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Experimental Analysis of Adhesive Joint Strength and Moisture Level of Pineapple Leaf Fiber (PALF) from Different Location within a Stem

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Abstract: The utilization of pineapple leaf fiber (PALF) as textile fiber material will have a very important meaning that is in terms of utilization of agro-waste. Pineapple leaf fiber (PALF) has different characteristics due to pineapple leaf's position. Utilization of PALF from base of the plant stem is more appropriate to be used as textile fiber material. PALF categorized as staple fiber (short fiber) which needs to have a connecting process. The connecting process is usually carried out by dead knotted.The research objective was to know the effect of the position of pineapple leaves at the stem and various adhesive materials to characteristics of pineapple fibers. The research was conducted on September 2018 until March 2019 at Department of Agricultural Technology Sriwijaya University and Center for Textiles Bandung, West Java Province. The study used Factorial Random Design with two treatment factors of the pineapple fibers location in the stem consisting of three levels namely the upper part (A1), the middle (A2) and the bottom (A3) and the type of adhesive consisting of two levels, polyvinyl alcohol (B1) and polyester resin (B2). This study used three parameters, moisture content (%), tensile strength / bundle (gf), and tensile strength (gf). The result of this research showed that the difference of location of fibers in pineapple leaves affect the moisture content (%), tensile strength/bundle (gf), and tensile strength (gf). The combination of interaction location of pineapple fibers on leaves and the type of adhesive significantly affected the moisture content (%) of MC and MR, tensile strength/bundle (gf) of Fmax and Emax. The best treatment was found on the treatment combination of lower fiber treatment and polyester adhesive (A3B2), namely MC 3.18%, MR value in A3B2 treatment of 3.28%. The best treatment of tensile strength/bundle is in the A3B2 treatment of 1779.8 gf for the value of F max and the E max value found in the treatment A3B2 which is 4.79%.
Keywords: pineapple, fiber, moisture content, tensile strength, bundle, strands

Abstrak (Indonesia): Penelitian ini bertujuan untuk mengetahui pengaruh letak daun nanas dan berbagai bahan perekat terhadap karakteristik serat nanas. Penelitian ini dilaksanakan pada bulan September 2018 sampai Maret 2019 di Jurusan Teknologi Pertanian Universitas Sriwijaya dan Balai Besar Tekstil Kota Bandung Provinsi Jawa Barat. Penelitian ini menggunakan metode Rancangan Acak Lengkap Faktorial (RALF) dengan dua faktor perlakuan letak serat nanas pada batang yang terdiri dari tiga taraf yaitu bagian atas, bagian tengah dan bagian bawah dan jenis perekat yang terdiri dari dua taraf yaitu polivinil alkohol dan resin polyester. Penelitian ini menggunakan tiga parameter yaitu kadar lembab (%), kekuatan tarik/bundel (gf), dan kekuatan tarik/helai (gf).Hasil penelitian ini menunjukkan bahwa perbedaan letak serat pada daun nanas berpengaruh terhadap kadar lembab (%), kekuatan tarik/bundel (gf), dan kekuatan tarik/helai (gf). Interaksi kombinasi letak serat nanas pada daun dan jenis perekat berpengaruh nyata terhadap kadar lembab (%) MC dan MR, kekuatan tarik/bundel (gf) Fmax dan Emax. Perlakuan terbaik terdapat pada kombinasi perlakuan serat bagian bawah dan perekat polyester (A_3B_2) yaitu MC 3,18%, nilai MR pada perlakuan A_3B_2 sebesar 3,28%. Perlakuan terbaik kekuatan tarik/bundel terdapat pada perlakuan A_3B_2 sebesar 1779,8 gf untuk nilai F max dan nilai E max terdapat pada perlakuan A_3B_2 yaitu 4,79%.
Kata Kunci: nanas, serat, kadar kelembaban, kekuatan tarik, bundel, helai

1. Introduction

Pineapple is a topical plant known scientifically as *Ananascomosus*from family of *bromeliaceae*. The family bromeliaceae consist of 2794 species that have adapted in wide range of habitats ranging from terrestrial to epiphytic, shady to full sun, and from hot humid tropics to cold dry subtropics [1]. Pineapple leaves are returned to the land for use as fertilizer. Adult pineapple plant can produce 70-80 leaves or 3-5 kg with water content of 85%. After harvesting the waste part consists of leaves 90%, stem shoots 9% and stem 1 %. The utilization of pineapple leaf fiber as textile fiber material will have a very important meaning that is in terms of utilization of agro-waste [2]

Pineapple is one of alternative plants that produce fiber that has been used only as a source of food, while pineapple leaves can be used as textile fiber material [2]. Pineapple leaf fiber (PALF) is very common in tropical regions and very simple to extract fiber from its leaves. Pineapple leaf fibers are extracted from pineapple leaves, have cellulose about 80% wt [3]. PALF is generally used in making threads for textile fabrics from several decades. Present application of PALF for various purposes is textile, sport items, baggage, automobiles, cabinets, mats, and so forth [4].

Pineapple leaf fiber (PALF) has different characteristics due to pineapple leaf's position. The position of fiber in pineapple leaf consists of the top, middle and bottom. The utilization of PALF from base of the plant stem is more appropriate to be used as textile fiber material because it has higher lightness level [5].

PALF categorized as staple fiber (short fiber) which needs to have a connecting process. The connecting process is usually carried out by dead knotted. This method is difficult, especially to be used for large amounts of pineapple fiber. Besides taking a long time, it also requires more labor. Therefore, this study connects the fiber using chemicals. They are polyvinyl alcohol (PVA) and polyester resin as a solution for connecting pineapple fiber.

Polyvinyl alcohol can be used as fiber reinforcement for textile materials [6]. Polyester resin (PR) is a thermosetting polymer that excellence in physical properties and electrical resistance as an adhesive [7]. The use of these two adhesives includes the use of an adhesive method can replace traditional methods of connecting pineapple fiber. This research aims to determine the effect of the leaf position and various adhesive materials on the characteristic of pineapple fiber.

2. Methods

Research started by collecting pineapple leaves from cultivation garden in Muara Enim, South Sumatera. Pineapple leaves from base (bottom) with a height of 0-100 mm (A1), middle with 100.01-200 mm (B1), the top with height > 200 mm (B3) [5]. Fibers collecting step from pineapple leaves using the procedure [8]. Two overlapped ends of PALF are glued by PVA and PR in the gluing method [9]. This technique produces a thick joint and rigid structure because of the rigidity of the glue (adhesive) used. Also, drying of the adhesive are dried in the sun. This research used factorial random design with two treatment factors, they are, PALF position on the stem and Adhesive Material such as Polyvinyl Alcohol (B1) and Polyester Resin (B2). The data were analyzed using analysis of variance processed with differences considered significant when $P < 0.05$. Separation means were carried out by least significant difference (LSD).

2.1 Moisture Level

Measuring the moisture level of pineapple leaf fibers was done after the connecting process. In fiber, moisture usually called moisture regain (MR) and moisture content (MC). Moisture regain is the percentage between the water content towards the absolute dry weight. MR (%) and MC (%) can be known as follows [10]:

1. Two grams of pineapple leaf fiber samples are firstly weighed for initial weight.
2. The pineapple fiber samples inserted into the cleaned cup.
3. The cup containing pineapple fiber samples put into the oven and heated at 105-110°C until they reach a fixed weight (i.e. at the twice weighing with 15 minutes pause. This usually needs 1.5 hour drying time.
4. Samples are weighed after reaching a fixed weight (Dry Weight).
5. After that, the moisture regain level can be calculated using the following formula:

$$\textit{Moisture regain}\ (\%) = \frac{B-BK}{BK} \times 100\%$$

Moisture content can be calculated using the following formula:

$$\textit{Moisture Content}\ (\%) = \frac{B-BK}{B} \times 100\%$$

Description:
B = original weight
BK = absolute dry weight

2.2 Tensile strength / bundle

Tensile strength / bundle testing was done by means of a tensile strength machine. The tensile strength testing is related to the stretch and tenacity of the fiber that can be known [10]. The tensile strength testing of pineapple fiber was done as follows:

1. Preparing the pineapple fiber that has been connected using polyvinyl alcohol and polyester resin.
2. The fiber / strand clamped on the upper clamp, while the other ends of the thread are clamped on the bottom clamp and given load or force.
3. The motor drive handle pulled after being ascertained in the correct position.
4. The tensile strength of fiber per bundle can be obtained by the amount of load or the maximum force that can be held by the fiber.

2.3 Tensile Strength / strand

The test was carried out at Bandung Textile Center Laboratory. Tensile strength testing is force giving or tensile tension towards a material which aims to know or detect a material strength [11]. The testing of tensile strength / strand according to SNI 08-0768-1989 done by:

1. Preparing the pineapple fiber material that has been connected using polyvinyl alcohol and polyesterresin.
2. The fiber / strand clamped on the upper clamp, while the other ends of the fibers are clamped on the bottom clamp with load or force.
3. The motor drive handle pulled after being ascertained in the correct position.
4. The tensile strength of fiber per strand can be obtained by the amount of load or the maximum force that can be held by the fiber.

3. Results and Discussion

3.1. Changes in MC and MR towards fiber position and adhesive

Fiber is a material that can absorb moisture. Various types of fibers, due to leaf position, have different moisture content and the connection using polyvinyl alcohol adhesive**.** Changes in moisture level including moisture content (MC) and moisture regain (MR) towards fiber position and polyvinyl alcohol adhesive can be seen in Figure 3.1.

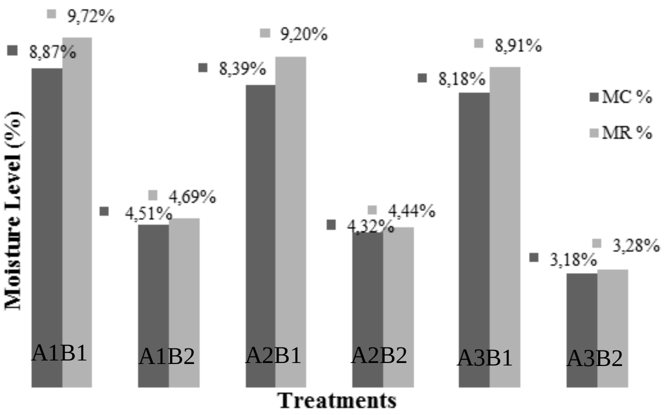

Figure 3.1 MC (dark grey box) and MR (light grey box) values towards fiber position and adhesive material

Figure 3.1 showed a change in MC in fiber position and polyvinyl alcohol adhesive. The highest MC value was found in treatment A1B1 (8.87%) which were the top fiber and polyvinyl alcohol adhesive. The A2B1 treatment (8.39%) showed the decreasing of MC value in the middle fiber and polyvinyl alcohol adhesive, while the lowest value was found in the treatment of A3B1(8.13%) which was the bottom fiber and polyvinyl alcohol adhesive. The decrease in MC values in each part of pineapple fiber was due to the differences in water content in the fiber.

Figure 3.1 also showed the MR change towards fiber position (top, middle and bottom) and polyvinyl alcohol adhesive. The highest MR value was found in A1B1 treatment of 9.72% while the lowest value was found in A3B1 treatment of 8.91%. The same decrease changes occurred in MC and MR were due to the treatment of young pineapple leaves that having the highest moisture content [12] and polyvinyl alcohol adhesive which is water-soluble.

Polyester is resistant to moisture [13]. The fiber position has a different amount of moist level when it is being connected using adhesive. The highest MC and MR values were found in A1B2 treatment (top fiber and polyester adhesive) that were 4.51% and 4.69%, and there was a decrease in MC and MR values as shown in treatment A2B2 (middle fiber and polyester adhesive), 4. 32% and 4.44%, while the lowest MC and MR values were found in treatment A3B2 (lower fiber and polyester adhesive), which were 3.18% and 3.28%. The result of MC and MR measurement on the position of fiber and polyester adhesive can be seen in Figure 3.2. Changes in MC and MR in Figure 3.2 showed there was a higher MR value than the MC value.

The data analysis result of moisture content diversity indicated that iber position, adhesive material and interaction of both factor significantly influenced on MC value at P <5% level. The result of further LSD showed MC change towards fiber position and adhesive material can be seen in Table 3.1, Table 3.2 and Table 3.3.

Table 3.1 Further the influence of pineapple fiber position and adhesive towards the value of moisture content

Treatment	Average	P < 0.05
		0.228
A3B2	3.18	a
A2B2	4.32	b
A1B2	4.51	b
A3B1	8.18	c
A2B1	8.39	c
A1B1	8.87	d

Description: The numbers followed by the same letter in the same column mean that they are not significantly different

The results of LSD (Table 3.1) showed the treatment of A3B2 was significantly different from others on MC changes. The treatment of bottom pineapple leaf fiber and polyester adhesive had lower moisture level than the middle and top fibers. Polyester has resistance to moisture as it is categorized as thermosetting polymers [13].

Table 3.2 Further the influence of pineapple fiber position on moisture content value

Pineapple Fiber Position	Average	P<0.05
		0.161
A3	5.68	a
A2	6.35	b
A1	6.69	c

Description: The numbers followed by the same letter in the same column mean that they not significantly different

Table 3.2 showed that treatment A3 was significantly different with A2and A1. Pineapple fiber is categorized as hygroscopic type that hygroscopic fiber is able to absorb more moisture [10]. The top position of pineapple fiber had higher MC value than the bottom and middle fibers. Pineapple leaf has outer layer consists of top and bottom parts which categorized as young fiber and old fiber [14]. The highest moisture level of pineapple fiber is in the top part, while the lowest moisture level is in the bottom part [12].

Table 3.3 The influence of adhesive materials on moisture content value.

Adhesive Materials	Average	P< 0.05
		0.131
B2	4.00	a
B1	8.48	b

Description: The numbers followed by the same letter in the same column mean that they are not significantly different

Table 3.3 showed that treatment B2 significantly different with treatment B1. The soluble adhesive is able to increase MC value on fiber position. MC value in polyvinyl alcohol adhesive was higher than MC value in polyester adhesive. Polyvinyl alcohol is soluble in water [15]. MC value which occurred in treatment B2 was lower B1. Polyester is easier to dense and resistant to moisture [13].

The results of diversity analysis of moisture regain showed that A, B and interaction between factors A and B had a significant influence on the MR value at the 5% level. The results of further P < 5% showed that change in MR on the fiber position and adhesive type can be seen in Table 3.4, Table 3.5 and Table 3.6.

Table 3.4 showed that all treatments were significantly different A1B1 treatment was significantly different from others. The treatment of top pineapple fiber which absorbed more water. Polyvinyl alcohol adhesive was soluble in water which resulting higher MR value. The highest water content of fiber is found in the top fiber [12].

Table 3.4 Further the influence of pineapple fiber position and adhesive material towards the value of moisture regain value

Treatment	Average	P< 0,05
		0.164
A3B2	3.28	a
A2B2	4.44	b
A1B2	4.69	c
A3B1	8.91	d
A2B1	9.20	e
A1B1	9.72	f

Description: The numbers followed by the same letter in the same column mean that they are not significantly different

Table 3.5 showed that treatment A3 was significantly different from treatment A2 and A1. The highest average of MR value (7.20%) found in treatment A1 while the lowest MR value (6.09%) found in treatment A3. The bottom pineapple fiber absorbed less water; this causes lower MR value obtained. MR value in fiber is influenced by fiber dimensions and mechanical properties of fiber [10].

Table 3.5 Further the influence of pineapple fiber position on moisture regain

Pineapple Fiber Position	Average	P< 0.05
		0.116
A3	6.09	a
A2	6.82	b
A1	7.20	c

Description: The numbers followed by the same letter in the same column mean that they are not significantly different

Table 3.6 showed that treatment B2 was significantly different from treatment B1. The MR values of the adhesives are affected by the nature of each adhesive. Polyester adhesive has a low MR Polyester has the ability to dry quickly and is resistant to moisture [7].

Table 3.6 Further the influence of adhesive materials on moisture regain

Adhesive Materials	Average	P< 0.05
		0.095
B2	4.13	a
B1	9.27	b

Description: The numbers followed by the same letter in the same column mean that they are not significantly different

The MR value of polyvinyl alcohol adhesive was higher than MR polyester because its property is easily soluble in water. Polyvinyl alcohol and polyester adhesives are volatile, but the highest MR value found in polyvinyl alcohol adhesive.

3.2 Changes in Tensile Strength/Bundle of F max and E max towards Fiber Position and Adhesive Materials

Fiber has the ability to resist traction and strain or called tensile strength. The tensile strength of fiber called gF (F). Strong fiber will make a strong thread. The tensile strength value will be related to the fiber elasticity value (E). The values of F max and E max on the fiber position and polyvinyl alcohol adhesive can be seen in Figure 3.2.

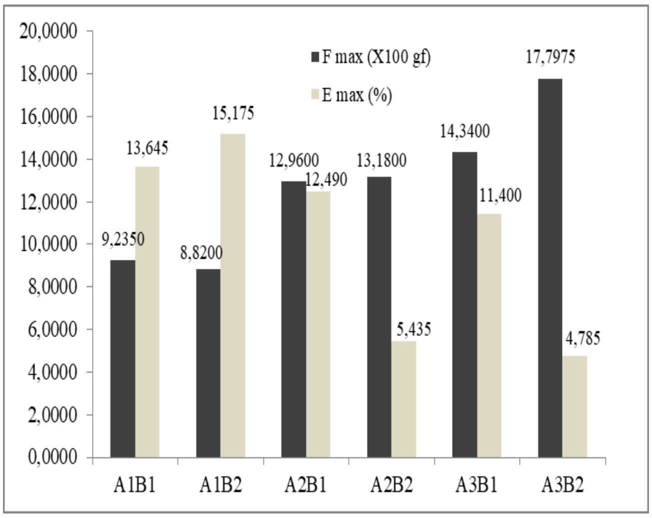

Figure 3.2 F max and E max values on fiber position and adhesive

Based on Figure 3.2, it revealed the F max difference was higher than the E max value toward the fiber position (top, middle, and bottom) and polyvinyl alcohol adhesive. The lowest F max value was shown in treatment A1B1of 923.5 gf which were the top fiber and polyvinyl alcohol adhesive. The increase in F max value occurred in the A2B1 and A3B2 that were 1296 gf and 1434 gf.

The highest change in the E max value towards the fiber position and adhesive material was found in the A1B1 treatment of 13.65% while the lowest elasticity value was in the A3B1 treatment of 11.40%. The level of effectiveness of a thread occurs if the tensile strength of a thread is high and elasticity is low [16].

The different fiber position will produce different values of F max and E max. The highest F max value was in the A3B2 treatment of 1779.8 gf and the lowest E max value was in the A3B2 treatment of 4.79%. The lowest F max value was found in treatment A1B2 which was 882 gf, while the highest E max value was found in A1B2 treatment which was 15.18%. F max and E max values on the fiber position and adhesive material can be seen in Figure 3.2.

The results of the analysis of diversity of F max tensile strength / bundle data indicated that factor A, factor B and interaction between factor A and B significantly influenced the F max value at the level of P<5%. The results of further P< 5% F max test on fiber position and adhesive materials can be seen in Table 3.7, 3.8 and 3.9.

Table 3.7 showed that treatment A3B2 significantly different from others treatments on F max value. Pineapple fiber that has undergone a connection process with polyvinyl alcohol has a higher tensile strength value than fiber that has not been connected, but polyester adhesive is water resistance which causes the tensile strength to be higher [17].

Table 3.7 Further the influence of pineapple fiber position and adhesive material towards the value of F max value.

Treatment	Average	P<0.05
		161.544
A1B2	882.00	a
A1B1	923.50	a
A2B1	1296.00	b
A2B2	1318.00	b
A3B1	1434.00	b
A3B2	1779.80	c

Description: The numbers followed by the same letter in the same column mean that they are not significantly different

Table 3.8 showed that treatment A1is significantly different from others. The F max tensile strength / bundle of the fiber indicated an increased value for each part of the fiber. The increase in F max value occurred in the bottom fiber, which was 1606.90 gf and the lowest was the top fiber 902.80 gf. The lowest tensile strength lies in the top fiber that has a smaller diameter than the bottom fiber [12].

Table 3.8 Further the influence of pineapple fiber position on F max value.

Pineapple Fiber Position	Average	P< 0.05
		114.229
A1	902.80	a
A2	1307.00	b
A3	1606.90	c

Description: The numbers followed by the same letter in the same column mean that they are not significantly different

Table 3.9 showed that treatment B1 was significantly different from treatment B2 on the value of F max. The process of pineapple fiber connection using two types of adhesives produced different F max tensile strength/bundle. The F max value of B2 was higher than the value of F max adhesive for polyvinyl alcohol. Polyester adhesive has a higher tensile strength value; this is because polyester is faster in the hardening process

[7].

Table 3.9 Further theinfluence of adhesive materials on F max value.

Adhesive Materials	Average	P<0,05
		0.095
B1	1217.83	a
B2	1326.58	b

Description: The numbers followed by the same letter in the same column mean that they are not significantly different

The analysis result of the E max diversity indicated that factor A, factor B and the interaction between factors A and B significantly influenced the value of elasticity/bundle at the level of P<0.05%. Further LSD test of E max value for pineapple fiber position and type of adhesive can be seen in Table 3.10, Table 3.11 and Table 3.12.

Table 3.10 showed that the elasticity value in the A3B2 treatment and A2B2 not significantly different, but significantly different on elasticity value in treatments A3B1, A2B1, A1B1 and A1B2. The E max value that occurred at the bottom fiber connection changed on the middle fiber, but the E max value obtained was not too high. The highest elasticity was found only in the top fiber.

Table 3.10 Further the influence of pineapple fiber position and adhesive material towards the value of E max value.

Treatment	Average	P<0.05
		2.974
A3B2	4.79	a
A2B2	5.44	a
A3B1	11.40	b
A2B1	12.49	b c
A1B1	13.65	b c
A1B2	15.18	c

Description: The numbers followed by the same letter in the same column mean that they are not significantly different

Table 3.11 showed that the E max value of treatment A3 was not significantly different from treatment A2, but was significantly different from treatment A1. The highest elasticity value was in A1, 14.41%. The top pineapple fiber classified as young fiber, and the older fiber (bottom fiber) has low elasticity. Fiber with low elasticity would create a proper level of fiber effectiveness to use [16].

Table3.11 Further the influence of pineapple fiber position on E max value.

Pineapple Fiber Position	Average	P<0,05
		2.103
A3	8.09	a
A2	8.96	a
A1	14.41	b

Description: The numbers followed by the same letter in the same column mean that they are not significantly different

Table 3.12 showed that the E max value on the type of adhesive revealed treatment B2was significantly different from treatment B1. The elasticity that occurred in polyvinyl alcohol adhesives was higher than polyester adhesive. Polyvinyl alcohol adhesive is flexible, which causes a high elasticity value, and has water resistance [6].Polyvinyl alcohol has good binding capacity and PVA is a high water soluble polymer [17].

Table 3.12 Further the influence of adhesive materials on E max value.

Adhesive Materials	Average	P< 0.05
		1.717
B2	8.47	a
B1	12.51	b

Description: The numbers followed by the same letter in the same column mean that they are not significantly different.

3.3 Changes in F max and E max Tensile Strength / Strand on Fiber Position and PVA Adhesive

The material strength towards the tensile force can be done by stress-strain test (tensile test). The tensile strength of fiber per strand aimed to determine the variation of fiber strength in each elemental fiber strand. The values of F max and E max on the fiber position and adhesive can be seen in Figure 3.3.

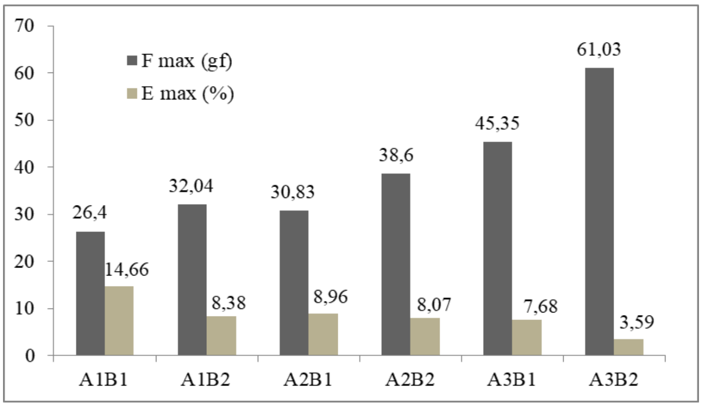

Figure 3.3 Tensile strength values per strand on the fiber position and adhesive

Figure 3.3 showed a higher difference in F max value compared to E max. The highest F max value was found in the treatment of A3B1, which was 45.35 gf and the lowest E max value was in the A3B1 treatment that was 7.68%. The lowest F max value found in A1B1 treatment (top fiber and polyvinyl alcohol adhesive), which was 26.4 gf, while the highest E max value was found in A1B1 treatment as much as 14.66%.

The F max value was higher than the E max value. The lowest F max value was found in treatment A1B2of 32.04 gf, an increase in the value of F max was found in treatments A_2B_2 and A_3B_2 which were 38.60 gf and 61.03 gf. E max (fiber elasticity) obtained a value that was comparable to the value of F max. The highest E max value found in the treatment of A1B2 which was 8.38%, the E max elasticity value decreased in treatment A2B2 and A3B2which were 8.07% and 3.59%. The value of tensile strength /strand F max and E max on the fiber position and polyester adhesive can be seen in Figure 3.3.

The analysis result of the diversity of F max the tensile strength / strand showed that factor A (fiber position) and factor B (type of adhesive) significantly affected the F max value at the level of P<5%. The results of further LSD test showed that F max value for the position on fiber position and type of adhesive can be seen in Table 3.13 and Table 3.14.

Table 3.13 showed that treatment A1was not significantly different from treatment A2, but was significantly different from treatment A3. The value of tensile strength / strand of F max on A3, was greater, that was 53.19 gf. Bottom fiber was significantly different, in which the leaf was stronger with large diameters will have a large tensile strength [12].

Table 3.13 Further the influence of pineapple fiber position on the F max value.

Pineapple Fiber Position	Average	P<0.05
		7.689
A1	29.22	a
A2	34.71	a
A3	53.19	b

Description: The numbers followed by the same letter in the same column mean that they are not significantly different.

Table 3.14 showed that treatment B1was significantly different from treatment B2 on the F max value. Polyvinyl alcohol and polyester, which were used as adhesives for connecting pineapple fiber, have different properties. A polymer that is easily soluble in water and significantly different from the properties of polyester [7, 17]. This caused the tensile strength/strand of F max polyvinyl alcohol (34.19 gf) lower than polyester, which was 43.89 gf.

Table 3.14 Further the influence of adhesive materials on the F max value.

Adhesive Materials	Average	P<0.05
		6.278
B1	34.19	a
B2	43.89	b

Description: The numbers followed by the same letter in the same column mean that they are not significantly different.

The analysis result of the E max value diversity showed that treatment of factor B significantly affected the value of E max per strand at the level of P<5%. The result of further LSD test showed that E max value on the type of adhesive (polyvinyl alcohol and polyester) can be seen in Table 3.15.

Table 3.15 Further the influence of adhesive materials on the E max value.

Adhesive Materials	Average	P<0.05
		3.707
B2	6.68	a
B1	10.43	b

Description: The numbers followed by the same letter in the same column mean that they are not significantly different.

Table 3.15 showed that B2 was significantly different from the B1on the E max value. E max value was the elasticity value obtained when testing tensile strength per strand. The elasticity value that occurred in treatment B1 was higher than B2. The lower polyester adhesive strength is due to the ease of hardening process occurrence. Polyester resin is faster in the hardening process with the addition of a catalyst [7].

4. Conclusion

Based on the results of research and statistical analysis that has been done, it can be concluded as follows:

1. Fiber position treatment in the leaf and the type of adhesive have significant effects on moisture level (MC and MR), tensile strength per bundle (F max and E max) and tensile strength per strand (F max).
2. The interaction of the fiber position and adhesive significantly affected the moisture level (MC and MR) and tensile strength per bundle (F max and E max).
3. The best treatment found in a combination of bottom fiber and adhesive material treatment polyester (A3B2), they were, MC 3.18%, MR value in A3B2 treatment was=3.28%, tensile strength per bundle A3B2 was 1779.8 gf F max value and A3B2 that was 4.79% E max value.

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