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Analysing Some Mechanical Properties of Cinnamon Powder Reinforced with Polymeric Materials Used in Dental Application

Abstract- *In the dentures industry, materials must be chosen to have good mechanical properties in order to resist the conditions that may occur in the mouth. A study was conducted to assess tensile strength, elasticity coefficient, elongation, flexural strength, flexural modulus with impact properties of poly methyl methacrylate resin as matrix strengthened with cinnamon powder and also analysing these mechanical properties by using (OriginLab) software program. The samples of Poly Methyl methacrylate bio composites which containing 2%, 4%, 6%, and 8% weight fractions of cinnamon powder and an unfilled as control sample were fabricated using "hand lay up" method. The results indicate that the addition of 8% weight fraction cinnamon powder into Poly Methyl methacrylate resin improved of ultimate tensile strength, modulus elasticity ,flexural strength, flexural modulus (62 MPa, 3.7 GPa, 96 MPa, 6.4 GPa) respectively, compared with the values of pure Poly Methyl methacrylate (51 MPa, 1.5 GPa, 78MPa, 2.0 GPa) respectively. Also can be noted that the elongation at break values decreases with an increase in weight fractions of filler, where the sample (Poly Methyl methacrylate +2% cinnamon) has the best value for elongation compared with samples reinforced (4%, 6% and 8% wt). The impact strength results observe the maximum value was present in the sample (Poly Methyl methacrylate+6% cinnamon). From the results, descriptive, One Way ANOVA statistical analysis and means comparison by used (Scheffe test and Tukey test) for all mechanical properties indicated, turns out if Sig equals 1 shows that the variance in mean is significant at the level of 0.05, whereas Sig is 0 designates that the mean variance is not significant at the level 0.05.***

Keywords- *Poly methyl methacrylate, Cinnamon powder, tensile properties, Flexural strength, Flexural modulus, Impact strength, Origin Lab.*

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1.Introduction

Composites are substances that do not resolve in any other and produce new material of unique advantages. Reinforcement materials in the form (particles or fiber or both together) usually are added to the based material to improve the mechanical properties, reduced shrinkage characteristic and improve bonding nature between the base material and the reinforcing material [1-2]. Composite materials which usually consist of a one or two materials' natural, non-toxic such as (jute fiber, eggshell, banana fiber, cinnamon, Clove, Pomegranate, Walnut.... etc.) are called bio-composite materials. Bio-composites materials are used in many applications, for example (teeth, prostheses, orthodontics, hip joints etc.…).

The bio-polymer resin composite materials are mostly used for immediate renovation, both posterior and anterior teeth, due to good mechanical and physical characteristic of these materials [3]. Poly Methyl methacrylate, a polymer used in the manufacture of a denture, an alternative to lose teeth and peripheral tissues, this material should be has good mechanical properties (impact strength, flexural strength and wear resistance.... etc.) and is compatible with the mouth environment, non-toxic and low water absorption [4-5]. Although Poly Methyl methacrylate materials it is widely used, but there are many drawbacks must be taken into consideration, so many researchers studied the effect of additives to improve mechanical and physical characteristic of Poly Methyl methacrylate material. Balos et al**.** [6] have studied effect of various additions Nano silica into Poly Methyl methacrylate resin matrix on modulus of elasticity and flexural strength. The samples are composed from Poly Methyl methacrylate resin reinforced with (0.05%, 0.1%, 0.2%, 0.5%, 1%, 2%) weight fraction Nano silica. Results observed the weight fraction (0.05% into Poly Methyl methacrylate) give the highest values of modulus of elasticity and

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flexural strength. Jha et al. [7] has studied the tensile strength, flexural strength with impact strength of Poly Methyl methacrylate resin strengthened by ridge gourd fiber. These samples consist from Poly Methyl methacrylate with (5%, 10%, 15% wt) ridge gourd fiber. The results indicate that the sample (Poly Methyl methacrylate +10% ridge gourd fiber) has maximum values of tensile strength and flexural strength, while the sample (Poly Methyl methacrylate +15% ridge gourd fiber) has a maximum value of impact strength. Haitham et al. [8] have investigation the tensile test, flexural test, impact test and hardness shore D for polymeric bio-composites made from (1% , 3% , 5% and 7%) weight fraction ZrO_2 into Poly Methyl methacrylate resin matrix. From results turns out the (7% ZrO_2 wt.) with Poly Methyl methacrylate resin have higher values of hardness shore D , ultimate strength and fracture toughness, while the (1% ZrO_2 wt.) with Poly Methyl methacrylate resin has a maximum value elongation. In the impact strength test (3% ZrO_2 wt.) has better values when comparing with other weight fractions. The objective of the current work is attempting to obtain the new bio-composites prepared from cinnamon powder into poly methyl methacrylate resin which is used in the denture application. Also study the effect of various additives cinnamon powder on tensile, flexural and impact test of the poly methyl methacrylate composite.

1. Materials

I. Poly Methyl methacrylate

Poly Methyl methacrylate cold curing used a resin matrix kind from (Castavaria) equipped with a company "Vertex–Dental" to production the bio-composite samples used in denture base. Some mechanical and physical characteristic of Poly methyl methacrylate is indicated on the Table 1.

Table 1: Some mechanical and physical characteristic of Poly methyl methacrylate according to the Company Processed (Vertex – Dental Company)

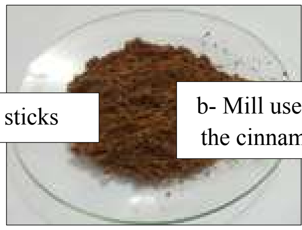
Flexural strength	Young modulus	Impact strength	Density	Water absorption
79 MPa	1.63 GPa	8.3 KJ/m^2	1.19 gm/cm^3	2.5%

II. Cinnamon Natural Material

Cinnamon is a tree belonging to the Laureaceae family and crosses one of the most significant spices used in everyday life cinnamon originally contains vital oils and other derivative, example cinnamaldehyde, cinnamic acid, and cinnamate. The cinnamon can be used as an antioxidant, antimicrobial and antinflammatory [9]. Cinnamon has a beneficial effect on oral health and is utilized to treat oral infection, treat toothache with removing bad breath [10]. In this research was used cinnamon sticks after grinding for 3 hours by (Mill) to obtain cinnamon powder that used as a strengthened material at a different weight fraction (2%,4%,6%,8%) with Poly methyl methacrylate resin. The Figure 1 shows steps to prepare cinnamon powder. The particle size distribution was examined using (MASTERSIZER 2000) for cinnamon powder after grinding as illustrated in Figure 2, where the average particle size for cinnamon powder was (24µm). The chemical composition of the cinnamon powder was examined using X-ray Fluorescence spectrometer Technique, Table 2 shows the ratio oxides of the elements existent cinnamon powder, while Figure 3 (A-B) shows the ratio of elements existent cinnamon powder under the influence reagent compton secondary molybdenum , reagent Barkla scatter HOPG respectively.

a- Cinnamon sticks

b- Mill used to grind the cinnamon sticks



C- Cinnamon after milling for 3 hours

Figure 1 :Steps to preparing cinnamon powder.

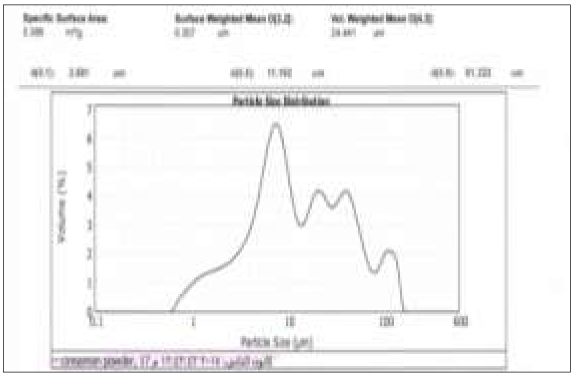
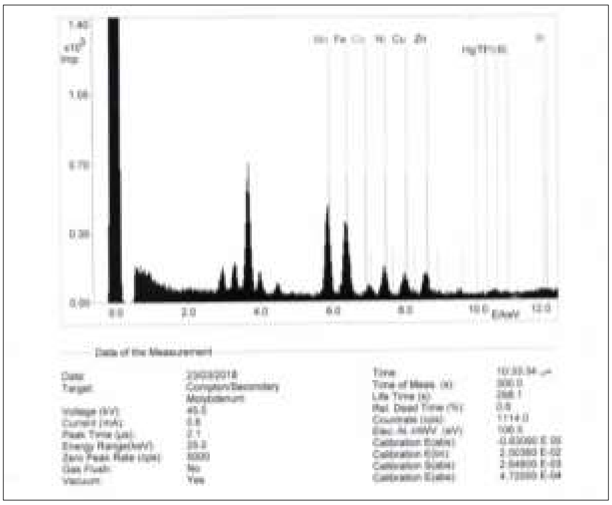


Figure 2: Distribution particle of cinnamon powder

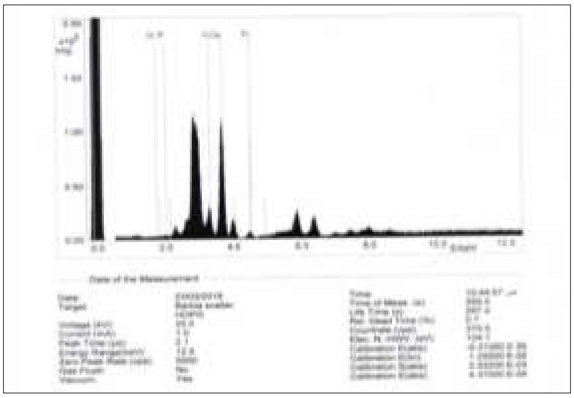
Table 2: Percentage oxides of elements existent cinnamon powder

Oxides Elements	Ratio %
Na_2O	0.45
MgO	0.86
Al_2O_3	0.20
SiO_2	0.13
P_2O_5	0.08
K_2O	0.55
CaO	4.66
TiO_2	0.17
MnO	0.25
Fe_2O_3	0.13
CoO	0.03
NiO	0.16
CuO	0.09
ZnO	0.07
Rb_2O	0.015
SrO	0.01
SnO_2	0.02



A

Figure 3: (A-B) X-Ray Fluorescence of the cinnamon powder



3. Preparation Samples of Bio-Composites Materials

The dimensions of mould used in this research to prepare samples were (150 mm ×150 mm×5 mm). The mold was made of glass and covered with a layer glass to achieve samples with fine surface and non-roughness. Poly methyl methacrylate denture base materials consist from monomer liquid and polymer powder. The mixing ratio of poly methyl methacrylate (cold cure) is usually about 17 gm powder and 9.5 gm liquid polymer. At the beginning, the specific ratio of polymer liquid is placed in a dry and clean glass flask and then adds the specified ratio of the dry powder gradually to the polymer liquid. The mixtures are mixed continuously and homogenously at room temperature and then pour the mixture into the middle of the mold. Leave the mixture inside the mold for 9-15 minutes at room temperature from beginning the mixing process to increase the viscosity of the mixture. Removing samples from the mold and put them in the oven at a temperature of 55 for 30 minutes [11] and cutting the samples according to ASTM of each test as shown Figure 4. Table 3 shows the composition details of bio-composite samples.

Tensile Test

Flexural Test

Figure 4: Composite samples after cutting according to ASTM (Tensile, Flexural and Impact test) .

Table 3 :Details composition of the samples

Samples	Composition (wt.)
A0	Pure PMMA
A2	PMMA+2% Cinnamon powder
A3	PMMA+4% Cinnamon powder
A4	PMMA+6% Cinnamon powder
A5	PMMA+8% Cinnamon powder

4. Mechanical Test

I. Tensile Test

Figure 5 shown dimensions samples of the tensile test L=150mm, W= 20mm and T=5mm according to ASTM D 638-03[12]. The tensile properties values can be calculated through equations (1) and (2) [13-14].

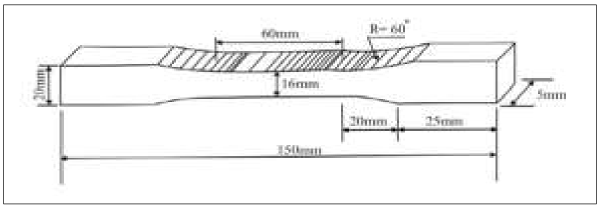


Figure 5 : Dimensions samples of the tensile test

$$\sigma = \frac{P}{A} \qquad (1)$$

Where:

σ**:** Tensile strength of sample MPa

P**:** applied load N

A: original crosses sectional area before testing m^2

$$\epsilon = \frac{\Delta L}{L^{\circ}} \qquad (2)$$

Where:

ϵ **:** strain

$\Delta L = L - L^{\circ}$

Where:

L**:** final length m

$L_{\circ}$**:** original length m

II. Flexural Test

Figure 6 shown dimensions samples of the flexural test L=100 mm, W= 10mm and T4.8=mm according to ASTM D-790 [15]. Flexural strength and flexural modulus can be calculated from equations (3) and (4) [16-17].

Impact Test **nsions samples of the flexural test**

$$F.S = \frac{3PL}{2bd^2} \qquad (3)$$

Where

F.S: flexural strength MPa

P: force N

L: length sample mm

b: thickness sample mm

d: width sample mm

$$E_B = \frac{PL3}{4\,b\,d3\,\delta} = \frac{m\,L3}{4bd3} \qquad (4)$$

Where:

E_B: Flexural modulus MPa

δ: deflection of samples mm

P: load applied N

L: support span mm

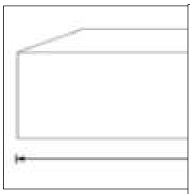
b: width of sample mm

d: thickness of sample mm

m: Slope of the tangent in the load- deflection curve N/mm

III. Impact Test

Figure 7 shown dimension samples of the impact test L=80mm, W=10mm and T=4mm according to standard (ISO-180) [18]. Impact strength can be calculated from equation (5) [19].



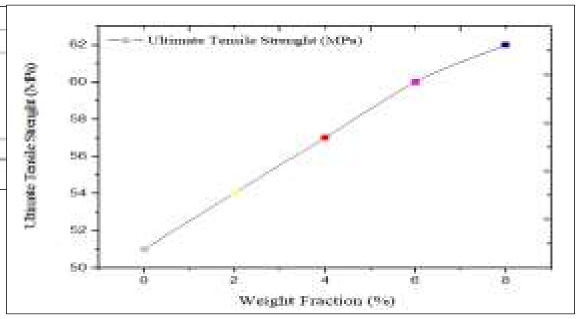


Figure 7: Dimensions samples of the impact test

5. Statistical Analysis

All statistical analysis was performed with (Origin Lab) program software using ((One-Way analysis)) of variance (ANOVA) with (Scheffe test and Tukey test) was utilized to analyze groups. The variations were always considered significant at (P-values) less than 0.05.

6. Discussion of Results

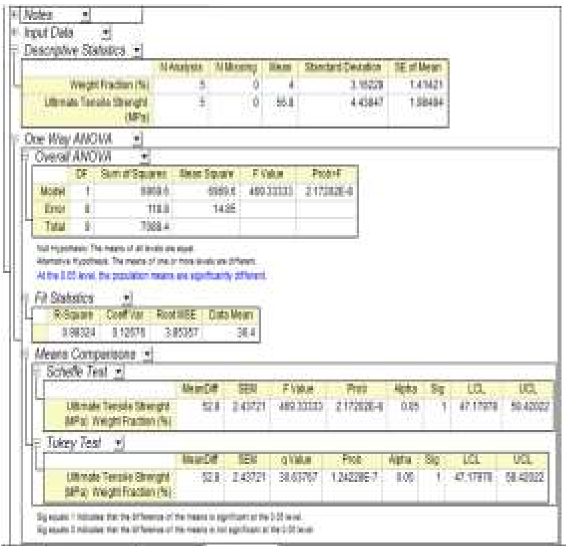
I. Ultimate Tensile Strength

Figure 8 shown the results of ultimate tensile strength performed on cinnamon powder based poly methyl methacrylate bio-composites. From the graph, there is clearly with the increased weight fraction of cinnamon powder leads to an increase tensile strength, where the sample (poly methyl methacrylate+ 8% cinnamon) has a high tensile value and improves the tensile strength property by 22% compared with pure sample. The reasons for increasing the tensile strength value; the first reason is that the elements and oxides found in cinnamon powder have increased the possibility of transfer the stress from poly methyl methacrylate polymer [20]. The second reason is that the average particle size of the cinnamon powder (6-200m) increases the covalent bond between the base poly methyl methacrylate resin polymer and the cinnamon powder material. Table 4 indicates the descriptive, One Way ANOVA statistical analysis and means comparison by used (Scheffe test and Tukey test) of the results ultimate tensile strength for the poly methyl methacrylate reinforced with various cinnamon powder (2%,4%,6% and 8%). From results analysis One Way ANOVA can be noted the mean values of all levels are equal, where (at the 0.05) level population means is significantly varying. Also, from (Tukey test and Scheffe test) notes if (Sig equals 1) indicates the difference of the means is significant at the 0.05 level. These meaning the weight fractions of cinnamon powder reinforced with poly methyl methacrylate were positively on the ultimate tensile strength value.

Figure 8: Ultimate tensile strength values as a function of cinnamon powder in PMMA.

Table 4: Results descriptive, One Way ANOVA and means comparison by (Scheffe ,Tukey test) of the ultimate tensile strength between all samples .

II. Modulus of Elasticity



Notes

Input Data

Descriptive Statistics

	N Analysis	N Missing	Mean	Standard Deviation	SE of Mean
Weight Fraction (%)	5	0	4	3.16228	1.41421
Ultimate Tensile Strenght (MPa)	5	0	56.8	4.43847	1.98494

One Way ANOVA

Overall ANOVA

	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	6969.6	6969.6	489.33333	2.17282E-8
Error	8	113.9	14.25		
Total	9	7083.4			

Null Hypothesis: The means of all levels are equal.
Alternative Hypothesis: The means of one or more levels are different.
At the 0.05 level, the population means are significantly different.

Fit Statistics

R-Square	Coeff Var	Root MSE	Data Mean
0.98324	0.12076	3.85357	38.4

Means Comparisons

Scheffe Test

	MeanDiff	SEM	F Value	Prob	Alpha	Sig	LCL	UCL
Ultimate Tensile Strenght (MPa) Weight Fraction (%)	52.8	2.43721	489.33333	2.17282E-8	0.05	1	47.17978	58.42022

Tukey Test

	MeanDiff	SEM	q Value	Prob	Alpha	Sig	LCL	UCL
Ultimate Tensile Strenght (MPa) Weight Fraction (%)	52.8	2.43721	30.63707	1.24229E-7	0.05	1	47.17978	58.42022

Sig equals 1 indicates that the difference of the means is significant at the 0.05 level.
Sig equals 0 indicates that the difference of the means is not significant at the 0.05 level.

Figure 9 refers to the relation between modulus of elasticity and weight fraction of cinnamon powder into poly methyl methacrylate composite. It can be seen that the properties of the elasticity modulus improve with increase weight fraction of cinnamon powder into poly methyl methacrylate bio-composite. This advance in the properties modulus of elasticity depends on to the nature of cinnamon powder in terms of high strength. Thus modulus of elasticity values increased from (1.5GPa) for poly methyl methacrylate to (3.7GPa) for (Poly methyl methacrylate + 8% cinnamon). The elasticity modulus values improvement about (146%) compared with the pure sample this is due to the mean particle size, distributed regular of cinnamon powder inside the poly methyl methacrylate resin and easiness the penetration of polymer matrix material this leads to create good interfaces between the matrix material and reinforcing material [21]. Table 5 shown the descriptive, One Way ANOVA statistical analysis and means comparison by used (Scheffe test and Tukey test) of the results elasticity modulus for the poly methyl methacrylate reinforced with various cinnamon powder (2%, 4%, 6% and 8%). From One Way ANOVA analysis turns out the means of all levels are equal, where (at 0. 05 levels) population means are significantly various. Also, from Scheffe test and Tukey test notes if (Sig equals 1) indicates the difference of the means is significant at (0.05 level). This meaning the weight fractions of cinnamon powder reinforced with poly methyl methacrylate has more significance on values modulus of elasticity.

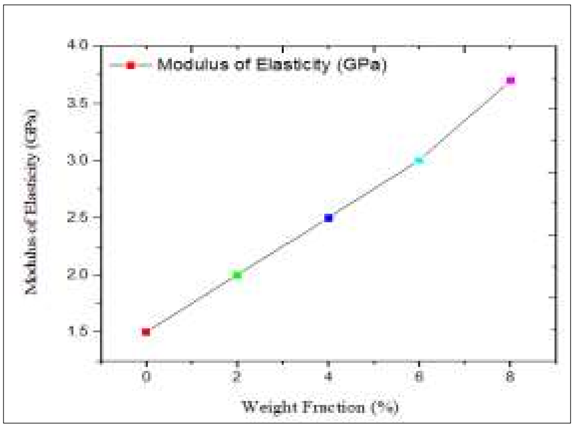
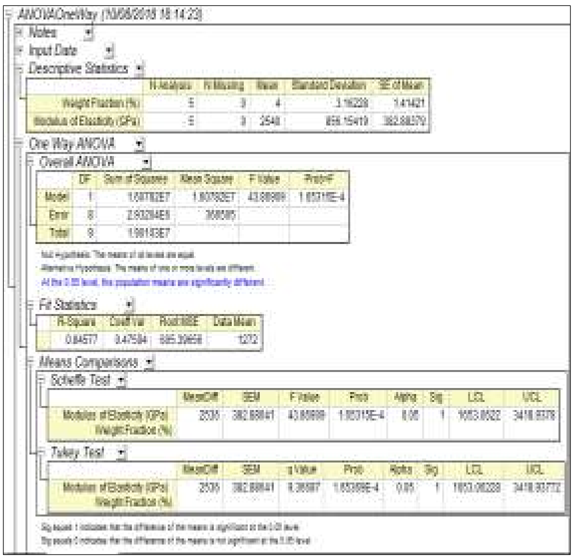


Figure 9 : Modulus of elasticity values as a function of cinnamon powder in PMMA.

Table 5 : Results descriptive, One Way ANOVA and means comparison by (Scheffe ,Tukey test) of the modulus of elasticity between all samples



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Notes

Input Data

Descriptive Statistics

	N Analysis	N Missing	Mean	Standard Deviation	SE of Mean
Weight Fraction (%)	5	0	4	3.16228	1.41421
Modulus of Elasticity (GPa)	5	0	2540	855.15419	382.68379

One Way ANOVA

Overall ANOVA

	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	1.60782E7	1.60782E7	43.88989	1.65311E-4
Error	8	2.93284E6	366605		
Total	9	1.90110E7			

Null Hypothesis: The means of all levels are equal.
Alternative Hypothesis: The means of one or more levels are different.
At the 0.05 level, the population means are significantly different.

Fit Statistics

R-Square	Coeff Var	Root MSE	Data Mean
0.84577	0.47584	605.30658	1272

Means Comparisons

Scheffe Test

	MeanDiff	SEM	F Value	Prob	Alpha	Sig	LCL	UCL
Modulus of Elasticity (GPa) Weight Fraction (%)	2536	382.68841	43.88989	1.65315E-4	0.05	1	1653.8522	3418.8378

Tukey Test

	MeanDiff	SEM	q Value	Prob	Alpha	Sig	LCL	UCL
Modulus of Elasticity (GPa) Weight Fraction (%)	2536	382.68841	9.36887	1.65369E-4	0.05	1	1653.09228	3418.90772

Sig equals 1 indicates that the difference of the means is significant at the 0.05 level.
Sig equals 0 indicates that the difference of the means is not significant at the 0.05 level.

III.Elongation Percentage

Figure 10 illustrates the value elongation percentage of the samples poly methyl methacrylate reinforced with various weight fraction cinnamon powders. It can be observed that elongation percentage values decreased with increasing weight cinnamon powder, where an elongation value of pure sample poly methyl methacrylate (3.9%) decreased to (2.7%) with addition 8% cinnamon powder. The reason is that increase weight fraction of the reinforcement material will be the concentration of stress in polymeric composite materials and thus lead to a decrease in the value of elongation at break. In addition, the elongation properties depend on the natural behavior of the polymeric composite material (brittle or ductile) and the natural bond between the polymer matrix material and strengthening materials [22-23]. Table 6 illustrates the descriptive, One Way ANOVA statistical analysis and means comparison by used (Scheffe test and Tukey test) of the results elongation percentage for the poly methyl methacrylate reinforced with various cinnamon powder (2%,4%,6% and 8%). From this Table can be noted One Way ANOVA analysis, the mean of all levels are equal, where at (0.05 level) population means are not significantly various. Also, from (Scheffe test and Tukey test) notes if (Sig equals 0) indicates the difference of the means is not significant at (0.05) level. This meaning that the weight fractions of cinnamon powder reinforced with poly methyl methacrylate was negative on the elongation percentage at break properties. From tensile properties, can be observed the pure poly methyl methacrylate has the lowest tensile strength and elasticity coefficient (51 MPa and 1.5 GPa), respectively. Ultimate tensile strength and elasticity coefficient raise with increase weight fraction cinnamon powder into poly methyl methacrylate resin reach to (62 MPa and 3.7 GPa) respectively, while the elongation percentage at break decrease (3.9% to 2.7%) with an increasing weight fraction of cinnamon powder.

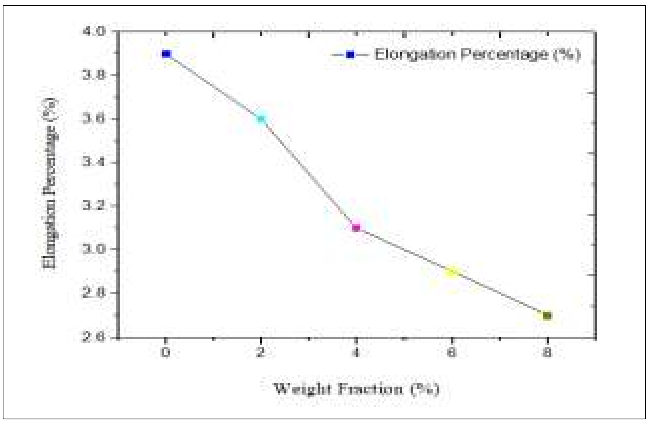

Figure 10: Elongation percentage values as a function of cinnamon powder in PMMA.

Table 6: Results descriptive, One Way ANOVA and means comparison by (Scheffe ,Tukey test) of the elongation percentage between all samples.

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Notes

Input Data

Descriptive Statistics

	N Analysis	N Missing	Mean	Standard Deviation	SE of Mean
Weight Fraction (%)	5	0	4	3.16228	1.41421
Elongation Percentage (%)	5	0	3.24	0.498	0.22271

One Way ANOVA

Overall ANOVA

	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	1.444	1.444	0.28181	0.60993
Error	8	40.992	5.124		
Total	9	42.436			

Null Hypothesis: The means of all levels are equal.
Alternative Hypothesis: The means of one or more levels are different.
At the 0.05 level, the population means are not significantly different.

Fit Statistics

R-Square	Coeff Var	Root MSE	Data Mean
0.03403	0.62531	2.26363	3.62

Means Comparisons

Scheffe Test

	MeanDiff	SEM	F Value	Prob	Alpha	Sig	LCL	UCL
Elongation Percentage (%) Weight Fraction (%)	-0.76	1.43164	0.28181	0.60993	0.05	0	-4.06137	2.54137

Tukey Test

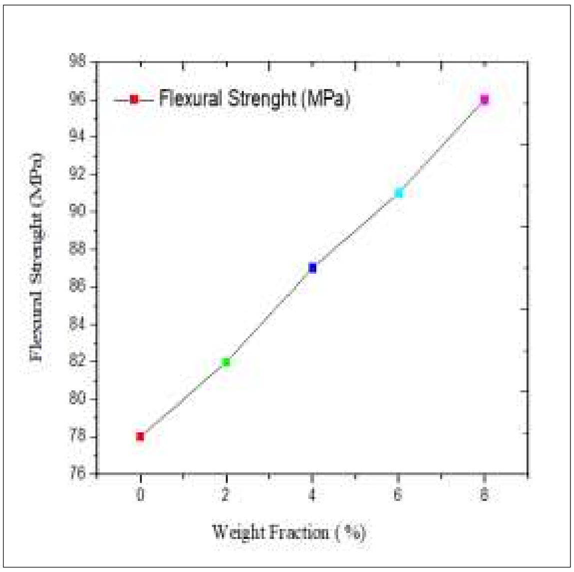
	MeanDiff	SEM	q Value	Prob	Alpha	Sig	LCL	UCL
Elongation Percentage (%) Weight Fraction (%)	-0.76	1.43164	0.75075	0.60993	0.05	0	-4.06137	2.54137

Sig equals 1 indicates that the difference of the means is significant at the 0.05 level.
Sig equals 0 indicates that the difference of the means is not significant at the 0.05 level.

IV. Flexural Strength

The flexural strength of poly methyl methacrylate strengthening with various weights fraction cinnamon powders is shown in Figure 11. Results showed that the weight fraction (2%, 4%, 6%, 8%) has influences were significantly in flexural strength of Poly Methyl methacrylate resin, where the sample (PMMA+8% Cinnamon powder) has higher values of flexural strength (96 MPa). Lastly, the percentage improvement of the flexural strength was (23.8 %). These resultly may be attributed to dispersal of the reinforced material in a matrix resin material, which negatively affects the grade of conversion that leads to a raise non-reactant monomer that acts as plasticizer [24-25]. Table 7 explains the descriptive, One Way ANOVA statistical analysis and means comparison by used (Scheffe test and Tukey test) for the results flexural strength of all samples. From One Way ANOVA analysis indicates the mean of all levels are equal, where at (0.05level) population means are significantly various. Also, from (Scheffe test and Tukey test) a note if (Sig equals 1) show the difference of the means is significant at (0.05 level). Nature interconnection between cinnamon powder reinforced and poly methyl methacrylate was good is the reason for the increase in values flexural strength.

Figure 11: Flexural strength values as function of cinnamon



powder in PMMA.

Table 7: Results descriptive, One Way ANOVA and means comparison by (Scheffe ,Tukey test) of the flexural strength between all samples.

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Notes

Input Data

Descriptive Statistics

	N Analysis	N Missing	Mean	Standard Deviation	SE of Mean
Weight Fraction (%)	5	0	4	3.16228	1.41421
Flexural Strenght (MPa)	5	0	86.8	7.12039	3.18434

One Way ANOVA

Overall ANOVA

	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	17139.6	17139.6	564.73147	1.04878E-8
Error	8	242.8	30.35		
Total	9	17382.4			

Null Hypothesis: The means of all levels are equal.
Alternative Hypothesis: The means of one or more levels are different.
At the 0.05 level, the population means are significantly different.

Fit Statistics

R-Square	Coeff Var	Root MSE	Data Mean
0.98603	0.12135	5.50908	45.4

Means Comparisons

Scheffe Test

	MeanDiff	SEM	F Value	Prob	Alpha	Sig	LCL	UCL
Flexural Strenght (MPa) Weight Fraction (%)	82.8	3.48425	564.73147	1.04878E-8	0.05	1	74.7653	90.8347

Tukey Test

	MeanDiff	SEM	q Value	Prob	Alpha	Sig	LCL	UCL
Flexural Strenght (MPa) Weight Fraction (%)	82.8	3.48425	33.60740	1.10851E-7	0.05	1	74.7653	90.8347

Sig equals 1 indicates that the difference of the means is significant at the 0.05 level.
Sig equals 0 indicates that the difference of the means is not significant at the 0.05 level.

V. Flexural Modulus

Figure 12 shown flexural modulus values results acquired of flexural test of the bio-composite 12. Can be observed from this figure, it the values of flexural modulus increases with increased weight fraction cinnamon powder in poly methyl methacrylate resin bio-composite. This is because the regular , randomly distribution and ease penetration poly methyl methacrylate resin outof the filler (cinnamon powder) to forming strong adherence at interfaces between matrix resin with strengthening material , all of these reasons result in increased flexural modulus with each increase in the weight fraction of the particles [26]. The presence of 8% cinnamon powder increases the value of the flexural modulus to (6.4 GPa) compared with the value of the flexural modulus (2.0 GPa) of the pure sample. Table 8 shows the descriptive, One Way ANOVA statistical analysis and means comparison by used (Scheffe test and Tukey test) for the results flexural modulus of all samples. From One Way ANOVA analyses refer the mean of all levels are equal, where at (0.05level) population means are significantly various. Also, from (Scheffe test and Tukey test) notes if Sig equals 1 indicate the various of the means are significant at (0.05 level). That means, nature bonded between cinnamon powder reinforced and poly methyl methacrylate was good this is the reason for the increase in values flexural modulus.

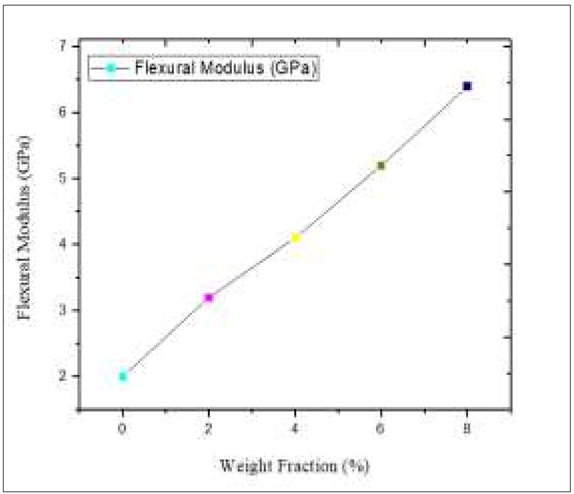

Figure 12: Flexural modulus values as a function of cinnamon powder in PMMA.

Table 8 : Results descriptive, One Way ANOVA and means comparison by (Scheffe,Tukey test) of the flexural modulus between all samples

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Notes

Input Data

Descriptive Statistics

	N Analysis	N Missing	Mean	Standard Deviation	SE of Mean
Weight Fraction (%)	5	0	4	3.16228	1.41421
Flexural Modulus (GPa)	5	0	4180	1709.38585	764.46058

One Way ANOVA

Overall ANOVA

	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	4.35974E7	4.35974E7	29.84072	5.99634E-4
Error	8	1.1688E7	1.46101E6		
Total	9	5.52855E7			

Null Hypothesis: The means of all levels are equal.
Alternative Hypothesis: The means of one or more levels are different.
At the 0.05 level, the population means are significantly different.

Fit Statistics

R-Square	Coeff Var	Root MSE	Data Mean
0.78859	0.57778	1208.7204	2092

Means Comparisons

Scheffe Test

	MeanDiff	SEM	F Value	Prob	Alpha	Sig	LCL	UCL
Flexural Modulus (GPa) Weight Fraction (%)	4176	764.4619	29.84072	5.99634E-4	0.05	1	2413.14737	5938.85263

Tukey Test

	MeanDiff	SEM	q Value	Prob	Alpha	Sig	LCL	UCL
Flexural Modulus (GPa) Weight Fraction (%)	4176	764.4619	7.72538	5.99679E-4	0.05	1	2413.14752	5938.85248

Sig equals 1 indicates that the difference of the means is significant at the 0.05 level.
Sig equals 0 indicates that the difference of the means is not significant at the 0.05 level.

VI. Impact Strength

This difference in impact strength of the bio-composites with 2%, 4%, 6%, 8% of cinnamon powder are shown in Figure 13. This Figure clearly indicates that the impact strength improves with the added weight fraction by 2%, 4% and 6% cinnamon powder, while decreases with addition weight fraction by 8% cinnamon powder. The sample (poly methyl methacrylate+6% Cinnamon) showed approximately 47.9% increment in impact strength from pure poly methyl methacrylate. The reason increasing the impact resistance is that the strong bond between reinforcement material and resin material causes formation of molecular bonds that prevent crack propagation through polymer composite materials [8]. The value of impact strength decreases when cinnamon powder is added by 8% weight fraction because the increase in surface area of reinforced materials and the increase in the stress, leading to the possibility of crack growth. Also, at high concentrations of the weight fraction reinforcing material effect on the interface area, thus reducing the energy dissipation during the test [27&28]. Table 9 shows the descriptive, One Way ANOVA statistical analysis and means comparison by used (Scheffe test and Tukey test) for the results flexural modulus of all samples. From this Table One Way ANOVA analysis, the mean of all levels is equal, where at (0.05level) population means are significantly various. Also, from (Scheffe test and Tukey test) a note if Sig equals 1 indicates the various of the means is significant at (0.05 level). That means nature bonded between cinnamon powder reinforced and poly methyl methacrylate was good to absorb energy during the test.

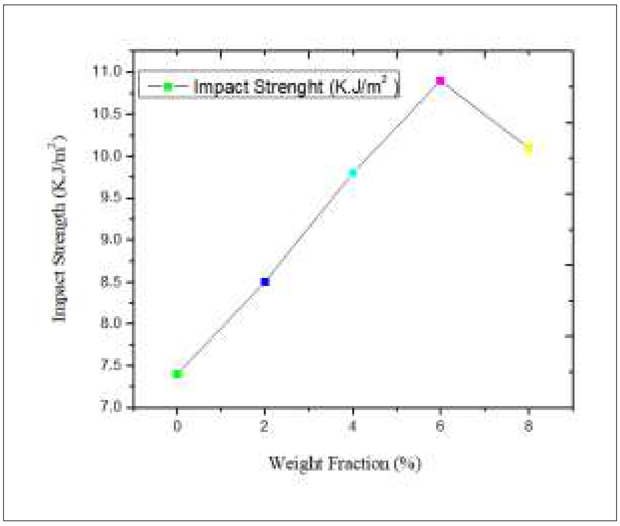
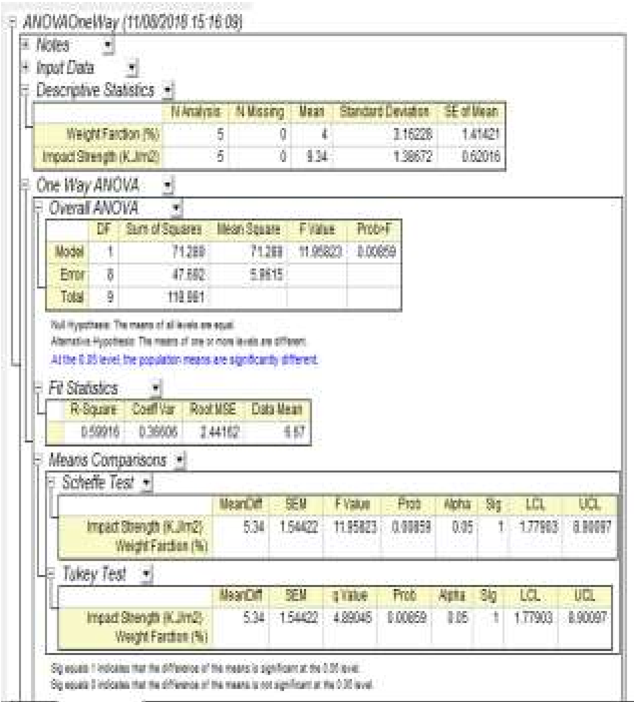


Figure 13: Impact strength values as a function of cinnamon powder in PMMA.

Table 9: Results descriptive, One Way ANOVA and means comparison by (Scheffe ,Tukey test) of the impact strength between all sample.



ANOVAOneWay (11/08/2018 15:16:08)

Notes

Input Data

Descriptive Statistics

	N Analysis	N Missing	Mean	Standard Deviation	SE of Mean
Weight Fraction (%)	5	0	4	3.16228	1.41421
Impact Strength (K.J/m2)	5	0	9.34	1.38672	0.62016

One Way ANOVA

Overall ANOVA

	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	71.289	71.289	11.95823	0.00859
Error	8	47.692	5.9615		
Total	9	118.981			

Null Hypothesis: The means of all levels are equal.
Alternative Hypothesis: The means of one or more levels are different.
At the 0.05 level, the population means are significantly different.

Fit Statistics

R-Square	Coeff Var	Root MSE	Data Mean
0.59916	0.36606	2.44162	6.67

Means Comparisons

Scheffe Test

	MeanDiff	SEM	F Value	Prob	Alpha	Sig	LCL	UCL
Impact Strength (K.J/m2) Weight Fraction (%)	5.34	1.54422	11.95823	0.00859	0.05	1	1.77903	8.90097

Tukey Test

	MeanDiff	SEM	q Value	Prob	Alpha	Sig	LCL	UCL
Impact Strength (K.J/m2) Weight Fraction (%)	5.34	1.54422	4.89045	0.00859	0.05	1	1.77903	8.90097

Sig equals 1 indicates that the difference of the means is significant at the 0.05 level.
Sig equals 0 indicates that the difference of the means is not significant at the 0.05 level.

7. Conclusions

From this study, we conclude that integration the cinnamon powder into the acrylic resin improved the ultimate tensile strength, young modulus, flexural strength, flexural modulus and impact strength. Maximum values of tensile strength, young modulus, flexural strength and flexural modulus are (62MPa), (3.7GPa), (96 MPa) and (6.4 GPa) respectively of specimens reinforced with (8%) weight fraction cinnamon powder. The sample reinforced with 2% cinnamon powder into poly methyl methacrylate has a maximum value of elongation percentage at break (3.6) when compared with the other weight fraction (4%, 6% and 8%), while the sample reinforced with 6% cinnamon powder into poly methyl methacrylate give maximum value of impact strength (10.9 KJ/m^2). From results, descriptive, One Way ANOVA statistical analysis and means comparison by used (Scheffe test and Tukey test) of all mechanical properties indicated , turns out if (Sig equals1) indicates the difference of the means is significant at (0.05 level), while if (Sig equals 0) indicates the difference of the means is not significant at (0.05) level . Therefore, there is for filler content a significant on tensile strength, young modulus, flexural strength, flexural modulus and impacts strength.

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