric material testing apparatus.

The study reveals that fabric MFL2 (50.04 kgf) has the highest tensile strength in the warp direction, followed by TFL2 (43.28 kgf) and TFL1 (37.59 kgf). Tensile strength is stronger in the warp direction due to increased thread density. In the weft direction, fabric TFL3 (54.86 kgf) has the highest tensile strength, followed by MFL5 (44.90 kgf) and MFL3 (44.46 kgf). According to Bonde and Asagekar's (2014) study on weft attributes, tensile strength rises with pick density, with the exception of satin fabric and core spun cotton/polyester weft, where strength rises with decreasing pick density.

Tensile strength is crucial for fabric performance and longevity. Modified floor loom fabrics have superior tensile strength in both warp and weft directions, ensuring longer lifespan. While neo-traditional floor loom fabrics have the highest tensile strength in the weft direction, MFL3 fabric exhibits greater elongation and stretch ability, withstands pulling forces, and can stretch more. When a moving material gets hooked on a sharp object, it often rips wider in a straight line due to the warp, which is the direction of the weft in textile materials. The study reveals that fabrics produced on traditional and modified floor looms have varying tearing strength values. TFL5, TFL4, and MFL3 fabrics have stronger tearing strength in both warp and weft directions, while MFL1,

MFL2, MFL4, MFL5, TFL1, TFL2, and TFL3 fabrics have less than 35.00 kgf.

Munagala and Chilukoti (2015) found a significant relationship between pick densities and tear strength in woven fabrics. The study found that increasing pick density in plain woven fabrics resulted in a denser fabric structure with more interlocking yarns. However, fabric MFL3 had the highest tearing strength among the fabrics from the modified floor loom. The findings in this study contradict Munagala and Chilukoti's assertion, as the tearing strength of fabrics produced on the neo-traditional floor loom increases with increase in pick density. However, the study did not show a decrease in tearing strength for fabric TFL3 due to an increase in pick density. At this point, the study finds and concludes that at pick density of 64 PPI, the Modified floor loom had a superior tearing strength MFL3 (44.1 kgf, 64 PPI) to TFL3 (16.4 kgf, 64 PPI) fabric produced on neo-traditional floor loom.

Tensile strength and thickness in woven fabrics are crucial for wrinkle resistance (Yang *et al*., 2003). Greater tensile strength lessens the possibility of wrinkle formation. Fabrics are stronger when pulled in the lengthwise direction. Kawabata and Niwa (1991) discovered that tensile strength was higher in the warp direction than to the weft direction, a tendency seen across all weave types. Since the fabrics produced on the neo-traditional and modified floor looms are all plain matt weave, this study collaborate with the findings of Govardhana *et al*. (2015) that reveals that higher pick density leads to higher fabric stiffness which was exhibited by fabrics MFL3, MFL4, MFL5 and TFL4 with more from the Modified floor loom . Furthermore, the research indicated that there was a significant effect of pick density on flexural rigidity, (Zhu *et al.,* 2017; Umair *et al.,* 2015).

The weave type, yarn composition, and pick density are all elements that affect tensile strength. The findings in this study do not absolutely disagreed with Kawabata and Niwa (1991) finding as only one fabric sample from the neo-traditional floor loom TFL3 and three fabrics from the Modified floor loom MFL3, MFL4 and MFL5 seems contrary where the tensile strength is higher in the weft than the warp direction. In both the weft and warp directions, the tensile strength of the fabrics was assessed; the fabrics with the highest tearing strength were TFL5, TFL4, and MFL3, while the fabrics with the lowest tearing strength were MFL1, MFL2, MFL4, MFL5, TFL1, TFL2, and TFL3.

6. CONCLUSIONS

The study analyzed indigenous textiles using neo-traditional and modified floor looms. Results showed higher tensile strength in MFL2 and TFL3 fabrics, and higher tearing strength in TFL4 and TFL5 fabrics. These differences were influenced by the tensile qualities of component fibers, yarn density, and count. No significant differences were found in mechanical properties except for Tearing Strength along the weft direction. However, a significant relationship was found between Tensile Strength and Elongation% in the weft direction. According to this study, in order to increase the Tearing Strength,

Tensile Strength and Elongation percent, *Aso-Oke* weaving requires an understanding of linear density, yarn count, and fibre kinds because weft yarns in indigenous woven fabrics can alter the fabric's mechanical qualities and intended use, therefore, the pick should have three to five yarn plies.

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