# HISTOLOGICAL STUDIES OF THE EFFECTS OF AQUEOUS EXTRACT OF CINNAMON BARK ON THE KIDNEY OF WISTAR RATS

**BY**

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## CERTIFICATION

1, AGHEMELO EMMANUEL OSEDEBAMEN, hereby certify that the work presented in this thesis for the award of a Bachelor of Science Degree (BSc) in Anatomy is the result Of and sole outm.t Of an independent research done by under the Supervision Of Dr. Mom0du Oghenakhogie and any assistance given has been duly acknowledged. I also certify that this thesis has not been submitted any*'here else in part or in full for any other examination or institution. All literatures and other sources of information consulted. cited or used in this research have been duly acknowledged in references.

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Date/Sign

## DEDICATION

My Parents: prof. and Miss. AT. Aghemelo and Mrs. Amina Agheme.

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My utmost gratitude goes to my Parents, Prof. and Mrs. AT. Aghcmelo for making my schooling their foremost priority. I would like to thank my major sulrrvisor, Dr.

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**ABSTRACT**

Aim Of this study is to investigate the effects Of aqueous extract Of Cinnamon bark on the kidney Of Wistar rat. Twenty (20) Adult Wistar rats Of weighing between I SO g•180g were used for this The rats were prvw•ured from the animal holdings Of Department Of Anatomy. School Of Basic Medical Sciences, University of Benin. Benin City. The animals were housed in the Department of Anatomy. University of Benin. Care and management Of animals was carried out in accordance with the guidelines for the care and use Of laboratory animals. The animals were allowed to acclimatize for a vxriOd Of two weeks before commencement Of experiment. The bark Of Cinnamon was purchased from the vegetable market Of "Stop to Shopv located opposite the University Of Benin. The bark was chopped into little bits and allowed to dry at room temperature. dried bark was pounded using wooden mortar and pestle and milled into fine in an electric blender. Five hundred grammes Ofthe powder were soaked in 2 liters of distilled water for 24 hours. The mixture was filtered with white filter and the residue would be separated from the filtrate. The filtrate was concentrated using Free7ß dried technique in the National Centre for Energy and Environment at the University of Bcnin. Benin City. •Ihc rats were randomly assigned into a Control group (A) and five treatment groups (B, C, and D) containing five (S) animals Rats in Group B administered With 100 mg/kg aqueous extract of Cinnamon bark; group C was administered with 200 mg/kg aqueous extract of Cinnamon bark; Group D 500 mg/kg aqueous of Cinnamon bark. Group E 1000 mg/kg aqueous extract of Cinnamon bark At the end of the exi*rimental period, the animals were sacrificed using Chloroform anesthesia and the kidney tissues were harvested and fixed in 10% buffer saline for routine histological procedure for hematoxylin and Eosin staining technique. Blood samples were collected from the descending abdominal aorta and preserved, in heparin coated tubes, for biochemical determination of Liver function tests. The data carried out using Statistical package for Social Sciences (SPSS) (version 16) rnanufactured by international Business Machine Corporation (IBM) in Armonk, New York. nie significance of the difference in the means of all parameters would determined using one-way analysis of variance (95% confidence interval). Result obtained showed that the Cinnamon extract showed that lower doses Of the extract had no deleterious effects on kidrry but however the highest dose Of 1000 mg/kg t›dy weight showed significant vascular.

# CHAPTER ONE

# INTRODUCTION

## 1.1 BACKGROUND

For centuries, different parts of plants have been used as spices in food preparation. Spices are typically dried aromatic plant materials, including seeds, fruits, roots, or bark, which are mainly added to foods to improve flavour, colour, and aroma (Savić et al., 2019). Their applications differ across cultures and countries because they are used not only in cooking but also in traditional medicine, perfumery, cosmetics, and religious practices (Bouba et al., 2012).

In recent years, the global demand for safer and healthier food products has increased significantly. As a result, spices are increasingly being explored as natural alternatives that can improve the taste, nutritional quality, and safety of foods (Ponzo et al., 2021). In some cases, they can also reduce the reliance on ingredients such as salt, sugar, and saturated fats, which are often associated with negative health effects. Additionally, spices have been reported to influence food texture and preservation (Mohammadi-Moghaddam et al., 2021).

Beyond their culinary role, many spices possess medicinal properties. Research has indicated that certain spices may contribute to the prevention or management of diseases such as cardiovascular disorders, cancer, and diabetes, while also aiding digestion (Rastogi et al., 2017; Peterson et al., 2019). Because of these beneficial effects, spices have gained importance in pharmacology, traditional medicine, and the food industry (Khanal et al., 2021).

For many years, the food industry relied heavily on synthetic additives to enhance colour, improve flavour, control microbial growth, and extend the shelf life of food products. Although these additives can be effective, prolonged or excessive consumption has been associated with certain health risks such as allergic reactions, cancer, and cardiovascular diseases (Juul et al.,

2021). Consequently, researchers have increasingly focused on natural plant-based substances that may serve as safer alternatives. Several studies have examined the nutritional, antimicrobial, and antioxidant properties of plant materials, as well as their potential to improve food preservation (Calo et al., 2015; Jayasena and Jo, 2013, 2014; Van Haute et al., 2016).

Among the many spices investigated, clove has received considerable scientific attention due to its strong antioxidant activity, which has been reported to be higher than that of many other spices (El-Saber Batiha et al., 2020). Clove is obtained from the dried flower buds of a tree that typically grows 8–12 m tall, commonly found in coastal regions at elevations of about 200 m above sea level. Traditionally, clove has been used to relieve pain, prevent nausea and vomiting, and act as an antiseptic (Batiha et al., 2020). It has also been reported to help manage gastrointestinal disorders such as stomach distension, spasms, and flatulence (Mbaveng and Kuete, 2017). In addition to its medicinal value, studies have shown that clove possesses a rich nutritional composition (Kumar-Dey et al., 2021).

Another widely studied spice is cinnamon, which contains several important bioactive compounds including cinnamaldehyde, eugenol, cinnamic acid, cinnamyl alcohol, and coumarin. These compounds contribute to its antimicrobial and antioxidant properties, making cinnamon useful in pharmaceutical applications (Kumar et al., 2019). Research has suggested that cinnamon may assist in the management of conditions such as rheumatism, neuralgia, eye inflammation, dyspnoea, vaginitis, and toothache. In the food industry, cinnamon has long been used as a flavouring agent, particularly in alcoholic beverages in Europe and in chocolate preparation in Mexico (Haddi et al., 2017).

In many African countries, especially Ghana, both clove and cinnamon are widely used in everyday life. Their buds and bark are commonly added to food as flavour enhancers and are

also used in traditional rituals and massage therapies. Their popularity in the region is largely attributed to their availability, affordability, and multiple uses.

## 1.2 STATEMENT OF RESEARCH PROBLEM

Chronic liver disease (CLD) represents a significant global health problem affecting people regardless of age, gender, ethnicity, or geographic location. It is considered one of the major causes of illness and death worldwide. Reports indicate that liver diseases rank among the leading causes of mortality related to digestive disorders, contributing to nearly two million deaths annually (Abdel-Misih, 2010).

Studies evaluating the prevalence of chronic liver disease have shown that it contributes substantially to the global burden of disease and mortality. Approximately 35 million deaths worldwide are attributed to chronic diseases each year, with liver-related conditions showing a steady rise in incidence over time. In Nigeria, viral hepatitis remains one of the most important causes of chronic liver disease.

Research indicates that 2–20% of the Nigerian population may be infected with hepatitis B or hepatitis C viruses (Vidona and Wadioni, 2018). The reported prevalence of hepatitis B infection ranges from 4.3% to 23.3%, while hepatitis C infection has been estimated between 0.5% and 15%, with variations depending on the region of the country. For instance, studies have documented prevalence rates of 4.3% in Port Harcourt, 5.7% in Ilorin, 11.6% in Maiduguri, and 8.3% in Zaria. Among pregnant women, a prevalence of 6.78% was reported in Ado-Ekiti. Higher rates have also been observed in some populations, including 13.5% in Lagos and 11.5% in Abuja among individuals living with HIV, while a seroprevalence of 23.3% has been reported among clinic attendees in Kano (Saab et al., 2016).

## 1.3 AIM AND OBJECTIIVE OF THE STUDY

The aim of this study is to investigate the effects of Aqueous extract of Cinnamon bark on the kidney of adult wistar rat. The specific objective is to determine the effects of the aqueous extract of Cinnamon bark on the histology of the kidney of wistar rat.

# CHAPTER TWO

# LITERATURE REVIEW

## 2.1 CINNAMON

The bark of different Cinnamomum species is widely recognized as one of the most valuable spices used around the world. Besides its culinary importance, cinnamon has also been utilized in both traditional and modern medicinal practices. Approximately 250 species have been identified within the genus Cinnamomum, and these trees are distributed across various tropical regions globally (Sangal, 2011; Vangalapati et al., 2012).

Cinnamon is widely employed in the flavour and fragrance industries because of its characteristic aroma. It is commonly incorporated into food products, perfumes, and medicinal formulations (Huang et al., 2007). The biological activities associated with cinnamon are largely attributed to compounds present in its essential oils, particularly cinnamaldehyde and trans-cinnamaldehyde, which contribute to both its fragrance and therapeutic properties (Yeh et al., 2013).

Research on Cinnamomum osmophloeum has shown that its leaf essential oil contains a high concentration of cinnamaldehyde. Because of this composition, the species is sometimes used as an alternative spice to Cinnamomum cassia (Chang et al., 2008). Similarly, essential oil extracted from Cinnamomum zeylanicum contains (E)-cinnamaldehyde, a compound that has been reported to exhibit antityrosinase activity, with cinnamaldehyde considered the main contributor to this biological effect (Marongiu et al., 2007; Chou et al., 2013).

In addition to essential oils, cinnamon bark contains polyphenolic compounds such as procyanidins and catechins (Nonaka et al., 1983). These procyanidins occur in both A-type and B-type linkages (Anderson et al., 2004; Peng et al., 2008; Tanaka et al., 2008). Extracts containing these compounds have demonstrated significant antioxidant properties, which may contribute to their potential health benefits (Peng et al., 2008; Tanaka et al., 2008).

Cinnamomum zeylanicum and Cinnamomum cassia, members of the Lauraceae family, are evergreen trees native to tropical regions and widely used across different cultures for medicinal and culinary purposes. The term “cinnamon” was adopted into the English language during the late fourteenth century from the Old French word cinnamone, which originated from Latin and the Greek–Phoenician term kinnamomon (Lankage, 2016).

Nutritionally, cinnamon contains minerals such as manganese, iron, calcium, and dietary fibre. It also contains several bioactive derivatives including cinnamaldehyde, cinnamic acid, and cinnamate, along with other polyphenolic compounds and antioxidants. These constituents have been associated with various biological activities, including anti-inflammatory, antimicrobial, antidiabetic, and anticancer effects. Recent studies have also suggested that cinnamon may play a role in the management of conditions such as Alzheimer’s disease, arthritis, diabetes, and arteriosclerosis (Hariri and Ghiasvand, 2016).

Additional compounds identified in cinnamon include coumarin, cinnamyl alcohol, eugenol, cinnamyl acetate, and cinnamic acid (Wang et al., 2013). Other studies have also reported the presence of several essential oil components, such as trans-cinnamaldehyde, l-borneol, caryophyllene oxide, β-caryophyllene, α-terpineol, terpinolene, and α-thujene (Tung et al., 2010). Apart from these phytochemicals, ground cinnamon contains carbohydrates, proteins, fats, fibre, moisture, and ash, as well as vitamins including A, B, C, E, and K. The exact chemical composition may vary depending on factors such as geographical origin and processing methods (Senanayake and Wijesekera, 2010).

**Figure 2.1:** image of Cinnamon bark (Wang *et al.,* 2021).

Cinnamon contains a wide range of bioactive compounds and chemical groups that contribute to its medicinal and nutritional value. These include essential oils, diterpenes, catechins,

proanthocyanidins, tannins, phenolic acids, colouring compounds, lignans, and mucilage. Many of these substances are responsible for the biological activities associated with cinnamon. In particular, the essential oils obtained from cinnamon have demonstrated antimicrobial and antifungal properties, in addition to possessing strong antioxidant activity (Perdones et al., 2014).

Studies have also shown that cinnamon essential oils may exhibit anti-inflammatory, antidiabetic, antitumor, antimutagenic, and memory-enhancing effects. Among the important active constituents are cinnamaldehyde and eugenol, which have been reported to inhibit the growth of both Gram-positive and Gram-negative bacteria (Sanla-Ead et al., 2021). According to Sharifi-Rad et al. (2021), bioactive compounds present in Cinnamomum species display several pharmacological properties, including antioxidant, antimicrobial, anti-inflammatory, antidiabetic, anticancer, and neuroprotective activities.

Despite these beneficial effects, the safety of consuming large amounts of cinnamon over a long period remains an important consideration. Research suggests that excessive intake may expose individuals to certain compounds present in cinnamon extracts. For this reason, the tolerable daily intake of coumarin has been estimated at approximately 0.1 mg per kilogram of body weight (Abraham et al., 2010). Risk assessment studies therefore emphasize monitoring compounds such as coumarin, trans-cinnamaldehyde, safrole, and styrene, which may be harmful at high concentrations.

Cinnamon bark is usually harvested twice annually, typically after the rainy seasons when the bark can be removed more easily due to increased humidity. The first harvesting generally occurs when the tree is about three years old, following pruning. During harvesting, side stems of

approximately three years of age are cut and the bark is removed. Only stems with a diameter ranging from about 1.2 to 5 cm are considered suitable for bark collection.

Before being marketed, cinnamon bark is often processed into powder form. Proper packaging is required to maintain its characteristic flavour and aroma. Moisture-resistant materials such as polypropylene packaging are recommended because they help preserve volatile flavour compounds, whereas polyethylene packaging is less suitable since aromatic components may diffuse through it (Azam-Ali, 2007).

Apart from its use as a culinary spice and flavouring agent, cinnamon is also incorporated into products such as chewing gum because of its refreshing effect and its ability to reduce unpleasant breath odour (Jakhetia et al., 2010). Some studies have suggested that cinnamon may contribute to colon health and potentially reduce the risk of colon cancer (Wondrak et al., 2010). It has also been reported to possess hemostatic properties, which may help prevent bleeding (Hossein et al., 2013), and may enhance blood circulation and tissue repair (Minich and Msom, 2008).

Furthermore, various investigations have demonstrated that cinnamon and its constituents possess numerous biological activities, including antimicrobial, antifungal, antioxidant, antidiabetic, anti-inflammatory, insecticidal, nematicidal, and anticancer effects (Chang et al., 2001; Matan et al., 2006; Kim et al., 2006; Tung et al., 2010; Lu et al., 2010). Traditionally, cinnamon has also been used in oral health care, where it serves as an ingredient in tooth powders and remedies for toothache, dental infections, and bad breath.

## 2.2 MEDICINAL USE

Cinnamon bark is widely recognized as a popular culinary spice used in many parts of the world. It is mainly added to foods as a flavouring and seasoning ingredient during cooking. Cinnamon is also used in the preparation of several food products, including chocolate, particularly in Mexico, which is known to be one of the largest importers of true cinnamon (Cinnamomum zeylanicum) (Azam-Ali, 2007). In addition, cinnamon is commonly incorporated into baked goods and desserts such as apple pies, doughnuts, and cinnamon rolls, as well as beverages like tea, hot chocolate, and certain alcoholic drinks.

In some regions, especially in the Middle East, cinnamon is frequently used in savoury dishes, including meals prepared with chicken or lamb. In the United States, it is often added to foods such as breakfast cereals, fruit-based meals, and bread products. Mixtures of cinnamon and sugar are also widely available and used as toppings for various foods. Another culinary application of cinnamon is its use as a flavouring component in pickling processes (Wang et al., 2021).

Unlike many other spices, cinnamon bark powder can be consumed directly and has long been an important ingredient in Persian cuisine. It is commonly added to soups, beverages, and sweet dishes, and is sometimes blended with rosewater or other spices to prepare sauces or curry mixtures used in stews. In addition, cinnamon powder may simply be sprinkled over desserts to enhance their flavour and aroma (Wang et al., 2021).

### 2.2.1 EFFECTS IN HUMANS

Cinnamaldehyde (CNAD), a key bioactive component of cinnamon, has been shown to protect the liver from damage. In studies involving mice infected with Salmonella typhimurium, CNAD reduced liver inflammation, oxidative stress, and apoptosis. These results suggest that

incorporating cinnamaldehyde into the diet could potentially prevent liver injury caused by bacterial infections in both animals and humans (Wang et al., 2021).

Cinnamon bark essential oils also exhibit potent antimicrobial activity. For instance, these oils can induce oxidative stress in Klebsiella pneumoniae, damaging the bacterial cells and reducing their viability (Yang et al., 2019). Similar antibacterial effects have been reported with other plant-derived essential oils, such as those from oregano. The antimicrobial mechanisms of these oils are thought to involve disruption of microbial cell membranes, inhibition of efflux pumps, increased membrane permeability, and lowered intracellular ATP levels (Aljaafari et al., 2021). Consequently, cinnamon and other essential oils hold promise as natural agents for controlling bacterial, fungal, and viral infections, with potential applications in medicine.

Traditionally, cinnamon essential oils have been used like other volatile plant oils to address digestive issues and relieve cold symptoms. Their antimicrobial properties also make them useful as natural food preservatives. Some studies have highlighted cinnamon's pharmacological benefits in managing type 2 diabetes, especially in improving insulin sensitivity, although most research has focused on Cinnamomum cassia, with fewer studies examining Cinnamomum zeylanicum.

Historically, cinnamon has been employed for oral health, including relief of toothache and bad breath, and it is believed to aid digestion and alleviate cold symptoms (Jing et al., 2018). Tea made from C. zeylanicum bark has been suggested to counter oxidative stress due to its high antioxidant content. Additionally, cinnamon may have aphrodisiac properties, and its antioxidant levels are comparable to those found in a cup of pomegranate juice or half a cup of blueberries (Jing et al., 2018).

Recent developments in nanotechnology have further enhanced the antimicrobial potential of essential oils. Nanocapsules combining cinnamon, thyme, and ginger essential oils, encapsulated in chitosan via ionic gelation, have shown long-lasting antibacterial effects against Escherichia coli, Bacillus subtilis, and Staphylococcus aureus. These composite nanocapsules could serve as effective natural preservatives for food and pharmaceutical products due to their extended activity (Jing et al., 2018).

### 2.2.2 ADVERSE EFFECTS REPORTED IN HUMANS

Several scientific investigations have demonstrated that cinnamon possesses multiple biological activities, including antimicrobial, antiviral, antifungal, antioxidant, antitumor, and antihypertensive effects. In addition, studies suggest that cinnamon may exhibit antidiabetic, gastroprotective, and immunomodulatory properties, which contribute to its importance in traditional and modern medicine (Grant-Alfieri et al., 2013).

Despite these beneficial effects, some reports have indicated that excessive or prolonged consumption of cinnamon may produce adverse reactions. The most commonly reported effects include gastrointestinal discomfort and allergic responses, although these symptoms are usually mild and resolve on their own. While cinnamon is generally regarded as safe when used as a culinary spice or flavouring agent, high doses taken for medicinal purposes should be carefully monitored to prevent potential health risks (Hajimonfarednejad et al., 2018).

Exposure to large quantities of cinnamon may also cause irritation of the mouth and throat, leading to coughing, gagging, or vomiting. Inhaling cinnamon powder can irritate the respiratory tract and may result in breathing difficulties or lung irritation (Grant-Alfieri et al., 2013). Another condition associated with cinnamon exposure is cinnamon contact stomatitis (CCS),

which is a rare reaction that may occur after consuming foods or products containing artificial cinnamon flavouring. Healthcare professionals who manage oral conditions should be aware of this reaction in order to provide accurate diagnosis and treatment (Georgakopoulou, 2010).

Cinnamon-related contact stomatitis is relatively uncommon, and its symptoms are often non-specific, making diagnosis challenging. The condition may resemble other inflammatory diseases of the oral mucosa. Patients typically develop white or reddish patches accompanied by a burning sensation in the affected areas. High concentrations of compounds such as coumarin and cinnamaldehyde have been associated with the development of oral irritation and ulcers (Vivas and Migliari, 2015).

In addition to oral irritation, excessive exposure to these compounds may also contribute to liver toxicity or reduced blood glucose levels (Deng, 2012). Furthermore, very high intake has been linked to possible cancer risks, respiratory problems, and interactions with certain medications (Abraham et al., 2010).

Although oral lesions caused by cinnamon flavouring agents are uncommon, they may sometimes go unrecognized. Patients frequently report a burning sensation in the mouth as the main symptom. Clinically, the lesions may appear as reddish patches, sometimes accompanied by keratosis or ulceration, usually affecting the buccal mucosa or the lateral surface of the tongue. In many cases, these reactions are associated with products such as cinnamon-flavoured chewing gum, and symptoms generally improve within one to two days after discontinuing the product (Allen and Blozis, 1998).

### 2.2.3 FUNGICIDAL ACTIVITY

Numerous studies have reported that cinnamon extracts and essential oils possess strong antifungal properties against a variety of plant pathogens. Early investigations demonstrated that essential oil obtained from Cinnamomum zeylanicum exhibited significant antifungal activity against important fungal species such as Botrytis cinerea and Aspergillus flavus (Wilson et al., 1997; Montes-Belmont and Carvajal, 1998). Further studies also confirmed its effectiveness against several fungal pathogens responsible for plant diseases, including Colletotrichum musae, Lasiodiplodia theobromae, and Fusarium proliferatum associated with banana infections (Ranasinghe et al., 2002). Additional research indicated inhibitory effects on fungal species such as Oidium murrayae, Colletotrichum gloeosporioides, and Fusarium oxysporum, demonstrating the broad antifungal potential of cinnamon-derived compounds (Chu et al., 2006; Barrera-Necha et al., 2008; Barrera-Necha et al., 2009).

The antifungal effectiveness of cinnamon has also been observed in the management of plant diseases affecting agricultural crops. For instance, cinnamon-based preparations have shown inhibitory effects against Rhizoctonia solani and Alternaria solani, pathogens responsible for root rot and early blight in crops such as tomato (Nguyen et al., 2009; Yeole et al., 2014). In horticultural crops, cinnamon microemulsions have demonstrated strong control activity against grey mould of pears caused by Botrytis cinerea (Wang et al., 2014). Similarly, cinnamon bark powder and aqueous extracts have been reported to reduce fungal growth and improve plant development in treated crops compared with untreated controls (Kowalska et al., 2020).

Comparative studies involving other plant extracts have shown that both clove and cinnamon extracts exhibit antifungal activity against fungal pathogens such as Botrytis cinerea. These effects are largely attributed to bioactive compounds including cinnamaldehyde in cinnamon and

eugenol in clove, which contribute to their antimicrobial properties (Oliveral et al., 2016; Sernaite et al., 2020). However, in some cases clove extracts demonstrated slightly higher inhibitory activity than cinnamon extracts at lower concentrations.

Cinnamaldehyde, a major component of cinnamon oil, has been widely studied for its role as a natural bio-fungicide. Research has shown that this compound can effectively inhibit the growth and development of several plant pathogenic fungi such as Colletotrichum lagenarium and Phytophthora capsici (Yan-Feng et al., 2015). These inhibitory effects are associated with disruption of fungal cell structures, including damage to cell walls and membranes, which ultimately prevents fungal growth.

Several studies have also demonstrated the effectiveness of cinnamon oil in controlling Fusarium species, which are responsible for serious plant diseases and mycotoxin contamination in crops. Cinnamon oil, rich in cinnamaldehyde, has been shown to inhibit the growth of Fusarium verticillioides and reduce mycelial development by causing structural damage to fungal cells (Xing et al., 2014; Xing et al., 2016). Microscopic observations revealed significant alterations in fungal morphology, including cell wall disruption, membrane disintegration, and loss of cytoplasmic contents.

Because of these properties, cinnamon oil is increasingly considered a potential natural alternative to synthetic fungicides in agriculture and food preservation. Several essential oils, including cinnamon, clove, oregano, thyme, and savory oils, have been evaluated for their ability to control fungal pathogens affecting crops such as maize and wheat. These oils have demonstrated inhibitory effects against pathogens including Penicillium spp., Fusarium spp., and Pythium spp., suggesting their possible use as organic seed treatments (Christian, 2007).

Additional investigations have confirmed that cinnamon extracts can inhibit the growth of fungi responsible for crop diseases such as crown rot in bananas and white mould in potatoes. Experimental results indicated that cinnamon extracts significantly reduced fungal growth and disease severity both in laboratory and storage conditions (Ojaghian et al., 2014; Mohammed et al., 2015). Similarly, aqueous extracts of cinnamon bark have demonstrated strong inhibitory activity against pathogenic fungi such as Alternaria alternata and Fusarium oxysporum (Fawzi et al., 2009).

Overall, these findings highlight the broad antifungal potential of cinnamon and its bioactive constituents, particularly cinnamaldehyde and eugenol. Due to their ability to inhibit fungal growth and reduce plant disease incidence, cinnamon-derived compounds are increasingly being explored as environmentally friendly alternatives to chemical fungicides in agricultural and food preservation systems.

### 2.2.4 BACTERICIDAL ACTIVITY

Research conducted by Imad et al. (2016) demonstrated that Cinnamomum zeylanicum exhibits strong antimicrobial activity, mainly attributed to the presence of E-cinnamaldehyde, a major bioactive compound in cinnamon. Their findings showed that the methanolic extract of the plant possesses both antifungal and antibacterial properties. Because of these characteristics, cinnamon bark essential oil has attracted interest as a potential natural antimicrobial agent.

However, the practical use of this essential oil is often limited by its high volatility and rapid degradation, which can reduce its effectiveness. To overcome this limitation and improve its stability, researchers have developed techniques to encapsulate cinnamaldehyde (CNAD) within

mesoporous silica nanoparticles (MSNPs). This encapsulation method helps to protect the active compound and prolong its antimicrobial activity.

In another study, the encapsulated cinnamaldehyde nanoparticles were incorporated into a sodium alginate coating applied to seeds in order to control seed-borne diseases. The treatment was evaluated against Pseudomonas syringae pv. pisi, a bacterial pathogen responsible for pea bacterial blight. Interestingly, the concentration of cinnamaldehyde used in the alginate coating was extremely low (less than 0.0000034% v/v), which is significantly lower—up to 90,000 times less—than the concentrations of free cinnamon oil previously reported to control certain bacterial infections (Bravo et al., 2018).

### 2.2.5 INSECTICIDAL ACTIVITY

Cinnamon has been recognized for its potential as a natural insect repellent. Both cinnamon oils and their constituents, particularly cinnamaldehyde, have shown insecticidal activity against a variety of pests (Haddi et al., 2017). Cinnamon leaf oil, for instance, is highly effective in killing mosquito larvae, with its major active compounds—including cinnamaldehyde, cinnamyl acetate, eugenol, and anethole—playing a key role.

Research on C. cassia bark derivatives demonstrated notable insecticidal and fumigant effects against the oak nut weevil (Mechoris ursulus). Using filter paper diffusion, trans-cinnamaldehyde caused 100% and 83.3% mortality at concentrations of 2.5 and 1.0 mg/paper, respectively. Other compounds, such as eugenol and salicylaldehyde, also showed strong insecticidal effects, while cinnamyl alcohol was less potent. Fumigation tests indicated that closed environments enhanced

effectiveness, suggesting that cinnamon's activity results from both fumigant and contact toxicity (Il-Kwon et al., 2000).

Cinnamon oil has also been applied to control thrips on onions, reducing the number of Thrips tabaci adults on treated plants (Pobożniak et al., 2016). Similarly, essential oils from C. cassia demonstrated promising activity against other agricultural pests, including the diamondback moth (Plutella xylostella), green peach aphid (Myzus persicae), and two-spotted spider mite (Tetranychus urticae), with LD50 values showing effectiveness across different extraction methods (Bueyong et al., 2017).

Studies on storage pests, such as the bean weevil (Acanthoscelides obtectus), showed that cinnamon essential oil reduced reproduction and growth, and acted as a repellent. Other pests, including the flour beetle (Tribolium castaneum), maize weevil (Sitophilus zeamais), and lesser grain borer (Rhyzopertha dominica), were similarly affected at low concentrations mixed with stored grains (Jumbo et al., 2014). Additionally, extracts from C. cassia bark and cinnamon oil were highly effective against Sitophilus oryzae and Callosobruchus chinensis, with fumigant action playing a significant role in closed containers (Soon-Il Kim et al., 2003). Cinnamon oil also deterred oviposition in Cydalima perspectalis (Szelényi et al., 2020).

### 2.2.6 NEMATICIDAL ACTIVITY

The nematicidal effects of C. cassia and C. zeylanicum oils, from both bark and green leaves, along with their chemical constituents, were evaluated against adult Bursaphelenchus xylophilus using a direct contact assay. The oils demonstrated toxicity, with LC50 values ranging from 0.084–0.085 mg/mL for cassia oil and 0.064–0.113 mg/mL for cinnamon oil. Among the 45

compounds tested, trans-cinnamaldehyde exhibited the strongest activity (LC50 = 0.061 mg/mL), followed by ethyl cinnamate, α-methyl-trans-cinnamaldehyde, methyl cinnamate, and allyl cinnamate (0.114–0.195 mg/mL). Additional compounds such as 4-methoxycinnamonitrile, trans-4-methoxycinnamaldehyde, trans-2-methoxy-cinnamaldehyde, ethyl α-cyanocinnamate, cinnamonitrile, and cinnamyl bromide also displayed significant nematicidal activity (0.224–0.502 mg/mL). These findings suggest that these cinnamon-derived compounds could serve as effective agents against B. xylophilus, the causal organism of pine wilt disease (Kong et al., 2007).

### 2.2.7 EFFECT OF CINNAMON OIL ON PLANT GROWTH

Studies have evaluated the effects of seed treatments with different concentrations of cinnamon oil and tea tree oil on the field emergence and yield of parsley var. Berlinska and lettuce var. Ewelina. Cinnamon oil was found to reduce emergence in both species, with the strongest negative effect observed at a 15% concentration. In contrast, tea tree oil, tested at 55% and 70% concentrations, did not show toxicity and even improved field emergence, particularly for lettuce. Similar trends were noted for the rate and uniformity of emergence, with 15% cinnamon oil reducing the number of emerging plants in both crops (Orzeszko-Rywka et al., 2012).

Laboratory and greenhouse experiments investigated the allelopathic effects of essential oils from cinnamon, lavender, and peppermint on the germination of Mediterranean weeds, including Amaranthus retroflexus, Solanum nigrum, Portulaca oleracea, Chenopodium album, Sinapis arvensis, Lolium spp., and Vicia sativa. Essential oils were applied at four concentrations under controlled conditions (0.2, 0.6, 1.8, and 5.4 mg/L) and semi-controlled greenhouse conditions (5.4, 21.6, 86.4, and 345.6 mg/L). In controlled conditions, concentrations of 1.8 and 5.4 mg/L completely inhibited germination. Under greenhouse conditions, 345.6 mg/L of cinnamon oil fully suppressed the germination of Amaranthus retroflexus. Overall, the concentration of the oil

had a stronger influence on weed susceptibility than the type of oil, though cinnamon oil showed particularly strong inhibitory effects.

The use of essential oils as natural herbicides has been highlighted for sustainable agriculture because of their biodegradability, low environmental persistence, and safety for vertebrates, birds, fish, and mammals, making them valuable agents in plant protection (Cavalieri and Caporali, 2010).

## 2.3 ORGAN OF STUDY

### 2.3.1 KIDNEY

Kidneys are a pair of excretory organs situated on the posterior abdominal wall, one on each side of the vertebral column. The kidneys are reddish-brown in color and it is well protected by muscles, fats and ribs. The right kidney is slightly lower than the left kidney due to the presence of the liver. For men, the weight of each kidney ranges from 125–175 g, whereas for women it is 115–155 g. A fibrous capsule made of dense, asymmetric connective tissue covers them directly, keeping them protected and helping to maintain their shape. They measure roughly 11–14 cm in length, 6 cm in width, and 4 cm in thickness. Surrounding this capsule is a robust renal fascia, which is encased in a shock-absorbing layer of adipose tissue known as the renal fat pad. Strong anchoring of the kidneys to the posterior abdominal wall in a retroperitoneal position is provided by the fascia and, to a lesser extent, the peritoneum that covers them. Each kidney is bean shaped.it has superior and inferior pole, medial and lateral borders, anterior and posterior surfaces.

### 2.3.2 SUPERIOR AND INFERIOR POLE OF THE KIDNEY

The superior pole of each kidney is broad and is in close contact with the corresponding Suprarenal gland, their inferior poles are pointed.

### 2.3.3 SURFACES OF THE KIDNEY

The kidneys have their anterior and posterior surfaces. The anterior surface faces towards the anterior wall of the abdomen whereas the posterior surface is facing the posterior abdominal wall. The major convexity laterally and small concavity medially of the kidney serve as the margins dividing these surfaces. The kidney's hilum, which is where the ureter and renal vein exit the kidney and the renal artery enters, is marked as the center of the minor concavity.

### 2.3.4 BORDERS

The medial and lateral margins of the kidney are present. The medial border is concave, while the lateral border is convex, pointing toward the postero-lateral wall of the abdomen.

The medial border of the kidney contains a landmark called the hilum of the kidney, which is the entry and exit point for the kidney vessels and ureter. The most superior vessel is the renal vein which exits the kidney, just under it is the renal artery that enters in, and under the artery is the exiting ureter.

### 2.3.5 HISTOLOGY

The kidney is composed of two primary layers: the outer cortex and the inner medulla, which together contain roughly a million nephrons responsible for urine production. The renal cortex surrounds the medulla and extends into the fibrous capsule, forming columns that separate the renal pyramids of the medulla. The cortex houses the glomeruli as well as the proximal and distal convoluted tubules of the nephrons. Collecting ducts pass from the cortex into the medulla, eventually emptying into the renal papillae, the pointed tips of the pyramids.

Blood supply to the cortex is rich, with cortical radiate (interlobular) arteries branching from the arcuate arteries at the corticomedullary junction. These arteries give rise to afferent arterioles, which deliver blood to the glomeruli. Filtered blood exits via the peritubular capillaries in the

cortex and the vasa recta in the medulla, eventually draining into cortical radiate veins and arcuate veins.

The medulla appears striated due to the parallel arrangement of tubules and collecting ducts. Each renal pyramid, along with the surrounding cortical tissue, forms a renal lobe, which is further divided into lobules. Multiple nephrons converge into a single collecting duct within each lobule.

The functional unit of the kidney, the nephron, consists of a renal corpuscle and a renal tubule. Nephrons are classified as cortical or juxtamedullary based on the location of their corpuscles and the length of their tubules. The renal corpuscle filters blood, forming an ultrafiltrate that enters the tubules. The glomerulus is a capillary network within the corpuscle, surrounded by Bowman's capsule, which consists of visceral and parietal layers. Specialized podocytes in the visceral layer wrap around capillaries, forming filtration slits that allow water and small solutes to pass while retaining cells and large proteins.

The nephron loop (loop of Henle) in the medulla regulates water and salt reabsorption via its descending and ascending limbs, which are lined with simple squamous epithelium. Collecting ducts carry urine from multiple nephrons through the medulla to the minor calices via the papillary ducts of Bellini. Epithelial lining varies: cortical ducts are simple columnar, medullary ducts are simple cuboidal, and papillary ducts are simple columnar.

The juxtaglomerular apparatus (JGA) regulates kidney function and blood pressure. It consists of macula densa cells in the distal tubule, granular juxtaglomerular cells in the afferent arteriole, and extraglomerular mesangial cells, which interact to modulate filtration and renin release.

### 2.3.6 BLOOD SUPPLY TO THE KIDNEY

Each kidney receives blood from a single renal artery, which branches laterally from the abdominal aorta. The left and right renal arteries arise just below the superior mesenteric artery, with the left typically positioned slightly higher than the right. To reach the right kidney, the right renal artery passes behind the inferior vena cava, whereas the left artery travels a shorter route to the left kidney. Additional accessory renal arteries may also supply the kidneys, and collectively these vessels are known as extrahilar renal arteries.

Upon entering the kidney at the hilum, the renal artery divides into anterior and posterior branches. The anterior branch further subdivides into five segmental arteries, each serving a specific kidney segment, while the posterior branch supplies the kidney's posterior region. Segmental arteries then branch into interlobar arteries, which continue to form arcuate arteries at the corticomedullary junction. From the arcuate arteries, interlobular arteries emerge, eventually giving rise to afferent arterioles that deliver blood to the glomeruli for filtration. This extensive branching highlights the kidney's rich vascular network.

### 2.3.7 NERVES SUPPLY TO THE KIDNEY

The renal plexus innervates the kidneys. This plexus receives information from the parasympathetic neural system via the vagus nerve, as well as from the sympathetic nervous system via the lower thoracic splanchnic nerves, which regulate vascular tone.

Because the kidney's sensory nerves connect to the spinal cord at levels T10–T11, flank pain consistently raises the possibility that the associated kidney isn't functioning properly.

# CHAPTER THREE

# MATERIALS AND METHOD

## 3.1 ANIMAL CARE AND MANAGEMENT

Adult Albino rats, weighing between 180-200 g, were purchased from the animal holdings of Ambrose Ali University, Ekpoma. The animals were housed in the Department of Anatomy, University of Benin, Benin City. Care and management of animals was in accordance with the guidelines for the care and use of laboratory animals. The animals were allowed to acclimatize for a period of two weeks before commencement of experiment.

## 3.2 COLLECTION AND EXTRACTION OF PLANT MATERIAL

The root of *Annona muricata* was obtained from the Farm project of the University of Benin. The root of *Annona muricata* were air dried at room temperature for 8 weeks. The dried specimen was chopped into smaller bits using a pestle and mortar and into fine powdered form using a laboratory miller. The powdered specimen was divided into three portions. Each portion weighed 500 g and was mixed with 1000 ml of distilled water. The mixture was filtered using laboratory filter paper (Whatman No.10) with cotton wool plug. The filtrate was placed on a rotary evaporator for extraction at 40$^{o}$C. The extract from each portion was weighed using an electric weighing scale. The extract was then stored in a refrigerator at -2$^{o}$C. A portion of the pasty extract was dissolved in an aqueous solution (water) daily and administered to the experimental animals.

## 3.3 EXPERIMENTAL DESIGN

Animals were randomly assigned into a Control group (A) and three treatment groups (B, C, and D) containing five (5) animals each. Animals in Group B were administered with 500 mg/kg body weight of *Annona muricata* extract only; Group C were given 5 mg/kg body weight of *Lead acetate* only; Group D animals were administered with 500 mg/kg body weight

of *Annona muricata extract and 5 mg/kg body weight of Lead acetate.* The weight of animals was taken daily, using a top loader weighing balance, throughout the experimental period and the difference in weight was determined.

### 3.4 ANIMAL SACRIFICE

At the end of the experimental period, the animals were sacrificed by cervical dislocation and the kidney tissues were harvested and fixed in 10% buffer saline.

### 3.5 TISSUE PROCESSING

The tissues were trimmed to about 3-5mm thick sections and processed according to method of Drury and Wallington (1980). They were dehydrated for one hour each at room temperature through ascending grades of ethanol: 70 % ethanol, 90 % ethanol, Absolute ethanol 1 and Absolute ethanol 11. The dehydrated tissues were cleared at room temperature in two changes of Xylene for one hour in each change. The tissues were infiltrated in two changes of molten paraffin wax multi block plastic embedding mould. The paraffin blocked tissues were then be trimmed and mounted on wooden chalk for sectioning on a rotary microtome. Sections of 5 micrometers thickness were produced from the tissue blocks using a rotary microtome (Bright B5143, Huntington, England). The sections were transferred into water bath at (40 °C) to allow spreading of the folded ribbons of sections. These sections were mounted on clean glass slides and they would be dried at 40 ºC on a slide drier to enhance adherence of the sections of the slides. Hematoxylin and Eosin staining procedures as described by Drury and Wallington (1980) would be adopted.

### 3.7 HEMATOXYLIN AND EOSIN STAINING

Paraffin wax is poorly permeable to stain; the sections were deparaffinized in two changes of xylene for two minutes in each change. Xylene was removed because it does not mix freely

with aqueous solution and low grades of alcohol used in preparing stains. Thus, sections were then hydrated using a series of descending grades of alcohol until water is used. The purpose of this process is to prepare the tissue to stain with a dye that has been dissolved in an aqueous solvent. Procedures of H& E as described by Drury and Wallington (1980) and Scheehan and Hrapchak (1980) was adopted as follows:

a) Sections were dewaxed in two changes of xylene for two minutes in each change.
b) Sections were rehydrated in descending grades of alcohol (absolute I, absolute II, 95 %, 90 %, 70 %, and 50 % ethanol) for two minutes each.
c) Sections were rinsed in distilled water for three minutes.
d) Sections were stained in hematoxylin for 15 – 20 minutes.
e) Excess hematoxylin stain were removed by rinsing well in running tap water for two to three minutes (sections would be examined microscopically at this stage to confirm sufficient degree of staining).
f) Sections were differentiated in acid alcohol (0.5 % HCL in 70 % ethanol) for two to three seconds. The blue staining of hematoxylin changed to red by the action of the acid.
g) Sections was then rinsed well in running tap water for 10 – 15 minutes to remove excess differentiator and regain the blue color of the sections as observed with the naked eye.
h) Sections were counter stained in 1% aqueous eosin for two to four minutes.
i) Excess stain were washed off in running tap water and examined under microscope.
j) Sections were dehydrated rapidly in ascending grades of ethanol (50% through absolute ethanol), cleared in xylene and mounted in a synthetic resin medium (DPX) using clean glass cover slip.

### 3.7 PHOTOMICROGRAPHY

Histological sections were examined under Leica DM750 research microscope with a digital camera (Leica ICC50) attached. Photomicrographs of the tissue sections were taken at x 100 and x 400 magnifications.

# CHAPTER FOUR

# RESULT

### 4.1: HIISTOLOGY

Result showed that Cinnamon extract at various doses does not have any deleterious effect on the histoarchitecture of the kidney of wistar rats. However, there was marked congestion of the vessels that supply the kidney parenchyma.

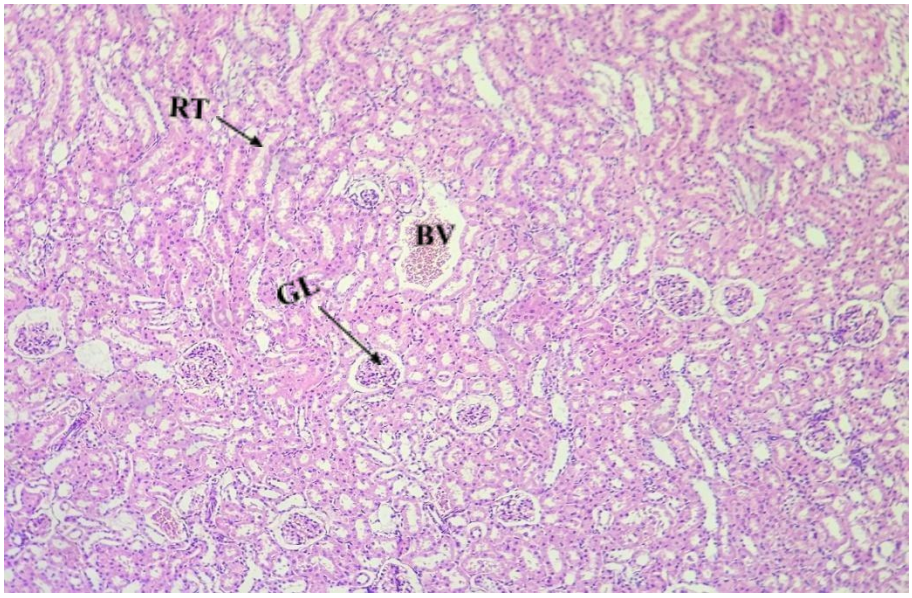


**Plate 4.1:** Micrograph of kidney of rats in Control (group A): GL-Glomerulus; RT- Renal Tubule; BV-blood vessel; H&E x 100

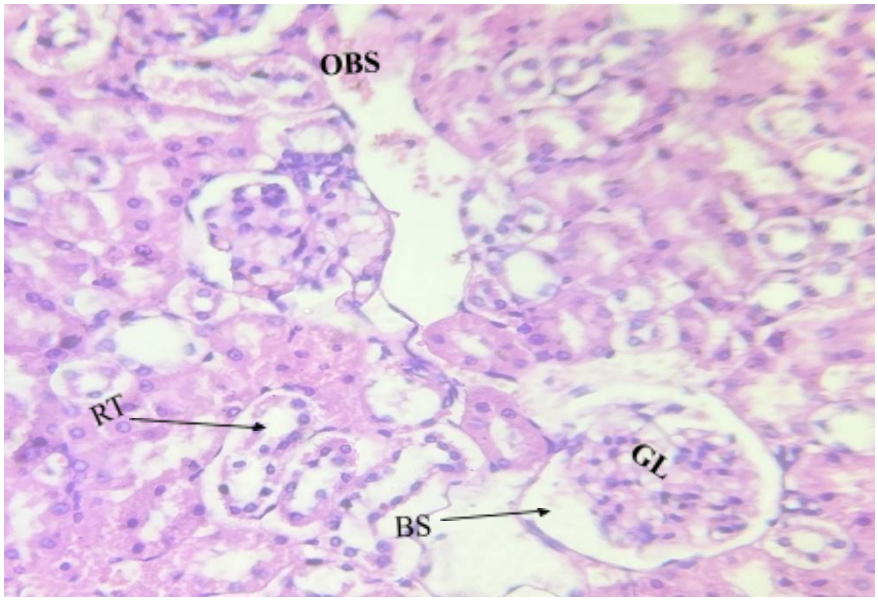


**Plate 4.2:** Micrograph of rat kidney in control group A: RT- Renal tubule; GL- Glomerulus; BS – Bowman's space; H&E x 400

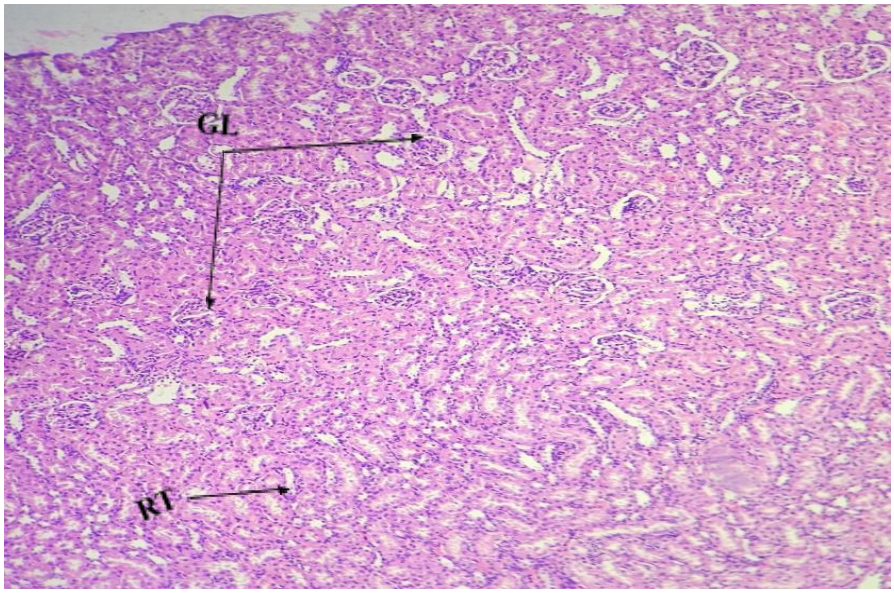


**Plate 4.3:** Micrograph of kidney of rats treated with 100 mg/kg body weight of Cinnamon extract (group B): GL-Glomerulus; RT- Renal Tubule; BV-blood vessel; H&E x 100

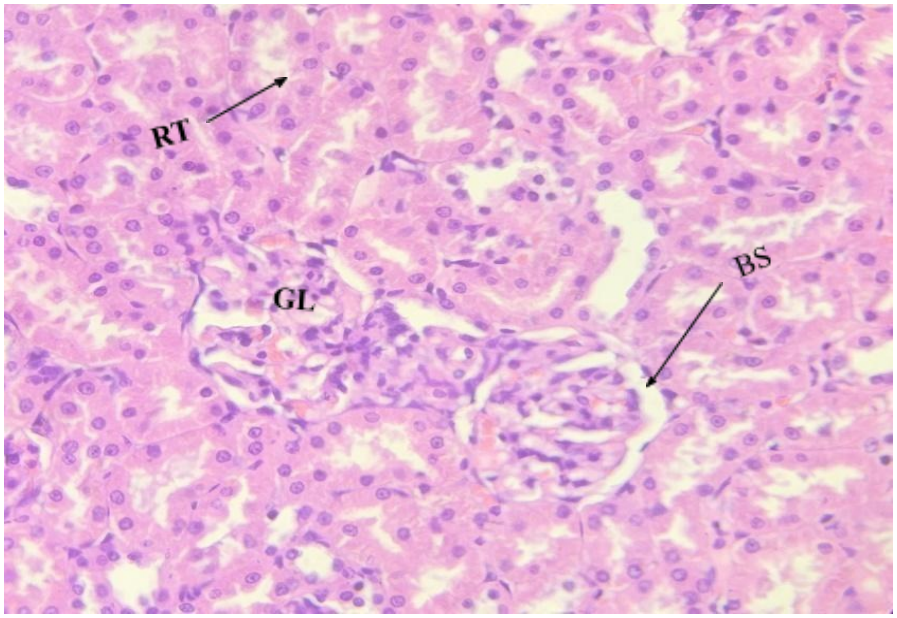


**Plate 4.4:** Micrograph of kidney of rats treated with 100 mg/kg body weight of Cinnamon extract (group B): GL-Glomerulus; RT- Renal Tubule; BV-blood vessel; H&E x 400

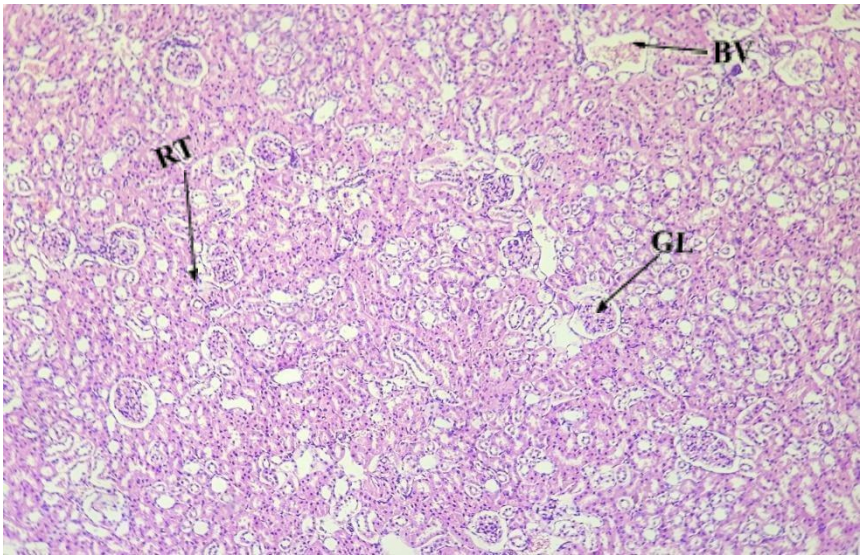


**Plate 4.5:** Micrograph of kidney of rats treated with 200 mg/kg body weight of Cinnamon extract (group C): GL-Glomerulus; RT- Renal Tubule; BV-blood vessel; H&E x 100

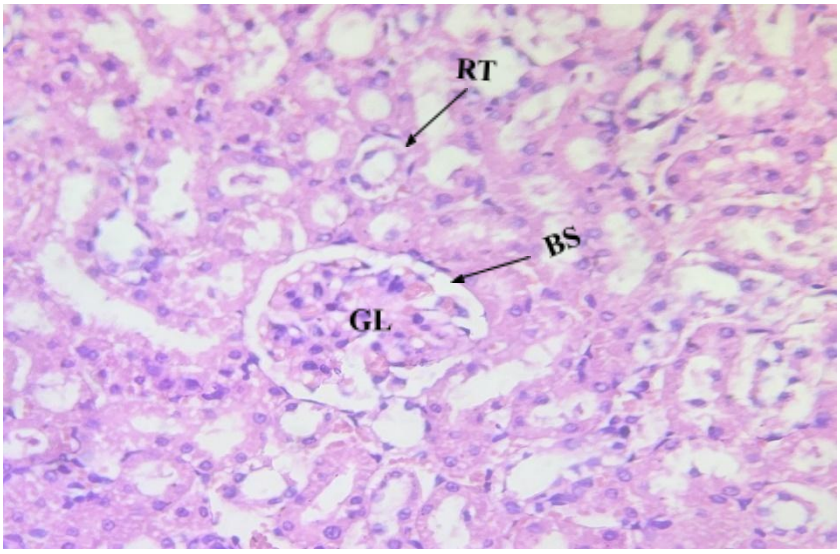


**Plate 6:** Micrograph of kidney of rats treated with 200 mg/kg body weight of Cinnamon extract (group C): GL-Glomerulus; RT- Renal Tubule; BV-blood vessel; H&E x 400

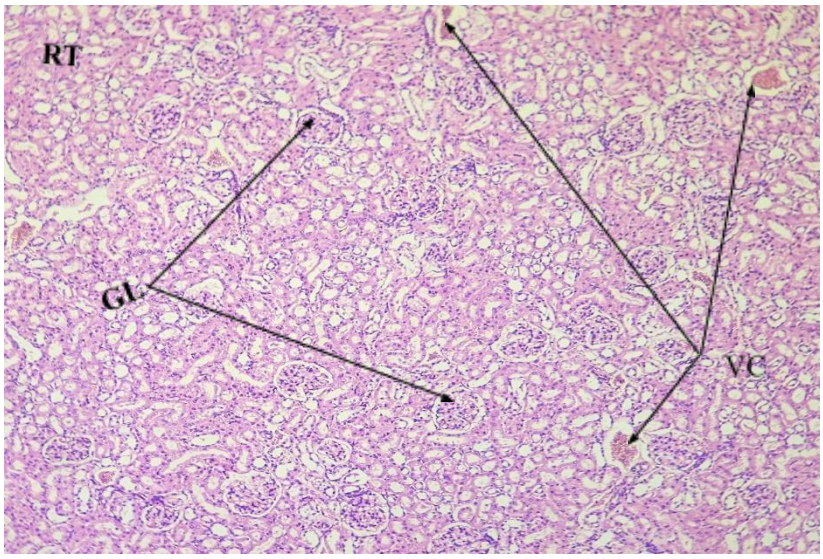


**Plate 4.7:** Micrograph of kidney of rats treated with 500 mg/kg body weight of Cinnamon extract (group D): GL-Glomerulus; RT- Renal Tubule; VC-vascular congestion; H&E x 100

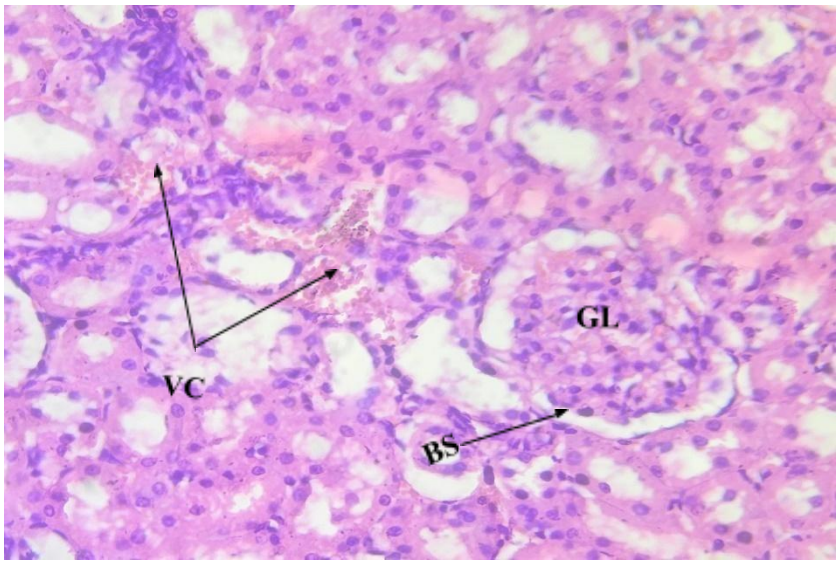


**Plate 4.8:** Micrograph of kidney of rats treated with 500 mg/kg body weight of Cinnamon extract (group D): GL-Glomerulus; RT- Renal Tubule; VC-vascular congestion; H&E x 400

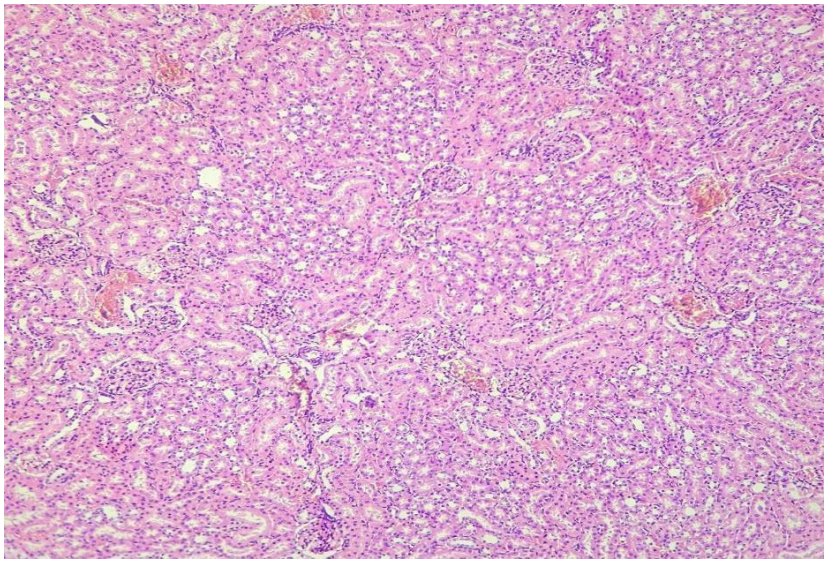

**Plate 4.9:** Micrograph of kidney of rats treated with 1000 mg/kg body weight of Cinnamon extract (group E): GL-Glomerulus; RT- Renal Tubule; VC-vascular congestion; H&E x 100

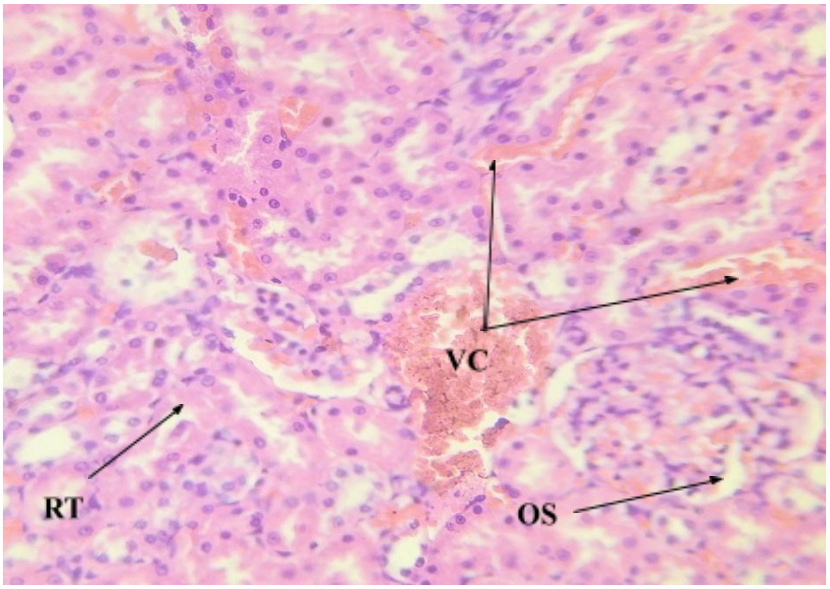


**Plate 4.10:** Micrograph of kidney of rats treated with 1000 mg/kg body weight of Cinnamon extract (group E): RT- Renal Tubule; VC-vascular congestion; OS - obliterated Bowman's Space; H&E x 400

# CHAPTER FIVE

## DISCUSSION

In this study, we explored the effects of varied doses of aqueous extract of Cinnamon bark on the kidneys of wistar rats following oral treatment. Although animals treated with Cinnamon bark extract showed no obvious signs of distress during the experimental period, they appeared to be less active and alert compared to the control group. There were no clear differences between the skin colors of the groups. As far as the histopathological studies were concerned, they showed degenerative changes and atrophy in renal tissues of the rats treated with Cinnamon bark in this study and this was exacerbated in the group receiving highest dose.

More so, Cinnamon is reported to be used for the treatment of diabetes, attributable to the phenolics contained therein, and it is possible that its beneficial role in diabetic nephropathy treatment is plausible. For renal markers of injury (ketones, proteins, and albumin) as well as qualitative histological evaluations, these derangements were more prominent with the higher dose of Cinnamon. In agreement with our study, other studies reported toxic side effects on the renal tissue, which subsequently impacted renal function (Vasanth and Kurian, 2017), but this does not agree with studies by Luo *et al.* (2013) and Yan *et al.* (2015), possibly due to the fact that refined active compounds were tested directly or perhaps due to the differences in the experimental design as some were tested on animals in diabetic states. Although our study did not report antioxidant markers, Cc has been reported to be rich in type A polyphenols, demonstrated to be responsible for improvements in fasting glucose even in clinical trial subjects

(Anderson *et al.,* 2008). The extract has also shown a significant ameliorative role in the antioxidant system in response to elevated levels of titanium dioxide nanoparticles or titanium dioxide bulk salt-induced oxidative stress with restoration of the histological damages in rat livers treated with titanium dioxide nanoparticles or titanium dioxide bulk salt (Shakeel *et al.,* 2017).

In conclusion, our findings revealed that Cinnamon extract caused injury to the kidneys in normal healthy rats. The toxic effects appear appeared dose-related. It is recommended that detailed immunological and electron microscopic evaluations of the tissues be carried out alongside other markers of kidney injuries (biochemical assays for enzymes) in order to clearly establish specific alterations according to the dosage used.

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