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Fracture Behavior of Adhesively Bonded Al3003 – Epoxy –Al3003 Joints

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ABSTRACT

Al3003-Epoxy-Al3003 adhesive bonded joints were investigated in this paper because of their frequent use as an applied adhesive joint design in engineering practice. In this study, the effects of surface roughness, type of adhesives, and surface structure on adhesion and shear behaviors were studied. The experimental specimens have been made of aluminum 3003 as adhered material, and two types of epoxies were used as adhesive. Experimental results show that epoxy with filled particles play an important role during the testing of the samples for peel and shear tests. The adhesive aluminum joints failed in cohesive mode due to the high- stress levels generated in the adhesive, which indicates that the adhesion to the aluminum surface is stronger than that of the interior part of the adhesive. The optimal conditions for each parameter were identified of the 3003 aluminum adhesively bonded joints.

Key Words: joints; single-lap; adhesive; roughness.

INTRODUCTION

Composite joint design has received much interest in the automobile and aerospace industries. The major advantages of the laminated joints are high resistance to corrosion and fatigue, high-strength-to-weight ratio, and efficient load distribution [1]. Generally, the laminated composites can be joined either mechanically or adhesively. Adhesive joints do not require holes; however, they are susceptible to surface roughness, adhesive type, and surface structure [2, 3]. Adhesive bonding offers advantages for joining materials, since it avoids the need for drilling holes and inserting fasteners; these are significant sources of stress concentration and increased weight. Moreover, the replacement of fasteners by adhesive joints also reduces time and effort required for assembly processes [4].

Many scientific studies have been carried out on composite laminated joints. Sergio et al. [3]

investigated the effects of various surface treatments on adhesively aluminum 2024-aluminum 2024 joints that were used in aeronautical structures, and the optimum surface treatment is defined for each sample type. Ramazan et al. [5] studied the influence of adhesive thickness and filler content on the mechanical properties of the aluminum 1100 lap joints, and found that filler improved the shear strength by 36%. The effects of curing time and environmental conditions on the adhesively aluminum laminates were investigated by De wild et al. [6]. In this study, the importance of the surface pretreatment play an important role on the adhesion of such aluminum laminates. The thermal behavior of the aluminum adhesive joints and the effects of the fillers was investigated [7]. Sofia et al. used the floating roll peel test to evaluate the adhesion properties of the bonded composite-to-Al2024 alloy

joint, and found that such test is an effective method to evaluate the adhesion properties [8]. GH Asl et al. investigated the strain rate dependency of the single-lap joint by using different metal adherents.

In the present work, an Al300-Epoxy-Al3003 adhesive bonded joint was fabricated. The effects of epoxy types, surface roughness, and surface structure on adhesion and shear strengths were analyzed. Peeling tests were performed to measure the bonding behavior. Shear strength tests were performed to investigate the shearing behavior for the various set of experimental conditions.

EXPERIMENTAL PROCEDURE

The specifications of the materials used for this study are shown in Table 1. The aluminum strips were cut to dimensions based on the standard of the peel test and single-lap shear test. The schematic of the pressing process is shown in Figure 1. In the pressing process, the aluminum strips were cut to specific dimensions and degreased before applying the epoxies at the interface. For the epoxies, two different types were used. Type A is pure epoxy without any additives, while Epoxy B has steel particles mixed with it (LOCTITE Inc.). The steel particles diameter is around 300-400 μ m as described by the manufacturer (LOCTITE Inc.), and the is 5%

of the quantity.

In order to investigate the effects of the surface roughness of the adhesive bond, sandpapers with different grit sizes (Grit 400, 120, and 60) were used for sanding. After sanding, two different epoxies were applied at the interface between the two roughened Al3003 strips. After applying the epoxies, the multilayer test samples were pressed to a certain thickness to assure the same thickness of the epoxy layer for all samples.

Another group of aluminum samples were had holes with a diameter of 1 mm on the surface at the bonding area. The holes were introduced to see how they would affect the behavior of the adhesive joint during the testing. The holes were drilled using mini CNC machine in different patten (5 holes and 8 holes in each side with fixed distance between each two holes)

The adhesion between the Al plates was investigated using the T-peel test. A typical force response from the peel test is shown in Figure 2. The peel strength is calculated by dividing the average load by the sample width, which is 20 mm, as shown in equation 1.

The manufacturing process parameters and their settings are summarized in Table 2

Table 1: Specification of materials (McMaster manufacturer, and (LOCTITE Inc.).

Material	Chemical composition (wt. %)	Tensile Strength (MPa)	Yield Strength (MPa)	Elongation (%)
Al3003	98.6 Al, 1.2 Mn, 0.12 Cu, and 0.08 others	130	125	10
Epoxy-A	Epoxy resin / Polymercaptan hardener	16 (Tensile strength MPa)		
Epoxy-B	Epoxy resin / Polymercaptan hardener/316 steel particles	22 (Tensile strength MPa)		

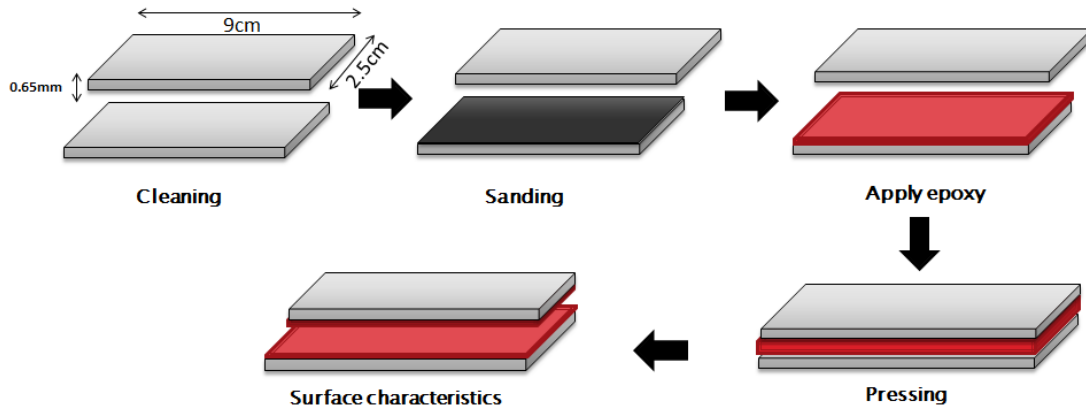


Figure 1: Schematic of manufacturing process of the Al3003-Epoxy-Al3003 adhesive joint

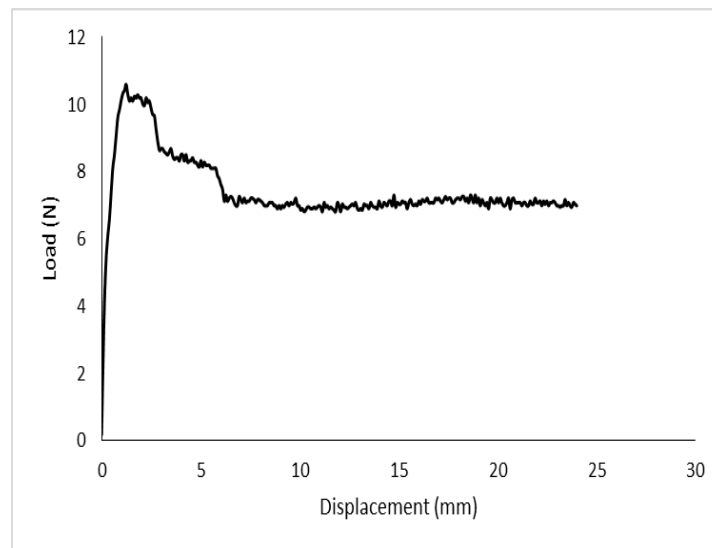


Figure 2: A typical force response from the peel test.

$$\text{Average peel strength} = \frac{\text{average load (N)}}{\text{bond width (mm)}} \quad (1)$$

The single-lap shear test was used to determine the maximum shear load that the multilayer sample can withstand before failure

occurs. The schematic and the dimensions of the sample are shown in Figure 3.

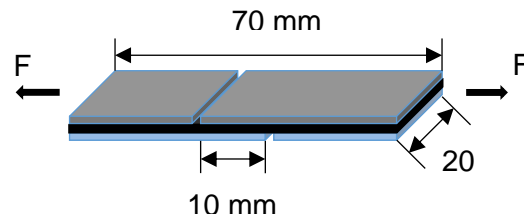


Figure 3: The schematic and the dimensions of the sample.

Table 2: Manufacturing process parameters and their settings.

Parameters	Values
Surface roughness (grit)	Al3003 as-received, 400, 120, and 60
Epoxy types	With and without particles
Al surface structure	Holes and no holes

RESULTS AND DISCUSSION

The effects of surface roughness and epoxy types were analyzed on the bond strengths and shear strengths of pressed Al3003-Epoxy-Al3003 adhesive bonded joints.

Effect of surface roughness and Epoxy type on adhesion strength

In order to investigate the effects of surface roughness on adhesion strength, sandpapers with various grit sizes of 400, 120, and 60 were used to roughen the AL3003 surfaces. Table 3 shows the

used sandpaper with grit and particle sizes along with the surface roughness that was produced. 3D optical profiler (ZYGO) was used to measure the surface roughness after sanding, and Figure 4 shows the colored topography and intensity map after sanding sample of (P120 grit size). The initial surface roughness of the as-received Al3003 sheet was $R_a = 0.6 \mu\text{m}$. After using sandpaper papers with grit of 400, 120, and 60 the surface roughness values changed to $9 \mu\text{m}$, $29 \mu\text{m}$, and $61 \mu\text{m}$, respectively.

Table 3: Sandpaper grit size and produced surface roughness.

Sandpaper grit size	Produced surface roughness (μ)
P400	9
P120	29
P60	61

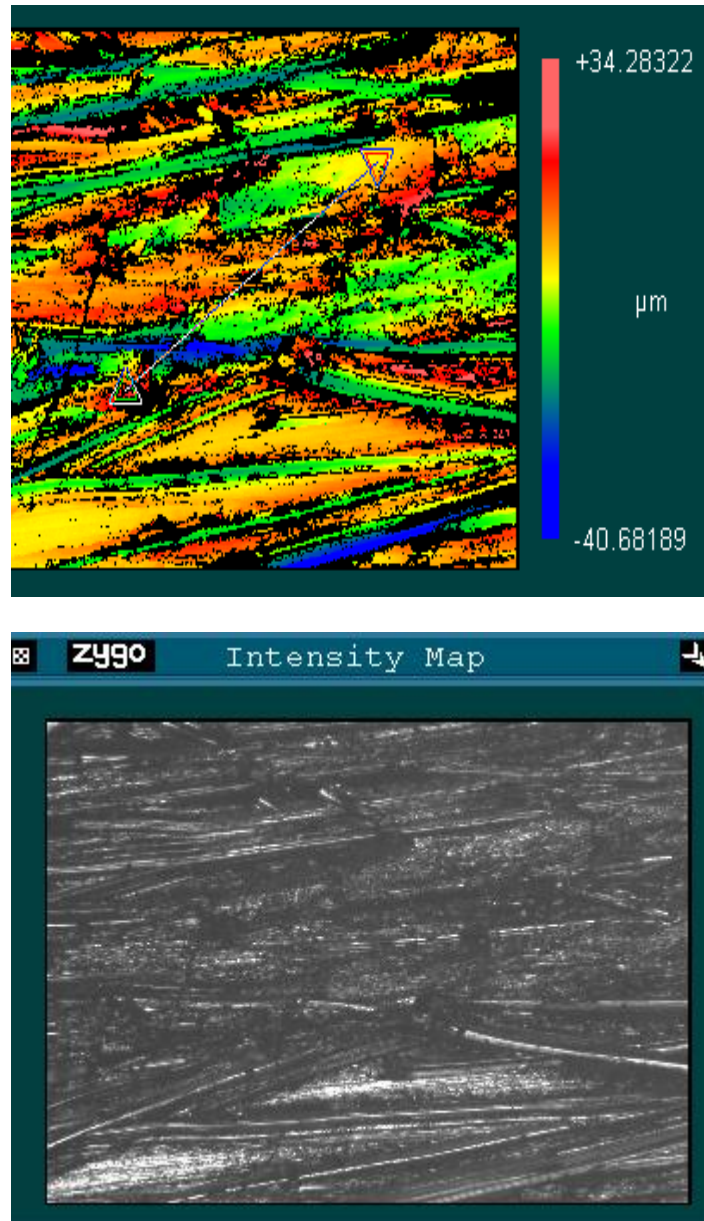


Figure 4: 3d ZYGO profile image of the Al3003 roughened with sandpaper grit sizes grit p120 ($R_a=29 \mu\text{m}$).

Figure 5 shows the peel strength at various levels of surface roughness for Epoxy-A, and the peel strength increased as the surface roughness increased. The peel load of the multilayer Al-Epoxy-A-Al increased by 52%, 161%, 261%, compared with the as-received sample. The various sandpapers produced surfaces with high asperities and deep valleys, which directly affected the mechanical

interlocking at the bond interface between the molted epoxy and hard-sharpened Al3003 surface. For epoxy-B, the peel loads of the as-received, 400, 120, and 60 sandpapers are 37.5 N/mm, 75 N/mm, 147.5 N/mm, and 275 N/mm, respectively; this is shown in Figure 6. Table 4 summarizes the comparison of the Epoxy-A and Epoxy-B peel strengths with the same surface roughness. It can be noticed that Epoxy-B with steel particles shows more enhancement compared to the epoxy without particles. The presence of the particles at the interface during the peel test (Mode 1 fracture) helps to increase the

resistance of the peeling before complete particles at the interface act like bridging between the adhesive and the aluminum sheet. In addition, the as-received Al3003 sample did not

fracture occurred. The presence of the show much change as compared to the samples with roughened surfaces for both types of epoxies.

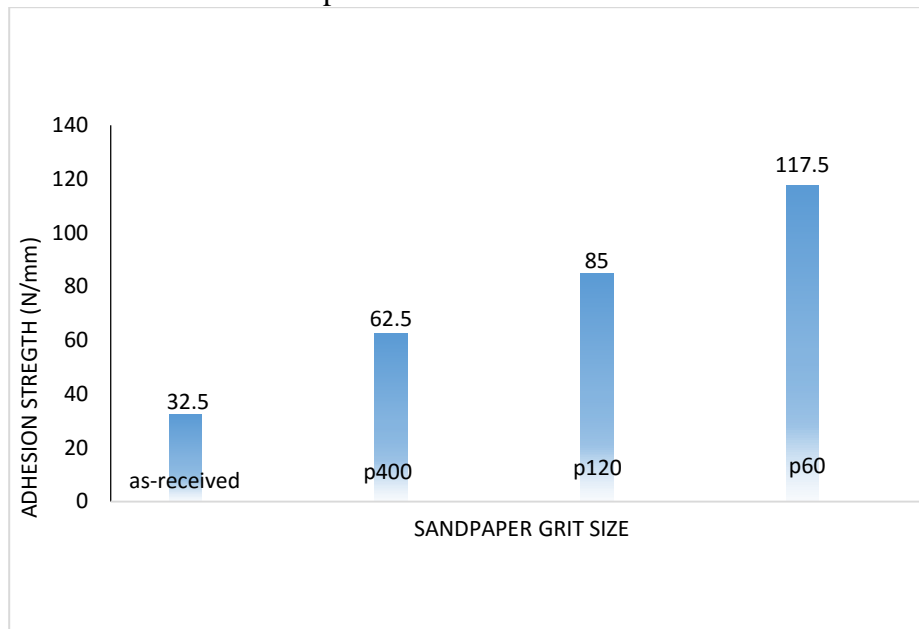


Figure 5: Peel strength versus various surface roughness for Epoxy-A

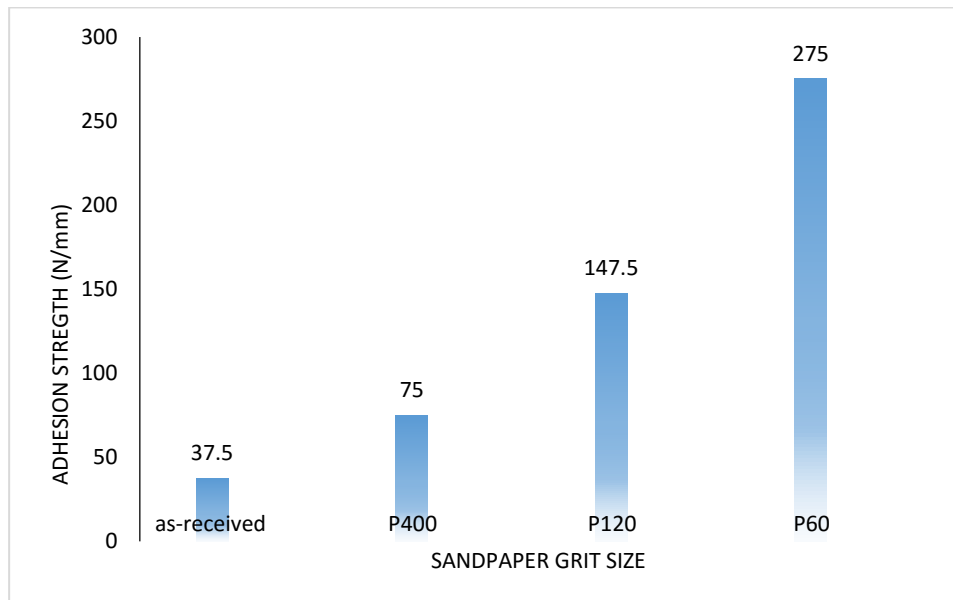


Figure 6: Peel strength versus various surface roughness for Epoxy-B

Table 4: The comparison of the Epoxy-A and Epoxy-B peel strengths.

	Epoxy-A	Epoxy-B	Efficiency (+/-)
As-received	32.5	37.5	15% (+)
Sandpaper (400)	62.5	75	20% (+)
Sandpaper (120)	85	147.5	73% (+)
Sandpaper (60)	117.5	275	134% (+)

Figure 7 shows the fracture surfaces after the peeling of samples of P400 and P60. It can be seen that both samples have adhesive and cohesive failures at the interface, to various degrees. Sample (P60), with a high surface roughness, shows more cohesive failures on both sides of the Al layers; this explains the high values of the peel strength. Sample (P400) with low surface roughness shows more

adhesive failure than the sample with high surface roughness. Increasing the surface roughness caused the transition of the failure mode from adhesive to cohesive; but generally, increasing the surface roughness improved the overall adhesion strength [3].

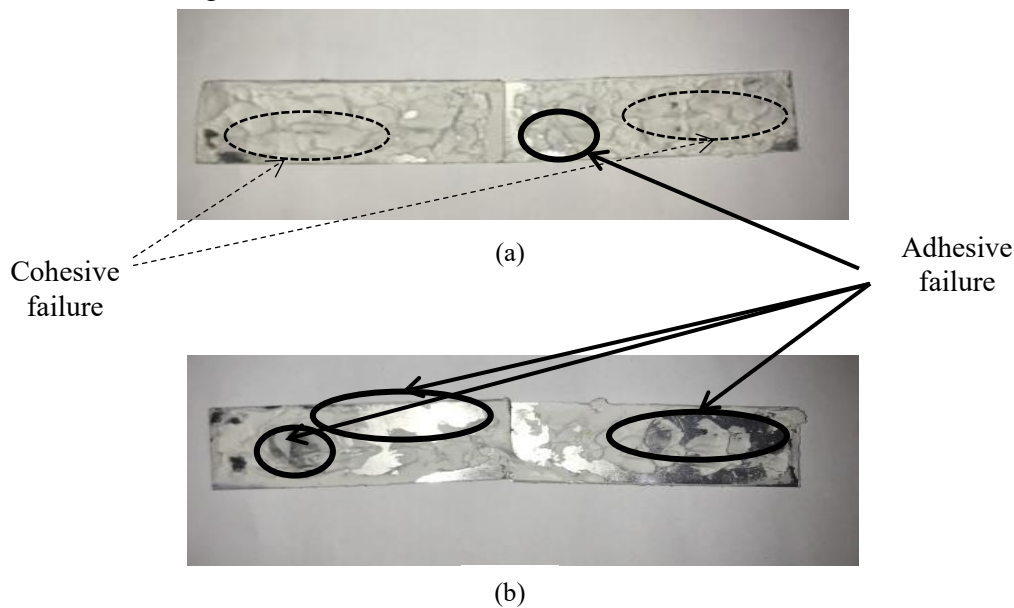


Figure 7: Fracture surfaces of Al3003/Epoxy-Al3003 after peel test for different surface roughness values: (a) Sandpaper grit P60 ($R_a=61 \mu\text{m}$) and (b) sandpaper grit 400 ($R_a=9 \mu\text{m}$).

Effect of surface roughness and Epoxy type on shear strength

The relationship between the shear strength and the various surface roughness of the Al3003 is shown in Figure 8. For the Al3003 as-received samples for both epoxies, types A and B, samples

fractured at shear strengths of 52.13 MPa, and 71.73 MPa, respectively. For Epoxy-A, as the surface roughness increased, the shear strength increased, and the Al3003 samples were torn at the high surface roughness. This indicates that the bond is actually more robust than the actual Al3003 sheet. The same behavior and trend was observed for the Epoxy-B with steel particles. When there is a high surface roughness, high shear strength can be noted for the sample created with Epoxy-B. The presence of the particles at the interface with a roughened surface

helps to increase the resistance of the sliding (Mode 2) fracture. In general, an increase in the surface roughness may lead to high degree of resistance to shear force during the testing.

Figure 9 shows the samples of P60 and P400 of the torn Al3003 sheet. The crack is perpendicular to the applied load, and the sample was unable to withstand the high load.

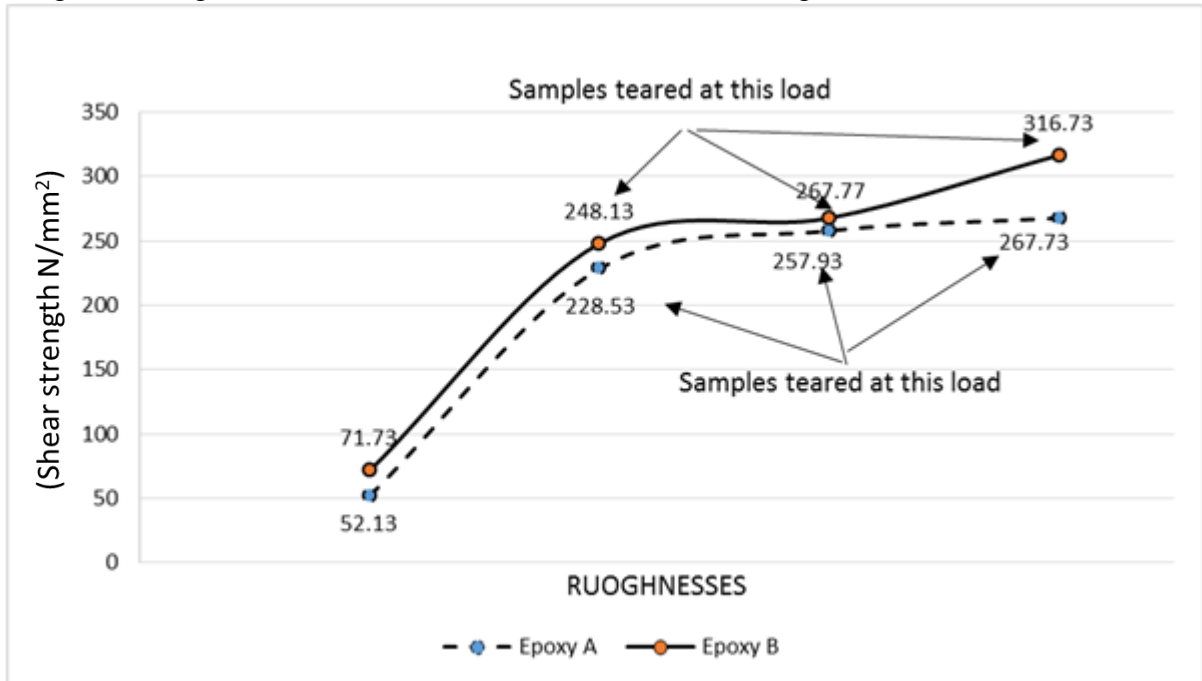


Figure 8: Relationship between the shear strength and the various surface roughness of the AL3003.

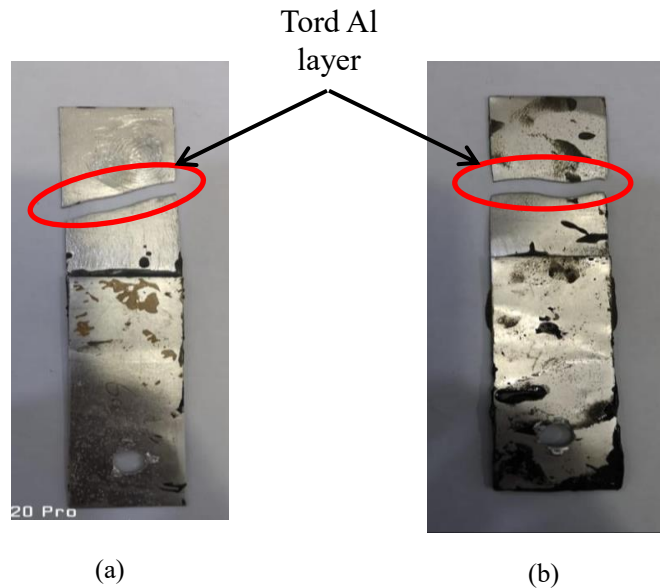


Figure 9: Torn Al3003 layer at the shear test for (a) P60 sample and (b) P400 sample.

Another set of samples were manufactured by drilling holes at the two sides of the bonding area (five and eight holes) with a diameter of 1 mm. The objective was to investigate the effects of surface topography and structure at the Al3003 sheet. Figure 10 shows the shear strength behavior for both Epoxies A and B at the same surface roughness (P60), with two different numbers of holes (five and eight). For the sample with five holes at the bonding area, nearly the same shear strength was obtained

during the testing. However, the shear failure was caused a tear in the sample that had eight holes. Samples with holes at the bonding area demonstrated improved shear strength and resistance during the testing, compared with samples without holes tested under the same conditions. Testing showed that increasing surface roughness along with drilling holes in the surface of the Al3003 help to increase the shear load.

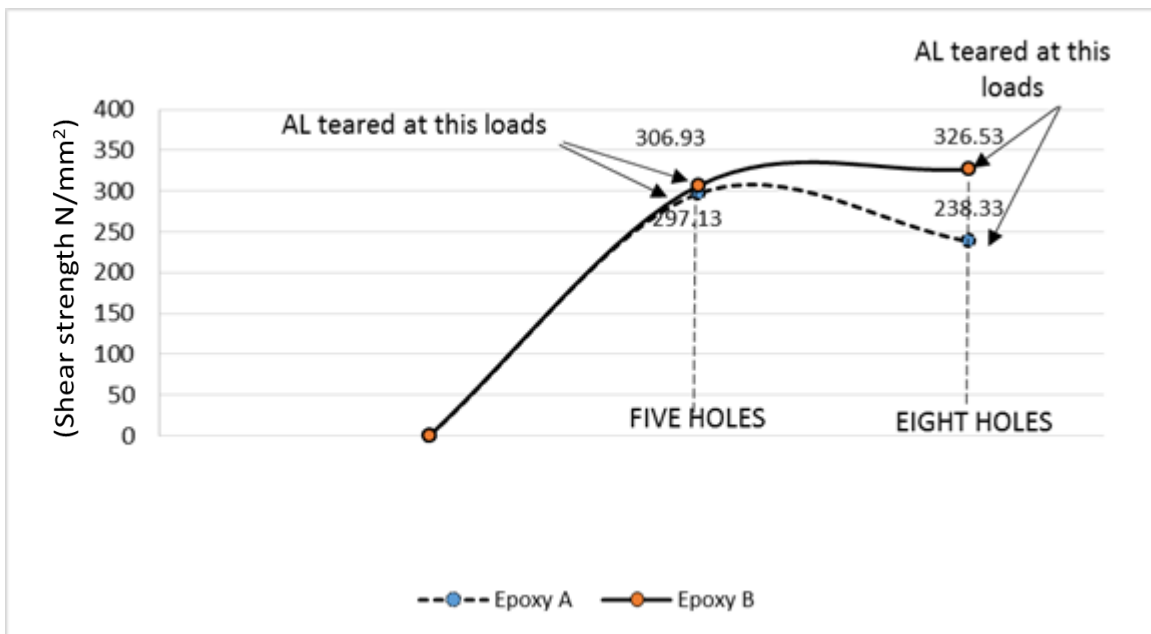


Figure 10: Shear strength behavior for both Epoxies A-B

Figure 11 shows the shear strength versus the surface roughness for two groups of samples with five and eight holes for one side at the bonding area. In general, Epoxy-B with particles has high shear strength for both sets of samples (five and eight holes). Introducing the holes for both sides (eight

holes) increased the load by 36% compared to having holes on only one side. Figure 12 shows the samples of the shear strength where eight holes samples tore before shearing happened, and five holes shear due to the presence of cohesive failure. (Adhesion strength N/mm^2)

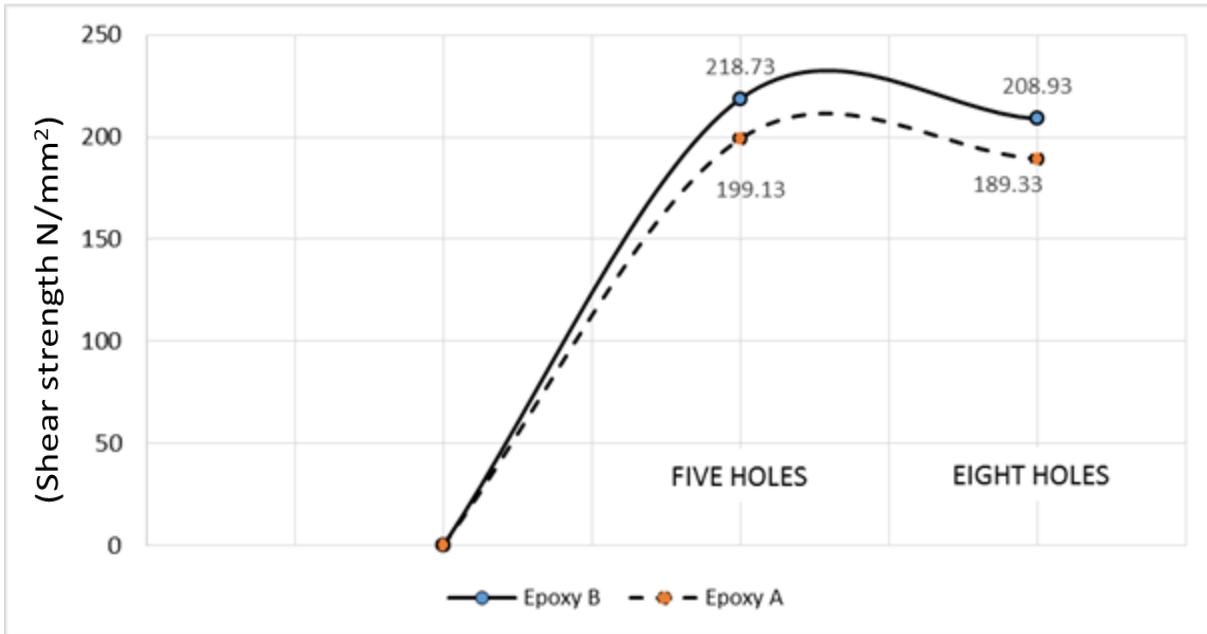


Figure 11: Shear strength versus the surface roughness for two groups of samples that have 5 and 8 holes for one side at the bonding area

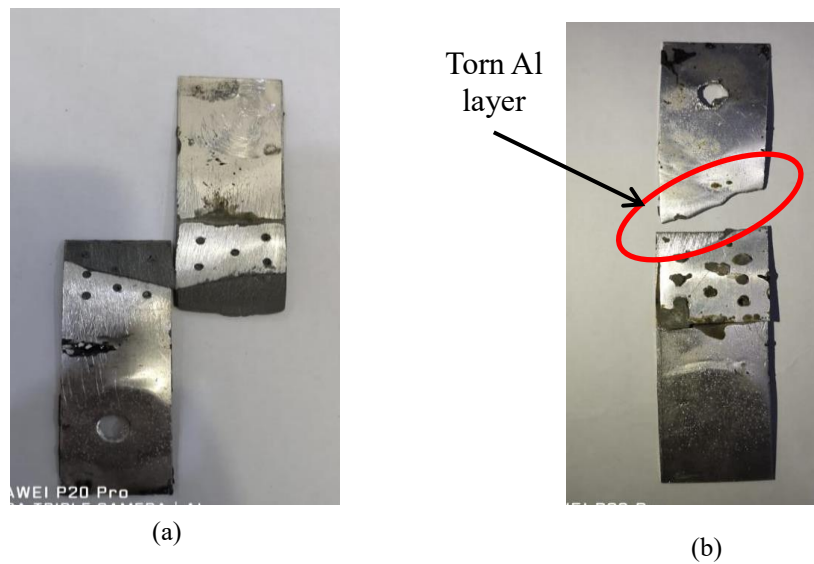


Figure 12: Samples of adhesive Al3003 joint at the shear test for (a) 5 holes sample and (b) 8 holes sample.

CONCLUSIONS

In this paper, Al3003/Epoxy/Al3003 adhesive-bonded joints were fabricated to achieve direct bonding of the layers. The following conclusions can be obtained:

- Al3003/Epoxy/Al3003 adhesive-bonded joints with varying surface structures were successfully manufactured.
- Increasing surface roughness led to an increase in the peel load due to the increase of the surface bonding area.
- Increasing the surface roughness helped to

increase the shear load.

- Epoxy with steel particles facilitates a robust bonding, especially in Mode I fracture.
- The presence of the varying topography at the bonding area plays a vital role in the bonding and the behavior of the adhesive joint during the testing.

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سلوك الانهيار والكسر لوصلات الألمنيوم والايوكسي

سعيد عبدالله سعيد موسى

قسم الهندسة الميكانيكية-كلية الهندسة

جامعة جازان

المملكة العربية السعودية

المُلخَص

في هذه البحث، تم دراسة وصلات الألمنيوم والايوكسي نظرا لتعدد استخداماتها وتطبيقاتها المختلفة. في هذه الدراسة تمت دراسة تأثير خشونة السطح ونوع المواد اللاصقة وبنية السطح على سلوكيات الالتصاق والقص. تم تصنيع العينات التجريبية من الألمنيوم ٣٠٠٣ كمادة ملتصقة ، واستخدم نوعان من الإيوكسي كمواد لاصقة. تظهر النتائج المخبرية أن الإيوكسي المدعم بالجسيمات المايكرونية يلعب دورًا مهمًا أثناء اختبار العينات لاختبارات التقشير والقص. فشلت وصلات الألمنيوم اللاصقة في وضع التماسك بسبب مستويات الضغط العالية المتولدة في المادة اللاصقة ، مما يشير إلى أن الالتصاق بسطح الألمنيوم أقوى من التصاق الجزء الداخلي من المادة اللاصقة. تم تحديد الظروف المثلى لكل متغير للوصلات ٣٠٠٣ الملتصقة من الألمنيوم.

الكلمات المفتاحية: الوصلات، اختبار القص، اللاصق، خشونة السطح.

Larvicidal and latent effect of *Juniperus procera*, Family (Cupressaceae) extracts on the filarial vector, *Culex pipiens* (Diptera: Culicidae)

Hanan Abo El-Kasem Bosly

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ABSTRACT

The larvicidal and delayed effects of the methanol, petroleum ether and acetone leaves extract of *Juniperus procera*, against *C pipiens* mosquito 2nd instar larvae, were evaluated. The efficacy of methanol extract seemed to be more effective with LC₅₀, 17.46 mg/L followed by petroleum ether with LC₅₀, 32.33 mg/L and then acetone, LC₅₀ 40.00 mg/L. Moreover, methanol and petroleum ether extracts exerted a highly delayed toxic effect on the pupae and adults resulted from treated larvae, whereas acetone extract showed no delayed effects on pupae and adults. The methanol extract showed the highest pupal and adult mortality 100% and 66.67% at concentrations 35 and 15, respectively. While petroleum ether recorded 62.22% and 83.33% at 40 mg/L, respectively, Methanol extract profound adult emergence inhibition 85.71% at 15 mg/L concentration recording IC₅₀ value (10.60) for adult emergence inhibition. While ether and acetone extracts showed 62.50% and 10.34% adult emergence inhibition at 40 mg/L concentration recording IC₅₀ values (35.18) and (76.32), respectively. The growth index of the immature stages significantly decreased from 9.63 in control to 0.79 at 15 mg/L of methanol extract and to 2.34 and 7.93 at 40 mg/L of ether and acetone extracts, respectively. Petroleum ether extract exhibited significant effects on the fecundity, fertility and sterility index while acetone extract showed non-significant effects as compared with the control group. Hence, these extracts can be used as an effective alternative to the existing synthetic pesticides for the control of *C pipiens*.

KEY WORDS: *Culex pipiens*, *Juniperus procera*, Larvicidal, Adult Emergence, IC₅₀, Growth Index, Fecundity.

INTRODUCTION

Culex mosquitoes, especially *C. pipiens* and *C. quinquefasciatus* (Diptera: Culicidae) are the main vectors of *bancroftian filariasis* and arboviruses as

West Nile Virus in many regions of the world including the Middle East including Saudi Arabia (Subra and Hebrard 1975, Omar 1996, Omar *et al.*, 2000, Pichon 2002, Abdel-Hameed *et al.*, 2004, Chandran *et al.*, 2004).

Mosquito control is very important to tactic mosquito- borne disease.

Pyrethroid and organophosphate insecticides are used extensively to control disease vectors (Hardstone *et al.*, 2006; Daaboub *et al.*, 2008). The rapidly emerging resistance to chemical insecticides is currently considered challenge facing the vector control programs. (Bisset *et al.*, 1997; Xu *et al.*, 2005; World Health Organization (WHO), 1976). Extensive application of insecticides for vector control in Saudi Arabia have accelerated the level of developed resistance. In addition to resistance, some mosquitocides associated with other undesirable effects including hazardous effects against non-target animals, environmental problems and human health concerns (Rawani *et al.*, 2009). Hence, the approval of an insecticide is limited not only to the insect mortality but extended mainly to its environmental safety (Kabar and Gichia, 2001). As though, pest management by insect growth regulators reduce the damage produced by insects to products, as their population will be reduced via disturbed metamorphosis and reduced fecundity (Tunaz and Uygun, 2004). Surveying for suitable alternatives to synthetic insecticides showed that the phytochemicals are a good choice according to their relative safety, worldwide availability and cheap. Accordingly the screening for locally available plant materials for mosquito control could be an alternative cheaper than expensive imported products enhancing both the local employment and the public health (Bowers *et al.*, 1995). Several effective eco-friendly

insecticidal/mosquitocidal trials in Saudi Arabia as alternatives to conventional mosquitocidal compounds were previously studied (El-Sadawy *et al.*, 2016 and 2018; El-Kersh *et al.*, 2016; Ahmed *et al.*, 2017).

Juniperus procera is a coniferous tree native to the mountains of eastern Africa from eastern Sudan south to Zimbabwe, and the southwest of the Arabian Peninsula and exists in Saudi Arabia/Yaman (Adams, 2013). It has been traditionally used to treat several diseases such as hyperglycemia, hepatitis, jaundice, bronchitis, tonsillitis and pneumonia (Burits *et al.*, 2001; Loizzo *et al.*, 2007; Seshathri and Thiyagarajan, 2011; Alqasoumi *et al.*, 2012; Al-Attar *et al.*, 2016; Alkhedaide, 2018).

In our lab, we have investigated the mosquitocidal effect of *Tribulus terrestris* (Zygophyllaceae) against 3rd instar larvae and adults of mosquito, *Anopheles arabiensis* (El-Sheikh *et al.*, 2012) and the effect of *Thymus vulgaris* essential oil against the 3rd instar larvae of *Aedes aegypti* (Bosly, 2015). In addition to evaluation of the larvicidal, pupicidal, adulticidal and ovicidal effects of two essential oils of *Ricinus communis* and *Zingiber officinalis* against the housefly *Musca domestica* L. (Bosly, 2017).

The present work aimed to study the larvicidal and delayed effects of the *Juniperus procera* leaves extracts via methanol, petroleum ether and acetone,

against *C. pipiens* mosquito under the laboratory conditions.

MATERIALS AND METHODS

Mosquito

Adult stage of mosquitoes (*Culex pipiens*) was supplied from the Center for Disease Vector in Jizan, which is identified. They were reared for several generations in Biology Department, Faculty of Science, Jazan University according to the methods described by (El-Sheikh *et al.*, 2011) and morphologically identified according to (Harbach, 1985). Rearing was under controlled conditions (27 ± 2 °C, RH $70 \pm 10\%$ and 12-12 light-dark regime). Adult mosquitoes were kept in wooden cages and daily provided with sponge pieces soaked in 10% sucrose solution for 3-4 days after emergence. Then females were allowed to take a blood meal from a pigeon. Plastic cup containing dechlorinated tap water was placed in the cage for egg laying. The resulting egg rafts were picked up from the plastic dish and transferred into plastic pans containing three liters of tap water and left for 24 h for hatching. Resulting larvae were provided daily with fish food as a diet (Diaz-Nieto *et al.*, 2016).

Plant collection and preparation of crude extract:

Fresh leaves of *J procera* (Family: Cupressaceae) collected of Al-Hashr in Fifa (South of Saudi Arabia) (Latitude, $17^{\circ} 27' 35''$ N and Longitude, $43^{\circ} 2' 16''$ E) during September 2018. The plant was identified by plant taxonomist in Biology Department, Faculty of Science,

Jazan University according to (Migahid, 1988). The leaves were washed and dried in the shade at room temperature ($27-31$ °C) for 7 days till they become brittle, then powdered using commercial electrical stainless steel blender (Philips, Model Number: HR2058). The extraction was performed using three samples (100g/sample) powder and was extracted by soaking and filtration three times each by 300 ml aqueous 70% methanol, the second by acetone and the third by petroleum ether at room temperature. After 24 h, the supernatants were filtrated through a Whatman filter paper No. 5. Then dried in a rotary evaporator at 40°C for 2-3 hours for methanol extract and 40-60 minutes for other solvents (El-Sheikh *et al.*, (2016). The dry extracts were weighed and kept under -4°C until used for experiments.

Larvicidal bioassays:

Larvicidal activities were determined for the methanol, petroleum ether and acetone leaf extracts at concentrations 15, 20, 25, 30, 35 and 40 mg/L. Twenty *C. pipiens* larvae were exposed to each extract in 200 ml plastic cups containing each extract concentration as a replicate. Three replicates per extract per concentration and control were conducted as non-treated. Larvae were observed daily until adult emergence. The following parameters were measured in this study: developmental period, growth index and mortality rate of larvae, pupae and adults, where adults calculations based on the number of alive pupae and mortality based on the dead adults from that emerged according to

(El-Sheikh *et al.*, 2011 and 2016). The sum of the pupal mortality % and the pupal/adul intermideates % with the adult emergence% is 100%. Larval and pupal development time were recorded as the number of days from the start of the experiment until pupation and adult emergence. Then emerged adults were identified by sex according to (Granados-Echegoyen *et al.*, 2014).

Reproductive potential:

Females that emerged from treated larvae as well as non-treated control ones were allowed to mate with equal number of virgin normal non treated males in cages for 24h (Mala *et al.*, 2014). Then, the aforementioned females were allowed to take a blood meal from a pigeon and number of eggs produced was counted using a binocular stereomicroscope (Model: CZM6, Labo America Inc. based in Fremont, California, USA). The preoviposition period (gonotrophic cycle) was calculated as the interval between blood feeding and commencement of oviposition and eggs were sorted into two categories, hatched and non-hatched eggs (Mala *et al.*, 2014; Shehata, 2018).

Statistical analysis:

Data from all replicates were pooled for analysis (WHO, 2005). The percentage mortality was calculated by Abbott's formula (Abbott, 1925). The mean mortality data of the three replicates per concentration were calculated. Because the control mortality was less than 5%, hence the mortalities of treated groups necessitated not to be corrected according to the WHO guidelines for

laboratory testing of mosquito larvicides (WHO, 2005). Data from all of the three replicates were pooled for analysis. LC₅₀ and LC₉₀ values were calculated from a log dosage-probit larval mortality regression line using SPSS software (IBM SPSS Statistics v22 – 64bit) by probit analysis at significant ($p < 0.05$) and 95% confidence limits of upper confidence limit and lower confidence limit, and chi-square values were calculated using the software. IC₅₀ and IC₉₀ values were calculated from a log dosage-probit regression line using SPSS for the adult emergency inhibition % as previously mentioned. Results represented as Mean \pm SD. Hatching Rate (HR) was calculated according to Chugh *et al.*, (2011) with the following formula

$$HR = \frac{\text{number of hatching eggs}}{\text{total number of eggs}} \times 100$$

RESULTS

Data given in table (1) indicated the average weights of the dry methanol, petroleum ether and acetone materials from 100g of leaves. As shown from the results, these amounts were varied from solvent to another, methanolic extract produced higher weights ($9.52 \pm 1.1\text{gm}$) followed by acetone extract ($3.17 \pm 0.27\text{gm}$) and petroleum ether extract ($1.92 \pm 0.14\text{gm}$).

Larvicidal, pupicidal and adulticidal activity:

The cumulative mortality rate of larvae, pupae and adults were adversely affected by the latent toxicity of the methanolic extract as compared with the petroleum

ether and acetone extracts represented in table (2) and LD₅₀ (Lethal concentration required to kill 50 per cent of the larvae exposed) probit regression line is plotted in Figure (1). LC₅₀ value of the methanol extract (17.46 mg/L) proved to be more effective against *C. pipiens* than the petroleum ether and acetone extracts (32.33 and 40.00 mg/L) respectively. Where, complete pupal and larval mortalities were produced at 35 and 40 mg/L, respectively, and no adults emerged at concentrations (20, 25 and 30 mg/L). The data presented in table (2) showed the IC₅₀ values (concentration which to inhibit the emergence of 50% of mosquito adults emergence), the IC₅₀ value of the methanol extract (10.60 mg/L) and for the petroleum ether extract (35.18 mg/L) and for acetone extract (76.32 mg/L). The toxicity percentages of the *J. procera* extracts based on LC₅₀ values and the recorded IC₅₀ values for the Adult emergence inhibition (table 2 and Fig. 1) can be arranged in a descending order as follows: methanol extract > petroleum ether extract > acetone extract.

Effect on developmental periods and growth index:

Methanolic extract of *J. procera*, significantly ($P < 0.05$) increased the larval developmental time to 14.30 at 15 mg/L, compared with 8.20 days for the control group table (3). Pupal duration was delayed to 3.70 days at 15 mg/L, compared with 2.18 days for control group. Moreover, petroleum ether extract were significantly prolonged larval and pupal duration at all concentrations, compared with the control group. Larval

and pupal developmental periods were not adversely affected by acetone extract except at the highest concentration (40 mg/L), where it was significantly prolonged to 9.11 respectively, compared with 8.20 days for the control group table (3). Generally, as concentration increased, for methanol and petroleum ether extracts, the growth index decreased, while growth index for treatment by acetone extract not affected (Table 3).

Pre-oviposition period, fecundity, fertility and sterility index:

Data in table (4) showed the mean pre-oviposition period (the period between feeding and oviposition) of females that developed from larvae previously treated with petroleum ether extract significantly increased at all concentrations used, compared with control. Moreover, the pre-oviposition period in case of acetone extract was insignificantly affected when compared with control. Egg fecundity significantly ($P < 0.01$) declined from 221.60 for control to 61.00, 87.80, 111.40, 133.90, 156.70 and 172.80 eggs/♀ as a result of exposure to 40, 35, 30, 25, 20 and 15 mg/L petroleum ether extract, respectively. That from females resulted from treated larvae; a marked decrease in the hatchability percent at all concentrations used of petroleum ether was observed inversely proportion to increased concentration. The lowest fertility was 0.00 and 23.50% at 40 and 35 mg/L, respectively. In addition, a positive correlation between the sterility index and petroleum ether concentration was observed. Where, it was 100, 90.46 and 78.21% at 40, 35 and 30 mg/L;

respectively compared to 0.0% for the control group table (4). The pre-oviposition period, fecundity and fertility of females produced from larvae previously exposed to acetone extract were not statistically different affected compared with the control.

Table 1: The weight of dry methanol, petroleum ether and acetone soluble material from 100g of *Juniperus procera* leaves

Extracting material	Extract weight (g) \pm SD
Methanol	9.52 \pm 1.10
Petroleum ether	1.92 \pm 0.14
Acetone	3.17 \pm 0.27

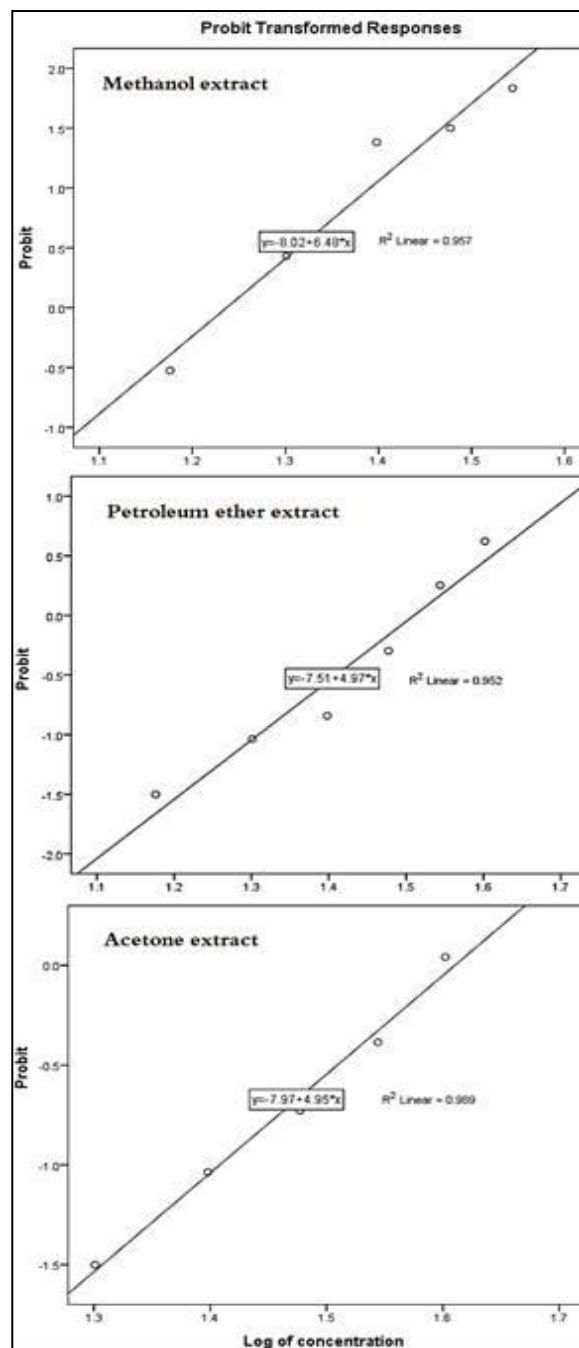


Figure (1): Probit regression responses of methanol, petroleum ether and acetone extracts of *Juniperus procera* against *Culex pipiens* larval mortality.

Table 2: Late toxic (cumulative) effect of *Juniperus procera* tested extracts on different stages of *Culex pipiens*

Extract	Conc. (mg/L)	Larval mortality/ Replicate ^a	LC (b) Larval mortality	(Chi) ²	Mean of pupal mortality%±SD	Inter.%	Mean of emerged adults ± SD ^a	%Adult mortality	%Adult emerged inhibition	IC (b)Adult emerged inhibition	(Chi) ²
Methanol	Control	0.33 ± 0.58			0.00 ± 0.00	0	19.67 ± 0.58	0	0		2.43
	15	6.00 ± 1.00	LC ₅₀ : 17.46 (16.09-18.62)	3.39	7.24 ± 1.05	78.57	2.00 ± 1.00	66.67	85.71	IC ₅₀ : 10.60 (6.51-12.47)	
	20	13.33 ± 2.08			15.08 ± 1.37	85	0.00 ± 0.00	0	100		
	25	18.33 ± 1.53			33.33 ± 28.87	60	0.00 ± 0.00	0	100		
	30	18.67 ± 1.15	LC ₉₀ : 26.47 (24.74-28.92)		83.33 ± 28.87	25	0.00 ± 0.00	0	100	IC ₉₀ : 15.70 (13.99-17.11)	
	35	19.33 ± 0.58			100.00 ± 0.00	---	0.00 ± 0.00	---	100		
	40	20.00 ± 0.00			---	---	---	100			
---					---	---	100				
Petroleum Ether	15	1.33 ± 0.58	LC ₅₀ : 32.33 (30.29-34.98)	4.47	3.51 ± 3.04	0	18.00 ± 2.00	3.7	3.57	IC ₅₀ : 35.18 (33.39-37.49)	3.67
	20	3.00 ± 1.00			5.90 ± 0.35	0	16.00 ± 2.00	10.42	5.88		
	25	4.00 ± 1.00			16.58 ± 2.86	0	13.33 ± 2.52	27.5	16.67		
	30	7.67 ± 0.58	LC ₉₀ : 56.63 (49.30-69.98)		37.52 ± 4.87	0	7.67 ± 2.52	39.13	37.84	IC ₉₀ : 59.17 (52.75-69.58)	
	35	12.00 ± 2.00			49.47 ± 6.37	0	4.00 ± 2.65	58.33	50		
	40	14.67 ± 1.15			62.22 ± 3.85	0	2.00 ± 2.00	83.33	62.5		
Acetone	15	0.00 ± 0.00	LC ₅₀ : 40.00 (36.78-45.45)	1.4	0.00 ± 0.00	0	20.00 ± 0.00	0	0	IC ₅₀ : 76.32 (56.32-97.62)	4.48
	20	1.33 ± 0.58			0.00 ± 0.00	0	18.67 ± 1.53	0	0		
	25	3.00 ± 1.00			0.00 ± 0.00	---	17.00 ± 2.00	0	0		
	30	4.67 ± 0.58	LC ₉₀ : 68.75 (57.16-94.53)		0.00 ± 0.00	0	15.33 ± 1.53	0	0	IC ₉₀ : 135.70 (110.79-160.11)	
	35	7.00 ± 1.73			2.38 ± 4.12	0	12.67 ± 2.52	0	2.56		
	40	10.33 ± 0.58			10.37 ± 0.64	0	8.67 ± 1.53	0	10.34		

(^a) Mean ± SD of mortality per replicate (n=20) for the three replicates. LC₅₀, LC₉₀ and IC₅₀, IC₉₀ values were calculated for pooled of the larval and Adults three replicates from a log dosage-probit analysis at significant (p < 0.05). (^b) 95% Confidence interval. LC50: Lethal concentration required to kill 50 per cent of the population exposed and LC90: Lethal concentration required to kill 90 per cent of the population exposed. IC50: Lethal concentration exposed required for larvae that cause 50 per cent of adult emergence inhibition. IC90: Lethal concentration exposed required for larvae that cause 90 per cent of adult emergence inhibition. Inter: Pupa/adult Intermediates. % Adult mortality (dead adults after emergence)

Table 3: Effect of *Juniperus procera* extracts on developmental periods (days) of *Culex pipiens* immature stage

Extract	Conc. (mg/L)	Larval Period	Pupal Period	Mean development Period	Growth Index
Methanol	Control	8.2±1.1 ^a	2.18±0.33 ^a	10.38±1.48 ^a	9.63
	15	14.3±1.4 ^b	3.7±0.41 ^b	18.0±1.2 ^b	0.79
	20	---	---	---	--
	25	---	---	---	---
	30	---	---	---	---
	35	---	---	---	---
	40	---	---	---	---
Petroleum Ether	Control	8.20±1.1 ^a	2.18±0.33 ^a	10.38±1.48 ^a	9.63
	15	10.27±1.2 ^b	2.63±0.3 ^b	12.90±1.5 ^b	7.48
	20	11.43±1.3 ^c	2.89±0.6 ^b	14.32±0.9 ^c	6.58
	25	11.35±1.3 ^c	3.31±0.6 ^c	14.66±1.9 ^{cd}	5.66
	30	11.66±1.7 ^c	3.57±0.5 ^{cd}	15.23±2.2 ^{de}	4.01
	35	12.14±1.4 ^c	3.77±0.5 ^d	15.91±1.9 ^{ef}	3.00
	40	12.39±1.6 ^c	4.03±0.5 ^e	16.42±2.1 ^f	2.34
Acetone	Control	8.20±1.1 ^a	2.18±0.33 ^a	10.38±1.43 ^a	9.63
	15	8.14±0.9 ^{ab}	2.19±0.41 ^a	10.33±1.30 ^a	9.68
	20	8.22±1.1 ^{ab}	2.23±0.32 ^a	10.45±1.42 ^a	9.57
	25	8.26±1.2 ^{ab}	2.21±0.40 ^a	10.47±1.60 ^a	9.55
	30	8.31±1.2 ^{ab}	2.23±0.42 ^a	10.54±1.62 ^a	9.57
	35	8.59±1.1 ^{ab}	2.22±0.37 ^a	10.81±1.47 ^a	9.02
	40	9.11±1.2 ^b	2.19±0.45 ^a	11.30±1.65 ^a	7.93

Data expressed by Means ± SD and different superscripts indicate significance (P>0.05).

Table 4: Effect of *Juniperus procera* petroleum ether and acetone extracts on preoviposition period, fecundity, fertility and sterility index of *Culex pipiens*.

Extract	Conc. (mg/L)	No. of tested	Preoviposition period	No. of eggs laid	Hatched eggs		Sterility Index
					Total	%	
Petroleum Ether	Control	10	5.10±0.29 ^a	221.60±8.70 ^a	2163	97.6	00
	15	10	6.58±0.32 ^b	172.80±9.60 ^b	1355	78.4	37.36
	20	10	7.12±0.51 ^{bd}	156.70±10.40 ^b	1068	68.1	50.66
	25	10	7.61±0.47 ^{cd}	133.90±13.30 ^c	790	59.0	63.47
	30	10	7.52±0.63 ^{cd}	111.40±13.30 ^d	471	42.3	78.21
	35	5	8.43±0.65 ^{cd}	87.80±11.20 ^{ef}	103	23.5	90.46
	40	1	9.00±0.00 [*]	61.00±0.00	00	00	100
Acetone	15	10	5.27±0.32 ^a	216.90±8.30 ^a	2101	96.8	2.92
	20	10	5.14±0.22 ^a	229.80±8.60 ^a	2224	96.8	2.85
	25	10	5.29±0.28 ^a	217.00± 9.40 ^a	2111	97.3	2.38
	30	10	5.22±0.34 ^a	219.70±8.90 ^a	2098	95.5	3.87
	35	10	5.19±0.30 ^a	214.80±10.20 ^a	2009	93.5	7.14
	40	10	5.33±0.42 ^a	209.80±9.80 ^a	1965	93.7	9.12

Data expressed by Means ± SD and different superscripts indicate significance (P>0.05). * One adult resulted from treated larvae.

DISCUSSION

Mosquitoes transmit serious human diseases, causing millions of deaths every year (Dua *et al.*, 2009). Use of conventional insecticides to control vector mosquitoes has caused physiological resistance and adverse environmental effects in addition to high operational cost (Al-Sarar, 2010; World Health Organization, 2012; Zhu *et al.*, 2020). The use of conventional insecticides for mosquito control is no longer encouraged. In line with different effective eco-friendly insecticidal/mosquitocidal studies were performed as previously introduced, natural products of plant origin with insecticidal properties have been used in the recent pest control of different insect pests and vectors (Djeghader *et al.*, 2018).

In the current study, *J. procera* leaves extracts evoked a variable degree of larvicidal activity depending on solvent used in extraction and the extract concentration. The highest larvicidal activity attained by methanol extract by providing 100% mortality at 40 mg/L with LC₅₀ (17.4 mg/L) followed by petroleum ether with LC₅₀ (32.33 mg/L) and acetone extract with LC₅₀ (40.00 mg/L). These results especially with methanolic extract are in accordance with previous study of (Karunamoorthi, *et al.*, 2014), which tested *J. procera* essential oil against *An. arabiensis* larvicidal activity under laboratory conditions and the recorded LC₅₀ was 14.42 mg/L. Moreover, in line to many previous studies evaluated the larvicidal activities of the essential oils from *Juniperus* species against mosquito

species (Tahghighi *et al.*, 2019). The larvicidal activities related to the leaves bioactive constituents, terpenes terpenoids and sesquiterpenes with previously reported significant insecticide potential, essentially as ovicidal, larvicidal, adulticidal, repellency, antifeedant, growth and reproduction inhibitors (Adams, 1990; Kinyanjui *et al.*, 2000; Gnankiné and Bassolé, 2017; Samaha *et al.*, 2017). The study results also in accordance with a previous study (Djeghader *et al.*, 2018) reported that saponin extract was evaluated for larvicidal activities against laboratory-reared colonies of *C. pipiens*. The LC₅₀ value of the saponin was 11.7 mg/L. However, the LC₅₀ values of *Acacia nilotica* seed extracts was 48.08 and 62.86 mg/L, for petroleum and acetone extracts, respectively against 4th instar larvae of *Culex quinquefasciatus* (Vivekanandhan *et al.*, 2018). Tests with *Calotropis procera*, *Polygonum hydropiper* and *Thevetia neriifolia* against larval mortality of mosquito *Cx quinquefasciatus* showed LC₅₀ values 167.48, 341.79 and 209.45 ppm, respectively (Islam and Hossain, 2018). Methanolic extract of *L. camara aculeata* showed 100% larvicidal activity against the fourth instar larvae of *Cx. quinquefasciatus* with LC₅₀ 39.54ppm compared with chloroform LC₅₀ 86.91ppm and acetone LC₅₀ 98.10 ppm (Hemalatha *et al.*, 2015).

In the current study, methanolic and petroleum ether extracts of *J. procera* showed a latent lethal effect on pupae and adults resulted from treated larvae. These results are in accordance with previous study by Al-mekhlafi *et al.*,

(2018), where they tested *Solenostemma argel* extracts against *C. pipiens*. Also, (Hasaballah and Moselhy, 2015), used petroleum ether extracts of 4 plants namely *Azadirachta indica*, *Phragmites australis*, *Rosmarinus officinalis* and *Rhizophora mucronata* against *C. pipiens*. A study of (Kovendan *et al.*, 2012), used *Orthosiphon thymiflorus* leaf extract against *Anopheles stephensi*, *Culex quinquefasciatus* and *Aedes aegypti* and another study used *Tephrosia purpurea* extracts against filarial vector *Culex quinquefasciatus* (El-Sheikh and Shalaby, 2014). In addition, the failure in adult emergence could be due to the insufficient accessibility of chitin during metamorphosis that caused death of larvae and pupae entangled in the weak integument (Arivoli and Tennyson 2011). The decrease in the percentage of *C. pipiens* adults emerged from larvae treated with methanolic and petroleum ether extracts confirms the previously results reported by Al-mekhlafi *et al.*, (2018), where, the highest concentrations of *S. argel* chloroform fruit extract inducing less than 50% inhibition in *C. pipiens* adult emergence. Previous study recorded (El-Sheikh and Shalaby, 2014) that no adult emergence when larvae of *C. pipiens* treated with methanolic extract of *T. purpurea*. A study of (Bream *et al.*, 2018) also recorded 55.5 to 83.3% inhibition in *C. pipiens* adult emergence at all concentrations used with petroleum ether extract of *Musa acuminata* leaves.

Moreover, treatment of *C. pipiens* larvae with *J. procera* methanolic and petroleum ether extracts resulted in latent effects on

larval and pupal developmental times, while acetone extract had insignificantly effect on larval and pupal developmental times. Similar observations were recorded in previous plant extracts studies of *S. argel* against *C. pipiens* and using petroleum ether extract of *A. indica* (leaves, stems) against *C. pipiens* (Hasaballah and Moselhy, 2015; Al-mekhlafi *et al.*, 2018). As regard to the IC₅₀ values, the metanol extract was resulted the most effective against *C. pipiens* mosquitoes to inhibit the adult emergence compared with that in either petroleum ether or acetone extracts. Similar findings have been obtained in previous study (Al-Ghamdi *et al.*, 2009) which recorded IC₅₀ values of the insect growth regulator, Dudim (0.0003 ppm) proved to be more effective against *C. pipiens* than the Neem oil (70 ppm) and concluded their safety and advantages over some currently used chemical insecticides. Recently, (Abdelgaleil and El-Sabrou, 2020) investigated the toxic and developmental properties of three essential oils from *Artemisia monosperma*, *Origanum vulgare* and *Schinus molle* against *C. pipiens*. The study recorded that the oil of *O. vulgare* was strongly inhibited adult emergency with IC₅₀ value of 10.50 mg/L. Additionally, the oils exhibited significant prolongation of the larval and pupal periods. Meanwhile, the oils drastically shortened adult periods of *C. pipiens*.

The current study showed reduction in fecundity and hatchability of *C. pipiens* females may be due to the effect of tested extracts on the ovaries of emerged females. The current study results are in

consistent with previous study of (Djghader *et al.* 2018), which indicated that saponin extract affected the fecundity and hatchability of *C. pipiens* females recording 44.8% and 55.2% inhibition of eggs production and hatchability at 75.85 µg/L, respectively. Hasaballah and Moselhy, (2015) previously recorded remarkable reduction in the fecundity of *C. pipiens* adult females for *Azadirachta indica*, *Phragmites australis*, *Rosmarinus officinalis* and *Rhizophora mucronata* tested plants and especially *A. indica* and *Rh. Mucronata*. Where, the induced effect was part of the plant and concentration of the extract dependent, the methanolic leaves extract showed a remarkable reduction effects on fecundity and fertility more than methanolic stems extract against *C. pipiens* (El-Sheikh and Shalaby, 2014).

To prove the validity of the results and mode of action of petroleum ether extract on fecundity and hatchability. A previous study in the histological examination of ovaries of heavy metals-treated *C. pipiens* females generally showed a reduction in the number of developed oocytes. In addition, signs of degenerative processes in oocytes were observed (Fouda *et al.*, 2011). In insects, either juvenile hormone or ecdysteroid controls the ovarian development that includes oocyte growth and Vitellogenesis (Bownes, 1989). In the present study abnormal deleterious effects on the ovary may be occurred due to the alteration in corpus allatum and juvenile hormone components or concentration. Earlier studies evaluated the activity of neem (*A. indica*) and ricinoleic acid on

Rhipicephalus sanguineus, and observed that these had inhibitory effects on oocytes, thereby preventing them from reaching advanced stages of development (Denardi *et al.*, 2011; Arnosti *et al.*, 2011).

Conclusion:

In summary, *Juniperus procera* leaves extracts as used in the present study especially methanolic and petroleum ether can be considered as new promising control agents against *C. pipiens*. Further studies on this plant species including mode of action, synergism with other biocides under field conditions are needed.

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Competing interest

The author declare no competing financial and non-financial interests.

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التأثير السمي اليرقي والممتد لمستخلصات نبات العرعر (الفصيلة: السروية) على البعوضة الناقلة لمرض داء الفيل كيولكس بيبينز (ثنائية الأجنحة: البعوض، كيوليسيدى)

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المُلخَص

تم تقييم التأثيرات السمية والممتدة لثلاث مستخلصات من أوراق نبات العرعر (الميثانولي، الإيثر البترولي والاسيتون) ضد يرقات العمر الثاني من بعوضة كيولكس بيبينز (*Culex pipiens*). حيث تشير النتائج إلى أن المستخلص الميثانولي أظهر أعلى كفاءة باستخدام نصف الجرعة المميتة (LC50) مسجلا قيمة 17.4 ملجم/لتر يليه مستخلص الأثير البترولي، 32.33 ملجم/لتر ثم الأسيتون، 40.00 ملجم/لتر. كان لمستخلص الميثانول والإيثر البترولي تأثيرات سمية ممتدة على الطورين، العذارى والبالغة الناتجة من اليرقات المعاملة، بينما لم يظهر ذلك بالنسبة لمستخلص الأسيتون. وتشير النتائج بوضوح أن للمستخلص الميثانولي تأثيرات سمية عالية على نسبة إماتة العذارى والبالغة حيث سجلت 100 و 66,67% عند تركيزات 35 و 15 ملجم/لتر على التوالي وبالنسبة للإيثر كان 62,22 و 83,33% عند 40 ملجم/لتر على التوالي. بالإضافة إلى ذلك، فإن مستخلص الميثانول أظهر تأثيرات حادة في تثبيط ظهور الطور البالغ عند التركيز 15 ملجم/لتر بنسبة 85,71% مسجلا 10,60 ملجم/لتر وهو التركيز المثبط لظهور 50% من البعوض البالغ (IC₅₀)، بينما أظهر مستخلص الأثير والاسيتون في تثبيط ظهور الطور البالغ نسبة 62,50 و 10,34% عند التركيز 40 ملجم/لتر على التوالي وكانت قيم (IC₅₀) (35,18 ملجم/لتر) و (76,32 ملجم/لتر) على التوالي. توضح النتائج النقص المعنوي في مؤشر نمو المراحل غير البالغة من 9,63 في المجموعة الضابطة إلى 0,79 عند تركيز 15 ملجم/لتر للمستخلص الميثانولي بينما بلغ 2,34 و 7,93 عند تركيز 40 ملجم/لتر لمستخلص الأثير والاسيتون على التوالي. تشير النتائج المتحصل عليها بوضوح أن مستخلص الإيثر البترولي له تأثيرات معنوية على مؤشر عدد البيض ونسبة الفقس بينما لم يظهر مستخلص الأسيتون تأثيرات إحصائية مختلفة مقارنة بالمجموعة الضابطة. ومن ثم، يمكن استخدام هذه المستخلصات كبديل فعال لمبيدات الآفات الاصطناعية الموجودة للسيطرة على بعوضة كيولكس بيبينز.

الكلمات المفتاحية: بعوضة كيولكس بيبينز، نبات العرعر، المبيد اليرقي، ظهور الطور البالغ، مؤشر النمو،

الخصوبة.

Analytical Study of the Spread of Infection Disease in Saudi Arabi: COVID-19 Case

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Abstract:

In this paper, we will introduce an associate analytical study for the Kermack-McKendrick model for Covid-19 to review the spreading within the Kingdom of Saudi Arabia. We'll study the behavior of its outbreak supported by numerical simulation. Additionally, we will provide also a statistical analysis of disease spread over 6 cities over the Kingdom.

Keywords: Mathematical model, COVID-19, SIR.

Introduction:

COVID-19 is one of the most dangerous and deadly diseases in the world today. Where many people have died due to this serious disease that is still killing the lives of many people around the world. The coronavirus COVID-19 is affecting 208 countries and territories around the world The majority of COVID-19 cases are concentrated within in

several major cities: Riyadh, Mecca, Jeddah, Dammam, and Medina. These cities contain 37% of 34 million population of Saudi. At of 12 June 2020, there were 123,308 total cases in Saudi Arabia, 82,548 recoveries and 932 deaths ([16]). The first case was discovered in Arabia Saudi on 8 March 2020.

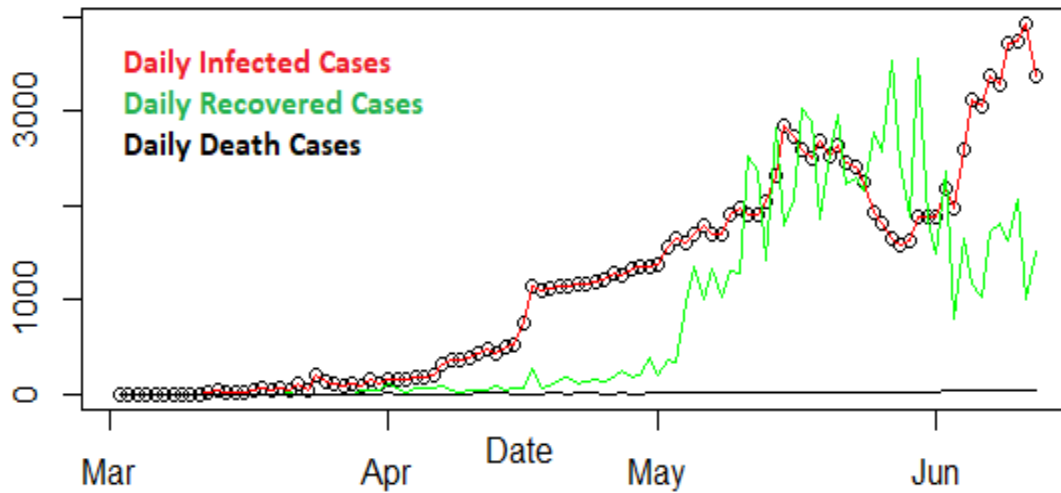


Figure 1: Daily cases with COVID-19 from 8 March to 12 June in KSA

Mathematical models mimic the effects of the disease on many different factors and levels including high or low temperatures and high or low humidity effect. Data of susceptible, infected and recovered patients will be collected and analyzed from cold, temperate and hot places around Saudi Arabia. If we assume that we have a single patient and we begin to study how the disease affects the interactions between cells in that single patient who has become a host of the virus (models inside the host) then we discussed all the methods and factors that Help and work to spread infection and virus from this person to the surrounding environment through several population groups supposed to be present in it through his daily life that may be separate (geographically) [7-12]. Models that simulate the spread of disease within cities and among the

population, such as those used to predict a COVID-19 outbreak.

In this paper we will introduce analytical study for Kermack-McKendrick model for Covid-19 to study the spread of the Corona virus in the Kingdom of Saudi Arabia.

Kermack-McKendrick Model:

One of the most important SIR models is the Kermack-McKendrick model, which is a model of the number of people with infectious disease in a closed community over time. It has a major role in the study of the behavior of epidemic diseases, as it has been suggested to explain the rapid rise and decrease in the number of patients with epidemics such as plague (London 1665-1666, Bombay 1906) and Cholera (London 1865). It is assumed that the population size is constant (that is, no births or deaths due to illness or deaths due to natural causes), the incubation period of the

infectious agent is immediate, and the duration of infection is the same as the duration of the disease. It also

assumes a completely homogenous society without age, spatial or social structure.

$$\begin{aligned}\frac{dS}{dt} &= -\beta SI \\ \frac{dI}{dt} &= \beta SI - \gamma I \\ \frac{dR}{dt} &= \gamma I\end{aligned}\quad (1)$$

where t is time, $S(t)$ is the number of susceptible people, $I(t)$ is the number of people infected, $R(t)$ is the number of people who have recovered and developed immunity to

the infection, β is the infection rate, and γ is the recovery rate. The time evolution of these equations was governed through key value or the so-called epidemiological threshold,

$$R_0 = \frac{\beta S}{\gamma}$$

R_0 is defined as the number of secondary infections caused by a single primary infection or the number of infected individuals as a result of direct contact with a single infected person before his death or recovery.

When $R_0 < 1$, each person who contracts the disease will infect fewer than one person before dying or recovering, so the outbreak will peter out $\frac{dI}{dt} < 0$.

When $R_0 > 1$, each individual who gets infected will infect more than one person, so the epidemic disease will spread ($\frac{dI}{dt} > 0$).

R_0 is most important quantity in

epidemiology. The basic reproductive number R_0 is an important value for disease modelling studies. Epidemiologists are required to determine this value for COVID-19 as an epidemic disease. Primary estimation of R_0 for COVID-19 showed range values 2-3. Defining R_0 can determine the conditions needed to stop the disease spread. This value is dependent on the success of vaccination and the percentage of vaccination coverage required to control the disease.

Statistically Analysis for the Model:

Timeline:

On 6th February, in response to the spread of COVID-19 pandemic was

by stopping all direct flights between Saudi Arabia and China. The following graph the principal

measures implemented in Saudi Arabia.

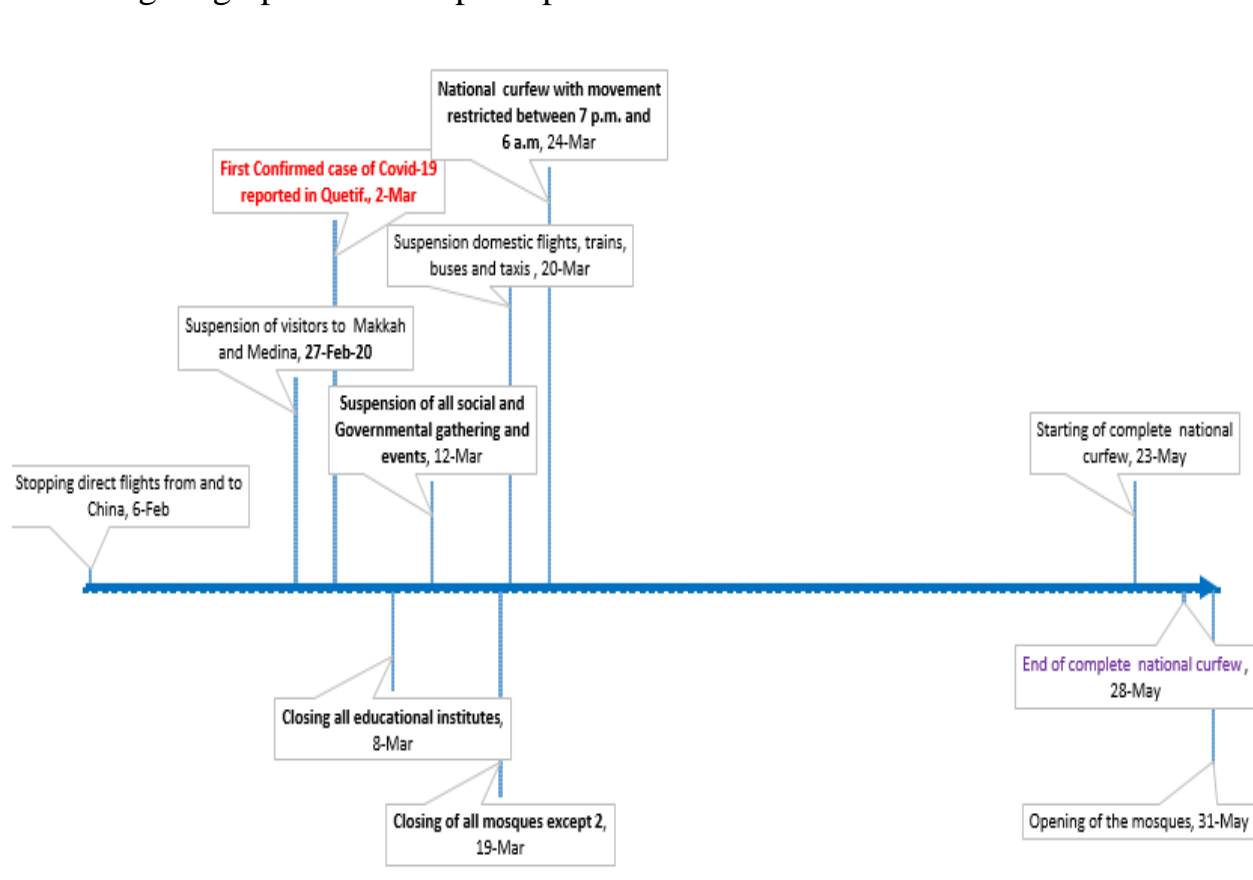


Figure 2: Time line of major precautions done by Saudi Arabia to flat the curve of COVID-19 infection from 26th February to 12 June 2020

In between when needed, some lockdown and isolation of several suburbs and districts in major cities was done to flattening the curve of infected cases and to control the outbreak. Between May 23th and May 27th, 2020, a complete curfew was imposed.

Data:

The data was collected daily from 8 March to 12 June 2020 on the website of Ministry of Health, 2020 [14]. We focus on 6 cities of Saudi Arabia and on covid'19 infection, recovered and death cases. We have obtained the following table since the feeding of this plague until June 12th, 2020.

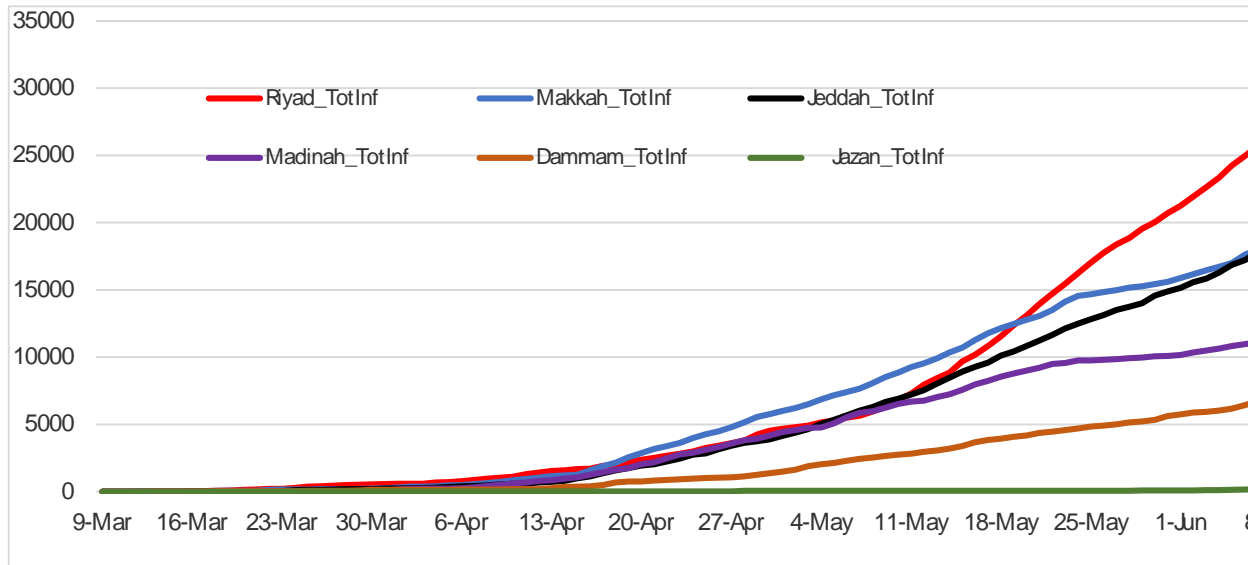


Figure 3: Cumulative of infected cases from March 9th to June 12th in 6 cities

After 20 May, the total of infected persons in Riyadh is increasing and becomes greater than all other cities.

And after half of cities had more than 15 000 infected cases. Jazan City had the lowest total infected cases.

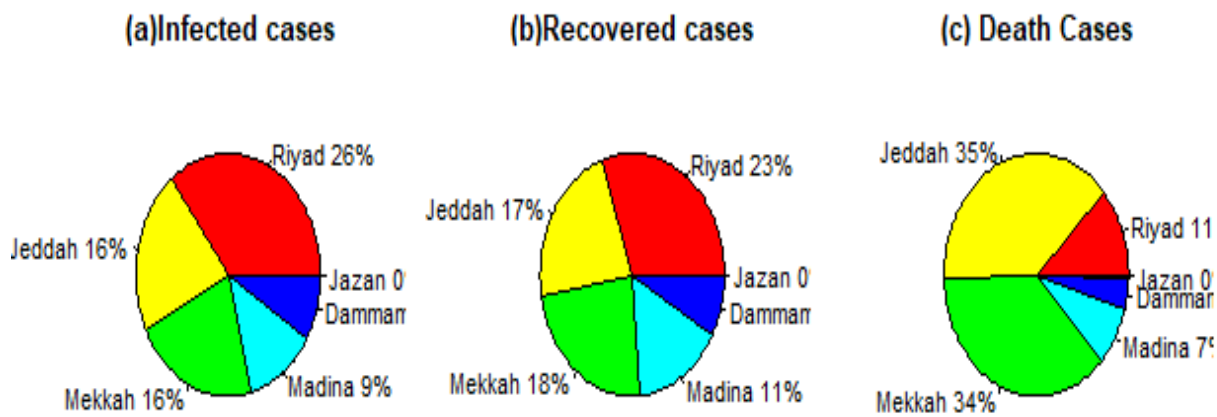


Figure 4: Percentages of Infected cases (a), Recovered cases (b), Death cases (c) over Cities regarding the total cases of Saudi Arabia

The total of infected cases over these 6 cities corresponds to 73%. And 75% of recovered cases exist in these cities and 91% of death cases. In the above figure, we found that Jeddah has the

bigger number of recovered cases and the higher number of death followed by Riyadh and two holly cities Mekkah and Madina (69% of all cases). Jazan city has small cases for three states

and are negligible corresponding of all country.
The estimation of the infection rate and the recovery from the data collected on

	Riyad	Makkah	Jeddah	Madinah	Dammam	Jazan
β	0.00888	0.00471	0.00479	0.00264	0.00237	0.00008
γ	0.75697	0.791719	0.835293	0.86758551	0.55683	0.711670481

Table 1: The infection rate β , and recovery rate γ for 6 different cities in Saudi Arabia.

The simulation of data using Matlab software gives the following graphs:

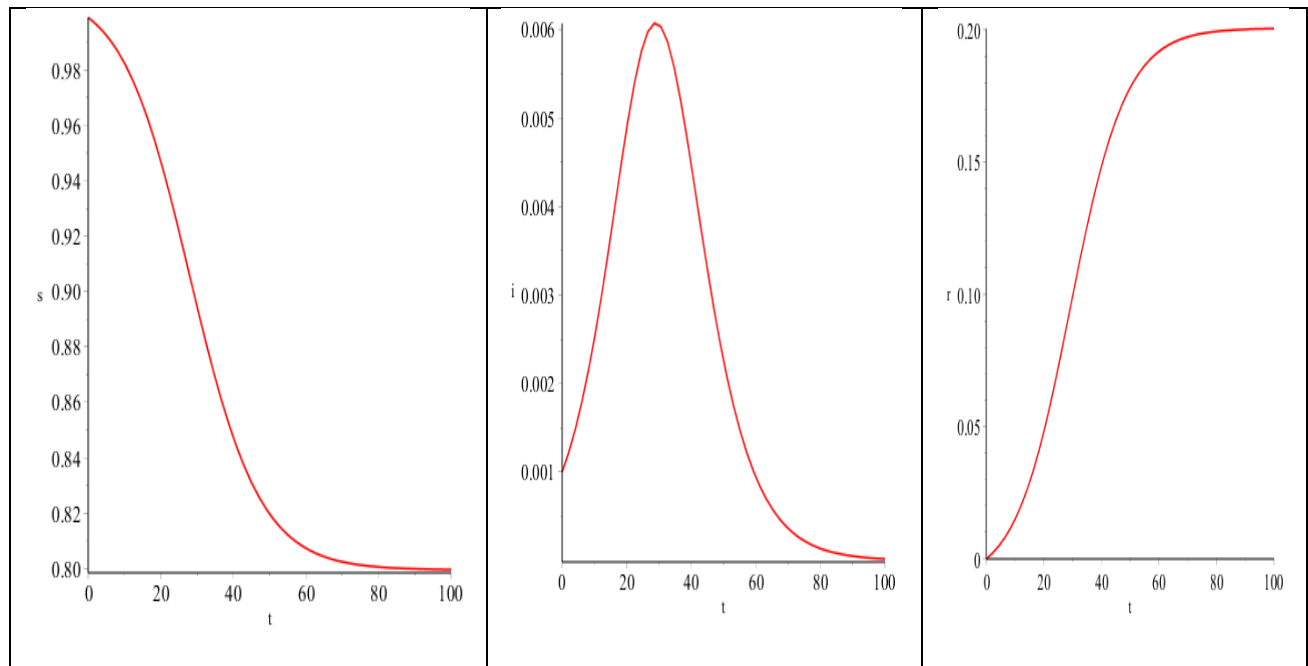


Figure 5: The simulation of the model equation (1) with respect to time t
with the parameters $\beta=1, \gamma=0.9$

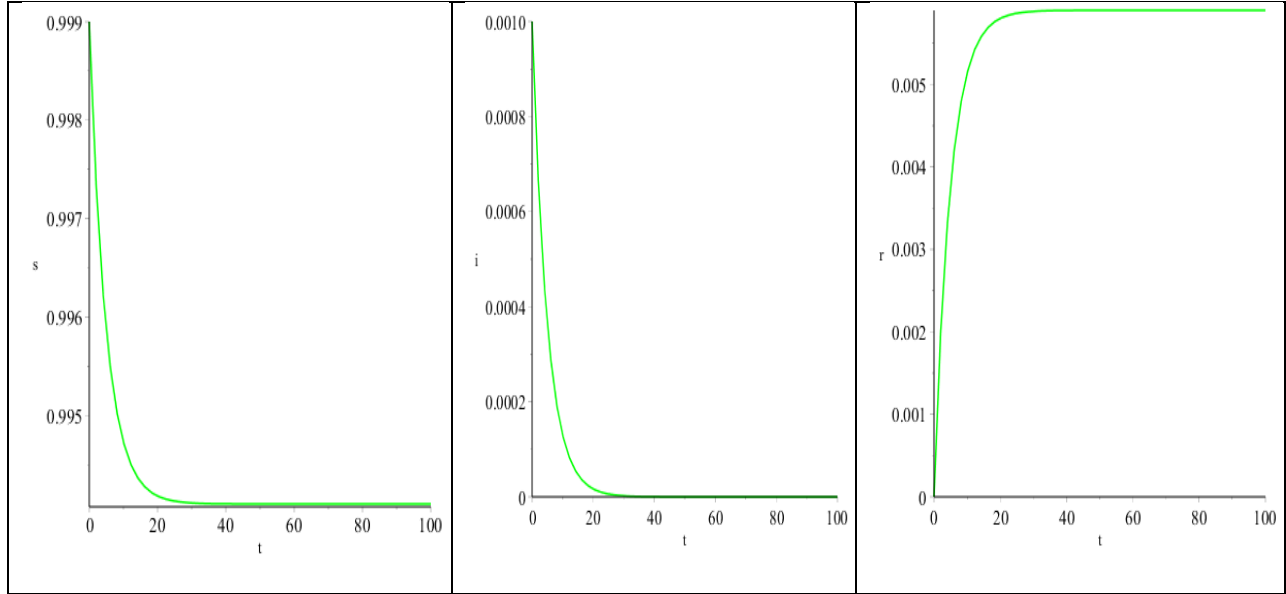


Figure 6: The simulation of the model equation (1) with respect to time t with the parameters $\beta=1, \gamma=1.2$

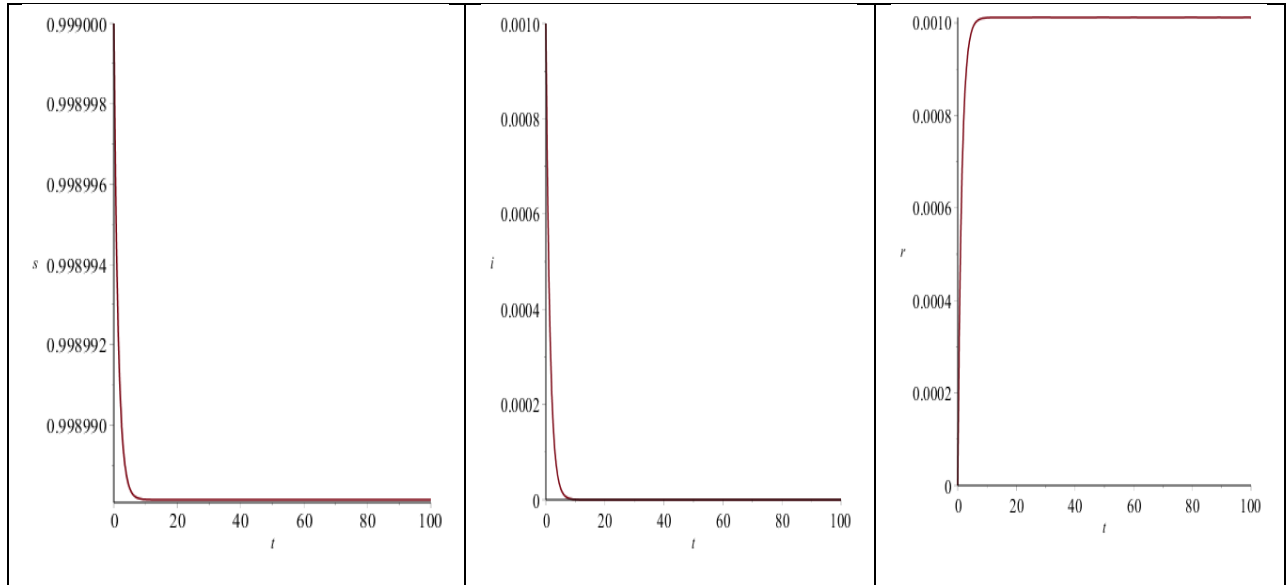


Figure 7: The simulation of the model equation (1) with respect to time t with the parameters $\beta=0.00888, \gamma=0.7569$

It is easy to deduce that: $N=S(t)+I(t)+R(t)$ is a constant and from the first and third equation of system (1) and using the equation:

$$S(t) = S_0 e^{\frac{-\beta R(t)}{\gamma}}, S_0 = \frac{1}{\beta} \quad (2)$$

The third equation of the system (1) will be:

$$\frac{dR(t)}{dt} = \gamma \left(N - R(t) - S_0 e^{\frac{-\beta R(t)}{\gamma}} \right) \quad (3)$$

Solving the equation (4) by utilize Maple’s LambertW function [13] to visualize the epidemic threshold. We will obtain the LambertW function:

$$uf = \frac{\text{LambertW}\left(\frac{999}{1000} \lambda e^{-\lambda}\right)}{\lambda} + 1, \lambda = \frac{\beta}{\gamma} \quad (4)$$

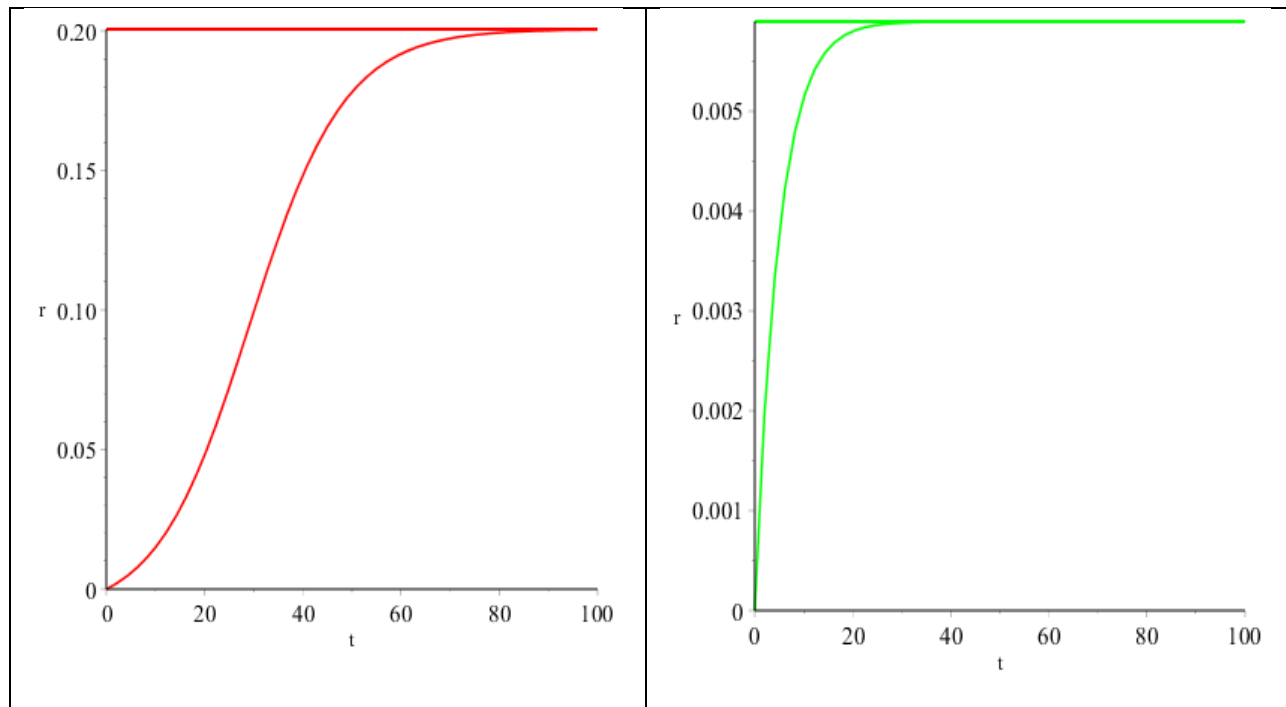


Figure 8: The simulation of the equation (3) with respect to time t with the parameters $R(t)$ when $\gamma=0.9$ or 1.2 and the corresponding uf will be $uf=0.2005682172$ or 0.00589822 respectively

Treatment:

We conducted a study of 50 patients treated in private hospitals in Egypt. These patients were taking α -chymotrypsin medications for other medical reasons, and we found that their incidence of COVID-19 did not exceed 3.7%. Therefore, by studying the dynamic behavior of disease spread and seeing medical studies of the symptoms caused by COVID-19 and causes of death, we suggested an important drug (α -chymotrypsin) that would contribute to a 85% lower death rate. We therefore recommend the World Health Organization and the Food and Drug Administration for sufficient clinical trials of this drug. This medication can convert critical case of COVID-19 into a stable case. Below is a description of how the drug works α -chymotrypsin [18-22]. α -chymotrypsin : Anti-inflammatory ampoules Each ampoule contains 450 chymotrypsin units in the form of crystals dehydrated and rapidly soluble in the solvent found with each ampoule as chymotrypsin has properties that analyze the non-living proteins that form natural swelling and therefore break down the substances that cause local fibrosis caused by infections Acute and chronic, and as such is considered to have an effective enzymatic effect as an anti-inflammatory and removes local swelling that follows surgeries or is caused by local injuries.

Recommendation

First: We recommend conducting adequate clinical trials on the use of the proposed drug (α -chymotrypsin) to end the suffering of the injured, to reduce the mortality rate of COVID-19's patients and to make symptoms of the virus as a seasonal flu. (Note: There are many alternatives to this medicine for every pill or drink).

Second: We know that scientists need enough time to produce a vaccination for COVID-19. We must give him enough time, so we advise everyone to use regular flu vaccine to relieve the symptoms of the krona virus.

Third Recommendation:

Exercising daily and regularly for at least 45 minutes, following precautionary and preventive measures.

Conclusions and Discussions:

In this research, we discussed the spread of the Corona virus in various places in the Kingdom of Saudi Arabia by numerical and analytical methods. COVID-19 is a new virus and has a high speed of spread and is transmitted to people in multiple ways, including the direct and indirect methods. We have tracked the spread of the virus in specific regions in the Kingdom of Saudi Arabia during approximately 13 continuous weeks on a daily basis in more than one city in the Kingdom of Saudi Arabia, and the opinion has settled on focusing in this study on 6 different cities from the south, the city of Jazan and the

east, the city of Dammam, in addition to the capital, Riyadh, of nature. Different in terms of demographic and economic diversity, and the city of Mecca, the religious capital of the Islamic world, is visited by different nationalities. We were also interested in Medina. Finally, we had to study Jeddah as well. On the other hand, the Ministry of Health in the Kingdom of Saudi Arabia has made great efforts, as it has conducted more than 770,696 tests to detect the Corona virus, at a rate of approximately one test for every 45 people. After using this important information and with the help of mathematical analysis supported by the statistical analysis of the dynamic behavior of the mathematical model that we presented, the possibility of estimating the number of cases that have been cured of the virus and overcome it. For example, in the time period between May 5 and May 15, 2020. The incidence of cure increased

to 4 times compared to April. Also, at the end of May, the virus cure rates exceeded infection rates by a tremendous one. The numbers recorded today for the injured, recovered, and deaths are the results of previous infections days ago, taking into account the incubation period of the Corona virus. Finally, we can say: The situation will be stable in the Kingdom of Saudi Arabia, unless new strains of the COVID-19 emerge. Finally: We found that most people who use (α -chymotrypsin) injections do not have any symptoms of COVID-19. We can say that (α -chymotrypsin) injection will be an effective drug that relieves the human body from the symptoms of severe krona virus infection and turns dangerous cases of infected people into stable conditions. Therefore, we recommend adequate clinical trials on the use of α -chymotrypsin injections and their alternatives to treat COVID-19.

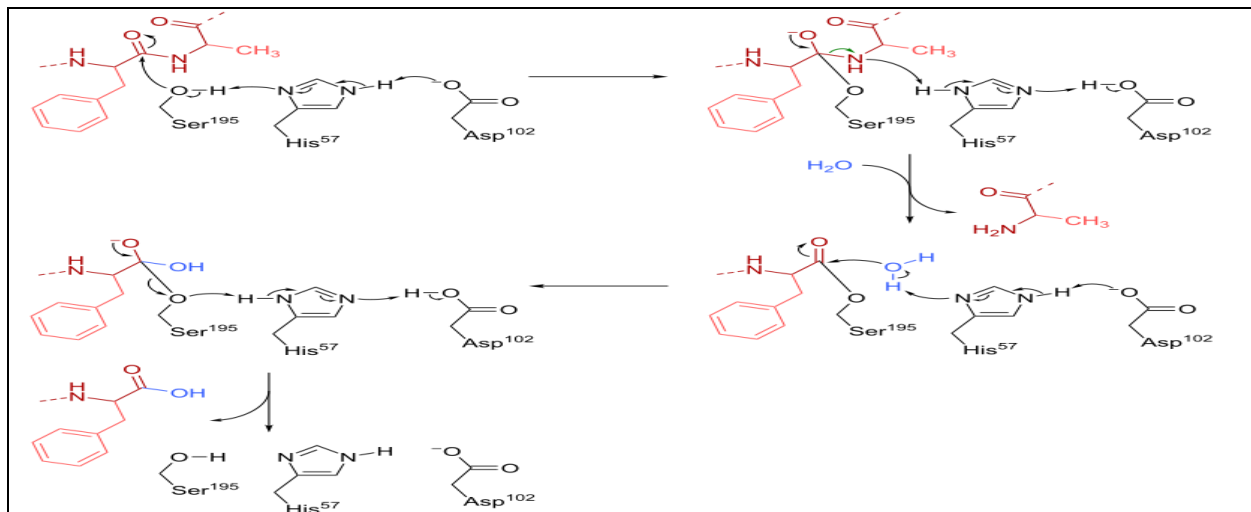


Figure 9: Mechanism of peptide bond cleavage in α -chymotrypsin

Acknowledgement

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المُلخَص

في هذا البحث ، سوف نقدم دراسة تحليلية مرتبطة بأحد أهم النماذج الرياضية التي تساعدنا في دراسة إنتشار الأمراض والفيروسات المعدية تحديداً (نموذج Kermack-McKendrick) بهدف دراسة إنتشار Covid-19) إنا قمنا بإختيار البارامترات وحسابها إحصائياً بغرض دراسة إنتشار Covid-19 داخل المملكة العربية السعودية. درسنا السلوك الديناميكي لإنتشار Covid-19 تحليلياً وقمنا بتدعيم دراستنا أيضاً بالحاكاة العددية. بالإضافة إلى ذلك ، سوف نقدم أيضاً تحليلاً إحصائياً لإنتشار الفيروس في ٦ مدن مختلفة من مدن المملكة العربية السعودية إختارنا جازان من الجنوب والدمام من الشرق بالإضافة إلى أهم أربع مدن مأهولة بالسكان (مكة والمدينة المنورة وجدة والرياض). تختلف هذه المدن من حيث التنوع الديموغرافي والإقتصادي فمثلا مدينة مكة العاصمة الدينية للعالم الإسلامي يزورها جنسيات مختلفة. كنا مهتمين أيضاً بالمدينة المنورة. أخيراً ، كان علينا دراسة جدة والرياض أيضاً. من جانب آخر ، بذلت وزارة الصحة في المملكة العربية السعودية جهوداً كبيرة ، حيث أجرت أكثر من ٧٧٠٦٩٦ فحصاً للكشف عن فيروس كورونا ، بمعدل فحص واحد تقريباً لكل ٤٥ شخصاً. بعد إستخدام هذه المعلومات المهمة وبمساعدة التحليل الرياضي المدعوم بالتحليل الإحصائي للسلوك الديناميكي للنموذج الرياضي الذي قدمناه ، إمكانية تقدير عدد الحالات التي تم شفاؤها من الفيروس والتغلب عليه. على سبيل المثال ، في الفترة الزمنية بين ٥ مايو و ١٥ مايو ٢٠٢٠. ارتفع معدل حدوث العلاج إلى ٤ مرات مقارنة بشهر أبريل. أيضاً ، في نهاية شهر مايو ، تجاوزت معدلات الشفاء من الفيروس معدلات الإصابة بنسبة هائلة. الأرقام المسجلة اليوم للمصابين والمتعافين والوفيات هي نتائج الإصابات السابقة قبل أيام ، مع مراعاة فترة حضانة فيروس كورونا. أخيراً يمكننا القول: سيكون الوضع مستقرًا في المملكة العربية السعودية ، ما لم تظهر سلالات جديدة من COVID-19.

أخيراً قدمنا في هذا البحث توصية هامة بخصوص عقار (α -chymotrypsin) قد يكون الدواء الذي يقضي على خطورة Covid-19. حيث أننا أجرينا دراسة على ٥٠ مريضاً تم علاجهم في مستشفيات خاصة في مصر. كان هؤلاء المرضى يتناولون أدوية α -chymotrypsin لأسباب طبية أخرى ، ووجدنا أن نسبة الإصابة بـ COVID-19 لم تتجاوز ٣,٧٪. لذلك ، من خلال دراسة السلوك الديناميكي لإنتشار المرض ورؤية الدراسات الطبية للأعراض التي يسببها COVID-19 وأسباب الوفاة ، إقترحنا عقارًا مهمًا (α -chymotrypsin) من شأنه أن يساهم في خفض معدل الوفيات بنسبة ٨٥٪. لذلك نوصي منظمة الصحة العالمية وإدارة الغذاء والدواء بإجراء تجارب سريرية كافية لهذا الدواء. يمكن لهذا الدواء التعامل مع الأعراض الخطيرة لـ Covid-19 مما يحول الحالات الحرجة الى حالات مستقرة ، وفيما يلي وصف لكيفية عمل الدواء α -chymotrypsin [18-22]: أمبولات مضادة للالتهابات تحتوي كل أمبولة على ٤٥٠ وحدة كيموتريسين في الشكل من البلورات المخففة وقابلة للذوبان بسرعة في المذيب الموجود مع كل أمبولة حيث أن الكيموتريسين له خصائص تحلل البروتينات غير الحية التي تشكل تورمًا طبيعيًا وبالتالي تكسر المواد التي تسبب التليف الموضعي الناجم عن الالتهابات الحادة والمزمنة ، وعلى هذا النحو يعتبر للحصول على تأثير إنزيمي فعال كمضاد للالتهابات ويزيل التورم الموضعي الذي يتبع العمليات الجراحية أو الناجم عن الإصابات الموضعية. لذلك نوصي بإجراء دراسات كافية على إمكانية اعتماد هذا العقار دواء لفيروس كورونا.

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نائب المشرف العام

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جميع حقوق الطبع محفوظة. لا يسمح بإعادة طبع أي جزء من المجلة أو نسخه بأي شكل وبأي وسيلة سواء كانت إلكترونية أو آلية بما في ذلك التصوير والتسجيل أو الإدخال في أي نظام حفظ معلومات أو استعادتها بدون الحصول على موافقة كتابية من رئيس تحرير المجلة.



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المجلد ٩ العدد ١ (ذوالقعدة ١٤٤٢ هـ - يوليو ٢٠٢١ م)

ردمك : ٦٩١٣-١٦٥٨



- ٤- نقد الكتاب
٥- الخطابات الموجهة إلى المحرر ، والملاحظات والردود ،
والنتائج الأولية .

تقوم هيئة التحرير، بالنظر في نشر المواد المعرفية ذات الصلة بذلك الفرع، وتقدم البحوث الأصلية، التي لم يسبق نشرها، وفي حال قبول البحث للنشر تؤول كل حقوق النشر للمجلة و لا يجوز نشره في أي منفذ نشر آخر ورقيا أو إلكترونيا، دون إذن كتابي من رئيس هيئة التحرير .

- مجلة جامعة جازان للعلوم التطبيقية دورية علمية محكمة تنشرها الجامعة، وهي تهدف إلى إتاحة الفرصة للباحثين لنشر إنتاجهم العلمي وتقوم المجلة بنشر المواد الآتية :
١- البحث : ويندرج تحت تخصص الباحث ويجب أن يحتوي على إضافة للمعرفة في مجاله .
٢- المقالة الاستعراضية التي تتضمن عرضاً نقدياً لبحوث سبق إجراؤها في مجال معين أو أجريت في خلال فترة زمنية محددة.
٣- البحث المختصر.

تعليمات النشر في المجلة

مثال : هادي، أحمد بن جابر. (٢٠١١م)، " استخدام تقنية النانو لتعريف الشفرات الوراثية "مجلة جامعة جازان، ١، ١ : ٢٠٠-٢٢٠.

ب- يشار إلى الكتب في المتن داخل قوسين بالاسم والتاريخ . أما في قائمة المراجع، فيكتب الاسم الأخير للمؤلف، ثم الاسم الأول، ثم الأسماء الأخرى أو اختصارا لها، ثم سنة النشر بين قوسين، فعنوان الكتاب بين علامتي تنصيص، ثم بيان الطبعة، فناشر، فمدينة النشر : ثم صفحات الكتاب إن وجدت.
مثال :

- ١- تقديم المواد : يقدم أصل البحث مخرجا في صورته النهائية متضمنا الإشارة إلى أماكن الجداول والأشكال داخل المتن و مطبوع على هيئة صفحات مرقمة ترقيما متسلسلا، مع ضرورة إرفاق قرص ممتط مطبوع عليه البحث على برنامج Ms Word باستخدام النظام المتوافق مع IBM ، وسيعتبر عن قبول أي بحث لا يلتزم مؤلفه بهذه التعليمات.
٢- الملخصات: يرفق ملخصان بالعربية والإنجليزية للبحوث و المقالات الاستعراضية والبحوث المختصرة على ألا يزيد عدد كلمات كل منهما على ٢٠٠ كلمة، وعلى عمود واحد بعرض كتابة ١٣ سم.

٣- لا بد من احتواء كل بحث على كلمات مفتاحية (Key Words)توضع أسفل الملخصين العربي والانجليزي على ألا تزيد عن عشر كلمات.

٤- الجداول والمواد التوضيحية: يجب أن تكون الجداول والرسومات واللوحات مناسبة لمساحة الصف في صفحة المجلة ١٦ × ٢٤ سم بالحواشي، ويتم إعداد الأشكال الخطية على برامج الحاسب الآلي، ولا تقبل إلا أصول الأشكال. كما يجب أن تكون الخطوط واضحة ومحددة ومنتظمة من حيث كثافة الحبر وتناسب سمكها مع حجم الرسم، ويراعى أن تكون الصور الفوتوغرافية (الضوئية) الملونة وغير الملونة مطبوعة على ورق لماع، أو محملة على برنامج (Adobe Photoshop) مع كتابة عنوان لكل جدول، وتطبيق لكل شكل وصورة، والإشارة إلى مصدر المادة إن كانت مقتبسة.

٥- الاختصارات: يجب استخدام الاختصارات المقننة دولية مثل : سم، م، كم، سم، مل، مجم، كجم...إلخ.

٦- المراجع :يشار إلى المراجع داخل المتن بنظام الاسم والتاريخ، وتوضع المراجع جميعها في قائمة المراجع بنهاية المادة مرقمة ومتباعدة نظام ترتيب البيانات البيولوجرافية التالي :

أ- يشار إلى الدوريات في المتن بنظام الاسم والتاريخ بين قوسين على مستوى السطر، أما في قائمة المراجع فيبدأ المراجع بنكر الاسم الأخير للمؤلف، ثم الاسم الأول، ثم الأسماء الأخرى أو اختصاراتها بالخط الأسود، ثم سنة النشر بين قوسين، فعنوان البحث كاملا بين علامتي تنصيص " " ، فاسم الدورية، فرقم المجلد، ثم رقم العدد : ثم أرقام الصفحات تفصل بشرطة .

عبدالهادي، محمد علي، (١٤٣٣هـ)، " مقدمة في التقية الحيوية"، جامعة جازان، جازان.

ويجب عدم استخدام الاختصارات المرجعية مثل : المرجع نفسه . المرجع السابق...إلخ.

٧- أ- الحواشي: تستخدم لتزويد القارئ بمعلومات توضيحية، ويشار إليها في المتن بأرقام مرتفعة عن السطر. وترقيم التعليقات متسلسلة داخل المتن. وفي حال الضرورة؛ يمكن الإشارة إلى مرجع داخل الحاشية عن طريق استخدام كتابة الاسم والتاريخ بين قوسين وبنفس طريقة استخدامها في المتن، وتوضع الحواشي أسفل الصفحة التي تخصها والتي ذكرت بها وتفصل بخط عن المتن وبخط أصغر.

ب- يستخدم في تخريج الأحاديث والآثار الطريقة المنهجية المعتمدة في هذا الفن وهي كالتالي : اسم المؤلف - اسم الكتاب - رقم الجزء والصفحة والحديث.

٨- المواد المنشورة في المجلة تعبر عن وجهة نظر صاحبها، ولا تعبر بالضرورة، عن رأي مجلة جامعة جازان.

٩- يتأكد الباحث من صحة اللفظ وسلامة لغة البحث، وخلوه من الأخطاء اللغوية والنحوية.

١٠- للمجلة الحق في تحديد أولويات نشر البحوث.

١١- المجلة غير ملزمة بإعادة البحوث التي تصل إليها سواء أحيزت للنشر أم لم تجز.

١٢- يتم إخضاع جميع البحوث المستلمة لفحص مبدئي، من قبل هيئة التحرير، لتقرير أهليتها للتحكيم، ويحق لها أن تعتنر عن قبول البحث دون إبداء الأسباب.

١٣- تصدر المجلة مرتين في العام.

المملكة العربية السعودية
وزارة التعليم العالي
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مجلة
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للعلوم التطبيقية

جامعة جازان

دورية علمية محكمة

المجلد ٩ العدد ١ (نوالقعدة ١٤٤٢ هـ - يوليو ٢٠٢١ م)

ردم: ١٦٥٨-٦٩١٣