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Studies on Antibacterial Activity of Back of Pawpaw (Carica papaya) on *Staphylococcu aureus* and *Escherichia coli*

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Abstract: *The antibacterial activity of back of pawpaw was tested on Staphylococcu aureus and Escherichia coli. All bacterial isolates were identified and characterized using standard microbiological techniques. Extraction was done using the aqueous and ethanolic methods while treatment application was done following standard methods. Parameters such as zones of inhibition, MIC and MBC were determined. Data was subjected to appropriate descriptive and inferential statistics using the Minitab software package (version 16.0). The two test organisms showed evidences of resistance to both aqueous and ethanolic extracts at lower concentrations. At 50mg/ml and 100mg/ml, the aqueous extracts performed better than the ethanolic extracts in S. aureus and E.coli, although the ethanolic extract gave better results (10mm) than the aqueous (7.5mm) extracts at 200mg/ml) in S. aureus. As a result, E. coli isolates were inhibited more than S. aureus isolates at 200mg/ml of aqueous extracts. At this level of concentration, S. aureus was more inhibited in ethanolic extract. MIC of aqueous extract showed that S. aureus was inhibited at 100mg/ml while E. coli was inhibited at 50mg/ml after 24 hours of incubation. MIC of ethanolic extract showed that S.aureus was inhibited at 50mg/ml while E. coli was inhibited at 25mg/ml after 24 hours of incubation. Therefore, inhibition by the plant extract depends on the type of bacteria and method of extraction. Carica papaya extracts demonstrated antibacterial properties against the test organisms.*

Keywords: *Carica papaya, Antibacterial, Staphylococcu aureus, Escherichia coli.*

1. INTRODUCTION

Nature has been a source of medicinal agents for thousands of years and since the beginning of man (Bonjar et al., 2004).. In Nigeria, almost all plants are medicinal and the application of medicinal plants especially in traditional medicine is currently well acknowledged and established as a viable profession (Bonjar et al., 2004). Plants are sources of chemicals used as drugs in herbal medicine. Some of these plant extracts are incorporated in cosmetic amends like soaps, lotions, pomades and tooth pastes because of their curative properties (Igwe et al., 2013). The quest to fully elucidate and authenticate these plant chemicals and their efficacy is born by the fact that they are used in synergy (in herbal medicine) as infusions, decoctions, concoctions, compresses, tinctures, ointments, poultices, powders, syrups, salves and teas (Igwe et al.,2013). Carica papaya a juicy and tasty fruit, belonging to family Caricaceae is scientifically known as Carica papaya Linn (Anuar et al., 2008). It is grown in various parts of the world, including India, tropical America and Europe. It is commonly known as Papaya melon tree, Pawpaw or papau, Kapaya, Lapaya, Papyas, Papye, Tapayas, Fan mu gua. Papaya plant is laticeferous as they contain specialized cells known as laticifers. Lactifiers secrete latex and dispersed throughout most plant tissues (Anuar et al., 2008).

Papaya plant (*Carica papaya* L.) is widely found in all part of the world. Almost all parts of the plant can be utilized by humans for food or for medicinal purposes (Dawkins,*et al.*, 2003, Yismaw *et al.*, 2006 2007; Naya *et al.*, 2007). According to Ehrichi (2010), Plants are used in the dried form due to differences in water content within different plant tissue before extractions. Ehrilich (2010) also stated that studies about the effect of plant extract against different types of bacteria are still one of the most important fields of researches. The extracts thus obtained after extraction may be used as medicinal

agents normally expected to contain phytochemicals. Eusaniha *et al., (*2012) observed that, the chemicals are the natural defense system against diseases and pest (Despite tremendous progress in human medicines, infectious diseases caused by microorganisms are still a major threat to public health (Dash, *et al.,* 2011). According to WHO (2003), the increasing pervasive use of traditional medicines has prompted the WHO to promote the integration of traditional medicine into the national health care systems of some countries.The utilization of herbal plants to treat various human diseases is cosmopolitan and universal, particularly in third world countries due to their easy access and low cost, compared with advanced Western medicines (Haque *et al.*, 2016; Petrovska, 2012).

The world is facing a growing threat from multidrug-resistant (MDR) gram negative such as *Pseudomonas aeruginosa, Acinetobacter baumannii* and *Klebsiella pneumonia* as well as Gram positive bacteria such *Staphylococcus aureus* (Jones *et al*., 2009). The rapid spread and dissemination of Multidrug-resistant bacteria worldwide represents a major public health problem. The development of antibiotics decreased the mortality among the human and animals leading to a better life expectancy. But the foolish use of antimicrobials and selection pressure the microbes have developed resistance which became more prominent during last few decades. With the evolution of Methicilin-resistant *Staphylococcus aureus* (MRSA), Hospital-acquired MRSA, Community acquired MRSA and MDR TB (Multidrug resistant tuberculosis) challenge for the clinicians have increased to a greater extent. Thus there is need to synthesize new drug which will help in combating the challenge of drug resistance.

The bacteria's increased resistance to antibiotics led the extensive research and development of innovations in creating more powerful antimicrobial agents (Djeussi, 2013). Some potential sources of plants have been studied because they contain many bioactive components that can be utilized in therapy and has a low toxicity inside it making them highly useful in the treatment of infectious diseases. Therefore, the purpose of this study is to test the inhibitory effects of bark of paw-paw extract at a concentration of 100mg/ml, 50mg/ml, 25mg/ml, 12.5mg/ml and 6.25mg/ml against *Staphylococcus aurues,* and *Escherichia coli* The aim of this study was to determine the antibacterial activity of back of pawpaw on *Staphylococcu aureus* and *Escherichia.*

2. MATERIAL AND METHODS

2.1. Collection of *Carica papaya L.* bark

Bark of Carica papaya leaves was collected from a settlement in Mkar located at Ortese farm yard, Mkar, Gboko Local Government Area, Benue State, Nigeria.

2.2. Identification of the Bark

The bark was taken for identification and authentication at the Department of Crop, Soil and Pest

Management, Federal University of Agriculture Makurdi (UAM), Benue State, Nigeria.

2.3. Collection of Clinical Isolates

Isolates of Staphylococcus aurues and Escherichia coli were obtained from Myom hospital, Gboko. All bacterial isolates were identified and characterized using standard microbiological techniques as described by Cheesbrough (2006).

2.4. Processing of Extracts

5ml Lb broth cultures of *E coli* and *Pseudomonas aeruginosa* were grown overnight, next day the 1% bacterial cultures of each strain was prepared by putting 100ul of incubated culture into the 10 ml of autoclaved Lb broth, replicates of each strain were made, one was labeled mutant type and other one as wild type. After that the tubes were given the incubation for 5 hours at 37˚C. Then the mutant labelled test tubes of *E.coli* and *Pseudomonas aeruginosa* were exposed to UV rays under UV illuminator for 3 minutes, after that the mutant labelled tubes were wrapped in the foil paper. Both the mutant and wild type strains containing test tubes were given the incubation at 37˚C for 24 hours. Next day, the bacteriocin activity of each strain (mutant *E coli* and *Pseudomonas aeruginosa*, wild type *E coli* and *Pseudomonas aeruginosa*) was tested on the *Micrococcus luteus, Staphylococcus epidermidis and Bacillus cereus* by the help of bacteriocin antimicrobial activity assay.

2.5. Preparation of 0.5 McFarland Turbidity Standards

The standard was prepared according to (McFarland, 1970) as modified by (Murray, 2011), One ml of 1% Sulphuric acid was gently added to 99ml of sterile distilled water in a 250 ml conical flask, and mixed well. In another 100ml beaker containing 50ml of sterile distilled water, 0.5g of dehydrated Barium Chloride was dissolved, 0.5ml of the barium chloride solution was then added to 99.5ml of the Sulphuric acid solution, and mixed well, 4ml of the turbid solution were transfer into a capped test tube (Murray, 2011).

2.6. Preparation of Inoculum

The Stock organisms were inoculated in three different properly labeled test tubes containing 10mls of Mueller Hinton Broth and was incubated for 24 hours at 370C. The resulting turbidity was compared to 0.5 McFarland turbidity standards (Ochei and Kolhatkar, 2007).

2.7.Double Dilution Procedure of the Ethanolic and Hot Water Extracts

Two (2) grams of each extract was reconstituted in 10ml of sterile distilled water. This gave a concentration of 200mg/ml of extract as stock solution, into tubes 1-6 each, 2ml of sterile distilled water was place. Serial doubling dilution of the stock was then carryout by transferring 2.0ml into the next tube. The last tube containing only sterile distilled water was serve as a control. This procedure was repeated for the five tubes giving a serial dilution concentration of 200, 100, 50, 25, 12.5 and 6.25mg/ml respectively. (Ochei and Kolhatkar, 2007).

2.8. Determination of Antibacterial Activity

The disc method described by Ochei and Kolkataker (2007) was used. Discs of 6mm in diameter made of Whiteman filter No.1 were impregnated with the various concentrations (6.25mg/ml-200mg/ml) diluted extract and was dried at 40^0C for overnight in hot air oven and were stored at 4^0C until use. Muller Hinton agar plates were prepared in triplate and use for each extract. A sterile cotton swab was dip into the adjusted suspension. The swab was rotated several times and pressed firmly on the inside wall of the tube above the fluid level. This removed the excess inoculum from swab. The dried surface of Muller Hinton agar plate was inoculated by streaking with swab over the entire sterile agar surface. This procedure was repeated for streaking two more times. The impregnated discs were dispersed onto the surface of the inoculated agar at appropriate spatial arrangement using ethanol dipped and flamed forceps. The plates were inverted and placed in an incubator at 37^0C for 24hours. Zone of inhibition was measure and recorded after 24hours of incubation.

2.9. Determination of Minimum Inhibitory Concentration (MIC)

MIC was carried out at varying concentrations of 200, 100, 50, 25, 12.5, and 6.25mg/ml of the Ethanolic and aqueous Extracts, Two ml of Muller Hinton broth was transferred to test tubes 1-8 using 2ml syringes, tube 7 which contain 2ml of the medium with the isolates were served as positive control while tube 8 which contain 2ml of Muller Hinton broth with extract was served as negative control. Doubling dilutions was be prepare from tubes 2 using 0.5ml amounts of the working inoculums previously adjusted to 0.5 cells/ml (0.5 McFarland Turbidity Standard) was transferred into tubes 1-6. Tube 7 contain 2.0 ml Broth and 0.5ml of the working inoculums without the extracts; Tube 8 contain 2.0ml Broth and extract without inoculum and tube 9 contain 2ml broth, inoculum and antibiotics as positive control. All the test tubes were incubated at 37^0C for 24 hours .The concentrations that show no visible growth of the test organism was taken as the Minimum Inhibitory Concentration (MIC) (Ochei and Kolhatkar, 2007).

2.10. Determination of Minimum Bactericidal Concentration (MBC)

For each set of test tubes in the MIC determination, a loop of broth from those tubes which was not show any visible growth was then inoculated on a sterile Muller Hinton agar. Muller Hinton agar plates was streak with the test organisms only to serve as control. The plates were incubated at 37^0C for 24 hours. The plates that show no visible growth was recorded as the Minimum Bactericidal Concentration (MBC) (Ochei and Kolhatkar, 2007).

2.11. Analysis of Data

Data obtained from this study was subjected to appropriate descriptive and inferential statistics using the Minitab software package (version 16.0). Chi square test of association was applied at appropriate degree of freedom with 95% confidence limit. T-test was also applied accordingly.

3. RESULTS AND DISCUSSION

Table 1 gives the results of qualitative tests of *Staphylococcus aureus* susceptibility by aqueous *Carica papaya* extracts from three different culture plates. The test organism was resistant to the treatments (0% susceptibility) at lower concentrations (12 mg/ml and 25 mg/ml) but 100% susceptibility was achieved at 50mg/ml, 100mg/ml and 200mg/ml concentrations of the treatments and Ciprofloxacin control. Table 2 shows the exact measurements of zones of inhibition (ZIs) of *Staphylococcus aureus* in aqueous *Carica papaya* extracts in three culture plates. There were no inhibition of the test organism at 12mg/ml and 25 mg/ml of the extract in all plates. Zones of inhibition were in the range of 4-5mm at 50mg/ml; 8.5-9mm at 100mg/ml and 7-7.5mm at 200mg/ml concentration of the extract. The observed differences in zones of inhibition among the five treatment levels as are statistically significant (χ^2 = 16.23, P=0.003, P<0.05). Inhibition was highest (9mm) at 100mg/ml of extract but lower than the 10mm inhibition recorded in Ciprofloxacin antibiotic (Figure 1).

Table1. *Qualitative Susceptibility Test of aqueous Carica papaya Extracts on Staphylococcus aureus*

Concentration (mg/ml)	Plate 1	Plate 2	Plate 3	Overall Plates Result
12	Resistant	Resistant	Resistant	0% susceptibility
25	Resistant	Resistant	Resistant	0% susceptibility
50	Susceptible	Susceptible	Susceptible	100% susceptibility
100	Susceptible	Susceptible	Susceptible	100% susceptibility
200	Susceptible	Susceptible	Susceptible	100% susceptibility
Ciprofloxacin	Susceptible	Susceptible	Susceptible	100% susceptibility

. **Table2.** *Measurement of Zones of Inhibition of Staphylococcus aureus in aqueous Carica papaya Extracts. (χ2 @ 4df= 16.23, P=0.003, P<0.05).*

Concentration (mg/ml)	Zones of Inhibition (mm) in Plate 1	Zones of Inhibition (mm) in Plate 2	Zones of Inhibition (mm) in Plate 3	Highest Zones of Inhibition (mm) recorded
12	0	0	0	0
25	0	0	0	0
50	5	4	5	5
100	9	8.5	9	9
200	7	7.5	7.1	7.5
Ciprofloxacin	10	9.8	9.5	10

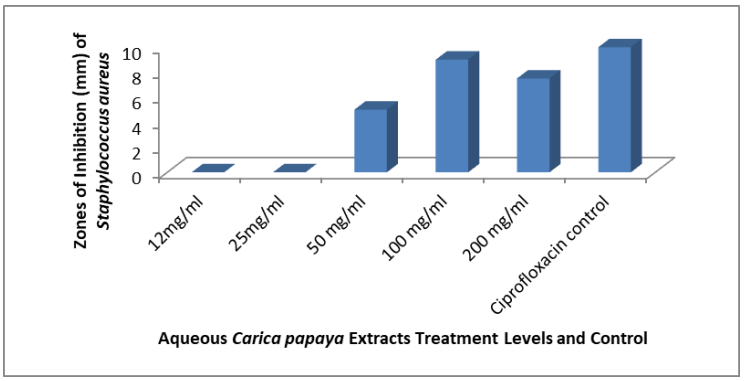

Figure1. *Zones of Inhibition of Staphylococcus aureus in aqueous Carica papaya Extracts Extracts and the Control.*

Table 3 gives the results of qualitative tests of *Staphylococcus aureus* susceptibility by ethanolic *Carica papaya* extracts from three different culture plates. The test organism was resistant to the treatments (0% susceptibility) at 12mg/ml, 25mg/ml and 50mg/ml concentration but 100%

susceptibility was achieved at 100mg/ml and 200mg/ml concentrations of the treatments and Ciprofloxacin control. Table 4 shows the exact measurements of zones of inhibition (ZIs) of *Staphylococcus aureus* in ethanolic *Carica papaya* extracts in three culture plates. There were no inhibition of the test organism at 12mg/ml, 25mg/ml and 50mg/ml of the extract in all plates. Zones of inhibition were in the range of 5.9-6mm at 100mg/ml and 9-10mm at 200mg/ml concentration of the extract. . The observed differences in zones of inhibition among the five treatment levels are statistically significant (χ^2 = 26.5, P=0.000, P<0.05). Inhibition was highest (10mm) under the highest treatment level (200mg/ml) with equal zone of inhibition recorded as the Ciprofloxacin antibiotic (Figure 2).

Table3. *Qualitative Susceptibility Test of Ethanolic Carica papaya Extracts on Staphylococcus aureus.*

Concentration (mg/ml)	Plate 1	Plate 2	Plate 3	Overall Plates Result
12	Resistant	Resistant	Resistant	0% susceptibility
25	Resistant	Resistant	Resistant	0% susceptibility
50	Resistant	Resistant	Resistant	0% susceptibility
100	Susceptible	Susceptible	Susceptible	100% susceptibility
200	Susceptible	Susceptible	Susceptible	100% susceptibility
Ciprofloxacin	Susceptible	Susceptible	Susceptible	100% susceptibility

Table4. *Measurement of Zones of Inhibition of Ethanolic Carica papaya Extracts on Staphylococcus aureus. (χ^2@ 4df = 26.5, P=0.000, P<0.05).*

Concentration (mg/ml)	Zones of Inhibition (mm) in Plate 1	Zones of Inhibition (mm) in Plate 2	Zones of Inhibition (mm) in Plate 3	Highest Zones of Inhibition (mm) recorded
12	0	0	0	0
25	0	0	0	0
50	0	0	0	0
100	6	5.9	6	6
200	10	9	9.8	10
Ciprofloxacin	10	9.8	9.5	10

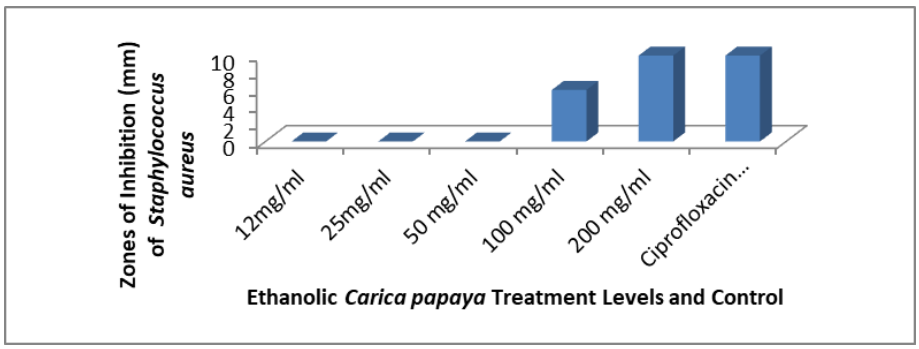

Figure2. *Zones of Inhibition of Staphylococcus aureus in EthanolicCarica papaya Extracts and the Control.*

The inhibitory effects of aqueous and ethanolic extracts on *Staphylococcus aureus* are compared in Table 5. All plates showed signs of *Staphylococcus aureus* resistance to both aqueous and ethanolic extracts at 12mg/ml and 25mg/ml levels of concentration. At 50mg/ml level, the aqueous extract gave 5mm zone of bacterial inhibition whereas there was none under ethanolic extracts. At 100mg/ml, the aqueous extracts also performed better than the ethanolic extracts. At the highest concentration (200mg/ml), the ethanolic extract gave better zone of inhibition (10mm) than the aqueous (7.5mm) extracts as shown in Figure 3. Test statistics (T-test) showed that the effects of two extract types on the test organism were the same (T=0.4, P=0.704, P>0.05).

Table5. *Comparative Effects of Aqueous and EthanolicCarica papaya Extracts on Staphylococcus aureus. T-test (aqueous/ethanolic) =0.4, P=0.704, P>0.05.*

Concentration (mg/ml)	Qualitative Overall Plates Result (%)	Qualitative Overall Plates Result (%)	Highest Zones of Inhibition (mm) recorded	Highest Zones of Inhibition (mm) recorded

	Aqueous extracts	**Ethanolic extracts**	**Aqueous extracts**	**Ethanolic extracts**
12	0% susceptibility	0% susceptibility	0	0
25	0% susceptibility	0% susceptibility	0	0
50	100% susceptibility	0% susceptibility	5	0
100	100% susceptibility	100% susceptibility	9	6
200	100% susceptibility	100% susceptibility	7.5	10
Ciprofloxacin	100% susceptibility	100% susceptibility	10	10

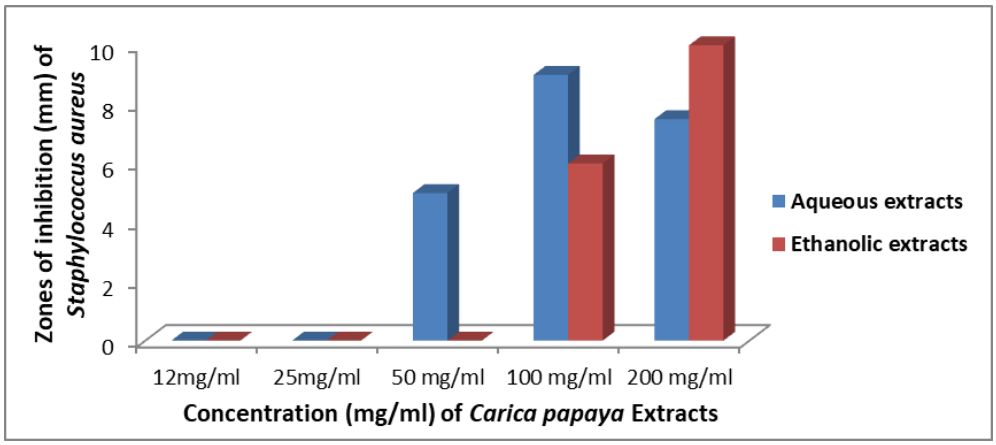

Figure3. *Comparative Effects of Aqueous and Ethanolic Extracts on Staphylococcus aureus.*

Table6. *Qualitative Susceptibility Test of Aqueous Carica papaya Extracts on Escherichia coli.*

Concentration (mg/ml)	**Plate 1**	**Plate 2**	**Plate 3**	**Overall Plates Result**
12	Resistant	Resistant	Resistant	0% susceptibility
25	Resistant	Resistant	Resistant	0% susceptibility
50	Susceptible	Susceptible	Susceptible	100% susceptibility
100	Susceptible	Susceptible	Susceptible	100% susceptibility
200	Susceptible	Susceptible	Susceptible	100% susceptibility
Ciprofloxacin	Susceptible	Susceptible	Susceptible	100% susceptibility

Table7. *Measurement of Zones of Inhibition of Aqueous Carica papaya Extracts on Escherichia coli*.

χ^2 @4df= 26.78, P=0.000, P<0.05).

Concentration (mg/ml)	**Zones of Inhibition (mm) in Plate 1**	**Zones of Inhibition (mm) in Plate 2**	**Zones of Inhibition (mm) in Plate 3**	**Highest Zones of Inhibition (mm) recorded**
12	0	0	0	0
25	0	0	0	0
50	7	7.7	7	7.7
100	6.5	5.8	6	6.5
200	15	14.5	15	15
Ciprofloxacin	11	12	13	13

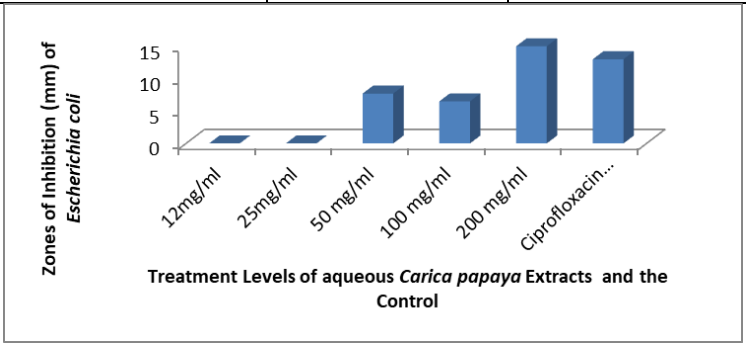

Figure 4: Zones of Inhibition of Escherichia coliin aqueous Carica papaya Extracts and the Control

Table 8 gives the results of qualitative tests of *Escherichia coli* susceptibility by ethanolic *Carica papaya* extracts from three different culture plates. The test organism was resistant to the treatments (0% susceptibility) at lower concentrations (12mg/ml and 25 mg/ml) but 100% susceptibility was achieved at 50mg/ml, 100mg/ml and 200mg/ml concentrations of the treatments and Ciprofloxacin control. Table 9 shows the exact measurements of zones of inhibition (ZIs) of *Escherichia coli* in ethanolic *Carica papaya* extracts in three culture plates. There were no inhibitions at 12mg/ml extract in all plates. The 25mg/ml concentration yielded little or no inhibitory effect on the *E. coli* isolates. Slight improvement was observed under 50mg/ml treatment level. Zones of inhibition were in the range of 5-5.8mm at 100mg/ml and 8.8-9.5mm at 200mg/ml concentration of the extract. The observed differences in zones of inhibition among the five treatment levels as are statistically significant (χ^2 = 15.43, P=0.004, P<0.05). The 200 mg/ml level gave the highest zone of inhibition of 9mm but it was lower than the 13mm inhibition recorded under Ciprofloxacin antibiotic (Figure 5).

Table8. *Qualitative Susceptibility Test of Ethanolic Carica papaya Extracts on Escherichia coli.*

Concentration (mg/ml)	Plate 1	Plate 2	Plate 3	Overall Plates Result
12	Resistant	Resistant	Resistant	0% susceptibility
25	Resistant	Resistant	Resistant	0% susceptibility
50	Susceptible	Susceptible	Susceptible	100% susceptibility
100	Susceptible	Susceptible	Susceptible	100% susceptibility
200	Susceptible	Susceptible	Susceptible	100% susceptibility
Ciprofloxacin	Susceptible	Susceptible	Susceptible	100% susceptibility

Table9. *Measurement of Zones of Inhibition of Ethanolic Carica papaya Extracts on Escherichia coli. χ^2 @4df= 15.43, P=0.004, P<0.05.*

Concentration (mg/ml)	Zones of Inhibition (mm) in Plate 1	Zones of Inhibition (mm) in Plate 2	Zones of Inhibition (mm) in Plate 3	Highest Zones of Inhibition (mm) recorded
12	0	0	0	0
25	0.1	0	0.5	0.5
50	3	2.9	3.1	3.1
100	5.8	5	5.6	5.8
200	9.5	8.8	9	9
Ciprofloxacin	11	12	13	13

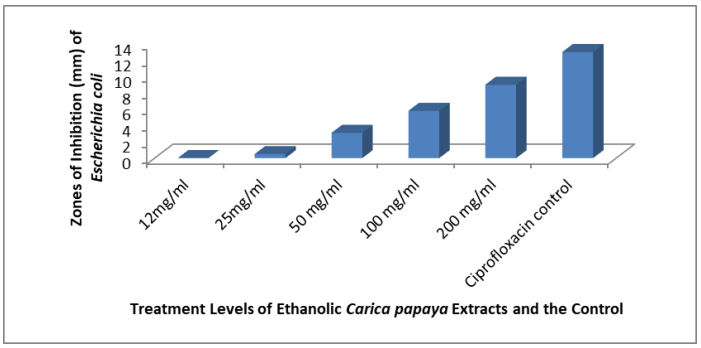

Figure5. *Zones of Inhibition of Escherichia coli in ethanolic Carica papaya Extracts and the Control.*

The inhibitory effects of aqueous and ethanolic extracts on *Escherichia coli* are compared in Table 10. All plates showed signs of bacterial resistance to both aqueous and ethanolic extracts at 12mg/ml and 25mg/ml levels of concentration. At higher treatment concentrations (50-200 mg/ml), zones of inhibition were 7.7mm, 6.5mm and 15mm in aqueous extracts whereas the ethanolic extract produced 3.1mm, 5.8mm and 9 mm zones of inhibition respectively. Analysis showed that aqueous extract gave higher zones of inhibition on *Escherichia coli* than the ethanolic extracts (Figure 6). Test statistics (T-test) showed that the effects of two extract types on the test organism were the same (T=0.66, P=0.532, P>0.05). *Escherichia coli* isolates were inhibited more than *Staphylococcus aureu* isolates at 200mg/ml of aqueous extracts. At this level of concentration, *Staphylococcus aureus* was more inhibited in ethanolic extract (Table 11). Table 12 below showed the minimum inhibitory concentration of aqueous extract of bark of pawpaw. *S. aureus* was inhibited at 100mg/ml while *E. coli* was inhibited at 50mg/ml after 24 hours of incubation. Table 13 shows the minimum inhibitory

concentration (MIC) of ethanolic extract of bark of pawpaw. *Staphylococcus aureus* was inhibited at 50mg/ml while *E. coli* was inhibited at 25mg/ml after 24 hours of incubation.

Table10. *Comparative Effects of Aqueous and Ethanolic Carica papaya Extracts on Escherichia coli. T-test (aqueous/ethanolic) =0.66, P=0.532, P>0.05.*

Concentration (mg/ml)	Qualitative Overall Plates Result (%)	Qualitative Overall Plates Result (%)	Highest Zones of Inhibition (mm) recorded	Highest Zones of Inhibition (mm) recorded
	Aqueous extracts	Ethanolic extracts	Aqueous extracts	Ethanolic extracts
12	0% susceptibility	0% susceptibility	0	0
25	0% susceptibility	0% susceptibility	0	0.5
50	100% susceptibility	100% susceptibility	7.7	3.1
100	100% susceptibility	100% susceptibility	6.5	5.8
200	100% susceptibility	100% susceptibility	15	9
Ciprofloxacin	100% susceptibility	100% susceptibility	13	13

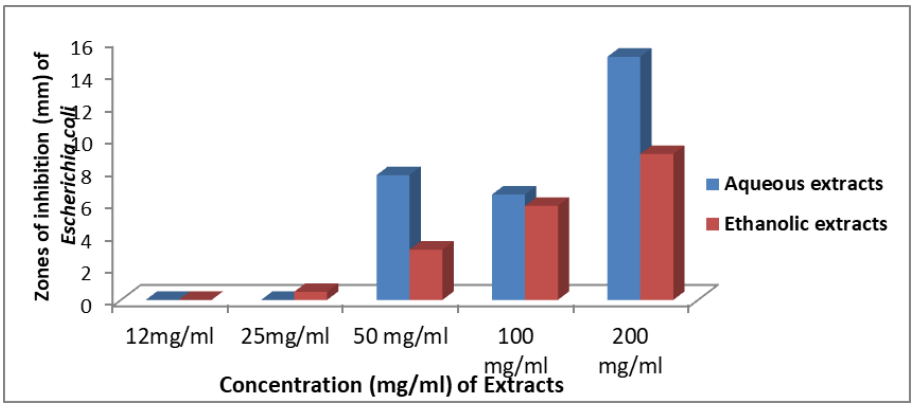

Figure6. *Comparative Effects of Aqueous and Ethanolic Extracts on Escherichia coli.*

Table11. *Comparative Zones of Inhibition of Aqueous and Ethanolic Carica papaya Extracts on Staphylococcus aureus and Escherichia coli. Ciprofloxacin = 10mm in Staphylococcus aureus; Ciprofloxacin =13mm in Escherichia coli.*

Concentration (mg/ml)	Aqueous extracts		Ethanolic extracts	
	Staphylococcus aureus	***Escherichia coli***	***Staphylococcus aureus***	***Escherichia coli***
12	0	0	0	0
25	0	0	0	0.5
50	5	7.7	0	3.1
100	9	6.5	6	5.8
200	7.5	15	10	9

Table12. *Minimum Inhibitory Concentration (MIC) of the Aqueous Extracts of bark of pawpaw.*

	Concentration of Extracts (mg/ml)						
Bacterial Isolates	**200**	**100**	**50**	**25**	**12.5**	**6.25**	**2ml Cipro**
Staphylococcus aureus	-	-	+	+	+	+	-
Escherichia coli	-	-	-	+	+	+	_

KEY: **+:** Shows Turbidity in the Test Tubes (Growth); **-:** Shows No Turbidity in the Test Tubes (No Growth).

Table13. *Minimum Inhibitory Concentration (MIC) of the Ethanolic Extracts of pawpaw bark.*

	Concentration in (mg/ml)						
Bacterial Isolates	**200**	**100**	**50**	**25**	**12.5**	**6.25**	**2ml Cipro**
S. aureus	-	-	-	+	+	+	-
E. coli	-	-	-	-	+	+	-

KEY:**+:** Shows Turbidity in the Test Tubes (Growth); **-:** Shows No Turbidity in the Test Tubes (No Growth).

4. DISCUSSION

Results have shown the efficacy of *Carica papaya* bark in the treatment of infections caused by *Staphylococcus aureus* and *Escherichia coli*. It has been reported that the plant contains some active ingredients that are highly abundant in all parts of the plant such as the root, stem, leaf and the unripe fruits (Vijendra *et al.,* 2010). Plant have the ability to synthesize a wide variety of chemical compounds that are used to perform important biological functions, and to defend against attacks from predators such as insets, fungi and herbivorous mammals (Aguoru *et al.* 2015). Medicinal values of pawpaw widely reported in many parts of Nigeria (Nwakaeze *et al.,* 2014) are in agreement with the outcome of this study. The plant was reported to inhibit *Escherichia coli*, *Salmonella typhi* and *Staphylococcus aureus* (Aguoru *et al.* 2015), thus confirming its medicinal importance in the treatment of diarhoea, typhoid fever, wound infection and some common gastrointestinal disorders of microbial origin. *Staphylococcus aureus* and *Escherichia coli* studied showed resistance to aqueous and ethanolic *Carica papaya* extracts at low concentration (<50mg/ml).However, the two test organisms were found to be susceptible to aqueous and ethanolic *Carica papaya* extracts at high concentration (>50mg/ml) with equal effect as Ciprofloxacin antibiotic drug. This report is in agreement with previous studies on *C. payaya* (Kala, 2005; Kasim *et al.*, 2012) stating that the plant extracts produced desired antimicrobial effect at 200mg/ml of the extract. Kasim *et al.* (2012) carried out phytochemical studies on some Nigerian plants including *Carica papaya*. It was reported that all parts of the plant had antimicrobial activities against major disease causing bacteria and fungi. The presence of alkaloids, saponins and combined anthraquinones was reported at high concentration. In the work of Kala (2005), *C. papaya* was among the plants reported to broad spectrum activity that can be used for the treatment of gastro intestinal disorders, urethritis, shigellosis, and typhoid fever.

Escherichia coli are both part of the normal human large intestinal microbiota and important pathogens associated with diarrhoeal illnesses worldwide (Binder, 2006), a leading cause of infant mortality worldwide. *Staphylococcus aureus* is a common pathogen in many bacterial infections. Both *E. coli* and *S. aureus* are common pathogens of the urinary tract infections (uropathogens) that are recalcitrant to treat using common antibiotics (Woodford and George, 2011). Microbes evolve over time and are able adapt to their environments and change in ways that ensure their survival. Occurrence of antibiotic resistance is a big challenge in treatment of microbial infections (Jacob and Cohen, 2016). In order to solve this challenge, it would be helpful to use *C. papaya* to cure microbial infections arising from *E. coli* and *S. aureus* since the extracts have proven effective against the test organisms. The outcome of this study has shown that *C. papaya* extracts were equally effective or more powerful than the antibiotic drug used. This position was upheld in previous studies (Jacob and Cohen, 2016). In the work of Nwakaeze *et al.* (2014), the aqueous extract of *C. papaya* displayed weak antimicrobial activity whereas, ethanolic extracts where profoundly effective against both Gramm+ve and Gramm –ve bacteria. In the present study, ethanolic extract of *C. papaya* extract showed better zone of inhibition on *Staphylococcus aureus* than the aqueous extracts. *Escherichia coli* isolates were susceptible to both aqueous and ethanolic extracts at high concentration. The aqueous extract produced higher antimicrobial effect than Ciprofloxacin antibiotic drug.

5. CONCLUSION

Staphylococcus aureus and *Escherichia coli* studied showed resistance to aqueous and ethanolic *Carica papaya* extracts at low concentration (<50mg/ml). However, the two test organisms were found to be susceptible to aqueous and ethanolic *Carica papaya* extracts at high concentration (>50mg/ml) with equal effect as Ciprofloxacin antibiotic drug. Ethanolic extract of *C. papaya* extract showed better zone of inhibition on *Staphylococcus aureus* than the aqueous extracts. *Escherichia coli* isolates were susceptible to both aqueous and ethanolic extracts at high concentration. The aqueous extract produced higher bactericidal effect than Ciprofloxacin antibiotic drug. Thus, the extracts of *C. papaya* at higher concentrations had antibacterial effect against the two pathogens. The extracts are therefore recommended in the treatment of infections associated with *S. aureus* and *E. coli*.

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