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Presented by:

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Theme

Study the influence of reinforcement loading and orientation on the properties of date palm -reinforced plastic composite.

In front of the jurors:

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الإهداء

أهدي هذا العمل المتواضع

إلى نفسي التي بذلت الكثير وتحملت الأكثر لي تصل لنقطة البداية هاته

إلى التي حملتني في فلكها تسع قروء وحملت احلامي لعقدين وقرطين الى شمسي حين تغيم سمائي وقمري حين يحلك ليلي أمي الغالية

إلى كتفي المتين وحصني المنيع من اذا طلبت منه نجمة عاد يحمل على ظهره السماء بما وسعت أبي الغالي

إلى من شد الله بهم عضدي وأضاء. بهم حياتي إخوتي (محمد عبد المؤمن عبد الحق)

وإلى وحيدتي وأميرتي ماريا

لى التي ربتني وأنا طفلة وأحبتني وأنا شابة خالتي. زوليخة

إلى خليلة عمري ورفيقة دربي ملاك دقيش

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Abstract:

In our study, we aimed to enhance the strength and durability of recycled plastic by investigating the impact of natural date palm fiber orientation and loading. We created reinforced composites using date palm fibers in two forms (mesh and petiole) and incorporated them into recycled plastic at loadings of 4%, 6%, 10%, and 20%. Various fiber orientations (-45, 45, 0, 90, and random) were tested. We measured the strength of the composite samples using a "Z050" tensile testing machine and compared it to that of ordinary recycled plastic.Our findings showed that the addition of fibers generally improved the Young's modulus, with values ranging from 0.919 to 3.125 MPa. For petiole fibers, the Young's modulus ranged from 1.717 to 1.869 MPa, with the highest value achieved at 20% fiber loading and 0/0 orientation. For mesh fibers, the Young's modulus ranged from 1.838 to 3.125 MPa, with the best result at 6% fiber loading and 0/0 orientation. This indicates that adding fibers increases the strength of recycled plastic, with the 0/0 fiber orientation yielding the best results. However, beyond a certain fiber loading, the fibers weaken and lose some properties.Microscopic examination revealed good adhesion between the matrix and the date palm fibers in the composite samples. This study concludes that fiber reinforcement, particularly at optimal orientations and loadings, significantly enhances the mechanical properties of recycled plastic.

Key words :

Plastic_reinforced_composite _recycling.

ملخص :في دراستنا، هدفنا إلى تعزيز قوة ومتانة البلاستيك المعاد تدويره من خلال دراسة تأثير اتجاه وتحميل ألياف نخيل التمر الطبيعية. قمنا بإنشاء مركبات معززة باستخدام ألياف نخيل التمر في شكلين (ليف وكرناف) وأدخلناها في البلاستيك المعاد تدويره بنسبة تحميل 4% و 6% و 10% و 20%. تم اختبار اتجاهات الألياف المختلفة (-45، 45، وقارناها بالبلاستيك المعاد "Z050" 0، 90، وعشوائي). قمنا بقياس قوة عينات المركب باستخدام جهاز اختبار الشد أظهرت النتائج أن إضافة الألياف حسنت بشكل عام معامل يونغ، حيث تراوحت القيم بين 0.919 و .تدويره العادي 3.125 ميجا باسكال. بالنسبة لألياف الكرناف، تراوح معامل يونغ بين 1.717 و 1.869 ميجا باسكال، مع تحقيق أعلى قيمة عند تحميل الألياف بنسبة 20% واتجاه 0/0. بالنسبة لألياف الشبكة، تراوح معامل يونغ بين 1.838 و 3.125 ميجا باسكال، مع أفضل نتيجة عند تحميل الألياف بنسبة 6% واتجاه 0/0. وهذا يشير إلى أن إضافة الألياف تزيد من قوة البلاستيك المعاد تدويره، مع تحقيق أفضل النتائج عند اتجاه الألياف 0/0. ومع ذلك، بعد تحميل SS كشفت الفحوصات المجهرية عن التصاق جيد .الألياف بنسبة معينة، تصبح الألياف أضعف وتفقد بعض خصائصها بين المصفوفة وألياف نخيل التمر في عينات البلاستيك المركب. تستنتج هذه الدراسة أن تعزيز الألياف، خاصة عند الاتجاهات والتحميلات المثلى، يعزز بشكل كبير الخصائص الميكانيكية للبلاستيك المعاد تدويره.

الكلمات المفتاحية :

بلاستيك_تقوية_مركبة_رسكلة

General introduction

General Introduction

Recycling is the process of reusing recyclable materials from waste to produce new products. Plastic recycling follows the same process and aims to recycle the plastic and can be used in manufacturing of new products. among the positive benefits of plastic recycling are reducing the consumption of natural resources such as oil and gas, decreasing carbon emissions produced during the production of new plastic, and mitigating environmental pollution caused by irresponsible disposal of plastic. [1]

Recycling plastic helps reduce waste and protect the environment, but it also has some drawbacks, such as: product quality(recycled plastic may have lower quality),weak resistance (recycled plastic may have lower resistance to external factors like heat and pressure, increasing the likelihood of damage and breakage)
And shortened lifespans(due to its low quality recycled plastic may lead to shorter product lifespans, contributing to increased waste pollution). [1]

The objective of this study To solve the problems mentioned previously, and enhance the quality of plastic , we proposed the following idea " the influence of fiber loading and orientation on the properties of date palm fiber -reinforced plastic composite " .

To acleive this objective the thesis is divided into four chapters :

- in the 1st chapter we talk We talked about natural fibers and their classification, giving an example of each type. Then we talked about the physical components of these fibers, in addition to their mechanical and physical advantages, the disadvantages and advantages of these fibers, then the types of matrices, the advantages of each type, and its use in making a reinforced composite.
- in the 2nd chapter We reviewed previous experiments and research in our field of study centered on composite materials, and we summarized these experiments and presented their steps and results.
- in the 3rd chapter We explained our experience that we carried out in the company's ENICAB laboratory to make our composite material consisting of plastic and fibers. We mentioned the steps of the experiment, the method used in the work, determining the loads and directions of the fibers, how to prepare

samples and their dimensions, and the equipment used in measurements and strength tests of the obtained composite material.

- in the 4th We talked about the results obtained when measuring the tensile strength shown by the tensile machine in the form of curves for the samples of the composite material that we made by loading the fibers, the trends, and the results of the chemical analysis that we carried out in the CRAPC laboratory at Kasdi Merbah University.

CHAPTER 1

Observation on natural fibers and composite materials

INTRODUCTION:

Composite material is a combination of two or more materials to get significant physical, mechanical, and chemical properties that cannot be achieved from constituent materials alone. Natural fiber is mostly utilized like a composite due to its highest strength-to-weight ratio.[2]_in this chapter we talking about natural fibers and their classification, giving an example of each type. Then we talked about the physical components of these fibers, in addition to their mechanical and physical advantages, the disadvantages and advantages of these fibers, then the types of matrices, the advantages of each type, and its use in making a reinforced composite.

1.Classifications of natural fibers:

The fiber is an elongated object with a length/diameter (L/D) ratio greater than one. In nature there is a wide range of natural fibers that can be distinguished by their origin Animal, vegetable and mineral. [3]

1.1 vegetable or lignocellulosic fibers:

The main chemical component of vegetable fibers is cellulose. So vegetable fibers are also called cellulosic fibers. Plant fiber is of plant origin, so it is also called vegetable fiber. Cotton, hemp, jute, flax, abaca, baya, ramie, sisal, bagasse, and banana are examples of plant fibers based on cellulose arrangements, usually with lignin. For example, cotton, jute, linen, ramie, sisal, and hemp….. [4]

Figure I. 1. [5]: vegetable fibers

1.2 **Animal Fibers:**

Animal fibers such as silk, wool, hair, feathers, etc. are considered the second most important source of natural fibers after vegetable fibers for reinforcement materials. Animal fibers are natural fibers that consist largely of certain proteins. Examples include silk, hair/fur (including wool), and feathers. Animal fibers commonly used in the manufacturing world as well as by hand spinners are sheep wool and silk. Alpaca and mohair fibers from Angora goats are also very popular. [3]

Figure I.2. [5]**:** Animal Fibers

1.3 **Mineral fibers:** Mineral fibers are made from minerals, usually inorganic materials such as rock, slag or glass. This term is often used to describe different types of insulating materials that are manufactured from these minerals, such as asbestos, fiberglass, and rock wool.[5]

Figure I.3. [5]**:** Mineral fibers

2. Classifications of vegetable fibers:

Vegetable fiber, also known as cellulosic fiber or plant fiber. Vegetable fibers are obtained from plants and are used in various industries such as textiles, papermaking, and construction. [5]

2.1 vegetable fibers (non-wood):

2.1.1 Bast fibers: These fibers are obtained from the stem of plants like flax, hemp, and jute. They are known for their strength and durability. [5]

Figure I.4. [5]**:** Bast fibers

2.1.2 leaf Fiber: Leaf fibers are obtained from the leaves of plants, such as sisal and henequen. They are stiff and have a rough texture. [5]

Figure I.5. [5]: leaf Fiber

2.1.3 **fruit fibers:**

Below are the most important plants that produce fiber seeds for industrial use. [3]

Figure I.6. [5]**:** coir fiber (fruit fiber)

2.1.3 .1 **Fibers from the cotton plant:**

Cotton is obtained from the cotton plant and is known for its softness, absorbency, and durability. Cotton is often used to make a variety of clothing items, such as t-shirts, jeans, towels, and sheets. [5]

2.1.3.2 **Coconut fiber (Coir):**

Coir is a fiber made from coconut shells and is known for its strength and natural roughness. It is often used to make mats, brushes, and rope, and is favored for its natural texture and durability. [5]

2.1.3.3 **Oil palm fiber:** It is obtained after removing the seeds . It is currently used as fuel for boilers .[3]

2.2 **Wood Fibers:** Wood fibers are usually cellulosic elements that are extracted from trees and used to make materials including paper. [6]

3. Characteristics of a vegetable fiber :

Generally, all plants contain cellulose, hemicellulose and lignin, which are the three main organic components of plants, and these natural structural polymers are known as lignocelluloses. [3]

3.1 **Chemical composition of a vegetable fiber:**

The structure and chemical composition of plant fibers is complex. Aside from the absorbed water, we find that the main fiber components are cellulose, hemicellulose and lignin, in addition to some plant extracts such as pectin and wax. [3]

3.1.1 **Cellulose:** The main component of most plant fibers is cellulose, which is found as a thin rod of microfibers along the fiber. The percentage of cellulose in the fiber determines its strength. [4]

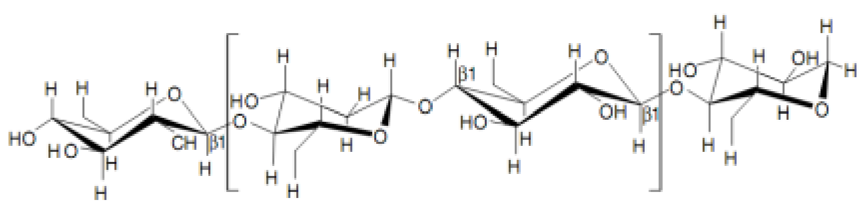


Figure I. 7[3]: Schematization of the polymeric structure of cellulose

3.1.2 **Hemicellulose:** After cellulose, hemicellulose is the second most abundant carbohydrate in lignocellulosic fibers and is a polysaccharide. [3]

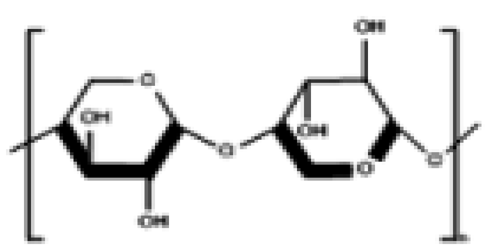


Figure I.8[3]: Chemical bonding of hemicellulose

3.1.3 **Lignin**: Lignin is a complex hydrocarbon It is characterized by its resistance to acid degradation and attacks by microorganisms. [3]

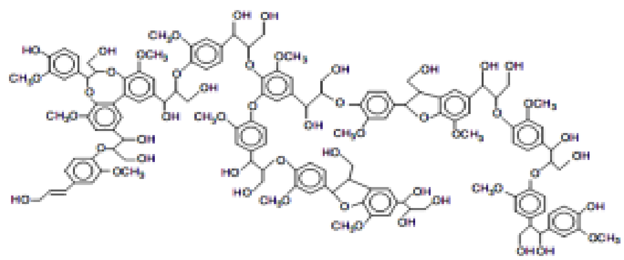


Figure I. 9[3]: Structure of lignin

3.1.4 **Pectin:**

Pectins are the most hydrophilic complex polymers in the plant It is used to join primary fibers .[3]

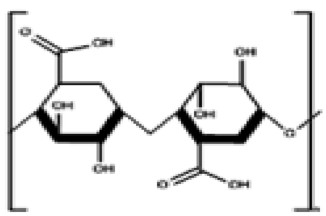


Figure I.10: Structure of pectin

4. Properties of vegetable fibers:

The physical and mechanical properties of vegetable fibers are of crucial importance in determining the fibers potential in various industrial applications.

4.1 Mechanical properties:

The main mechanical properties of vegetable fibers are tensile strength, modulus of elasticity and breakage deformation, The table contains some vegetable fibers and their mechanical properties. [7]

Table I.1[3]: vegetables fibers and their mechanical properties

Fiber type	Tensile strengh (Mpa)	Breakage deformation %	Modulus of elasticity (Gpa)
Bambo	140_800	2.5_3.7	27
Flax	500_900	1.3_3.3	50_70
Hemp	310_750	2_4	30_60
Jute	393_773	1.16_3	26.5
Banana	500_914	1_3.7	11_32
Pineapple	413_1627	0_1.6	42_57
Sisal	511_635	2_2.5	9_22
Coconut	106_175	15_40	4_13
Piassava	43_79	7.8_21.9	1.36_2.28
Curauà	488_752	1.3_4.9	31.8_64

4.2 Physical properties:

4.2.1 Density: Compared to other fibers or matrices, plant fibers are the lightest and least dense, as their density ranges between 0.50 to 1.50 g/cm3. [7]

4.2.2 Moisture: The normal range of fiber moisture ranges between 8 and 18%. They are dried in greenhouses for use in applications. [7]

4.2.3 Microfibrillar angle: It is the inclination of the chains that make up the fibers relative to the axis of the microfiber, and it is an indirect measure of the softness of the material. In general, the greater the micro-fibrillar angle, the less the fiber tends to agglomerate .[7]

5. Advantages and disadvantages of vegetable fibers:

5.1 Advantages: The material from which fibers are made is abundant in nature, and its production does not emit polluting gases. It is biodegradable, its cultivation does not require large techniques, and its final price is lower than synthetic fibers. In addition to the advantage of lower fiber density, which produces lighter composites .[7]

5.2 Disadvantages: And vegetable fibers on the other hand. subject to weather and climate change Provided by nature, changing its properties accordingly on geographical location, time or season of the year, and Other environmental conditions. [7]

6. Area of application of vegetable fibers: Lignocellulosic fibers are used in various applications such as paper and pulp making [8] secondary structural applications, automotive and used in construction |[9] applications. Currently, plant fibers are increasingly used in thermal acoustic insulation. [3]

7. Matrices used in the manufacture of composites:

7.1 Matrices used in composite materials fabrication: Polymers can be classified into two categories, thermoplastics and Thermosetting and thermoplastics materials are currently dominant. [3]

7.1.1 Thermosetting resins: Thermoset polymers are widely used in wood adhesives or in wood-based composites, especially those based on cellulosic fibers. Thermosetting resins provide an acceptable interfacial bond with the lignocellulosic fibers, even before surface modification. In addition, they offer distinct processing advantages over thermoplastic materials .[3]

Table I.2[3]**:** Properties of thermosetting resins

Property	Polyester resin	Vinyl ester resin	Epoxy
Density (g/cm ^{3})	1.2-1.5	1.2-1.4	1.1-1.4
Elastic modulus (Gpa)	2-4.5	3.1-3.8	3-6
Tensile strengh (Mpa)	40-90	69-83	35-100
Comperssive strengh (Mpa)	90-250	100	100

Elongation (%)	2	4-7	200
Cure shrinkage (%)	4-8	N/A	1-6
Water absorption (24h /20c^0)	0.1-0.3	0.1	1-2
Izod impact strengh (j/m)	0.15-3.2	2.5	0.1-0.4

7.1.2Thermoplastic resins: Thermoplastic resins are used in automotive applications due to their properties. which do not change under any chemical modification. This property is what has given plastic waste an exciting and growing interest. The properties of thermoplastics are in the table below. [3]

Table I.3[3]: Properties of thermoplastic resins

Property	PP	LDPE	HDPE	PS	Nylon 6	Nylon
Density (g/cm^3)	0.899 -0.920	0.910-0.925	0.94-0.96	1.04-1.06	1.12-1.14	1.13-1.15
Water Absorbation 24 hours (%)	0.01-0.02	<0.015	0.01-0.2	0.03-0.10	1.3-1.8	1.13-1.15
Tg(C)^0	-10 to -23	-125	-133to-100		48	1-1.6
Tm (C)^0	160-176	105-116	120-140	110-135	215	80
Heat deflection temp (C)^0	50-63	32-50	43-60	max220	56-80	75-90
Coefficient of thermal	6.8-13.5	10	12-13	6-8	8-8.6	7.2-9

Expansion (mm/mm/$C^0/10^5$)						
Tensile Strengh (MPa)	26-41.4	40-78	1.45-38	25-69	43-79	12.4-94
Elastic Modulus (GPa)	0.95-1.77	0.055-0.38	0.4-1.5	4-5	2.9	2.5-3.9
Elongation (%)	15-700	90-800	2-130	1-2.5	20-150	35->300
Izod Impact (j.m)	21.4-267	>854	26.7 - 1068	1.1	42.7-160	16-654

7.2. Composites based on vegetable reinforcements:

Recently, interest in vegetable fiber reinforced composite materials has increased due to their environmentally friendly properties and low cost . Numerous research works have been carried out in the world on the use of vegetable fibers as reinforcing material for preparation of various types of composites. [10]

7.2.1 vegetable Fibers used in the manufacture of composites: Due to the previously mentioned lower density and mechanical properties of vegetable fibers compared to synthetic fibers, vegetable fibers have attracted attention for their use as reinforcing agents for polymeric matrices. Among these fibers we mention Bast (hemp. Flax) leaf (date palm. pineapple. Sisal.) fruit (cotton. Coir). [3]

7.2.2 Mechanical properties of vegetable fiber composites:

Tensile, flexural and impact strength properties are more sensitive to matrix properties, as the elastic modulus depends on the fiber properties. The aspect ratio (D/L) is also very important. In the table below are the fibers and matrices used in the manufacture of composites based on vegetable fibers (the mechanical properties of these fibers are mentioned previously in the table **1.1) .[11]**

Table I.4[3]: Fiber/matrix used in the manufacture of vegetable fiber-based composites

Matrix polymer	Fibers
PE/PP/PVC/PolyUrethane	Wood fiber
PE/Natural rubber/Polyester_epoxy	Sisal
Epoxy	Abaca
PE/Polyerster	Pineapple
Polyester/PP	Sunhemp
Rubber	Oil palm
PE/PP	Kenaf
Natural rubber	Coir
Polyerster	Banana
PP	Flax
PP	Wheat straw
Epoxy	Bambo

7.2.2.1 Breaking stress:

a) Thermosetting composites: Composite materials developed with vegetable fibers provide good mechanical properties shown in the table below:

Table I.5 [3]: Mechanical properties of composites based on vegetable fibers

	Tensile		Flexural	
Natural fiber composite	Strengh (Mpa)	Modulus (Gpa)	Strengh (Mpa)	Modulus (Gpa)
Unidirectional_vinyl Ester	82_248	11_24	95_146	13
Unidirectional_Polyester	45_143	4_17	63_280	4_41
Unidirectional_Epoxy	65_535	6_16	84	5_24
Random_Polyester	18_92	2_7	50-155	4-5
Random _Epoxy	49_59	60-11	77-188	2-8

b) Thermoplastic composites:

In general, without surface modification, the tensile strength of thermoplastics will be decreased with the addition of low aspect ratio lignocellulosic reinforcement. Increasing reinforcement produces losses in composite strength., This is due to the weak aspect ratio of the fibers and their poor state of adhesion which makes them act like defects continuity in the matrix. The addition of reinforcement in the composite forms more voids of surface, resulting in unfavorable strength performance. [3]

7.2.2.2 Modulus of elasticity:

a) Thermosetting composites:

Thermosetting composites developed using plant fibers will give a wide range of elastic modulus performance depending on the fiber type. Due to the high stiffness of many lignocellulosic fibres, vegetable fiber composites can have relatively high modulus and are able to compare directly to glass fiber reinforced composites in many ways. Of the cases on an absolute basis, and in the table below there is a comparison between them.[3]

Table I.6[3]: Comparison between the properties of fiberglass/polyester and fiber composites vegetable/Polyester

Property	**Glass fiber (30wt. %)**	**Natural fiber (35Wt. %)**
Flex strengh (Mpa)	80	70
Flex Strengh (Gpa)	6.0	6.0
Elongation at break%	2.2	1.9
Impact strengh	38	20
Density	1.54	1.42

b) Thermoplastic composites: In general, the Young's modulus of composite materials increases with increasing fiber content. Vegetable fiber-based thermoplastic composites have similar properties compared to glass fiber-based composites. Thus vegetable reinforcement is a good competitor to synthetic fiberglass. [3]

7.2.2.3 Resilience:

a) Thermosetting composites: Compared with undiluted resins, fiber-reinforced thermoplastic composites will improve the impact resistance performance. Impact performance depends on the properties of the matrix and fibers, as well as their interface properties. While the inclusion of plant fibers provides a means of absorbing and redirecting impact energy as is the case for most types of reinforcement .[12].

b) Thermoplastic composites: In general, increasing lignocellulosic loads will result in a significant reduction in thermoplastic impact resistance. Vegetable fillers have relatively high modulus compared to thermoplastic matrices. They tend to provide stress concentration points in the matrix since the charges are unable to absorb enough energy to cause hardening. [3]

8) Conclusion:

This chapter presents a bibliographic study of natural fibers and biocomposites. the Classifications and Characteristics of vegetable fibers. Composites based on vegetable reinforcements and its properties.

Chapter2

Literature review

Introduction:

In this chapter we present a many Several studies and research in the same field of own study and its objectives, we mentioned the methods, details of the experiments, and the results obtained in this research.

Fanta and al .[13] in 2023 investigated the effects of fiber loading and orientation on the tensile properties of date palm fiber -reinforced polyester composite (DPFRPC).date palm fiber(DPF) And polyester resin were used as the reinforced and matrix ,respectively ,to create the composite sample using the hand layup method ,the researchers utilized a full factorial experimental desing with various fiber loading (20% ,30% and 40%) and orientation (0/0, 45/ -45, and 0/90 degrees).Exprimental results indicated that the tensile strength of DPFRCP Increased with fiber loading up to an optimum level (30)and then declined at higher loadings .additionally ,an increase in the fiber orientation angle led to a decrease in the tensile strength of the composite.

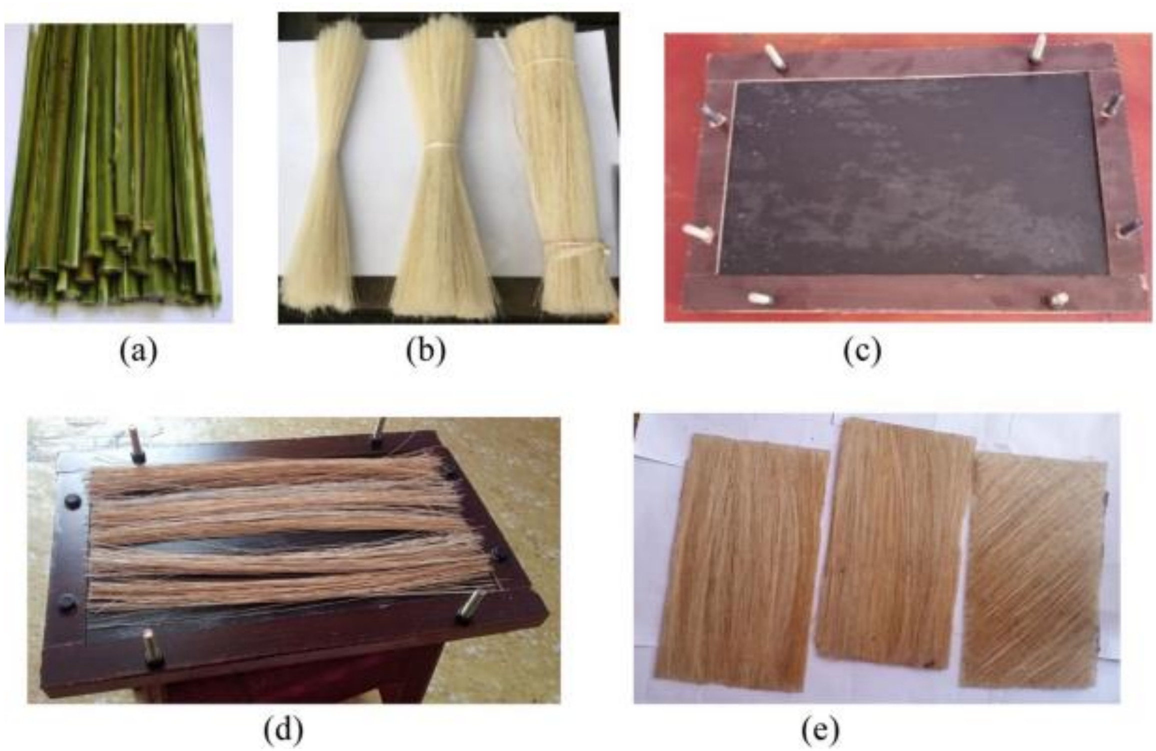


Fig II.1 .[13]**: DPF preparation process; a) rachis of date palm tree, b) extracted fiber, c) mold, d)composite making, e) fabricated composite.**

El-Shekeil and al [14]. in 2024 at Saudi Arabia have Studied development and characterization of biocomposites using date palm fiber (DPF) and nitrile butadiene rubber (NBR) for the purpose of studying the synergistic effects of DPF and NRB in developing biocomposites in various industriel application The method of producing composite materials is a mixing process using a Brabender internal mixer, followed by rolling. Different reinforcing materials and processing conditions were used to characterize and Analysis of mechanical properties of composites. These properties include tensile strength, tensile modulus (according to ASTM standards)., .The results showed that composites with 40% fiber loading showed the highest modulus of elasticity and Tear resistant But it showed increased fragility and stress with higher fiber content The compounds suggested their potential for various industrial applications, with best results obtained at 30% wt Fiber loading. The standard method and compression molding method showed significant improvement at 40 wt% fiber content.

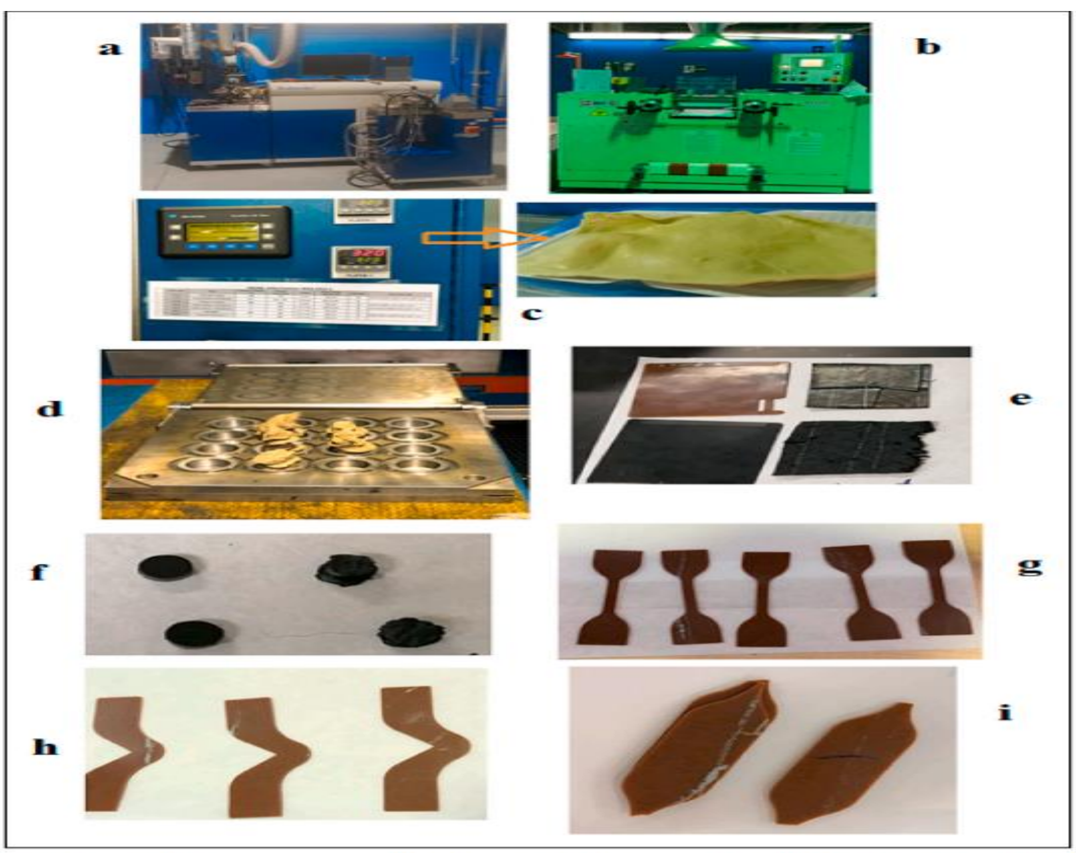


Fig II.2 [14]**: (a) Brabender internal mixer. (b) Roller mixer machine.**

(c) Curing device and final shape of the rubber after the roller machine. (d) Mold for the compression rest set. (d) Sheets prepared by compression molding for tensile and tear specimens. (f) Compression test specimens. (g) Tensile specimens. (h) Tear specimens. (i) Hardness specimens.

Khatun and al [15] in2023 at Bangladesh .have studied, the effect of adding short date palm mat (DPM) fibers to polystyrene was studied. The content was 5, 10, 15, 20 and 25% by weight. The matrix was studied for its physical, mechanical and thermal properties. Forced polystyrene composites were produced from short DPM fibers by a compression and fiber molding process The physico-mechanical and thermal properties were examined. Scanning electron microscopy (SEM) and Fourier transform infrared (FT-IR) analysis composite were also made. The results of the investigations revealed that the compounds with A fiber content of 10% showed improved mechanical and thermal properties compared to Other composite (better mechanical properties than 5, 15, 20 and 25 %). Bonding between the fiber matrix and polystyrene has been found in composites containing 10% fiber.

Abdellah and al [16] in 2023 at Egypt have studied the high-performance and low-cost composite materials. They treated date-palm fiber (DPF) with a 5 % NaOH solution and cleaned sheep wool with 50°C hot water and detergents. .composite specimens were then prepared with different fibre contents (0%, 10%, 20%, 30%) using a compression molding technique and they analysed the effect of fibre reinforcement on the mechanical properties (tensile, flexural, impact, and hardness)and composite density. .they also performed scanning electron microscopy (SEM) on the fibres before and after treatment as well as examined the fractured surfaces of all composite specimens after tensile. testing .the result indicated that the 20% (DPF/sheep)wool hybrid reinforced polyester produced the best result .it exhibited an ultimate tensile strength and modulus of 27 MPa and 3.69 GPa respectively .the ultimate flexural strength and flexural modulus were 35.4 MPa and 2507 MPa .respectively .the impact strength was 39.5kJ/m², and the hardness was 64 HB .the density decreased to the lowest value of 1.02 g/cm³with the 30% DPF/sheep wool hybrid .SEM images showed good adhesion and interfacial bonding between DPF/sheep wool hybrid fibers and the polyester matrix particularly at the 20% fiber content .

Fig II.3[16]**: Tensile test sample images after testing**

(a) neat polyester; (b) 10 % DPF; (c) 20 % DPF; (d) 30 % DPF; (e) 10 % DPF/sheep wool hybrid; (f) 20 % DPF/sheep wool hybrid; (g) 30 % DPF/sheep wool hybrid.

Yadav and al. [17] in 2023 at India have studied the Fabrication and mechanical behavior of date palm fibers reinforced high performance polymer composite Its purpose developing a biocomposites materials using wast milk pouches LDPE matrix reinforced with date palm fiber (DPF) and provide an environmentally friendly alternative for waste LDPE .using the method of hot compression molding .DPF fibers were treated with NAOH solution to enhance adhesion with LDPE.LDPE recycled from waste milk pouches . the fiber loadings was 20 %, 25 %, 30 %, 35 % and40 % (wt. %)during fabrication .mechanical tests .including tensile .impact and flexural tests .were conducted to assess the biocomposites pontential .the composite with 30% fiber content exhibited optimal tensile strength of 10.2 N/mm²and flexural strength of 17.86 N/mm².. the impact strength peaked at 47.53 kJ/mm² with 35% fiber loading ..results indicated that DPF /LDPE composite possess suitable mechanical properties for various applications .

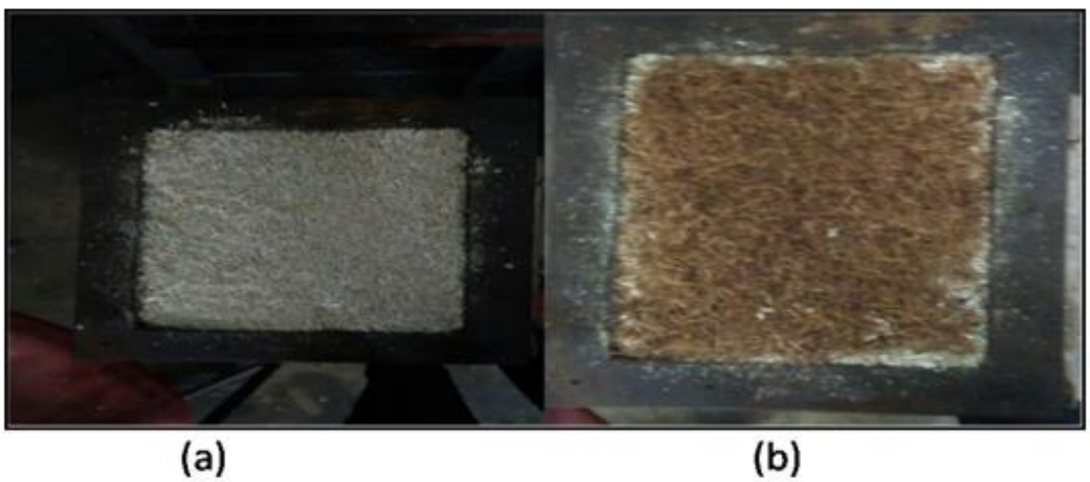


Fig II.4. [17]**: Fabrication of DPF-LDPE sandwich composite**

(a) Bottom layer with LDPE matrix (b) Middle layer with DPF fibers.

Saada and al [18] in 2024 at M'sila have Explored tensile properties of bio composites reinforced date palm fibers using experimental and Modelling Approaches . The objective of this study was to assess the tensile strength of epoxy biocomposites reinforced with palm fibers The objective of this study was to assess the tensile strength of epoxy bio-composites reinforced with palm fibers, both untreated and treated with sodium carbonate NaHCO3 at a concentration of 10 % (w/v) for 24 and 96 h, with varying weight percentages of fibers (15 %, 20 %, 25 %, and 30 %). To predict the mechanical performance of the composites, two methods were employed: artificial neural network (ANN) and response surface methodology (RSM). A Box-Behnken RSM design was used to conduct experiments and establish a mathematical model of the biocomposite behavior as a function of the fiber percentage in the samples, specimen cross-section, and treatment time. The ANN forecasts showed consistent expected values for the bio-composite sample behavior, with a correlation coefficient (R2) greater than 0.98 for Young's modulus and 0.97 for stress. Similarly, the correlation coefficients obtained by RSM for the mechanical properties were also highly satisfactory, with an R2 of 0.89 for Young's modulus and 0.87 for stress. Finally, the errors generated by each method (Box-Behnken and ANN) were compared to the experimental results.

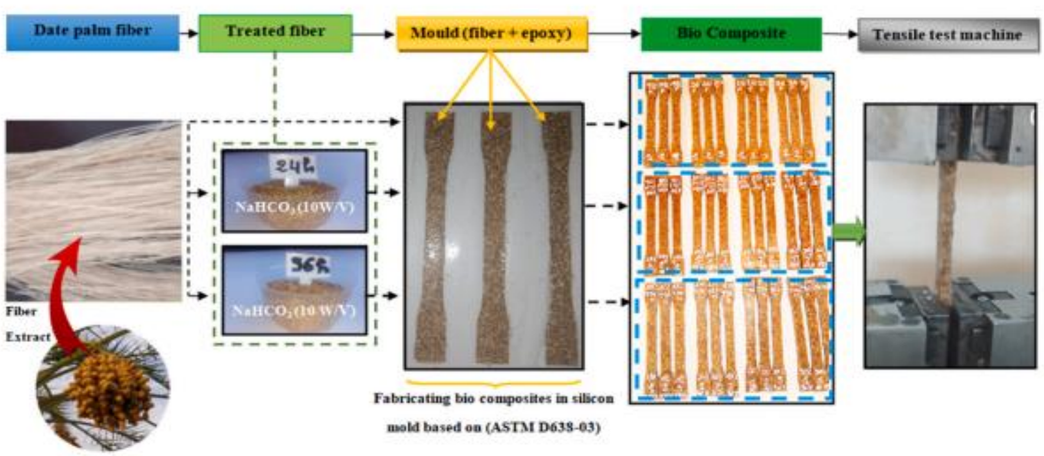
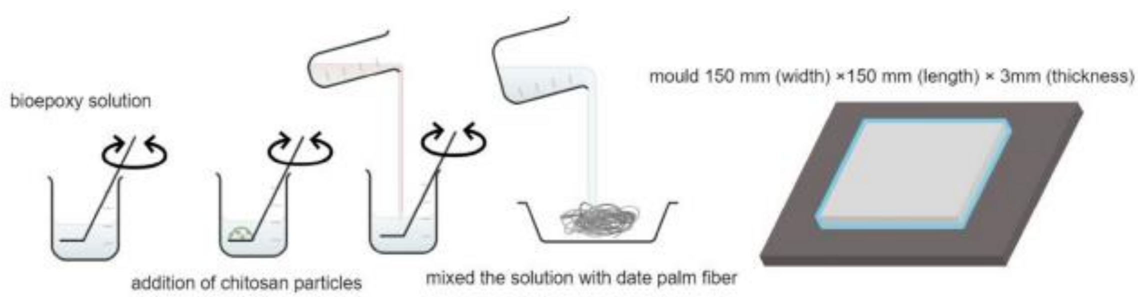


Fig II.5[18]**: Process for fig :developing and characterizing tensile specimens.**

Sarmin and al [19] in 2023 at Malaysia have studied the mechanical behavior of dual bonding filler; chitosan (CTS) and date palm (DP) fiber in bio-epoxy composites . The objective of this research was to find out if the addition of CTS particles to a DP/bio-epoxy composite could enhance its mechanical properties. The bio epoxy composites were prepared with 40%DP fiber and varied proportions of CTS filler (5%, 10%, 15%, and 20%).and a sample without CTS was prepared for comparison . the method of mixing involved dispersing,The components manually for 7_ 10 minutes before uniformly pouring them into a steel cast mold with specific dimension .the composite was then subjected to heat and pressure in a hot press at 110 C°for 10 minutes under a pressure of 250 bar . the results showed that bio-composite with high CTS content increased moisture content and dimensional .despite that DP/CTS20 showed superior mechanical properties compared to others CTS .albeit with higher water absorption and thickness swelling .



FigII .6[19]**: diagram of fabrication of DP/CTS bio-epoxy composites.**

Mlhem and al [20] in 2023 at United Arab Emirates have studied High-performance, renewable thermal insulators based on sialylated dates Poly (β-hydroxybutyrate) compounds reinforced with palm fibers . the objectif of this study is Developing insulating materials with minimal environmental. the method. is treated fibers were used to prepare poly(β-hydroxybutyrate) (PHB)-based composites via melt blending, thermo-compression molding, and annealing . The results showed that These compounds have an appropriate thermal conductivity of 0.0901-0.106 W/(M·K). In cold and hot water, sialylated fiber composites significantly decreased water absorption by 20% and .34%, respectively. The tensile strength of silicate fiber composites reached 18 MPa due to the improvement Compatibility, the highest compressive strength was 48.6 MPa with filler content of 40 wt%. heat The combustion of silyl fiber composites ranged from 20.79 to 21.94 MJ/kg.

Al Abdallah and Abu-Jdayil [21] in 2024 at United Arab Emirates have studied the Enhancement of water absorption properties of date palm fibers based composites via alkaline treatment .the aimed of this study aimed is to modify the surface properties of the natural fibers and enhance their water absorption capabilities. . The method of created composites is combining a matrix of polylactic acid (PLA) with date palm wood fibers (DPWF) for reinforcement. ,after the chemical treatment of the fibers with alkali NaOH and KOH. composites were fabricated,, , with fiber loading varing 0 to 40% . water retention tests were conducted at room temperature (cold) and 50 °C (hot) for 24, 48 h and until the absorption reached equilibrium. The results showed significant enhancement in water retention, particularly in the case of the NaOH-treated samples, which exhibited approximately a tenfold increase in water retention compared to untreated samples.

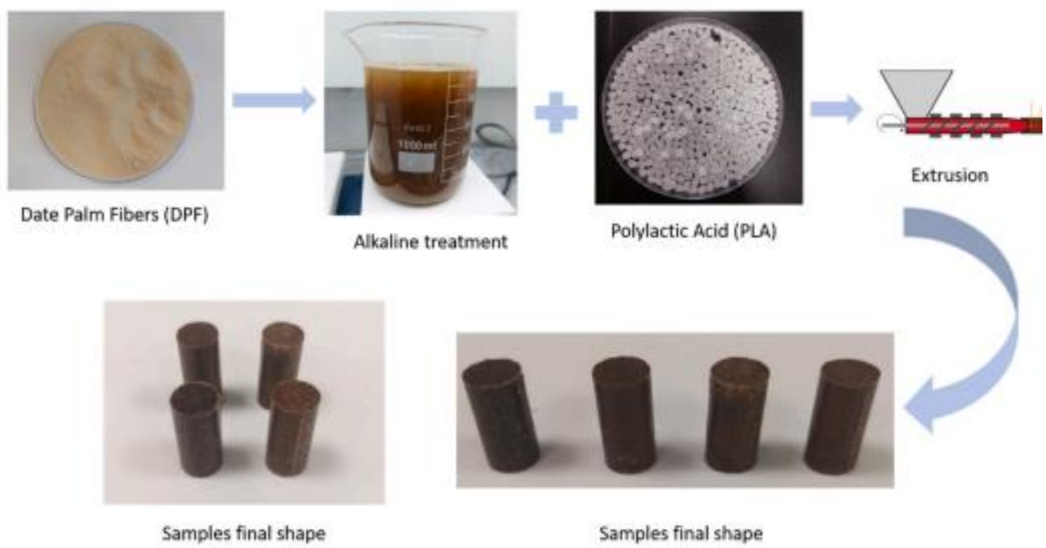


Fig II.7 [21] **: Raw materials, production methods, and final composites.**

Abdellah and al [22] in 2019 AT Egypt have studied the Tensile and Fracture Properties of Chemically Treatment Date Palm Tree Fibre Reinforced Epoxy. the aimed of this study is Date palm tree fibres (DPTF) are used as a natural reinforcement to be an attractive agent in the composite material industry. The method is mixing the fibers with epoxy resin after the chemical treatment to the fibres with ($CH3COOH$, HCl, and alkaline NaOH) with three different concentrations 10% and 20 % and 50 % at boiling temperature for 1 and 2hrs . . The tensile test is carried out over the standard tensile test specimens of that composite to study the effectiveness of reinforcement with the epoxy resin.the results showe that HCl treatment gives good compatibility with date palm trees fibres.

Fig II.8[22]**: Failure Modes of some samples of tensile specimens**

a)_ HCl b)_ NaOH c)_ CH3COOH for 1hr.

conclusion:in this chapter we have presented a many Several studies and research in the same field of own study and its objectives , we mentioned the methods, details of the experiments, and the results obtained in this research.

CHAPTER3

Introduction

In this chapter, we will discuss our experience in manufacturing our composite material, outlining each stage and experiment detail, the calculation method employed, the instruments used for measurements, and other pertinent details.

1- In order to applicated the idea, we applied to the company of (ENICAB) "Biskra" to allow us to use their machines .

To enhance the tensile strength of (LDPE 100% recycled), this study investigates the effects of fiber loading and orientation on the tensile characteristics of (LDPE 100% recycled) by experimenting with different fiber loading and orientations to find the optimal combination of fiber loading and orientations.

Table III.1[13]: Properties of different parts date palm fibers

Fiber type	Mesh	Petiole
Fiber diameter (mm)	0.78 ± 0.07	0.6 ± 0.013
Failure load (N)	49 ± 2	63 ± 5
Strain (%)	1.8 ± 0.0	2.4 ± 0.0
Tensile strength (MPa)	102 ± 8	212 ± 2
Young modulus (GPa)	5.5 ± 0.4	8.9 ± 0.8

1_**Materials and methods:**

Materials:

in this study date palm fiber was used as reinforcement, which was extracted from the petiole and the mesh of date palm tree after we cleaned it with water and dried it with a dryer for half an hour. The composite is (LDPE) which it raw materials is Nylon packaging waste. the (LDPE) was ground by a grinder for used directly like a matrice.

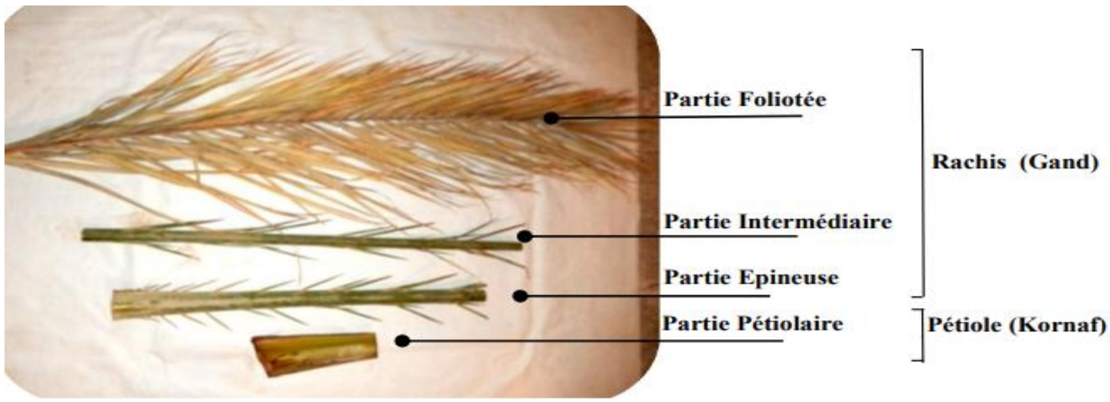
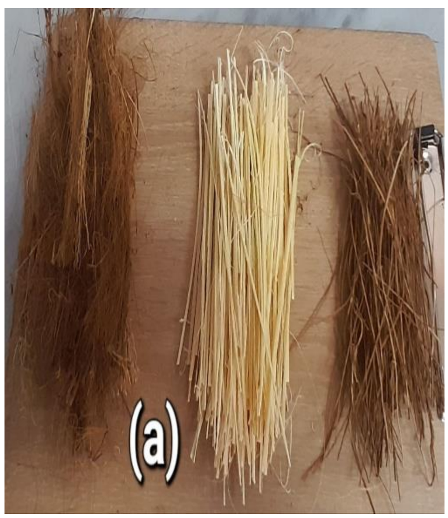


Fig III.1: necessary date palm tree parts



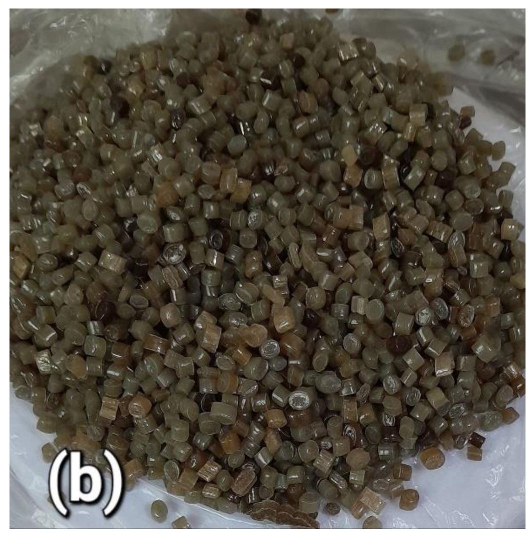


Fig III.2:(a): fibers extracted ; (b):LDPE ground

2_Fabrication of composite:

2_1 without fibers :

the hand layup method was used for this study, due to its simplicity and easy processing, the mold with dimensions of 13×13 $\mathbf{cm^2}$, we weight (48,47g) of the LDPE ground and put it in the mold of the extrusion machine and covered it with aluminum after which was heated to a temperature 150 C° for ten minutes almost . Then the mold gradually rises to the above and is covered with the horizontal surface of the machine. The process continues for a quarter of an hour in the chronometer . After this period, we increase the pressure every two minutes from 100MPA to 300MPA°. Then we begin to reduce the temperature until about 80C° and cool with water for at least six minutes, show in pictures below .

Fig III.3:experimental protocol

2.2 with fibers :

we repeat the same previous process ,but this once adding the fibers with loading of (4% ,6% ,10% and 20%)and orientation of (0/0 45/−45 0/90 network and random form).

a- **the mesh**: for a fiber loading of 4%and random form: We weighed 2g of the fibers using an electronic balance , We cut the fiber into small particles of 2mm in size, put half the amount of LDPE in the mold, then the fibers, then placed the remaining amount in the form of a sandwich. For fiber loading of 6% :We did the same process , where we weighed 3g of fibers and we put the fibers with orientations(0/0 45/−45 0/90), we put also put half the amount of LDPE in the mold, then the fibers, then placed the remaining amount in the form of a sandwich, As shown in the picture below.

Fig III.4:the leaf samples

b- **the betiole:** For the caravan, we weighed an amount of 3g of fiber, then we put half the amount of LDPE, then we distributed the fiber by loading (loading10) 45.0/90.00 and 0/0 (loading 20) in the form of a sandwich as well, As shown in the picture below.

Fig III.5:the petiole samples

- After the plastic cooled (the cooling was done with water for about five minutes), we removed it from the extrusion machine and cut it with the cutting machine shown in the picture .

Fig III.6:cutting machine

- We cut the samples with the follwing dimensions:

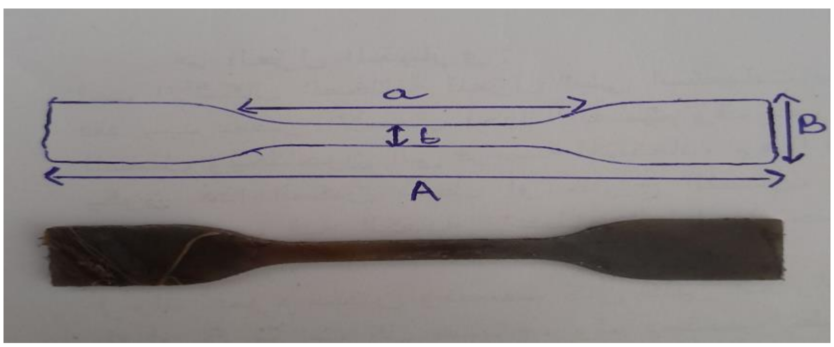


Fig III.7:the samples dimensions

Table III.2: the samples dimensions table

A	70mm
A	30mm
B	10mm
B	4mm

We cut **3** samples for every loading and orientations :

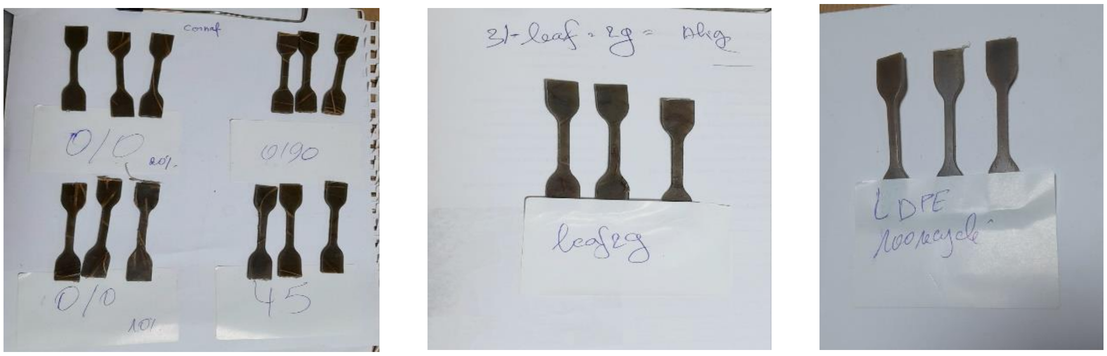


Fig III.8: cut samples

3_Mass and fraction of DPF and matrix in the composite material:

b- the mesh:

Fibers loading	Material	Mass(g)
4%	**DPF**	**2**
	Matrice	**48,47**
6%	**DPF**	**3**
	Matrice	**48,47**

b)_the petiole:

Fibers loading	Material	Mass(g)
6%	**DPF**	**3**
	Matrice	**48,47**
10%	**DPF**	**5**
	Matrice	**48,47**
20%	**DPF**	**10**
	Matrice	**48,47**

(a)

- **Orientation :**

a)_the mesh:

Loading	Orientation			
4%	Random			
6%	0/0	45	0/90	90

b)_the petiole:

Loading	Orientation	
6%	0/90	45
10%	0/0	
20%	0/0	

_we measured the tensile strengh of the samples with "Zwick/Roell(z050)''tensile machine (It is a German-made machine with a maximum capacity of up to 50kN, making it suitable for various applications including testing the strength of plastics, metals, and more. It is primarily benchtop with dimensions typically around 600mm (width) x 800mm (height) x 400mm (depth). Its key features include a high-precision digital load cell for accurate force measurement, as well as automatic and fast result accuracy) ,show in figure below. |[23]

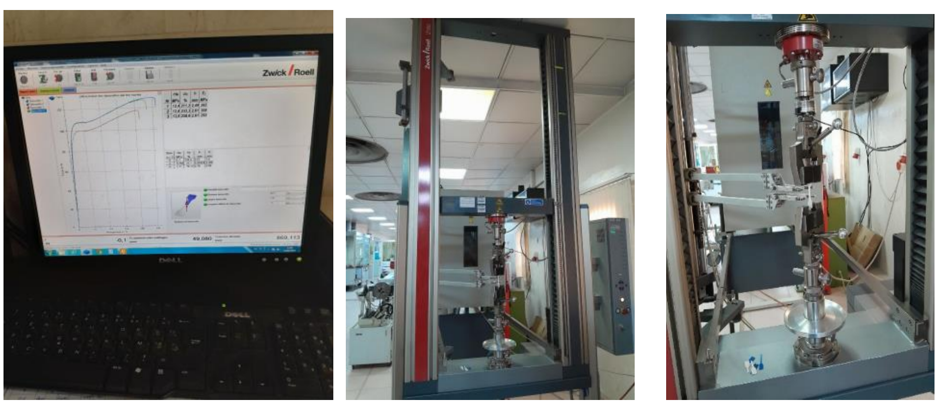


Fig III.9: tensile machine

Chapter 3

Conclusion:

In this chapter, we will discuss our experience in manufacturing our composite material, outlining each stage and experiment detail, the calculation method employed, the instruments used for measurements, and other pertinent details, The results of this experiment will be discussed in the next chapter.

Chapter 4

Results and discussion

Chapter 4

Introduction:

In this chapter, we will provide an explanation of the factor(the young modulus”E”) we calculated for the purpose of comparing between the samples of the composite material we manufactured using the steps mentioned in the previous chapter, along with the results of our experiment. We will also compare between the samples of the composite material, as well as review the results of Scanning Electronic Mecroscopy(SEM) the the samples of composite materials.

1- tensile test :

The tensile test is conducted by placing a small specimen of the material under study between the jaws of a tensile testing machine, which applies a progressive force until the specimen breaks. During this test, the elongation of the specimen and the applied force are recorded. These measurements are then converted into strain and stress. The tensile test provides several important values that characterize the mechanical properties of the material. Among these values we found:The Young's modulus (E), also known as the longitudinal elasticity modulus, expressed in (MPa) or (GPa). It represents the stiffness of the material and its ability to resist elastic deformation. It can be calculated from the stress-strain curves using the formula:

$$E = \frac{\Delta\sigma}{\Delta\varepsilon}$$

The elastic limit Re (σe), which indicates the stress level beyond which the material starts to deform permanently. The tensile strength Rm (σm), which corresponds to the maximum stress supported by the material before it breaks. The elongation at break A%, which measures the material's ability to stretch under force before breaking. This is an important property in certain applications. Poisson's ratio ν, which represents the relationship between transverse deformation (reduction in section) and longitudinal deformation (relative elongation) of the material in the elastic range. These mechanical parameters characterize the strength, ductility, and elastic behavior of the material when subjected to tensile stresses. They are essential for evaluating the performance and capacity of the material to withstand tensile forces in various applications**.** [24]

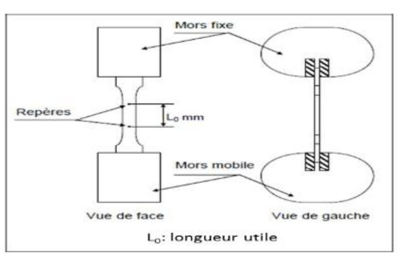


Fig IV. 1: The diagram of a tensile test of a specimen.

2- **Results** :

from the tensile test we remarque the values of young modulus “E”of studied materials ranged from 0,919 to 3,215 MPA:

a. **LDPE(without fibers):** Resin samples showed the average of Young’s moudulus **:** 1,457MPA. (Show in table)

b_**the petiole :** As for the petiole samples, we have noticed a noticeable improvement in young moudulus , as the samples with 20% loading and 0/0orientation samples showed an average of the Young moudulus1,869MPA , and the samples with 10% loading and 0/0orientation samples showed an average of the Young modulus1,720MPA,and the samples with 6%loading we found that :the sample with 0/90 orientation showed an average of young modulus” E:” the sample with 45orientation showed an average of young moudulus1,717MPA.

- all of the samples of material composite with petiole mentioned have an average young modulus “E” better than samples of (LDPE) 1,457MPA.so the material composite with petiole fibres was improved.(show in table)
- Except a sample of petiole with 6%and 0/90 it was a lower young modulus”E” than the others samples and LDPE samples (0,993MPA).
- The young modulus “E” of petiole ,loading (20%,10% and 6%)and (0/0,0/0,45) respectively ,increased approximately (12,8%,11,8%and 11,7%) respectively. also ,we Remarque the young modulus “E”of the petiole samples with 6%and orientation 0/90 decreased approximately 14,7%

c_**the mesh:**

For the mesh samples with 6% loading, we found: the samples with 0/0 orientation showed highest young modulus “E” 3,215MPAand samples with 0/90 orientation showed also an improvement in the young modulus “E” 2 ,144MPA, the samples with 90 orientation showed an average young modulus “E” 2,077MPA,the samples with 45/-45orientation showed an average 1,838MPA. For the samples of the mesh with random orientation and 4% fiber loading, we found a lower average young modulus “E” than LDPE samples and the others mesh samples (0,919MPA). .

- from the previous results we found that: the mesh samples showed a better young modulus "E" than the petiole sampleة , where it's the mesh samples showed a highest young modulus "E" 3,215MPA(with 6% fibres loading and 0/0orientation), but the petiole samples showed a high values of young modulus" E" 1,869MPA(with 20% fibres loading) and 1,720MPA(with 10%fiber loading and 0/0orientation)and average of young modulus "E" 1,717MPA(with 6%fiber loading and 45orientation).
- the mesh samples with fibres loading 6% and orientation (0/0,0/90,90and-45/45) showed a different values of young modulus where the samples with -45/45we found the average of young modulus"E" is 1,838MPA and when we change the orientation to 90 the average increase to 2,077MPA ,the same thing also happened when changed the orientation to 0/90the average of young modulus improved to 2,144MPA, the average of young modulus"E" was recorded the highest value in this experiment when we change the orientation to 0/0as it increase to 3,215MPA.so the young modulus "E" of mesh fibers (0/0,0/90,90, -45/45and 45)increased approximately (22%,14,7%, 14,4%and 0,12%) respectively. also ,we remarque the young modulus "E"of the mesh sample with loading 4%and random orientation which decreased approximately 15,8%. so the composite material with the mesh Fibers improved and showed a higher values of young modulus "E" better than petiole fibers.(show in table)and an improvement in young modulus "E" better than the petiole samples .

Table IV.1 :young modulus and average

Matrice	**Configuration (orientation)**	**Loading**	**Young modulus E (MPA)**			**The average (MPA)**
			Sample 1	**Sample 2**	**Sample 3**	
LDPE	/	/	1,532	1 ,460	1,380	1,457
THE PETIOLE	0/0	20%	1,818	1 ,890	1,900	1,869
	0/0	10%	1,721	1,690	1,750	1,720
	0/90	6%	1,009	0,960	1,010	0,993
	45		1702	1,690	1,760	1,717
THE MESH	00	6%	3 ,140	3,206	3,301	3,215
	090		2,123	2,111	2,200	2 ,144

	90		2,111	2,121	2 ,001	2,077
	45		1,930	1 ,806	1,779	1,838
	Random	4%	1,009	0,969	1,050	0,919

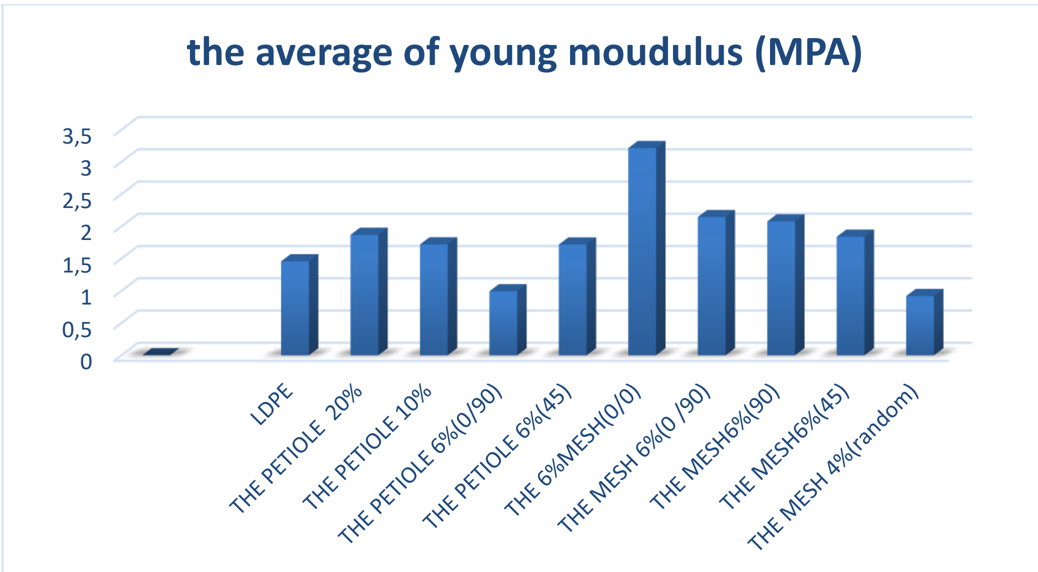
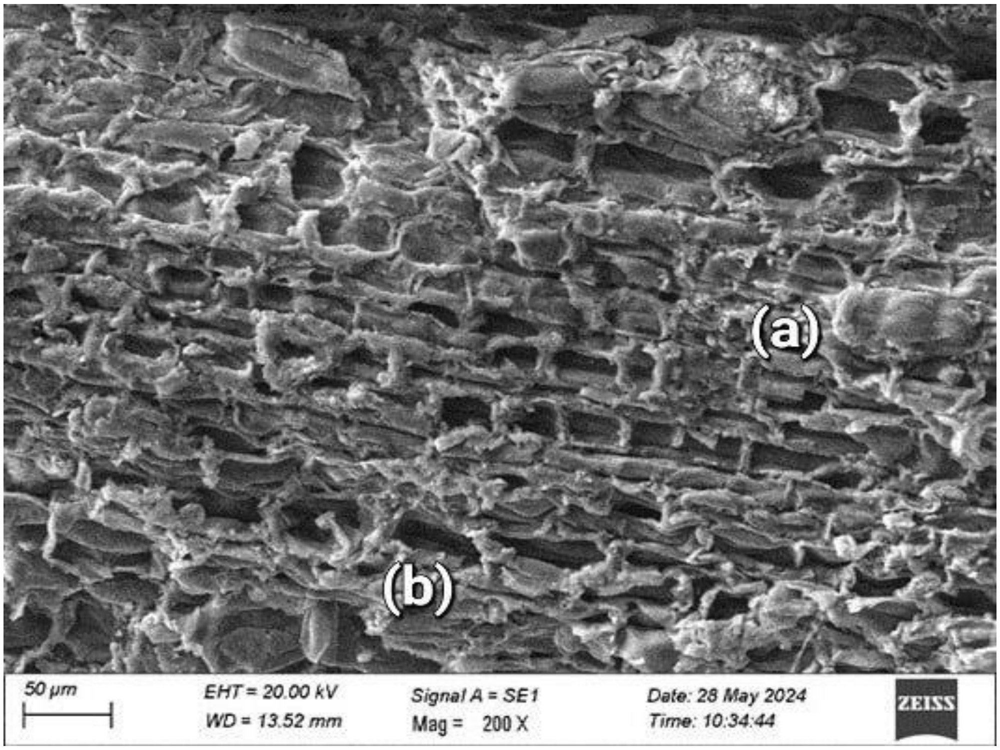


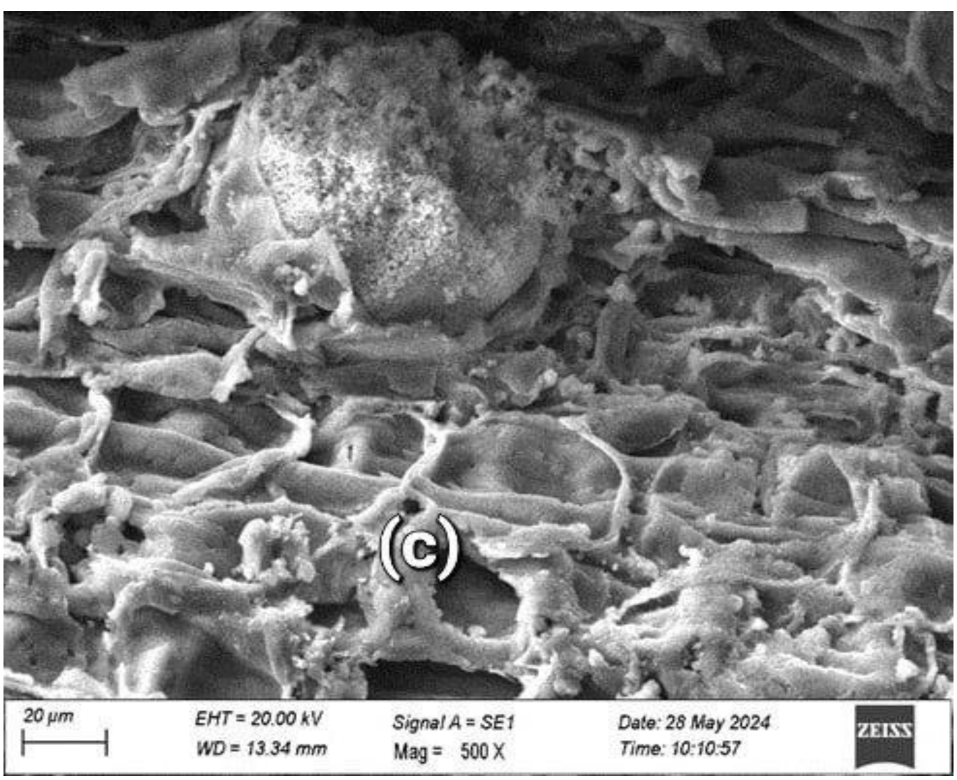
Fig IV.2: young modulus "E" average

3- Microscopy observation :

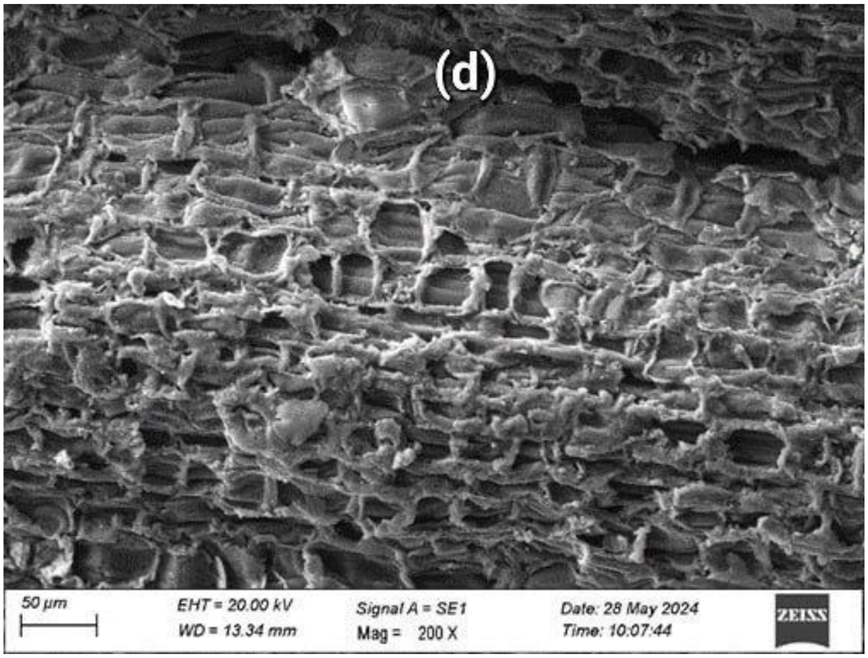
Figure n IV.2 show that the Scanning Electronic Mecroscopy(SEM)of composite materials studied intern of fiber /matrix surface The figure shows a good adhesion between the fibers and the matrix, along with a crack in the fiber region attributed to the installation process and tearing in the indicated area after the sample was broken in the tensile test applied to the sample. Additionally, the fracturing of the matrix in the indicated area is also attributed to the tensile test. A small foreign particle, likely a grain of sand, was observed, believed to be from the fibers or the location where the samples were prepared.



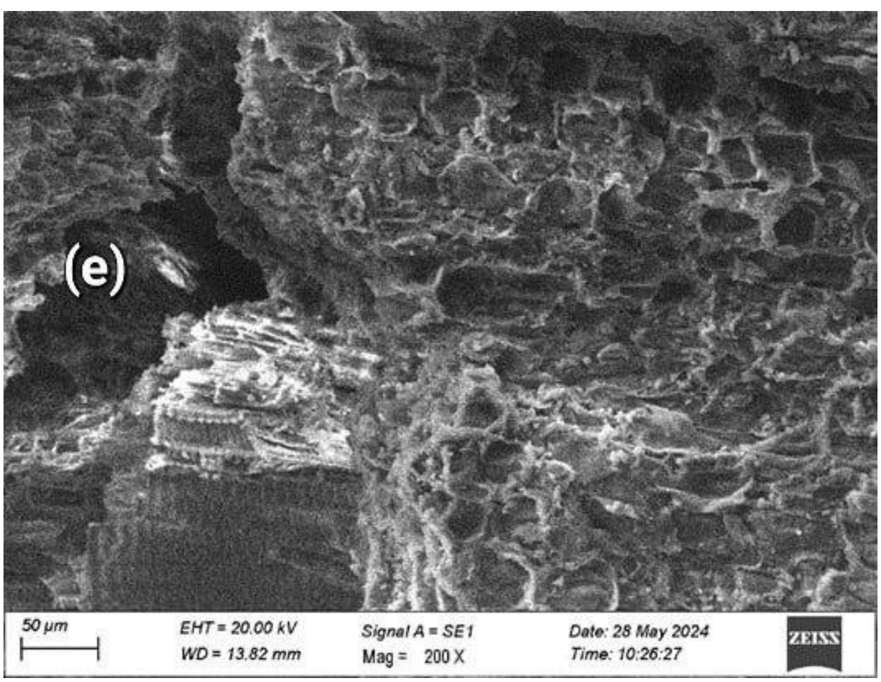
(a):the matrix (b):the adhesion between the matrix and fibers



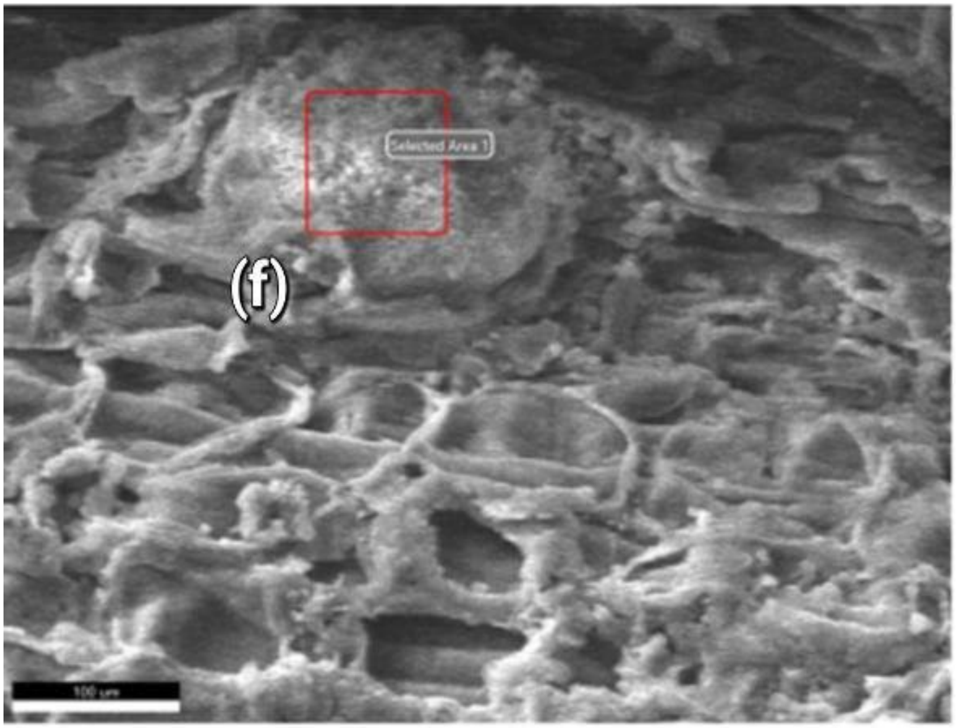
(c):the fibers



(d):the fiber fracture zone



(e):matrix craking



(f) :grain of sand

Fig IV.3: SEM results

Chapter 4

Conclusion :

In this chapter, we have provide an explanation of the factor(the young modulus”E”) we calculated for the purpose of comparing between the samples of the composite material we manufactured using the steps mentioned in the previous chapter, along with the results of our experiment. We will also compare between the samples of the composite material, as well as review the results of Scanning Electronic Mecroscopy(SEM) the the samples of composite materials. The results of the tensile test we conducted showed a significant improvement in the Young's modulus “E” for the samples of the petiole fiber with a fiber loading of (20/10/6)% and fiber orientation (0/0,/0/0,45) respectively increased with approximaty (1,28%,1,18%and 1,17%) respectively . We also observed good values in the Young's modulus for the samples of the composite material made from the mesh fibers, where the samples with fiber loading 6%and fiber orientation(0/0,0/90,90 and -45/45) improved approximaty (2,2%,1,47%, 1,44%and 0,012%) respectively.. From this, we conclude that adding the mentioned fibers with their mentioned loading increases the strength of the composite plastic. However, miscanthus fibers remain better for composite plastic manufacturing in this study.

General conclusion :

In this study we have present a new composite materials , Which was made from recycled plastic and palm fibers with specific fiber loadings and orientation . Several samples of the composite material were made in the ENICAB laboratory, we found An improvement in the strength (the young modulus"E") of the studied plastic for the petiole and mesh samples with loading of (6/10/20)% and fiber orientation (-45 /45/0/0,0/90.) The best result was observed for mesh fibers with loading of 6 %and fiber direction of 0/0. Mab showed that The samples showed good adhesion between the matrix and fibers in the composite material, and the fracture zones of the fibers and craking matrix also showed after tensile testing.

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Appendix 1

16.05.24

Zwick Roell

PV de l'essai

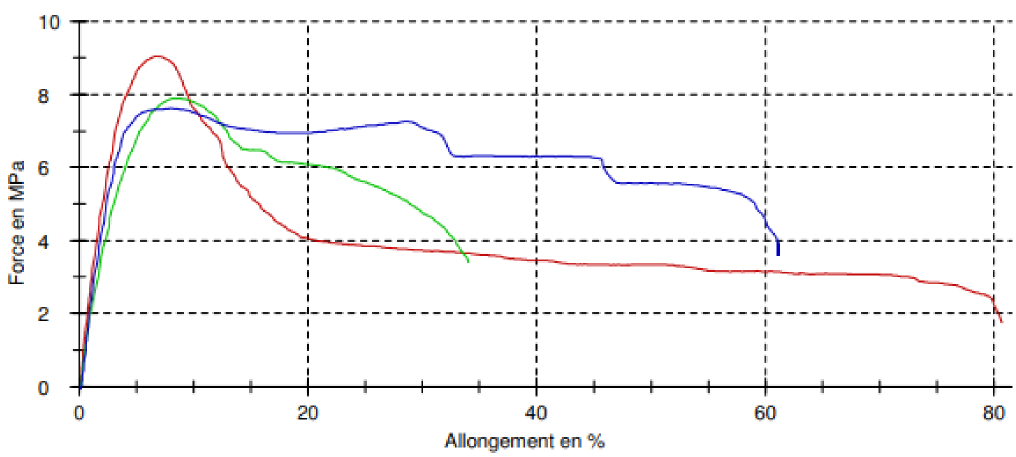
Titre	: PV de l'essai	Echantillon	:		
Norme d'essai	: CORNAF 00 10%	Type d'éprouvette	: Haltère		
Matériau	:	Opérateur	:		

Vitesse du module de traction : 5 mm/min
Vitesse d'essai : 100 mm/min

Résultats d'essai:

Nr	σ_M MPa	ε_B %	h mm	E_t MPa
1	9,05	80,7	2,47	466
2	7,89	34,0	2,4	415
3	7,61	61,1	2,46	336

Graphique de séries:



Statistiques:

Série n = 3	σ_M MPa	ε_B %	h mm	b mm
$\bar{x}$	8,18	58,6	2,443	3,8
s	0,761	23,4	0,03786	0,000
ν	9,30	39,97	1,55	0,00

CORNAF 00 10%.zs2 Page1/1

Zwick Roell

16.05.24

PV de l'essai

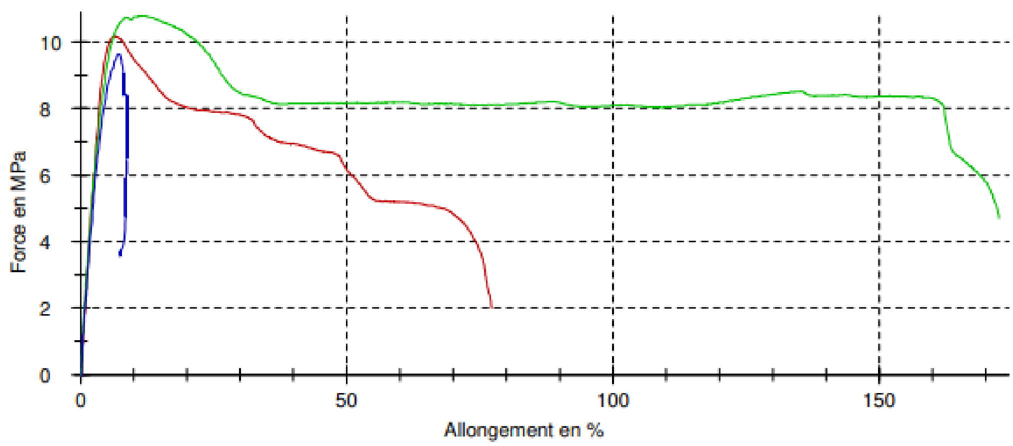
Titre : PV de l'essai
Norme d'essai : CORNAF 0/0 20%
Matériau :
Echantillon :
Type d'éprouvette : Haltère
Opérateur :

Vitesse du module de traction : 5 mm/min
Vitesse d'essai : 100 mm/min

Résultats d'essai:

Nr	σ_M MPa	ε_B %	h mm	E_t MPa
1	10,2	77,1	2,37	332
2	10,8	172,5	2,36	481
3	9,64	7,4	2,34	461

Graphique de séries:



Statistiques:

Série n = 3	σ_M MPa	ε_B %	h mm	b mm
$\bar{x}$	10,2	85,7	2,357	3,8
s	0,581	82,9	0,01528	0,000
ν	5,69	96,74	0,65	0,00

CORNAF 00 20%.zs2

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Zwick Roell

16.05.24

PV de l'essai

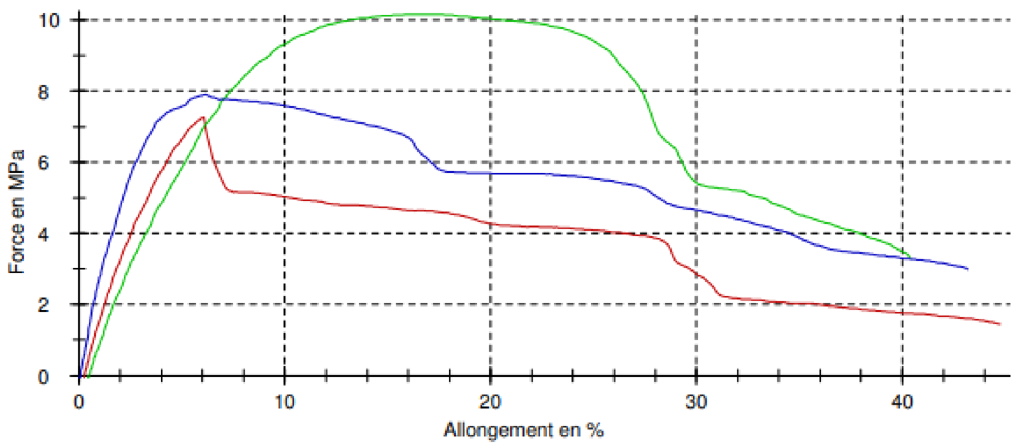
Titre	: PV de l'essai	Echantillon	:	
Norme d'essai	: CORNAF 45	Type d'éprouvette	:	Haltère
Matériau	:	Opérateur	:	

Vitesse du module de traction : 5 mm/min
Vitesse d'essai : 100 mm/min

Résultats d'essai:

Nr	σ_M MPa	ε_B %	h mm	E_t MPa
1	7,26	44,8	2,27	256
2	10,2	40,4	2,28	170
3	7,90	43,2	2,23	311

Graphique de séries:



Statistiques:

Série n = 3	σ_M MPa	ε_B %	h mm	b mm
$\bar{x}$	8,44	42,8	2,26	3,8
s	1,53	2,2	0,02646	0,000
ν	18,08	5,15	1,17	0,00

CORNAF 45.zs2 Page1/1

Zwick / Roell

16.05.24

PV de l'essai

Titre : PV de l'essai
Norme d'essai : CORNAF 0.90
Matériau :

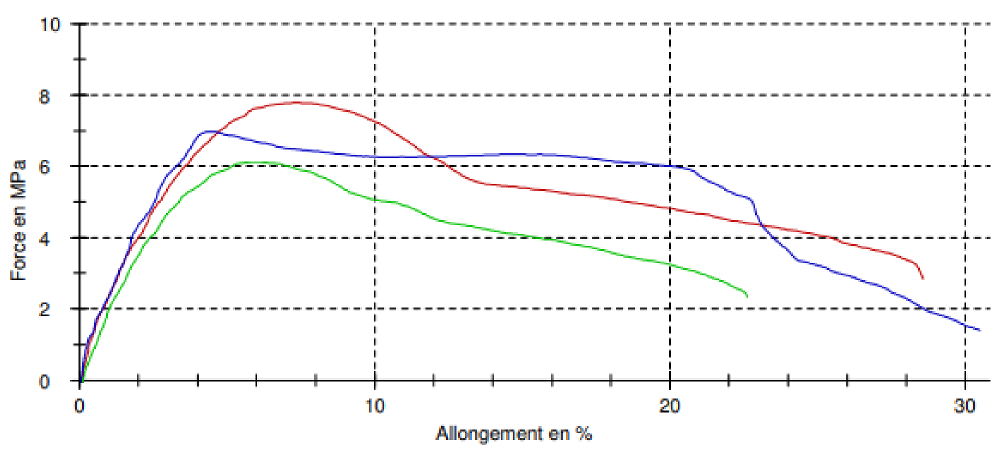
Echantillon :
Type d'éprouvette : Haltère
Opérateur :

Vitesse du module de traction : 5 mm/min
Vitesse d'essai : 100 mm/min

Résultats d'essai:

Nr	σ_M MPa	ε_B %	h mm	E_t MPa
1	7,78	28,6	2,35	734
2	6,12	22,6	2,41	383
3	6,96	30,5	2,47	542

Graphique de séries:



Statistiques:

Série n = 3	σ_M MPa	ε_B %	h mm	b mm
$\bar{x}$	6,95	27,2	2,41	3,8
s	0,830	4,1	0,06	0,000
ν	11,94	15,08	2,49	0,00

CORNAF 090.zs2

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16.05.24

Zwick / Roell

PV de l'essai

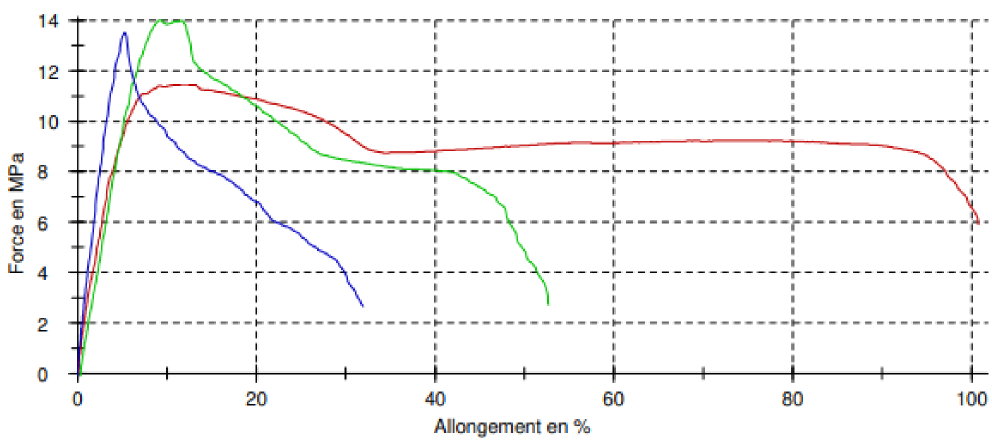
Titre	:	PV de l'essai	Echantillon	:	
Norme d'essai	:	LEAF 5% 090	Type d'éprouvette	:	Haltère
Matériau	:		Opérateur	:	

Vitesse du module de traction : 5 mm/min
Vitesse d'essai : 100 mm/min

Résultats d'essai:

Nr	σ_M MPa	ε_B %	h mm	E_t MPa
1	11,5	100,7	2	632
2	14,0	52,7	2,37	323
3	13,5	31,9	2,29	495

Graphique de séries:



Statistiques:

Série n = 3	σ_M MPa	ε_B %	h mm	b mm
$\bar{x}$	13,0	61,8	2,22	3,8
s	1,35	35,3	0,1947	0,000
ν	10,41	57,14	8,77	0,00

LEAF 5% 00.zs2 **Page1/1**

Zwick / Roell

16.05.24

PV de l'essai

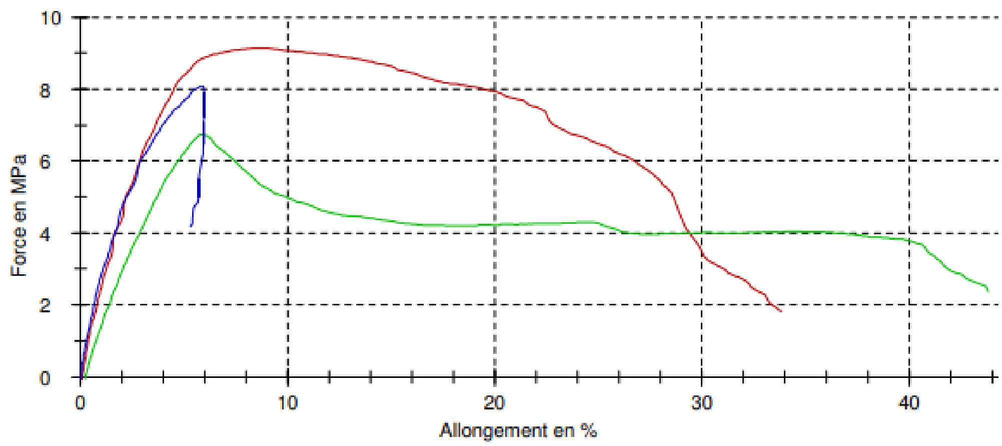
Titre	: PV de l'essai	Echantillon	:	
Norme d'essai	: LEAF 5% 45	Type d'éprouvette	:	Haltère
Matériau	:	Opérateur	:	

Vitesse du module de traction : 5 mm/min
Vitesse d'essai : 100 mm/min

Résultats d'essai:

Nr	σ_M MPa	ε_B %	h mm	E_t MPa
1	9,14	33,8	2,17	316
2	6,73	43,8	2,3	214
3	8,09	5,3	2,15	317

Graphique de séries:



Statistiques:

Série n = 3	σ_M MPa	ε_B %	h mm	b mm
$\bar{x}$	7,99	27,7	2,207	3,8
s	1,21	20,0	0,08145	0,000
ν	15,12	72,20	3,69	0,00

Zwick / Roell

16.05.24

PV de l'essai

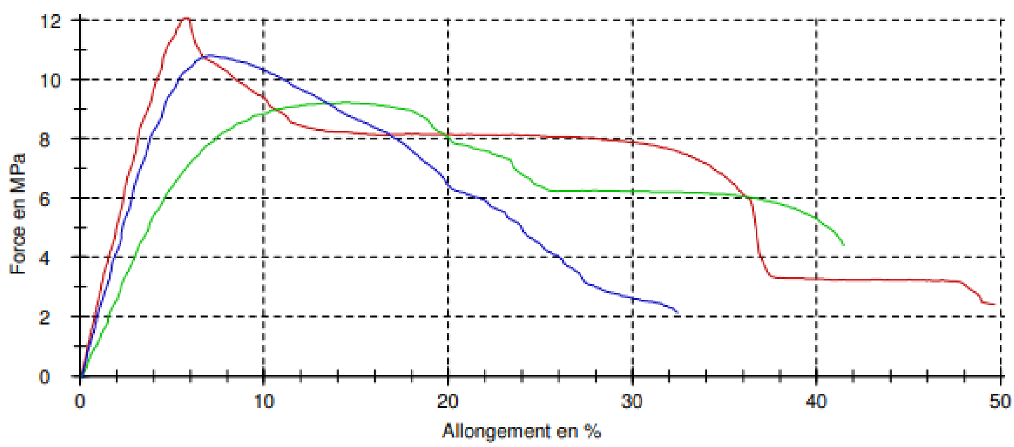
Titre	:	PV de l'essai	Echantillon	:	
Norme d'essai	:	LEAF 5% 090	Type d'éprouvette	:	Haltère
Matériau	:		Opérateur	:	

Vitesse du module de traction : 5 mm/min
Vitesse d'essai : 100 mm/min

Résultats d'essai:

Nr	σ_M MPa	ε_B %	h mm	E_t MPa
1	12,1	49,7	2,39	302
2	9,21	41,4	2,2	121
3	10,8	32,4	2,25	304

Graphique de séries:



Statistiques:

Série n = 3	σ_M MPa	ε_B %	h mm	b mm
$\bar{x}$	10,7	41,2	2,28	3,8
s	1,43	8,6	0,09849	0,000
ν	13,40	20,93	4,32	0,00

LEAF 5% 090.zs2 **Page1/1**

Zwick / Roell

16.05.24

PV de l'essai

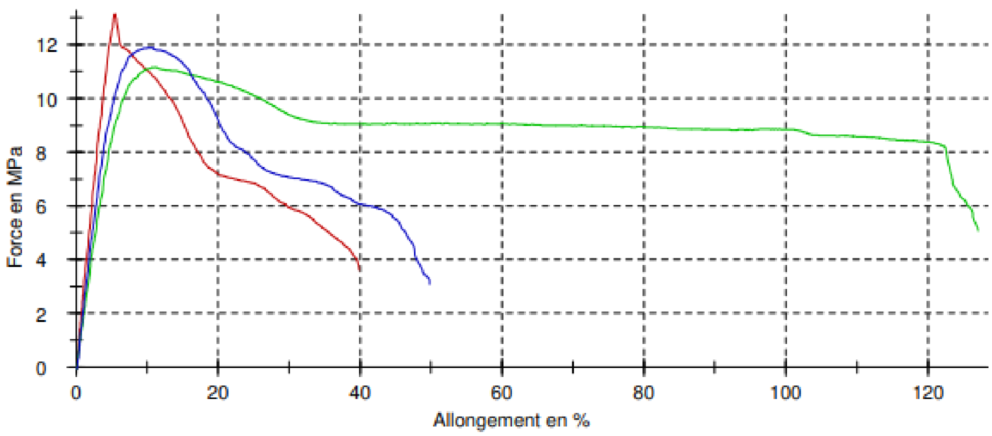
Titre	:	PV de l'essai	Echantillon	:	
Norme d'essai	:	LEAF 5% 90	Type d'éprouvette	:	Haltère
Matériau	:		Opérateur	:	

Vitesse du module de traction : 5 mm/min
Vitesse d'essai : 100 mm/min

Résultats d'essai:

Nr	σ_M MPa	ε_B %	h mm	E_t MPa
1	13,2	39,8	2,13	423
2	11,2	127,1	2,15	239
3	11,9	49,8	2,15	285

Graphique de séries:



Statistiques:

Série n = 3	σ_M MPa	ε_B %	h mm	b mm
$\bar{x}$	12,1	72,3	2,143	3,8
s	1,02	47,8	0,01155	0,000
ν	8,41	66,09	0,54	0,00

LEAF 5% 90.zs2

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