Influence of Using Different Blend Ratios of Banana Fiber on the Mechanical Properties of Woven Fabrics

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Abstract:

Mechanical properties are very important properties of woven fabric; it affects the stress that a textile material can withstand during use. Recently, attention has been increased toward the use of renewable resources especially of plant origin, keeping in view the ecological concerns. Banana fibre is biodegradable and has no negative effect on environment and thus can be categorized as eco-friendly fibre.

This paper is aiming to investigate the mechanical properties of (banana/cotton) woven fabrics based on three different weft arrangements which lead to different banana fibre ratios in weft direction (50% banana: 50% cotton, 33.4% banana: 66.6% cotton & 25% banana: 75% cotton) respectively. With three weave structures (plain 1/1, twill 2/2 and satin 4) differ from each other in the float length.

Mechanical Properties of produced samples were investigated according to ASTM standard methods including tensile strength, elongation, tearing and abrasion resistance. The results were evaluated using statistical analysis and it is noticed that there is a direct proportional relationship between increasing the banana fibre ratio and the tensile strength in warp direction and elongation in both directions, whilst there is an inverse relationship between the ratio of banana fibre and the tensile strength in weft direction, tear strength in weft direction and abrasion resistance.

The weave structure plain1/1 has scored a high rate of tensile strength in warp direction, tensile strength in weft direction, elongation in warp direction and abrasion resistance, on the other hand, the satin 4 weave structure has recorded a high value in tear strength in weft direction and elongation in weft direction.

Keywords

Natural fibers, Banana fibers, Mechanical properties, Woven fabrics, Eco-friendly fibers.

الملخص:

تعد الخواص الميكانيكية من اهم خصائص الاقمشة المنسوجة، والتي تؤثر علي مقدار الاجهادات التي تتحملها الاقمشة اثناء الاستخدام . زاد الاهتمام مؤخراً باستخدام المواد المتجددة خاصاً ذات الاصل النباتي نظراً لزياده الوعي والاهتمام البيئي . يمكن ان تصنف الياف الموز والتي لها القدرة علي التحلل الحيوي وليس لها تأثيراً ضارً علي البيئه بانها الياف صديقة للبيئه.

تهدف هذه الورقة البحثية لدراسة الخواص الميكانيكية لاقمشة (موز / قطن) المنسوجه باستخدام ثلاث ترتيبات لحمه مختلفه والتي تؤدي الي نسب خلط مختلفة من الياف الموز في اللحمات كما يلي: (٥٠% موز : ٥٠% قطن / ٣٣,٤% موز :

٦٦,٦% قطن / ٢٥% موز : ٧٥% قطن) علي التوالي . مع استخدام ثلاثة تراكيب نسجية مختلفة في طول التشييفة (ساده ١/١ ، مبرد ٢/٢ ، اطلس ٤).

تم اجراء الاختبارات للخواص الميكانيكية للاقمشة المنتجة تبعاً للمواصفات القياسية الامريكية بما في ذلك (**اولاً:** اختبار قوه الشد والاستطاله في كلاً من اتجاهي السداء واللحمه ، **ثانياً:** مقاومه التمزق في اتجاه اللحمه "علماً بان من متغيرات البحث لم يكن لها دلاله معنويه علي مقاومه التمزق في اتجاه السداء لذا لم يتضمن البحث نتائح هذا الاختبار" ، **ثالثاً:** مقاومه الاقمشة للتاكل بالاحتكاك) .

تم تقييم النتائج باستخدام التحليل الاحصائي وتلاحظ وجود علاقة طردية بين زياده نسبة الياف الموز وقوه الشد في اتجاه السداء والاستطاله في كلاً من الاتجاهين ، الا انة هناك علاقة عكسية بين زياده نسبة الياف الموز في الاقمشة المنتجة و قوة الشد في اتجاه اللحمه وقوه التمزق في اتجاه اللحمه و مقاومه الاقمشة لاحتكاك.

سجل التركيب النسجي **ساده ١/١** اعلي معدلات قوة الشد في كلاً من اتجاهي السداء واللحمة والاستطاله في اتجاه السداء ومقاومه الاقمشة لاحتكاك ، من ناحيةً اخري سجل التركيب النسجي **اطلس ٤** اعلي قيمه في قوه التمزق في اتجاه اللحمه والاستطاله في اتجاه اللحمه .

الكلمات الدالة :

الالياف الطبيعية ، الياف الموز ، الخواص الميكانيكية ، الاقمشة المنسوجة ، الالياف صديقة للبيئة.

I. Introduction:

In recent years, the huge usage of manmade fibres causes a lot of environmental pollution because of its non-degradability so searching for alternative fibres is of high demand (1). Different applications were trying to use vegetable fibres which prove themselves as an alternative fibre to its synthetic counterpart. This is because natural fibres are biodegradable, low cost, lightweight and abundant when compared to synthetic fibres (2).

Nowadays, the concern for the environmental contamination and the prevention of non-renewable and nonbiodegradable materials has attracted researchers seeking to develop new eco-friendly materials and products based on sustainability principles (1). Banana is one of the rhizomatous plants and currently cultivating in 129 countries around the world. It is the fourth most important global food crop (3,4).

Fibres may be obtained from different parts of the plant such as the bunch, stem, and leaf (4). as shown in below figure (1). Banana fibre can be extracted from banana stem by manual, mechanical, chemical and biological methods (5).

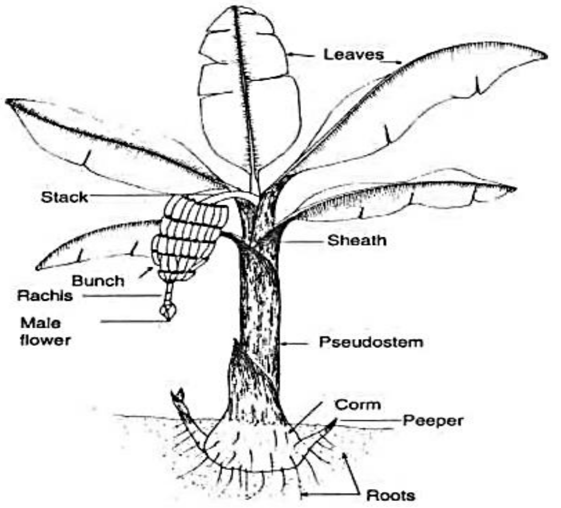	
Fig. (1) Different parts of banana tree [6].	**Fig. (2) Extracted banana fibres from pseudo-stem of plant. (Raw materials)**

Now, the banana fibre is a waste materials of banana cultivation, therefore without any additional cost these fibres can be extracted for industrial purposes [7,1,8].

Banana is one of the oldest cultivated plants, in Egypt [9]. The production of banana crop reached to 1.39 million tonnes in 2018 [10].

Banana fibres can be spun using almost all the methods of spinning including ring spinning, open-end spinning, and others spinning methods [11]. In this paper mechanical properties of produced fabric using 100% cotton & blended (banana/cotton) yarns as weft materials with three different arrangements of weft picks were studied.

II. Materials and Methods.

The main purpose of the present work is to study the effect of banana fiber ratio on the mechanical properties of produced fabrics.

2.1. Warp & Weft materials

Warp material for all produced samples was 100% cotton with yarn count 50/2 Ne, On the other hand, 100% cotton yarn and blended yarn (50% banana: 50% Cotton) were used for the weft with yarn count 20/1 Ne, the below table (1) shows mechanical properties of weft & warp yarns. Blended yarn (50% banana: 50% Cotton) was supplied by Banfab co. Ltd, India.

Table (1) Mechanical properties of weft & warp yarns.

Sample	direction	Count	Tenacity (CN/Tex)	Elongation (%)
100% Cotton	Warp	50/2 Ne*	13.8	4.6
Blended (50% Banana fiber: 50% Cotton fiber)	Weft	20/1 Ne	9.11	5.7
100% Cotton	Weft	20/1 Ne	12.3	4.5

*** Note:** Yarn count test was carried out according to (ASTM D 1907-01)

2.2. Specification of the machine used in producing the samples under study.

The research samples were produced at textile design & technology center – faculty of applied arts, using an electronic dobby machine with the specifications shown in the table (2).

Table (2) Specifications of the loom used in producing research samples

No.	Property	Specification
1	Weft insertion device	Rapier
2	Name of Loom	itema- R9500
3	Date of Manufacturing	2014
4	Manufacturing country	Italy
5	Speed of the machine	320 picks / min.
6	Shedding device	Dobby
7	Name of dobby	Stäubli
8	Width of warp without selvedge	163 cm
9	Reed used (dents per cm)	12 dents / cm
10	Denting	3 ends / dent

2.3. Specification of produced fabrics.

To investigate the effect of banana fiber ratio on the produced fabrics properties, ten samples were produced by using two parameters (weft ratio & weave structure). Three different arrangement of the weft yarns were used for producing research samples which lead to a difference in the banana fiber concentration, with three weave structures (plain 1/1 & Twill 2/2 & Satin 4) as shown in table (3).

Table (3) The operational specifications of produced samples

<table>
<tr><th>Sample Number</th><th>Weft arrangement</th><th>Weft Ratio *
Variable Parameter</th><th>Weave structure
Variable Parameter</th><th>Ends/cm
Constant Parameter</th><th>Picks/cm
Constant Parameter</th></tr>
<tr><td>1</td><td rowspan="3">1 Cotton: 1 Blended</td><td rowspan="3">75% Cotton: 25% Banana</td><td>Plain1/1</td><td rowspan="10">36</td><td rowspan="10">21</td></tr>
<tr><td>2</td><td>Twill 2/2</td></tr>
<tr><td>3</td><td>Satin 4</td></tr>
<tr><td>4</td><td rowspan="3">1 Cotton: 2 Blended</td><td rowspan="3">66.6 % Cotton: 33.4% Banana</td><td>Plain1/1</td></tr>
<tr><td>5</td><td>Twill 2/2</td></tr>
<tr><td>6</td><td>Satin 4</td></tr>
<tr><td>7</td><td rowspan="3">Blended</td><td rowspan="3">50% Cotton: 50 % Banana</td><td>Plain1/1</td></tr>
<tr><td>8</td><td>Twill 2/2</td></tr>
<tr><td>9</td><td>Satin 4</td></tr>
<tr><td>10 (Control)</td><td>Cotton</td><td>100% Cotton</td><td>Plain1/1</td></tr>
</table>

***Note:** Appendix (A) shows calculations of weft ratio for produced fabrics.

2.4. Measurements and Testing

Tests were carried out on produced samples to evaluate mechanical properties.

2.4.1. Weight test

This test was carried out according to the American Standard Specification of (ASTM D3776 - 09). [(12)]

2.4.2. Thickness test

This test was carried out according to the American Standard Specification of (ASTM D1777 – 96 (2015). [(13)]

2.4.3. Tensile strength and Elongation test (Grab method):

This test was carried out by using (SDL ATLAS tester) according to (ASTM D5034 -09 (2013). [(14)]

2.4.4. Tearing Strength (Elmendorf method)

This test was carried out by using (SDL ATLAS tester) according to (ASTM D1424 -09 (2013). [(15)]

2.4.5: Abrasion resistance test (mass loss):

This test was carried out by using (Martindale Abrasion Tester) according to (ASTM D4966 – 10). [(16)]

III. Result and Discussion:

This part is dealing with the test results that were carried out for all produced samples. it is also concerned with studying the effect of the research variables on the produced samples properties. The following table (4) shows the results of tests applied to the produced Banana / cotton fabrics.

Table (4) Produced fabrics testing results

	Variable Parameter		Results								
Sample Number	**Weft Ratio**	**Weave structure**	**Weight (g/m^2)**	**Thickness (mm)**	**Tensile Strength -warp (N)**	**Elongation - Warp (%)**	**Tensile Strength -weft (N)**	**Elongation - Weft (%)**	**Tear strength - Weft (N)**	**Abrasion resistance (%)**
1	75% Cotton 25% Banana	Plain 1/1	145	0.34	380.3	22.5	257.7	7	42.14	1.21
2		Twill 2/2	143.7	0.43	364.3	17.4	223.3	8.4	46	1.38
3		Satin 4	142.2	0.4	357.3	14.5	204.3	9.7	52.9	1.58

Follow table (4) Produced fabrics testing results

Sample Number	Variable Parameter: Weft Ratio	Variable Parameter: Weave structure	Results: Weight (g/m²)	Thickness (mm)	Tensile Strength -	Elongation - Warp (%)	Tensile Strength -weft	Elongation - Weft (%)	Tear strength - Weft (N)	Abrasion resistance (%)
4	66.6% Cotton 34.4% Banana	Plain 1/1	143.8	0.35	401.7	23	225	7.48	41.26	2.17
5		Twill 2/2	142.7	0.43	366.3	18.2	204	8.92	44.64	2.24
6		Satin 4	141.3	0.41	358.7	15.8	202	9.52	50.4	2.68
7	50 % Cotton 50 % Banana	Plain 1/1	141.7	0.34	405.7	24.6	180.7	7.83	39.84	2.47
8		Twill 2/2	138.9	0.42	373.3	19	166.3	9.57	42.9	2.65
9		Satin 4	137.5	0.4	366.3	17.1	158	10.95	48.4	3.1
10 (Control)	100 % Cotton	Plain 1/1	147.1	0.33	372.3	21.2	252.7	7.2	43.14	1.83

3-1: Tensile strength in warp direction:

Table (4) and figure (1) shows the results of Tensile strength in warp direction test carried out on the produced samples using the following parameters: different ratio of banana fibres in weft direction & weave structure.

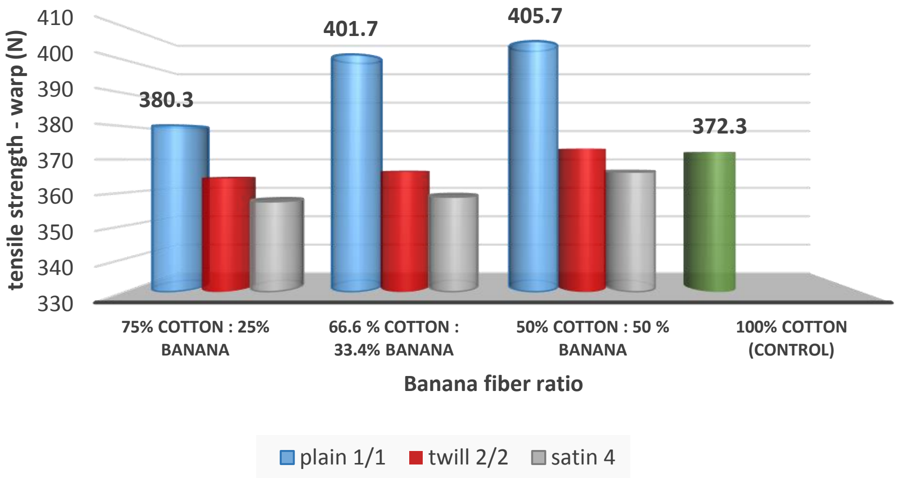

Fig. (1) Effect of banana fibre ratio & weave structure on tensile strength -warp.

Table (5) Regression equation and quadratic coefficient for the effect of banana fibre ratio on fabric tensile strength in warp direction for produced samples.

Weave structure	Regression equation	R^2
Plain 1/1	y = 90.736x + 363.11	0.7144
Twill 2/2	y = 36.865x + 354.65	0.9849
Satin 4	y = 37.371x + 347.26	0.9638

Where, **y** = Tensile strength-warp **x** = Banana fibre ratio

3-1-1: Effect of banana fiber ratio on tensile strength in warp direction:

From table (4&5) and figure (1) it can be noticed that, there is a direct relation between the tensile strength in warp direction and the ratio of banana fibres. This is because of the increase in the banana fibres ratio in picks per centimetre which have lowest density (**1.35 g/cm^3**) compared to cotton leads to increases the (banana/cotton) yarn volume, so that the yarns which are bulkier increases the warp crimp leading to an increase in the fabric tensile strength in the warp direction.

Sample (7) with weft ratio (50% banana: 50% cotton) and weave structure plain 1/1 has scored highest rates of tensile strength in warp direction compared to control sample (10).

*** Note:** comparison was taken place between the sample which has a high percentage of banana fibers (sample 7) and the sample without banana fiber (control sample 10) with the same weave structure for both samples, plain 1/1.

3-1-2: Effect of weave structure on tensile strength in warp direction:

From table (4) and figure (1) there is an inverse relationship between the float length and tensile strength in warp direction, the structure which has lowest float length (**plain 1/1**) has recorded higher rates of fabric tensile strength in warp direction followed by (**twill 2/2, satin 4)** respectively. This is due to the decrease in the float length increases the number of the intersections in the fabrics and increases the warp crimp, as a result the fabric tensile strength in warp direction increased.

3-2: Elongation in warp direction:

Table (4) and figure (2) shows the results of elongation in warp direction test carried out on the produced samples using parameters mentioned before.

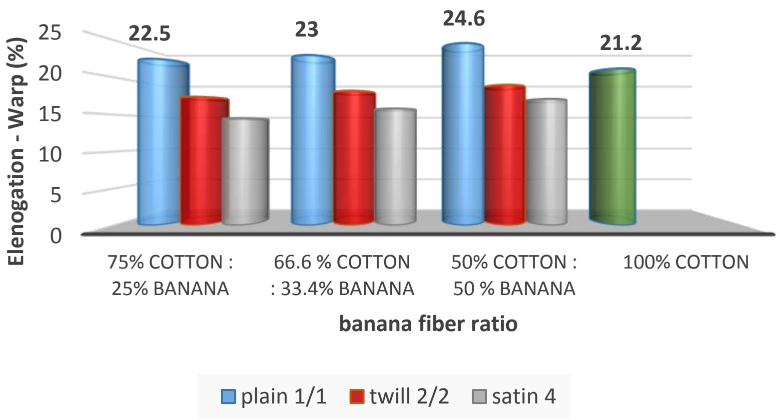

Fig. (2) Effect of banana fibre ratio & weave structure on elongation -warp.

Table (6) Regression equation and quadratic coefficient for the effect of banana fibre ratio on fabric elongation in warp direction for produced samples.

Weave structure	Regression equation	R^2
Plain 1/1	y = 8.5736x + 20.269	0.9887
Twill 2/2	y = 6.1784x + 15.968	0.9654
Satin 4	y = 10.04x + 12.172	0.9654

Where, **y** = Elongation -warp **x** = Banana fibre ratio

3-2-1: Effect of banana fiber ratio on elongation in warp direction:

From table (4&6) and figure (2) it is obvious that there is a direct relation between the elongation in warp direction and the ratio of banana fibres. This is due to the density of banana fibre is (**1.35 g/cm³**) [17], whereas the density of cotton fibre is (**1.54 g/cm³**). So the fabrics which have more percentage of banana fiber in wefts increases the warp crimp leading to an increase in the fabric elongation in the warp direction.

Density is defined as mass divided by volume, owing to this formula there is an inverse relationship between density and volume, as the fiber density decreases the volume of fibers increases and vice versa.

Sample (7) with weft ratio (50% banana: 50% cotton) and weave structure plain 1/1 has scored highest rates of elongation in warp direction compared to control sample (10).

3-2-2: Effect of weave structure on elongation in warp direction:

From table (4) and figure (2) it can be noticed that, there is an inverse relationship between the float length and elongation in warp direction, the structure which has lowest float length (**plain 1/1**) has recorded higher rates of fabric elongation in warp direction followed by (**twill 2/2, satin 4**) respectively. This is owing to the decrease in the float length increases the number of the intersections in the fabrics and increases the warp crimp, as a result the fabric elongation in warp direction increased.

3-3: Tensile strength in weft direction:

Table (4) and figure (3) shows the results of Tensile strength in warp direction test carried out on the produced samples using parameters mentioned before.

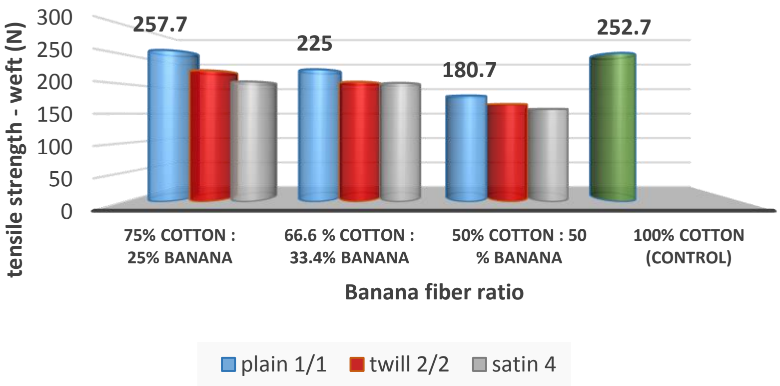

Fig. (3) Effect of banana fibre ratio & weave structure on tensile strength -weft.

Table (7) Regression equation and quadratic coefficient for the effect of banana fibre ratio on fabric tensile strength in weft direction for produced samples.

Weave structure	Regression equation	R^2
Plain 1/1	y = -302.23x + 330.34	0.99
Twill 2/2	y = -227.88x + 280.21	1
Satin 4	y = -196.39x + 259.06	0.9169

Where, **y** = Tensile strength-weft **x** = Banana fibre ratio

3-3-1: Effect of banana fiber ratio on tensile strength in weft direction:

From table (4&7) and figure (3) it can be noticed that, there is an inverse relation between the tensile strength in weft direction and the ratio of banana fibres. This is due to Blended yarn (50% Banana: 50% Cotton) as weft yarn has a low tenacity, 9.11 CN/Tex compared to 100 % cotton which has a tenacity, 12.3 CN/Tex, as shown in table (1).

Control sample (10) with weft ratio (100% cotton, without banana fiber) and weave structure plain 1/1 has scored highest rates of tensile strength in weft direction compared to sample (7).

3-3-2: Effect of weave structure on tensile strength in weft direction:

From table (4) and figure (3) it can be seen that, there is a direct relationship between the number of intersections in weave structure and elongation in weft direction, the structure which has a high number of intersections (**plain 1/1**) has recorded higher rates of fabric elongation in weft direction followed by (**twill 2/2, satin 4**) respectively. This is owing to increase the number of the interlacements per unit area in the produced fabrics leads to increase the weft crimp, as a result the fabric elongation in weft direction increased.

3-4: Elongation in weft direction:

Table (4) and figure (4) shows the results of elongation in weft direction test carried out on the produced samples using parameters mentioned before.

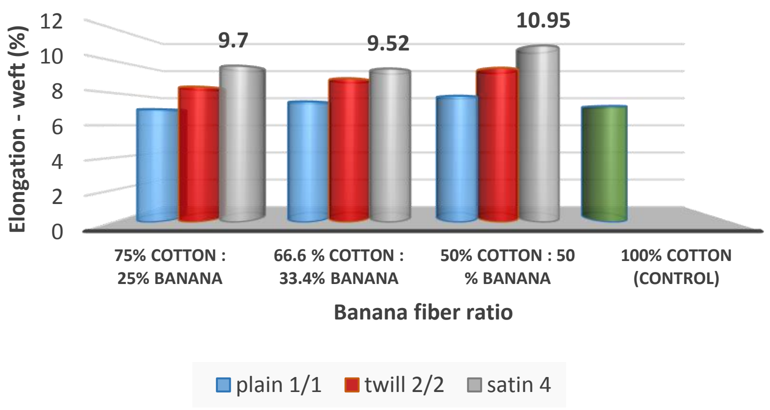

Fig. (4) Effect of banana fibre ratio & weave structure on elongation -weft.

Table (8) Regression equation and quadratic coefficient for the effect of banana fibre ratio on fabric elongation in weft direction for produced samples.

Weave structure	Regression equation	R^2
Plain 1/1	y = 3.1502x + 6.2984	0.925
Twill 2/2	y = 4.5729x + 7.311	0.9849
Satin 4	y = 5.5066x + 8.0669	0.809

Where, **y** = Elongation -weft **x** = Banana fibre ratio

3-4-1: Effect of banana fiber ratio on elongation in weft direction:

From the previous table (4&8) and figure (4) it is clear that there is a direct relationship between the elongation in weft direction and the ratio of banana fibres. This is owing to the stress–strain behaviour of Blended yarn (50% Banana: 50% Cotton) which has elongation (5.7 %), whereas the elongation of 100% cotton is (4.5%). So, as a result, the yarns which have more elongation percentage give a high fabric elongation in weft direction

Sample (7) with weft ratio (50% banana: 50% cotton) and weave structure plain 1/1 has scored highest rates of elongation in weft direction compared to control sample (10).

3-4-2: Effect of weave structure on elongation in weft direction:

Figure (4) shows that there is a direct relationship between the float length and elongation in weft direction. This is due to that satin 4 structure have a higher porosity between warp and weft yarns compared to plain 1/1, which leads to an increase in the free space in the tested fabric under the jaws of tensile testing machine. So as the result the weft yarns freely stretching in weave structure satin 4 compared to plain 1/1.

3-5: Tear strength in weft direction:

Table (4) and figure (5) shows the results of tear strength in weft direction test carried out on the produced samples using parameters mentioned before.

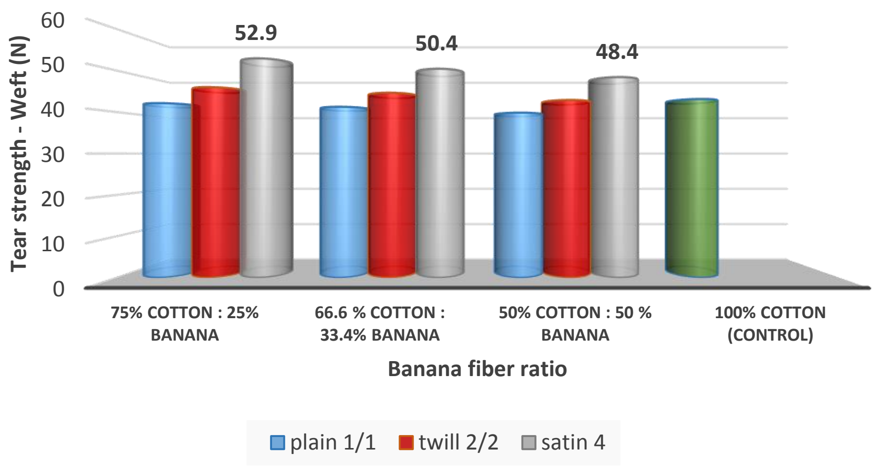

Fig. (5) Effect of banana fibre ratio & weave structure on tear strength - weft.

Table (9) Regression equation and quadratic coefficient for the effect of banana fibre ratio on fabric tear strength in weft direction for produced samples.

Weave structure	Regression equation	R^2
Plain 1/1	y = -9.1095x + 44.372	0.9973
Twill 2/2	y = -12.131x + 48.897	0.9865
Satin 4	y = -17.166x + 56.769	0.9382

Where, **y** = Tear strength -weft **x** = Banana fibre ratio

3-5-1: Effect of banana fiber ratio on tear strength in weft direction:

From table (4&9) and figure (5) it can be seen that, there is an inverse relation between the tear strength in weft direction and the ratio of banana fibres. This is due to low tenacity of Blended yarn (50% Banana: 50% Cotton) compared to 100 % cotton as weft materials.

Control sample (10) with weft ratio (100% cotton, without banana fiber) and weave structure plain 1/1 has scored highest rates of tear strength in weft direction compared to sample (7).

3-5-2: Effect of weave structure on tear strength in weft direction:

From figure (5) it can be seen that, **(Satin 4)** has recorded the high rates of fabric tear strength in weft direction followed by **(twill 2/2 & plain 1/1)** respectively. This is because of the open structure has more free space as a result the weft thread become more freely which causes increase on fabric tear strength in weft direction and vice versa.

3-6: Abrasion resistance:

Table (4) and figure (6) shows the results of abrasion resistance test carried out on the produced samples using parameters mentioned before.

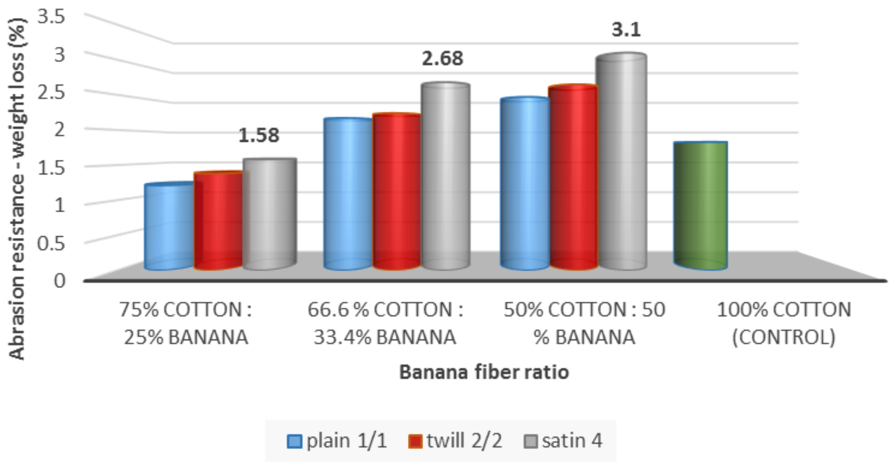

Fig. (6) Effect of banana fibre ratio & weave structure on abrasion resistance (after 2000 cycle).

Table (10) Regression equation and quadratic coefficient for the effect of banana fibre ratio on fabric abrasion resistance for produced samples.

Weave structure	Regression equation	R^2
Plain 1/1	y = 4.5869x + 0.2926	0.7861
Twill 2/2	y = 4.7141x + 0.3866	0.8562
Satin 4	y = 5.5824x + 0.4362	0.8186

Where, **y** = percentage of weight loss **x** = Banana fibre ratio

3-6-1: Effect of banana fiber ratio on abrasion resistance:

It can be noticed from table (4&10) and figure (6) that, there is a direct relationship between the weight loss percentage and the ratio of banana fibres. Because of the blended yarn (banana/ cotton) has a low tenacity compared to 100 % cotton as weft materials as shown in table (1), which leads to decrease in the abrasion resistance.

Control sample (10) with weft ratio (100% cotton, without banana fiber) and weave structure plain 1/1 has scored highest rates of abrasion resistance compared to sample (7).

3-5-2: Effect of weave structure on abrasion resistance:

It can be observed from figure (6) that, (**plain 1/1**) has recorded the highest rates of fabric abrasion resistance followed by (**twill 2/2 & satin 4**) respectively. This is because of the compact structure which has a high number of the intersections, leads to decrease in the float length on the surface of the fabric which facing the abrading fabric so as the result the abrasion resistance increases.

IV. Conclusions:

This study has established that the mechanical properties of (banana/ cotton) woven fabrics are influenced by its constructional parameters such as the weft arrangement which lead to different banana fibre ratios in weft direction and weave structure. The result of the experimental work and trials undertaken in this research evidently showed that:

- The tensile strength in warp direction, elongation in both directions tends to increase with the increase of banana fibers ratio in produced samples.
- It was noticed that, the banana fiber ratio has inverse relationship with the tensile strength in weft direction, tear strength in weft direction and abrasion resistance.
- The banana/ cotton samples with weave structure plain 1/1 have recorded the highest rates of tensile strength in warp direction, tensile strength in weft direction, elongation in warp direction and abrasion resistance.
- Produced samples with weave structure satin 4 have scored the highest values in fabrics tear strength in weft direction and elongation in weft direction

V. Appendix (A):

Table shows calculations of weft ratio for produced fabrics.

Sample No.	**Weft arrangement**	**Ratio between weft picks [1]**	**Ratio between weft picks [2] *Note: blend yarn (50% cotton: 50% banana)**	**Final weft ratio in produced fabric**
1 to 3	1 Cotton: 1 Blended	50% cotton + 50% Blended	50% cotton + (25% banana + 25% cotton)	75% Cotton: 25% Banana
4 to 6	1 Cotton: 2 Blended	33.3% cotton + 66.6% Blended	33.3% cotton + (33.3% banana + 33.3% cotton)	66.6% Cotton: 33.4% Banana
7 to 9	Blended	100% Blended	(50% banana + 50% cotton)	50% Cotton: 50% Banana

From the following explains we can investigate the calculations of final weft ratio in produced fabrics:

- In the first weft arrangement (1 cotton: 1 Blended), the ratio between the weft picks will be (**50% cotton**: 50% Blended) as seen in equation [1], whereas the blended yarn consist of (50% Banana: 50% cotton) so that the 50% Blended in equation [1] will be divided to (**25% cotton: 25% Banana**), the final equation [2] will be (50% cotton + (25% Banana + 25% cotton)) by summation the percentage of similar material. The final weft ratio in samples number 1,2& 3 will be (75% cotton: 25% Banana).

- In the second weft arrangement (1 cotton: 2 Blended), the ratio between the weft picks will be (**33.4% cotton**: 66.6% Blended) as seen in equation [1], whereas the blended yarn consist of (50% Banana: 50% cotton) so that the 66.6% in equation [1] Blended will be divided to (**33.3% cotton: 33.3% Banana**), the final equation [2] will be (33.4% cotton + (33.3% Banana + 33.3% cotton)) by summation the percentage of similar material. The final weft ratio in samples number 4,5& 6 will be (66.6% cotton: 33.4% Banana).

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