1.0 INTRODUCTION

1.1 Background to the Study

The cement industry is one of the seventeen most environmentally polluting industries listed by the United States Central Pollution Control Board (Worrell *et al.*, 2001). During the last few decades, the emission of dust and gases from cement industries has increased two-folds due to expansion in the cement industries to meet the high demand for cement for infrastructure (Raajasubramnran *et al.*, 2011). Dust and gas emissions from cement production facilities contain toxic elements, which pose a significant threat to the environment and humans (Bilen, 2010). Typical cement dust contains calcium, silicon, aluminum, manganese, zinc, and iron (Fell *et al*., 2010); in addition, cement dust produced from kilns fueled by burning of hazardous wastes may contain heavy metal, dioxin, particulate and chromium (Gbadebo and Bankole, 2007). The burning of waste as fuels and calcination of limestone may also produce sulphur dioxide, nitrogen dioxide, and carbon dioxide (Ade-Ademilua and Obalola, 2008; Akinola *et al*., 2008). The majority of these elements, when above regulatory limits, become potentially harmful to the biotic and abiotic components of the environment. These elements also have been implicated in many diseases, including respiratory, genetic, and blood diseases, skin and eye defects, multiorgan damage, and cancer (Meo, 2004).

The severity of injury caused by cement dust on animals depends on the composition, size and concentration of the dust. Other factors include how much dust is inhaled, the species of the exposed animal and its stage of development (Heather, 2003). A single short-term exposure to cement dust is not likely to cause serious harm. However, exposure of sufficient duration to cement dust can cause irreversible tissue destruction in the form of chemical burns, including third-degree burns (Davidovids, 1994). Acute effects such as eye, nose, and upper respiratory tract irritation, cough, expectoration, shortness of breath and wheezing have been recorded in humans due to exposure to cement dust (Lanqui *et al.*, 2001).

Decrease in red blood cell count of workers exposed to cement dust over a sufficient duration has also been reported (Calistus *et al.,* 2002). Marked histological damage has been observed in individuals exposed to cement dust (Zeleke *et al.,* 2010).

Despite the health hazards of cement dust, cement remains indispensable in the building industry attributable to its superiority to other materials. In fact, the discovery of Portland cement by a British bricklayer, Joseph Aspdin, in 1824, marked a turning point in history owing to its availability, durability, and reliability when compared to previously available building materials (Carey, 2005). Therefore, the health effects of cement dust must be mitigated in order to sustain the growth of the cement industry.

Several strategies have been employed to solve the effects of cement dust exposure. These methods include using efficient dust-filters and dust-collectors, planting trees to serve as dust-stoppers, planning settlements outside the coverage areas of cement dust, and using modern machines and technologies (Jan and Joachim, 1999). Other methods include using synthetic detoxifiers (for example, milk, and multivitamins), and incorporation of legislation against using hazardous waste as fuel (Jan and Joachim, 1999). But most of these strategies have not shown much success (Mojimoniyi *et al.,* 2007). The failures of these strategies are due to the lack of funds, strategy technicalities, weak environmental protection laws, and the nondisclosure attitudes of some cement manufacturers (Briggs, 2003). Consequently, pollution from cement plants remains a persistent problem with attendant health risks.

Some archaeological evidence shows that some phytonutrients such as milk thistle (*Silybum marianum*), red clover (*Trifolium pratence*), and dandelion (*Taraxacum officinale*) have been used to prevent or remove toxins from the body (Mindell, 1992). Milk thistle has been used for more than 2, 000 years as herbal remedy for various ailments, particularly liver and gall bladder disorders (Mindell, 1992). Several studies suggest that substances in milk thistle, especially a flavonoid called *Silymarin*, can protect the liver from toxins. *Silymarin* has antioxidant and antiinflammatory properties and may help the liver repair itself by growing

new cells. Laboratory studies also suggest that *Silymarin* and other active substances in milk thistle may have anticancer effects, which can stop cancer cells from dividing and reproducing (Agarwal, *et al.*, 2006). Moreover, red clover contains isoflavone, which may help protect against heart disease, stop cancer cells from growing, treat skin problems, and treat coughing (Kuhn and Winston, 2008). The dandelion also has antioxidant properties, and its roots and leaves are used to treat liver, kidney, skin, and eye problems (Kuhn and Winston, 2008).This study evaluates the effectiveness and potential of some food plants in reducing the effects of cement dust on rats living near cement factories.

1.2 Statement of the Research Problem

- There is a need to sustain the growth of cement industry owing to its affordability, durability, acceptability, reliability, and availability compared to previously available building materials.
- The health of people living around cement plants must not be compromised by cement production activities.
- To enhance sustainable development in the cement industry, the health effects of cement dust exposure on humans and animals must be mitigated.
- An effective strategy is necessary because conventional pollution prevention and control strategies in the cement industry have not been effective.
- With the current trends in plant-based nutrition, there is an urgent need to evaluate the chemopreventive and bioprotective efficacy of some food plants.

1.3 Aim of the Study

The aim of this study is to ameliorate the health effects of cement dust exposure on rats using phytonutrients.

1.4 Purpose of the Study

The purpose of the present research is to evaluate the efficacy of selected food plants on rats exposed to cement dust.

1.5 Objectives of the Study

The objectives of this study include the following: To

- determine the phytonutrients and phytochemicals present in the selected food plants
- evaluate the ameliorative efficacy of the plant extracts on morphology and some physical characteristics of rats exposed to cement dust.
- assess the chemopreventive efficacy of the plant extracts in rats exposed to dust
- evaluate the bioprotective and prophylactic efficacy of the plant extracts on haematological and biochemical parameters of rats exposed to cement dust.
- assess the cell-rebuilding efficacy of the plant extracts on lung, liver, and kidney tissues of rats exposed to cement dust.
- determine the protective efficacy of the plant extracts on the purity of the DNA of exposed rats.

1.6 Significance of the Study

The findings of the study will help prevent or ameliorate several health problems associated with cement dust exposure. This will enhance sustainable growth in the cement industry so that the industry can grow unhindered, and the health of local residents is not compromised.

1.7 Operational Definition of Terms

- **Abiotic**- non living components of the ecosystem.
- **Biotic**-living components of the ecosystem.
- **Acute toxicity (LD_{50})** – a dose that will kill half of the population of the rats treated with the plant extracts.

- **Antioxidant**- substances that may protect cells from the damage caused by unstable molecules known as free-radicals.
- **Bioprotective**- protective effects of the plant extracts on the cells, tissues, and organs of the exposed rats.
- **Chemopreventive**- prevention of accumulation of toxic elements in the tissues of the exposed rats.
- **Gerontology**-the scientific study of the biological, psychological, and sociological phenomena associated with old age and aging.
- **Hepatoprotective**- ability to protect damage to liver.
- **Haematinic**- ability to increase the haemoglobin of the blood.
- **Hazardous waste**- waste that has a substantial or potential threats to the public health or the environment.
- **Inbred**- the offspring produced from the mating of two genetically related parents.
- **Litter-** a litter is the number of offspring produced at one birth by a female animal.
- **Mixture-** combination of the crude extracts of the four selected food plants.
- **Normoglycemic**- the presence of a normal concentration of glucose in the blood.
- **Oxidative stress**- is a general term used to describe the steady state level of oxidative damage in a cell, tissue, or organ, caused by the reactive oxygen species (ROS). This damage can affect a specific molecule or the entire organism.
- **Phytochemicals**- are biologically active chemical compounds that occur naturally in plants.
- **Phytonutrients-** are nutrients derived from plant materials that have been shown to be necessary for sustaining human life.

1.8 Abbreviations and Acronyms

- **AAS-** Atomic Absorption Spectroscopy.
- **ALP**- Alkaline Phosphate.
- **ALT-** Alanine Amino Transferase.
- **APCM-** Associated Portland Cement Manufacturers.
- **AST**- Aspartate Amino Transferase.
- **ATSDR-** Agency for Toxic Substances and Diseases Registry.
- **BPA-** Breathe Pure Air.
- **CCPA-** Canadian Concrete Pipe Association.
- **CSRRC-** Cork Screw Road and Rural Community.
- **CVD-** Cardio Vascular Diseases.
- **EDTA-** Ethylenediaminetetraacetic acid (anti-coagulant).
- **EIA-** Environmental Impact Assessment.
- **EPA-** Environmental Protection Agency.
- **FoE-** Friends of the Earth.
- **GDP**- Gross Domestic Product.
- **GSH-** Reduced Glutathione.
- **HB-** Haemoglobin.
- **HCL-** Hydrochloric Acid**.**
- **H_2SO_4**- Sulphuric Acid.
- **IARC-** International Agency for Research on Cancer.
- **INTERCEM-** International Cement Manufacturer.
- **IPC**- Integrated Pollution Control.
- **KSA-** Kansas State University.
- **LUH-** Lagos University Herbarium.

- **NTP-** National Toxicology Program.
- **NAOH**- Sodium Hydroxide.
- **NIGERCEM**- Nigeria Cement Company.
- **OSHA**- Occupational Safety and Health Administration.
- **PCV**- Packed Cell Volume.
- **RBC**- Red Blood Cells.
- **RDA**- Recommended Dietary Allowances.
- **RDL**- Randox Laboratory.
- **RGR**- Relative Growth Rate.
- **RMC**- Rinker Materials Corporation.
- **ROS**- Reactive Oxygen Species.
- **RPM**- Revolution Per Minute.
- **UNICEM**- United Cement Manufacturers.
- **USEPA**- United States Environmental Protection Agency.
- **USFDA**- United States Food and Drug Administration.
- **WAPCO**- West African Portland Cement Company.
- **WBC**- White Blood Cells.
- **WHO**- World Health Organization.

2.0 LITERATURE REVIEW

2.1 Discovery of Ordinary Portland cement

Ever since civilization started to build, man has sought for a material that would bind stones into a solid mass (CCPA, 2004). The Assyrians and Babylonians used clay for this purpose, and the Egyptians advanced to the discovery of lime and gypsum mortar as a binding agent for building such structures as the pyramids. The Greeks made a further improvement, which was built upon by the Romans to develop cement that produced structures of remarkable durability (Lea, 1971). Most of the building foundations in the Roman Empire were constructed of a form of concrete. The great Roman baths (Built about 27 B.C), the Coliseum, and the huge Basilica of Constantine are examples of early Roman architectures in which cement mortar was used (CCPA, 2004).

The secret of Roman success in making cement was traced to the mixing of slaked lime with pozzolana, a volcanic ash from Mount Vesuvius. This process produced cement capable of hardening under water. During the middle ages, this art was lost, and it was not until the scientific spirit of inquiry revived that the secret of hydraulic cement was rediscovered (CCPA, 2004). Later, repeated structural failure of the Eddystone Lighthouse off the coast of Cornwall, England, led John Smeaten, a British Engineer, to experiment with mortars in both fresh and salt water. In 1956, these tests led to the discovery that cement made from limestone containing a considerable proportion of clay would harden under water. Making use of this discovery, he rebuilt the Eddystone Lighthouse in 1759, and it stood for 126 years before replacement was necessary (Lea, 1971). Large quantities of cement were then produced by burning a naturally-occurring mixture of lime and clay. The cement produced was called natural cement because its ingredients were mixed by nature, and its properties varied as widely as the natural resources from which it was made. However, in 1824, Joseph Aspdin, a bricklayer in Leeds, England, took out a patent on hydraulic cement that he called Portland cement. This is named because its colour

resembled the stone quarried on the Isle of Portland off the British coast (Lea, 1971). The Aspdin's method involved the careful proportioning of limestone and clay, pulverizing them, and burning the mixture into clinker, which was then ground into finished cement (Lea, 1971). Portland cement today, as in Aspdin's day, is a predetermined and carefully proportioned chemical combination of calcium, silicon, iron, and aluminum. Natural cement gave way to Portland cement, which is a predictable, known product of consistently high quality (CCPA, 2004). In Aspdin's day, Portland cement was not popular and its acceptability was not encouraging. Aspdin later established a plant in Wakefield to manufacture Portland cement, some of which was used in 1826 in the construction of the Thames River Tunnel. However, it was almost 20 years later when J. D. White and sons set up a prosperous factory in Kent that the Portland cement industry saw its greatest period of expansion. During this period, cement industries were built not only in England, but also in Belgium and Germany. Today, about 98 % of the cement produced in the United States is Portland cement (CCPA, 2004).

2.2 The Entry of Portland cement Into Nigeria Economy

The establishment of cement manufacturing company in Nigeria was initiated by the colonial government in 1950. This time, the government invited the Associated Portland Cement Manufacturers (APCM), later renamed Blue Circle Industries, to establish a plant in Nigeria. However, APCM spent about two years surveying Nigeria's limestone deposits and then decided not to go ahead with the plant (Esubiyi, 1995).

In 1954, the government convinced the Danish cement-equipment manufacturer, F.L. Smidth, and the firm's British associate, Tinnel Portland Cement Company, to enter a joint venture to build a cement-manufacturing plant in Nigeria. In 1957, the plant was built in Nkalagu, in Eastern Nigeria, and the company was named the Nigerian Cement Company (Nigercem). About a month later, APCM, in partnership with the United African Company and the Western Nigerian Development Corporation, formed West

African Portland Cement Company (WAPCO). The plant commenced production at Ewekoro in 1959 (Esubiyi, 1995). A few years after the formation of WAPCO, a clinker plant was set up to grind imported clinker and gypsum with an installed capacity of $0.6x10^6$t/year, but closed down within three weeks because of a lack of a technical expertise. After independence in 1961, Federal and Regional governments' participation in cement industry and manufacturing became more pronounced because it was considered politically expedient to participate in the ownership of industrial enterprises. In 1962, the Northern Government commissioned a German firm, Ferrostahl A.G, to install an integrated cement plant in Sokoto; in 1964, the Eastern Government commissioned a cement plant in Calabar; and in 1965, the Midwestern Region commissioned Continho Caro for the construction of a cement plant in Ukipilla. This pattern continued with the establishment of Ashaka Cement Company and Benue Cement Company, and by 1978, there were seven cement manufacturing companies in Nigeria (Esubiyi, I995).

In 1978, at the peak of the oil boom, the Federal Government went into a joint venture with Benin Republic to build a plant at Onigbolo in Benin. The philosophy behind this international collaboration was that some of the cement produced would be sold in Nigeria, which has a large market for it (Esubiyi, 1995). In 1979, West African Portland Cement Company Sagamu, Ogun State was commissioned and became operational (Esubiyi, 1995).

In order to meet the growing demand of the Portland cement in the country, the Federal government privatized the industry in the year 2003. There has been a vigorous expansion of capacity since 2006, with Obajana Cement Company (Dangote Group) commencing production in 2007. Benue Cement (renamed Dangote Group) increased its capacity from an estimated 0.45 million to 2 million in 2008, and now some 2.9-3.0 million tons, as a result of successive additions to its capacity. In 2010, United Cement Manufacturer (UNICEM) was commissioned and has added 2.5 million tons of capacity, while Lafarge

WAPCO also increased its available production by 2.2 million ton in 2011 (Furnivall and Abidoye, 2009).

Employment categories in the Nigerian cement industry range from the professional grades (the works, mechanical, production, electrical, and process engineers), to the skilled grades (the mechanists, pipe-fitters, welders, kiln mechanics, and kiln burners), to administrative staff, to unskilled labour (Esubiyi, 1995). All the cement manufacturing firms in operation in Nigeria were set up with a technical partner. These partners furnished the initial expertise needed for operations, so the proportion of expatriate personnel in most of the cement companies was initially high. However, with the implementation of the Nigeria enterprises promotion decrees of 1972 and 1977 and determined efforts to train Nigerians, the cement industry now has many Nigerians in its management and professional cadres (Esubiyi, I995).

Nigerian cement industry has a very good economic potential. As a major input provider, it provides linkages to other sectors of the economy, especially building and construction. Such linkages enhance physical and infrastructural development. The cement industry is a major regional employer of labour and contributes significantly to the country's Gross Domestic Product (GDP). Between 1981 and 1997, for example, about 27 percent of the total contributions of the manufacturing sector to the GDP were attributed to the cement industry, and this increased at a rate of two percent average per year, compared to only one percent of the entire manufacturing sector (INTERCEM, 2008).

In 2008, the Nigeria Cement Industry had an estimated market size of ₦36 billion (US $2.4 billion), or in aggregate consumption terms, 13.4 million ton, of which 46 % (6.2 million ton) was produced in Nigeria. However, the federal ministry of commerce and industry estimates that effective demand for cement in the year was around 18 million ton. As a result of increasing demand of cement for infrastructure and housing, domestic production volumes have grown at 25 % over the last four years. Hence, it was anticipated

that demand will remain strong, with industry growth averaging between 12 % and 15 % in 2009 and 10 % -12 % in 2010, despite the weak economic environment (Furnivall and Abidoye, 2009).

2.3 Typical Constituents of Portland cement

Several factors determine the chemical and physical properties of cement dust, and as such, the use of the term 'typical' cement dust when comparing different cement factories can be misleading. This is because cement varies markedly in chemical, mineralogical, and physical composition from factory to factory (Klemm, 1993). However, to provide a general reference point, typical cement dust contains calcium oxide, silicon dioxide, aluminum trioxide and iron oxide (Abdul-Wahab, 2006; Akpan *et al*., 2011; El-Abssawy *et al*., 2011**).**

2.3.1 Physical Properties of Portland cement

Boiling point	-	Not applicable
Vapour pressure	-	Not applicable
Vapour density	-	Not applicable
Solubility in water	-	Slightly soluble (0.1 - 1.0 %) in water
Appearance and odour	-	Whitish or grey powder and odourless
		(RMC, 2001)

2.3.2 Chemical Properties of Portland cement

Specific gravity	-	Normal range (1.5 - 2.9)
Melting point	-	Not applicable
Evaporation rate	-	Not applicable
pH (in water)	-	12- 13
		(RMC, 2001)

2.4 Toxic Substances in Cement Dust and Health Risks

The conventional fuels for Portland cement production are coal, oil, and natural gas (FoE, 1997). However, in the search to become commercially competitive, many Portland cement companies are now burning hazardous wastes as 'alternative fuel' to reduce costs (Cyrus and Fernando, 1997). Toxic elements that may be found in cement dust fueled by burning of hazardous wastes include:

2.4.1 Dioxins

Dioxins are found in emissions from tyre-burning kilns (CSRRC, 2003). The World Health Organization (WHO) has recently classified dioxins as the worst-known human carcinogens. Dioxins can also affect the immune system, fertility, and the unborn child. Owing to these reasons, the United States of America has reduced their safety levels for dioxins repeatedly. The United States Environmental Protection Agency (USEPA) concluded that the exposure to dioxins, even at minute levels, poses cancer risks and other health problems than previously suspected (CSRRC, 2003).

2.4.2 Particulate Matter

Particulates are extremely small particles that enter the lungs directly because they are too tiny to be filtered out. Particulate matter in cement dust poses less of a risk for cardiovascular diseases (CVD) than does smoking, obesity or inactivity. However, because of the large number of people affected and duration of exposure, the risk translates into a substantial increase in total mortality, thus representing a meaningful public health problem (Gollub, 2005). Numerous scientific studies have linked particle pollution exposure to various health problems such as irritation of the airways, coughing, difficulty in breathing, decreased lung function, bronchitis, and premature death in people with heart or lung disease (USEPA, 2011). Children and older adults with heart or lung diseases are the most likely to be affected by particulate pollution exposure. Nevertheless,

healthy individuals may experience temporary symptoms from exposure to elevated levels of particle pollution (USEPA, 2011).

2.4.3 Heavy Metals

Exposure to heavy metals can pose serious health problems. The exposure of a pregnant woman to lead can cause developmental problems in the fetus and the neurological development of the child, including its future intelligence (Cyrus and Fernando, 1997). Exposure to lead has also been implicated to cause basophilic stippling, nucleated red blood cells (RBC), decreased RBC, and anaemia of microcytic and hypochromic types (Chandralatha, 2003; ATSDR, 2005). Exposure to cadmium can affect the kidney, liver, and lung, causing histological damage and cancer (Jim, 2000). Mercury exposure at high concentrations can cause permanent damage to the brain, kidney, and fetus development. The nervous system is especially sensitive to the effects of mercury, provoking irritability, nervousness, trembling, vision and hearing loss, and memory problems (Cyrus and Fernando, 1997).

Chromium is a known carcinogen that can cause acute health problems such as eye irritation, lung allergies, and flu-like illness (Martin and Griswold, 2009). Long-term exposure to chromium may result in lung cancer, damage to liver, kidney, and gastric systems (Kimbrough *et al.*, 1999). In animal studies, high level of chromium affects the respiratory system and a lower ability to fight diseases was noted. Some of the male mice that were given chromium (VI) or chromium (III) in the laboratory by mouth had decreased number of sperms in the testes (Sidney, 2006).

2.4.4 Silica

Silica in the form of crystalline quartz and as a component of cement is listed as a potential carcinogen by the International Agency for Research on Cancer (IARC), National Toxicological Program (NTP), and Occupational Safety and Health Administration (OSHA). The NTP indicates that crystalline silica (respirable size) is a

known human carcinogen (group 1). International Agency for Research on Cancer (IARC), reported that there is sufficient evidence of carcinogenicity of crystalline silica to experimental animals, and on selected epidemiological studies of workers exposed to crystalline silica (RMC, 2001). There are reports suggesting that excessive crystalline silica exposure may be associated with adverse health effects involving the kidney, scleroderma (thickening of the skin caused by swelling and thickening of fibrous tissue), and other auto-immune disorders. Several studies of persons with silicosis also indicate an increased risk of developing lung cancer, a risk that increases with duration of exposure (RMC, 2001).

2.4.5 Aluminum

Aluminum is not considered to be a heavy metal like lead, but it can be toxic in excessive amounts and even in small amounts if it is deposited in the brain (ATSDR, 2005). Many of the symptoms of aluminum toxicity mimic those of Alzheimer's disease and osteoporosis (ATSDR, 2005). Aluminum toxicity can cause colic, rickets, gastrointestinal problems, interference with the metabolism of calcium, extreme nervousness, anaemia, headaches, and decreased liver and kidney function (ATSDR, 2011). Other health problems of aluminum exposure include memory loss, speech problems, softening of the bones, and aching muscles (ATSDR, 2008).

2.4.6 Gas Emissions

Exposure to carbon monoxide from cement production can negatively impact the central nervous system, and along with nitrogen oxides and sulphur dioxide, irritate the respiratory system (Cyrus and Fernando, 1997). In addition, exposure to the poisonous gases can aggravate the symptoms of people with lung diseases (asthma, chronic bronchitis). Exposure to these pollutants can also increase cardiac and circulatory problems (Cyrus and Fernando, 1997).

2.5 Economic Impact of Citing a Cement plant in an Environment

Barbara Wilson, a realtor in Sherman, United Kingdom, reports losing sales and prospective sales due to the possibility of citing a cement plant in Grayson County, where she made most of her sales. She stated that buyers know that it is undesirable to live near a cement plant, they also know that heavy industry attracts other heavy industries, and that there will be more and more of this in the area once it gets started. She added that the customers are concerned about the potential health problems of living near a cement plant as well as the loss of quality life (CSRRC, 2003). Another realtor, Mary Stevens, a multimillion dollar producer from Allen (Colling County) reports that a prospective buyer was absolutely committed to buying a house in Colling County until the news of the possibility of citing a cement plant in the community surfaced in the year 2003 (CSRRC, 2003). Furthermore, one Whitewright family in the United Kingdom had plans to open a business in downtown Whitewright, an area that is in need of important services such as a printer and shoe repair store, but this family immediately canceled these plans when the possibility of citing a cement plant in the environment surfaced (CSRRC, 2003). Generally, there is no place in the world that is home to a cement plant and would be considered a nice neighborhood, one a family would look forward to living in or near because of the health risk (CSRRC, 2003).

2.6 Conventional Pollution Prevention and Control Strategies in Cement Industries.

Conventional pollution prevention and control strategies in cement industries are capital intensive and involve several steps:

2.6.1 Before Citing the Factory

Environment Impact Assessment (EIA) of the proposed cement factory must be conducted. An independent consultant should be contracted to assess and study the scope of the factory, and identify possible environmental, social, and economic impacts of the

future activities of the cement plant (Cyrus and Fernando, 1997). The company will then appoint a well-qualified staff to supervise all relevant activities leading to pollution reduction. The appointed manager will serve as a focal point for further cooperation with the Environmental Protection Agency (EPA) and other agencies that will be working to improve the environmental performance of the cement plant.

The company must come up with a policy and, in conjunction with the environment protection agency, should spell out its mode of operation, parameters of the proposed factory, the type of fuel it will use (including hazardous wastes), and equipment in place for preventing or reducing emissions. Permission must be sought from the Environment Protection Agency (EPA) before burning wastes as fuels (FoE, 1997). Cement plants should also be located far away from residential areas depending on the capacity of the cement plant (Yang *et al.*, 1996).

2.6.2 After Citing the Factory

New machinery and technologies must be installed in the factory throughout and must be efficient. Efficient dust-filters must always be used, and packaging plants should be well equipped. Storage and transportation must be fast, and in no circumstance should dust allow to accumulate. Special attention should be given to alkali and chemical emissions. Oil in the factory should be collected and removed promptly. Dust extracted through the precipitations must be treated by fanning through the treatment plant into a reactor where it is treated with diluted sulphuric acid. The end product is put into storage where it is recycled through the cement mill (Cyrus and Fernando, 1997).

2.6.3 Use of Dust Collectors

There is a wide selection of application for Industrial Dust-Collectors. One industrial environment that requires serious dust collection is a cement plant (BPA, 2008). These dust control systems help meet or exceed regulatory requirements by providing low particulate matter emissions levels. By minimizing localized dust emissions these units

help protect both workers and plant equipment. The smooth operating system allows for faster and better-controlled cement production (BPA, 2008).

A variety of high efficient fabric filters have been used by cement manufacturers in their dust collectors for decades. The fabric filtration involves filtration of particulate matter, gravity settling of the dust cake and removal of dust from the dust collector (BPA, 2008). Fabric filters are used in different areas of cement production such as cement kilns, finish mills, material handling systems and bagging. The majority of cement production plants has between forty to eighty (40 – 80) separate filter controls systems (BPA, 2008). To ensure safety, employees should be careful to follow the entire manufacturer's instruction to properly operate and maintain their dust collection system. There are also government regulations and individual cement plant safety rules to be adhered to. This cannot be emphasized enough because of the serious health problems that can occur from being exposed to cement dust (BPA, 2008).

2.6.4 Personal Hygiene

Cleanup personnel should protect against cement dust inhalation and contact with wet cement. Spilled materials where dust can be generated must be avoided or packed promptly because it may expose cleanup personnel to respirable dust containing crystalline silica. Methods such as vacuuming (with appropriate filter) or wet mopping should be used in cleaning to minimize dust dispersion. Dry materials must be scooped carefully into suitable containers for disposal or reclamation. Wet or unhardened cement should be recycled or allowed to harden and disposed. Dusty clothing or wet clothing with cement fluids must be removed promptly and launder before reuse. Wash thoroughly after exposure to cement dust or wet cement mixtures (RMC, 2001).

2.7 Causes of the Failure of Conventional Pollution Prevention and Control Strategies in Cement Industries.

Conventional pollution prevention and control strategies in cement industries have not shown much success, especially in developing worlds. The failure of these strategies is due to lack of funds, strategy technicalities, weak environmental protection laws and concealment of facts by cement manufacturers (Singh and Pandey, 2011).

2.7.1 Lack of Funds

In developing countries, poverty has been a major hindrance to effective pollution prevention and control. Even in developed countries like United Kingdom and United States of America, pollution prevention and control have not been 100 percent successful with large proportions of annual national budgets allocated to pollution control. According to a researcher from Kansas State University, United States spend more than $ 4.3 billion annually on freshwater pollution mainly from agricultural runoff, well over $ 50 billion annually on pollution from automobiles and more than $ 234 billion yearly on industrial pollution (KSU, 2008).

2.7.2 Strategy Technicalities

Pollution prevention and control strategies in cement industry require a lot of processes. Prevention reduces or eliminates the use of chemical in products or processes while control strategy entails the capture, collection and appropriate storage of undesired chemicals from products. These processes are highly technical and require trained personnel who are not readily available, especially in developing countries (Durfee, 1999).

2.7.3 Concealment of Facts by Cement Manufacturers

In March 1997, The American Independent Environment Committee reported serious inadequacies in the way air pollution monitoring, and data analysis have been conducted. Analysis carried out by the independent consultant found that emissions of pollutants from

kilns burning wastes were often far greater than those burning coals and coke alone, which has been consistently denied by government monitoring Agencies. For example, in August 1995, the independent monitoring recorded 490 mg m^{-3} of particulates at a school downward Castle Cement plant in Clithroe in England against the 70 mg m^{-3} officially reported at the plant. When Douglas Bryce, head of Integrated Pollution Control (IPC) at the American Environment Agency, was asked why the Agency recorded the lowest set of readings of heavy metals from Castle Cement compared to the independent consultant, he replied merely that it all depends on the circumstances (FoE, 1997).

2.7.4 Weak Environmental Protection Laws

Weak environmental protection laws are a major problem of pollution control, mostly in developing countries. For instance, China passed the first version of its Environmental Protection Law in 1979. As of 2007, the Chinese government has enacted another 26 laws related to environmental protection, which are supported by more than 2, 000 regulations and decrees (Wang, 2007). These laws have established a legal framework supporting China's efforts to achieve environmental reform and sustainable development. However, the key pollution control legislation has been generally ineffective in mitigating serious violations of environmental law due in part to weak provisions for the effective punishment of violators within the laws and overly powerful local governments that prioritize economic growth over environmental protection (Wang, 2007).

2.8 Emergency and First Aid Procedures for People Exposed to Cement Dust.

The following are guidelines specified for administering First Aid to people exposed to cement dust (RMC, 2001).

2.8.1 Dry or Wet Cement in Eyes

Gently lift the eyelids and flush immediately and continuously with water until transported to an emergency medical facility.

2.8.2 Cement Dust on Wet Skin

Quickly remove contaminated clothing. Rinse the skin with water for at least 15 minutes. Rinsing the exposed area with dextrose water may slow the hardening process. For reddened or blistered skin, consult a physician.

2.8.3 Inhalation of Dust

Remove exposed person to fresh air and support breathing as needed. Consult a physician immediately if irritation persists.

2.8.4 Ingestion

If cement is ingested, the person should be given 4 to 8 oz of water or milk to drink. An unconscious or convulsing person must not be given anything by mouth. A physician must be consulted immediately.

2.9 History of Plant Medicine

Plant medicine, also called phytomedicine, refers to the use of seeds, berries, roots, leaves, bark or flowers from plants for medicinal purposes. Plants have been used for medicinal purposes long before recorded history (Steven, 2011). Ancient Chinese texts and Egyptian papyri describe medicinal uses of plants as early as 3, 000 BC. Africans and Native Americans used herbs in their healing rituals, while others developed medical systems such as Ayurveda and traditional Chinese medicine in which herbal therapies were used (Steven, 2011).

In the early 19th century, when chemical analysis first became available, scientists began to extract and modify the active ingredients of plants. Later, chemists began making their own versions of plant compounds and, over time, the use of herbal medicines declined in favour of these synthetic drugs. However, in the past 20 years in the United States, high cost of prescription medications, combined with an interest in returning to natural remedies, has led to an increase in herbal medicine use (Steven, 2011). Recently, the World Health

Organization estimated that 80 % of people, worldwide, rely on herbal medicines for some part of their primary health care (Steven, 2011).

2.10 Constituents of Medicinal Plants

2 .10.1 Phytonutrients

Phytonutrients are nutrients such as minerals and vitamins derived from plants. Studies have shown phytonutrients to be necessary for sustaining human life (Harper, 2011). The variety of phytonutrients is wide, and they are found in fruits, vegetables, legumes, grains, nuts and teas. High amounts can be obtained from fruits and vegetables, which have strong colours. Phytonutrients work in different ways and have different functions, which help maintain a healthy body. Some of them are antioxidants and help protect the body cells from oxidative damage, thus decreasing risk of some cancer types. They provide a good source of vitamin A and enhance immune response. Phytonutrients are also linked with prevention or treatment of diabetes and heart disease. Scientists have shown that consumption of vegetables and fruits have an important role in reducing risk for heart disease (Jackie, 2009).

2.10.2 Phytochemicals

Phytochemicals are used interchangeably with phytonutrients, however, phytochemicals are nonnutritious natural chemicals formed during the plants' normal metabolic processes (Okigbo *et al*., 2009). Classes of phytochemicals include the alkaloids, flavonoids, coumarins, glycosides, lycopenes, gums, carotenoids, polysaccharides, phenols, tannins, terpenes, and terpenoids (Okwu, 2004).

2.11 Nutritional and Medicinal Values of the Selected Food Plants

2.11.1 Roselle (*Hibiscus sabdariffa* Linn)

Roselle belongs to the family Malvacea and has more than 300 species, distributed in tropical and subtropical regions around the world (Wong *et al*., 2002). It is an annual herb

cultivated for its leaves, stem, seed, and calyces (Umerchuruba, 1997). Most hibiscus species are used as ornamental plants, but some are believed to have certain medicinal properties (Yadong *et al.,* 2005). Roselle is a highly acidic fruit with low sugar content and contains predominantly, succinic and oxalic acid. Roselle was found to contain a higher amount of ascorbic acid than orange and mango (Wong *et al.,* 2002). A hundred gram serving of frozen roselle would supply 100 % of current recommended dietary allowances (RDA) of 20 mg per day and is found to be a fair source of vitamin A (Holden *et al.,* 1999). Roselle is also rich in riboflavin, niacin, calcium, and iron (Babalola *et al.,* 2000; Pietta, 2000; Fasoyiro *et al.,* 2005). Antioxidants found in roselle include flavonoid, gossypetine, hibiscetine and sadderetine (Bako *et al.,* 2009).

Many parts of roselle are of value: the young leaves are eaten as cooked vegetables, especially with soup; the seeds are pounded into meal, which is used as oily soup or sauce after roasting; oil extracted from the seed is a substitute for castor oil; and the residue is used as soup cake (Aliyu, 2000). In countries like India, roselle calyces are utilized in producing refreshing beverages, jellies jam, and food preservatives (Clydesdale *et al.,* 1997). In Nigeria, the dried roselle calyces are prepared into refreshing drink called 'zobo.' The drink is becoming popular because it is easily processed at home and served chilled, packaged in plastic bottles or polythene films and serves as an income generation source for many women (Aliyu, 2000). Roselle is valued for its mild laxative effect and for its ability to increase urination, attributed to two diuretic ingredients, ascorbic acid, and glycolic acid. Owing to its citric acid content, roselle is used as cooling herb, providing relief during hot weather by increasing the flow of blood to the skin's surface and dilating the pores to cool the skin. The leaves and flowers of roselle are used as a tonic tea for digestive and kidney functions. The heated leaves are applied to cracks in the feet and on boils and ulcers to speed maturation. The ripe calyces, boiled in water, can be used

as a drink to treat bilious attacks. A lotion made from roselle leaves is used on sores and wounds (Yadong *et al*., 2005).

2.11.2 Moringa (*Moringa oleifera* Lam)

Moringa oleifera belongs to the family *Moringaceae.* Moringa is the most widely cultivated species of the family and is native to the Himalayan tribe of India, Pakistan, Bangladesh, and Afghanistan. This rapidly-growing tree was utilized by the ancient Romans, Greeks, and Egyptians but has been naturalized in many locations in the tropics (Fahey, 2005). All parts of the moringa tree are edible and have been consumed by humans. Many uses of moringa include biomass production, animal forage, biogas, domestic cleaning agent, blue-dye, fertilizer, foliar nutrient, green manure, and gum (Fahey, 2005). Three nongovernmental organizations, "Trees for Life", "Church World Service", and "Educational Concerns for Hunger Organization", have advocated moringa as natural nutrition for the tropics. Moringa leaves can be eaten fresh, cooked or stored as dried powder for many months without refrigeration, and reportedly without loss of nutritional value. According to the "Tree for Life Organization characterization", ounce-for-ounce moringa leaves contain more vitamin A than carrots, more calcium than milk, more iron than spinach, more vitamin C than an orange, and more potassium than a banana, and that the protein quality of moringa leaves rivals that of milk and egg (Fuglie, 1999; 2000). This plant family is also rich in compounds containing the simple sugar, rhamnose, and it is rich in a fairly unique group of compounds called glucosinolates and isothiocyanates (Bennett *et al.*, 2003; Fahey *et al.*, 2005). According to Hartwell (1971), the flowers, leaves, and roots of moringa are used in folk remedies for tumors, the seeds for abdominal tumors and the root decoction is used in Nicaragua for dropsy. Root juice is applied externally as counter-irritant. Moringa leaves are applied as a poultice to sores, rubbed on the temples for headaches, and said to have purgative properties. The barks, leaves, and roots are acrid and pungent, and are taken to promote digestion. Oil from

moringa is somewhat dangerous if taken internally, but is applied externally for skin diseases. The bark of moringa is regarded as antiscorbic, and exudes a reddish gum with properties of tragacanth, sometimes used for diarrhea. The roots are bitter, act as a tonic to the body and lungs, and are emmenagogues, expectorant, mild diuretic and stimulant in paralytic afflictions, epilepsy, and hysteria (Duke, 1983). The antioxidants in moringa include the carotenoid, niazimicin, and ptergospermin **(**Fuglie, 2000; Akhtar and Ahmed, 2005). Moringa also contains blood-forming minerals and nutrients such as calcium, zinc, potassium, sodium, magnesium, and vitamins (Cajuday and Pocsido, 2009). Moringa contains a flavonoid known as *Silymarin*, which has been observed by scientists to be anticancer and antiinflammation (Anwar *et al.*, 2007).

Despite the plethora of oral history of nutritional and medicinal importance of moringa, there is little or no scientific proof to back these claims (Duke, 1983; Fahey, 2005). Furthermore, in modern medicine, the benefits of the plant for the prevention and treatment of disease or infection that may accrue from either diet or topical administration of moringa preparations (for example, extracts, decoctions, poultices, creams, oils, emollients, salves, powders, porridges) are not quite so well known (Palada, 1996).

2.12.3 Ginger (*Zingiber officinale* Roscoe)

Ginger belongs to the family Zingiberacea and has been prized for centuries for its benefits to human health and well-being (Smith, 2010). Ginger originated in Asia, and was used widely as both a culinary and a medicinal herb in not only Asia but Indian and Arabic traditions as well. Ginger can grow approximately two to three feet tall, has sword-like leaves, and yellowish-green flowers, with leaves growing from a cane. The aromatic rhizome is the part that is used for both medicinal and culinary applications. Although ginger rhizome is commonly referred to as root, it is a misnomer, as it is actually a form of plump underground stem, not a true root. The rhizome may be used fresh, cooked in food or steeped as a tea. Its volatile oils, for example, gingerol and shogoal, may be distilled or

dried and ground and used in capsules or other powdered forms (Smith, 2010). In the Asian medicine tradition, ginger is considered to have warming attributes; it is favoured as a remedy for digestive ailments ranging from an upset stomach to diarrhea to abdominal bloating due to excessive gas, and nausea. It is therefore, frequently served as a condiment with greasy or fatty foods. Furthermore, it is believed that ginger is useful in the treatment of heart, circulatory, and menstrual problems, and is used to treat migraine headaches and arthritis as well. Ginger is also appreciated for its value as a stimulant, enhancing the flow of saliva, making it a beneficial treatment of maladies of the throat, such as laryngitis and sore throat (Smith, 2010). Modern conventional medicine is beginning to explore how ginger can be used to relief patients suffering from a range of illnesses. For example, there are a number of studies under way investigating ginger's role as an antiemetic and its potential for use in helping alleviate the symptoms of nausea and vomiting in patients undergoing chemotherapy. It may also reduce post-surgical nausea and vomiting, motion sickness, and prenatal morning sickness. Other studies show possible support for ginger's benefits in helping to ease the joint pains of various inflammatory conditions. However, more research and clinical trials will be necessary to obtain conclusive evidence. Ginger is available in capsules, tablets, liquid extracts and tinctures, and powders, as well as in teas, cookies such as ginger snap, and candies. Gingers may also be used raw. Although the use of small amounts of fresh ginger as in quantities consumed in ordinary culinary use is considered to be generally safe, dried, powdered, and extracted forms of gingers are considerably stronger and require more careful dosing. People suffering from gallstones or gallbladder disease should avoid ginger. Ginger may interact with certain medicines used to treat cancer, proton pump inhibitors, and blood thinners. Pregnant women may need to avoid consuming ginger in quantity. In any of these cases, a physician should be consulted before use (Smith, 2010). The bioactive compounds in ginger such as gingerol, eugenol, polyphenol, tannins, and flavonoids are useful in conditions such as cancer, arthritis, and

heart diseases (Shirin-Adel and Prakash, 2010). Studies have shown that pretreatment of rats with ethanolic extracts of ginger are effective in ameliorating carbon tetrachloride and acetaminophen (paracetamol) -induced acute hepatoxicity (Yemitan and Izegbu, 2006).

2.11.4 'Ugwu' (*Telfairia occidentalis* Hook-f)

'Ugwu' plant belongs to the family known as Cucurbitacea, and has been associated with man since 12, 000 BC (Esquinas-Alcazor and Gulick, 1983). 'Ugwu' is cultivated across lowland humid-tropics of West Africa, especially in Nigeria where it is one of the most common leaf vegetables consumed, mainly for their nutritional values (Axtell and Fairman, 1992). Common examples of plants in this family are cucumber, watermelon, pumpkin, squash, and melon (Jeffrey, 1990). New cultivars, which are better, being elongated and seedless seems to have replaced earlier forms of the plants (Jeffrey, 1990). The fruits of 'ugwu' are inedible but the leaves and seeds (without hulls) contain 21.2 % and 35.7 % protein, respectively and are edible to both man and animals (McGrath *et al*., 1989). The pharmacological importance of this family of plants is ample: Momocharin and luffaculin are two abortifacient proteins isolated from the plants from this family with ribosome-inhibiting properties, which have been used to induce second trimester abortion (McGrath *et al*., 1989). A third protein is trichosanthin (from *Trichosanthes* s*pecies*), which has demonstrated the capacity to inhibit the multiplication of human immunodeficiency virus (HIV) within lymphocytic and phagocytic cells (McGrath *et al*., 1989). Similarly, the aqueous extract of 'ugwu' has been shown to be hepatoprotective against garlic-induced oxidative stress (Oboh, 2005), while its ethanolic extract has demonstrated hypoglycemic properties both in normoglycemic and alloxan-induced diabetic rats (Schalm *et al.*, 1975). Aqueous extract of 'ugwu' plants has also been shown by scientists to increase the concentration of the haematological parameters, suggesting that the 'ugwu' extracts have hematinic properties (Oyeyemi *et al.*, 2008). 'Ugwu' contains antioxidants such as iron and vitamins, and its extracts are used in managing liver

problems and impaired immune systems (Eseyin *et al.*, 2005). Studies have shown aqueous and ethanolic extracts from the dark-green leaf of 'ugwu' to suppress or prevent the production of free-radicals and scavenge already produced free-radicals (Iweala and Obidoa, 2009; Kayode and Kayode, 2011). If young leaves of 'ugwu' plant are sliced and stored in a bottle to which coconut water and salt are added, it can be used for the treatment of convulsions in ethno medicine (Gbile, 1986).

2.12 Importance of Rats in Biomedical Research

Rats are the most commonly used experimental animals after mice, accounting for about 20 % of the number of animals used for scientific purposes (Festing, 1979). Since the last century, rats have been utilized in investigations in almost every aspect of biomedical research and testing, including toxicology, tetralogy, oncology, gerontology, cardiovascular research, immunology, dental research, immunogenetics, and parasitology. Rats are also the most widely used animals in behavioral studies, and they have been the animals of choice in nutrition research (Baker *et al*., 1980).

2.11.1 Wild Rats (*Rattus rattus* Linnaeus)

Rattus rattus, also known as roof rat, is believed to be native to India and possibly other IndoMalayan countries, but has been introduced through human travel overseas to all continents (Grzimek, 2003). *R. rattus* thrives in tropical regions and could adapt to extreme harsh climate conditions, and disturbed environments. It is most common in coastal areas as well as on large ships (Grzimek, 2003).

R. rattus is a medium-sized rat with relatively large ears and a tail that is nearly always longer than the body. Individuals weigh between 70 and 300 g, and are between 16 and 22 cm in head and body and a tail length of 19 cm or more. Males are longer and heavier than are females. Many members of the species are black with a lighter coloured ventral belly. The species is often divided into subspecies based upon colour patterns, which can occur

in any combination of black, white, grey, and agouti. The skull and nasal bones are relatively narrow. One of the main ways to differentiate between *R. rattus* and *R. norvegicus* is that *R. rattus* has a finer hair covering, a lighter skull, and a slightly differently shaped upper first molar (Allen, 1938; Corbet and Southern, 1977; Grzimek, 2003).

R. rattus often has smaller territories, and its home range is never more than about 100 m^2 (Nowak, 1999). The small home range is the most important characteristic that makes the rat suitable for this research because it confined the rats to the vicinity of the cement factory and nonmigratory.

2.11.2 Albino Rats (*Rattus norvegicus*)

Rattus norvegicus, otherwise called albino rat, is an inbred strain of its wild species, *R. norvegicus* (*B*). *R. norvegicus* are calmer, less likely to bite, can tolerate overcrowding, breed earlier, and produce more offspring than the wild rats. All these characteristics make albino rat a good choice for scientific research. Albino rats have been used as laboratory animals in such studies as cancer, pharmacology, neuroscience, transplantation, physiology, immunology, genetics, and aging research (George, 2000).

3.0 MATERIALS AND METHODS

3.1 Materials

3.1.1 Description of the Study Site

The Shagamu Cement Company is one of the oldest and second largest cement companies in Nigeria. The company was built in 1979 along Shagamu-Ikorodu motorway, about 2 km from Shagamu. Shagamu is a nodal city in Ogun State in South Western Nigeria on latitude 6° 5^{1} N and longitude 3° 6^{1} E (Akinola *et al.*, 2008). There are animal and human populations around the company predominantly factory workers, artisans, traders, and farmers (figure 1).

3.1.2 Sources of Animals

3.1.2.1 Wild Rat (*R. rattus* L.)

Eighty-five wild rats (85) weighing between 230 and 280 g were collected from the vicinity of the cement factory and another twenty (20) rats of the same species weighing between 208 and 274 g were collected from a cement dust-free zone, about 30 km from the cement factory (Salami *et al*., 2006). The rats were identified and authenticated by Mr. Nnamdi Amaeze in the Zoology Department, University of Lagos. The rats were left for about seven days in cages to acclimatize to the ambient temperature and humidity, and subjected to 12 hour light/dark cycle before commencing the research. Pellet feeds from the F. A Feeds industry, Lagos and water were given to the rats *ad libitum.*

3.1.2.2 Albino Rat (*R. norvegicus*)

One hundred and fifty albino rats (*R. norvegicus*) weighing between 185 and 200 g were sourced from the Department of Biochemistry, University of Ibadan in August, 2009. The rats were managed as described in the wild rats above before commencing the research.

Figure 1: Map of Nigeria showing location of Shagamu within Ogun State.

(Source: www.weather-forecast.com/locations/shagamu)

3.1.3 Source of the Plant Materials

The plant materials- roselle (*H. sabdariffa*), moringa (*M. oleifera.*), Ginger (*Z. officinale*), and 'ugwu' (*T. occidentalis*) were purchased from Ketu in Lagos metropolis. They were identified by a curator, Mr. Odewo T. Kolawole in the Department of Botany, University of Lagos and authenticated voucher samples were deposited in the Herbarium section (code numbers LUH 4394, LUH 4558, LUH 4396 and LUH 4395 for roselle, moringa, ginger and 'ugwu', respectively). See appendices VIII, IX, X, and XI, pages 174, 175, 176, and 177, respectively for the pictures of the samples.

3.2 Methods

3.2.1 Preparation of the Plant Materials

Fresh leaves of the plant materials were washed gently to remove impurities and air-dried under shade for one week. The dried leaves were milled into a powder using laboratory mill, Norris Limited, Poole, England at the Department of Pharmacognosy, University of Lagos. Besides the powder of individual plant materials produced, a mixture of the plant materials was also formed by mixing the four parts each of the ground plant materials in the ratio 1:1:1:1. The ground plant materials were then stored in desiccators before use.

3.2.2 Preparation of the Plant Extracts

The bioactive compounds were extracted from the plant materials using the method of Okigbo and Ogbonnaya (2006). Fifty grams (50 g) powder of each plant material and the mixture were put in 500 ml 95 % cold ethanol and were allowed to stand for 72 hours. The extracts thus obtained were filtered with muslin cloth and evaporated to dryness at a temperature of 40 ± 2^{o}C. The resulting dried extracts of each plant material yielded 6.6 g, 6.5 g, 6.2 g, 5.9 g, and 6.1 g of roselle, moringa, ginger, 'ugwu', and mixture, respectively. These dry extracts were reconstituted in water and were the decoctions used for the experiment.

3.2.3 Phytonutrients Analysis of the Plant Extracts

The phytonutrients present in the plant extracts were determined using thin layer chromatography (TLC) method as described by Meloan (1999).

. TLC was used to verify the identity of compounds in the plant extracts by comparing the refractive values of the compounds in the extracts with the refractive values of their standards on the same TLC plate. A TLC plate which serves as the stationary phase was a sheet of glass coated with a thin layer of a solid adsorbent made of silica, while the mobile phase consisted of ethanol. In principle, the components will differ in solubility and in the strength of their adsorption to the adsorbent thereby different compounds will have different refractive values.

3.2.4 Phytochemical Screening of the Plant Extracts

The phytochemicals present in the plant extracts were identified using standard procedures as described by Harbone (1973) and Sofowora (1993).

3.2.4.1 Alkaloids

The presence of alkaloids in the extracts was tested using the Wagner Dragendoff's test. About 0.2 g of the extracts was heated with 2 % H_2S0_4 for two minutes. The mixture was filtered and few drops of Dragendoff's reagent were added. An orange-red precipitate shows the presence of alkaloids.

3.2.4.2 Tannins

The tannins was tested in the plant extracts using the Ferric chloride test. Few quantities of the extracts were mixed with water and heated on a water bath. The mixture was filtered and ferric chloride was added to the filtrate. A dark-green solution shows the presence of tannins.

3.2.4.3 Glycosides

The Felling test was used to detect the presence of glycosides in the plant extracts. The extracts were hydrolyzed with HC1 solution and neutralized with NaOH solution. A few drops of Fehling's solution A and B were added. A red precipitate signals the presence of glycosides.

3.2.4.4 Reducing sugars

The reducing sugars were tested in the extracts using the Felling test. The extracts were shaken with distilled water and filtered. The filtrate was boiled with drops of Fehling's solution A and B for 5 minutes. An orange-red precipitate shows the presence of reducing sugars.

3.2.4.5 Saponins

The Frothing test was used to detect the presence of saponins. About 0.2 g of the extracts was shaken with 5 ml of distilled water and then heated to boil. Frothing (appearance of a creamy mass of small bubbles) shows the presence of saponins.

3.2.4.6 Flavonoids

The sodium hydroxide test was used to detect the presence of flavonoids in the extracts. Extract of about 0.2 g was dissolved in diluted NaOH and HC1 was added. A yellow solution that turns colourless signals the presence of flavonoids.

3.2.4.7 Phlobatanins

The presence of phlobatanins in the extracts was carried out using the hydrogen chloride test. The extract (0.5 g) was dissolved in distilled water and filtered. The filtrate was boiled with 2 % HCl solution. A red precipitate shows the presence of phlobatanins.

3.2.5 Acute Toxicity Test

The acute toxicity of the crude extracts of the plants was measured using the 'Classical LD_{50}' method described by Gabriel *et al.* (2008). Albino rats (36) of both sexes weighing

between 183 and 205 g were used for the studies. The rats were randomly distributed into six groups of 6 rats each and were made to fast for 12 hours before commencing the study. The control group received only distilled water, while the test groups were administered doses of 200, 400, 500, 700, 1500, and 2000 mg kg^{-1} of the crude extracts. The general symptoms of toxicity were monitored and recorded for each group within 24 hours.

3.2.6 Dosage Administered to the Rats

The acute toxicity test showed the plant extracts were nontoxic to the rats even at a dose of 2000 mg kg^{-1}. However, a dose of 400 mg kg^{-1} was chosen because a previous study by Adedapo *et al*. (2009) showed that moringa extracts work best on the biochemical and haematological parameters of rats at a dose of 400 mg kg^{-1}.

3.2.7 Study Design

The wild rats (*R. rattus*) were placed into seven groups, comprising 15 rats per group. Group one was tagged control 1, and rats in this group were obtained from the cement dust-free zone (about 30 kilometers from the factory). Group two was tagged control 2 and, together with groups three through seven, consisted of rats collected from the cement factory. All the wild rats in the seven groups were kept in the cement dust-free zone. The albino rats (*R. norvegicus*) were placed into six groups of 18 rats per group. Group one was the control, while groups two through six formed the test rats and the entire albino rats were exposed to cement dust at the factory. The weight, gross morphology, elemental analysis of lung tissues, haematological, biochemical, histopathological, and DNA purity analyses were carried out on the rats using standard protocols, before commencing the experiment. Groups three through seven of the wild rats and groups two through six of the albino rats were subsequently treated with ethanolic extracts of roselle, moringa, ginger, 'ugwu' and mixture, respectively, while group one and two (control 1 and control 2) of the wild rats and group one (control) of the albino rats received only distilled water. Thereafter, the weight, death rate, fertility rate, offspring survival rate, morphology, elemental analysis of lung tissues,

and haematological analysis were again monitored, monthly, for 180 days, while biochemical, histopathological, and DNA purity analyses were carried out after 180 days of exposure.

3.2.7.1 Relative Growth Rate (RGR) of the Rats

The relative growth rate of rats across groups was calculated using the formulae below:

$$RGR(\%) = \frac{WF - WI}{T} \; X \; 100$$

Where W_F =final weight;

W_I = initial weight; and T = period of exposure

(Winder *et al.*, 1990)

3.2.7.2 Percentage Death, Average Number of Newborn per Birth, and Percentage Offspring Survival.

The percentage death, average number of newborn per birth, and percentage offspring survival of the rats were calculated from the formula below:

$$Death\ (\%) = \frac{Number\ of\ deaths\ recorded}{Number\ of\ rats}\ x\ 100$$

$$\text{Average Number of Newborn per Birth} = \frac{Number\ of\ Newborns}{Number\ of\ Delivery}$$

$$Offspring\ survival(\%) = \frac{Nuumber\ of\ newborns\ that\ survived}{Number\ of\ newborns}\ x\ 100$$

3.2.7.3 Elemental Analysis of the Lung Tissues of Exposed Rats

The elemental analysis of the lung tissues of rats exposed to cement dust was carried out by Atomic Absorption Spectroscopy (AAS), using UNICAM model 969 Spectrophotometer in the Department of Chemistry, University of Lagos. The elemental analysis of the lung

tissues of rats in each group was done to measure the concentrations of toxic elements accumulated in the lungs of rats in each group over the period of exposure.

3.2.7.4 Haematological Studies

The haematological study of the rats exposed to cement dust was carried out at the Biochemistry Department, National Institute of Medical Research, Yaba, Lagos.

A) Blood Collection

The rats were sedated in a covered glass jar containing cotton wool soaked in 30 ppm chloroform in the laboratory. Each rat was pegged on a work-bench, and held firmly with office pins. Surgical blades were used to cut the chest region of the rats in a dorsoventral direction. Blood sample (5 ml) was then collected from a beating heart using sodium heparinized capillary tube through capillary action into EDTA bottles. EDTA was an anticoagulant and so the sodium heparin in the capillary tube (Hoff, 2000).

B) Determination of Packed Cell Volume

Microhaematocrit method as described by Bull and Hay (2001) was used to determine the packed cell volume (PVC). Two third of capillary tubes were filled with the blood samples collected. One end of the capillary tube was sealed using a Bunsen burner flame to prevent leakage, before, and during spinning in the microhaematocrit machine. The capillary tubes were arranged in the microhaematocrit machine, Model DSC-100MH-3 (Digisystem Laboratory Instruments Incorporation, Taiwan) accordingly after labeling. The blood samples were then centrifuged at 12, 000 rpm for five minutes. The centrifugation allows the separation of plasma from red blood cells. After five minutes, the blood samples in the capillary tubes were measured using a microhaematocrit reader. The respective results were then recorded.

C) Haemoglobin Determination

The Sahli-Hellige haemoglobin method described by Whitby and Britton (1935) was used to determine the haemoglobin of the rats. The Sahli-Hellige haemoglobin pipette was filled with blood to 0.02 ml mark and the pipette was wiped with an absorbent tissue to remove excess blood. The blood was expelled into a cuvette (test-tube) containing 5 ml of 0.1N HCl and allowed to stand for 5 minutes for colour development after which the absorbance of the sample was read at 540 nm. The absorbance of each blood sample was then compared with the haemoglobin calibration chart to obtain the reading expressed in g dl^{-1}.

D) Determination of Red Blood Cells

The red blood cell count (RBC) was calculated using the Neubauer chamber method (Hesser, 1960). Blood samples (0.2 ml) were put into a cuvette containing 2.0 µl of 10 % formaldehyde. The mixture (0.2 µl) was then transferred into a Neubauer chamber. The 10 % formaldehyde lyses the white blood cells, leaving only the red blood cells visible when mounted under the light microscope at a magnification x 80. The red blood cells were counted under the light microscope and recorded in million/cm^3.

E) Determination of White Blood Cells

The white blood cell (WBC) was also calculated using the Neubauer chamber method (Hesser, 1960). Thoroughly mixed blood sample (0.2 µl) in the EDTA bottles was put into a cuvette containing 2.0 µl of glacier acetic acid. The glacier acetic acid lyses the red blood cells leaving only the white blood cells. The mixture (0.2 µl) was taken into the Neubauer chamber. The Neubauer chamber was then covered with a cover-slip and mounted under the light microscope with magnification x 80 and counted accordingly. The number of cells seen was multiplied by hundred (x 100) and recorded respectively.

3.2.7.5 Biochemical Studies

The biochemical study of the exposed rats was carried out at the Biochemistry Department, National Institute of Medical Research, Yaba, Lagos.

A) Determination of Alanine Amino Transferase (ALT)

The ultraviolet method described by Bergmeyer and Bernt (1974) was used to determine ALT activity using Randox test kits (RANDOX laboratories, Crumlin, Antrim, UK). The reagent for ALT assay composes of Phosphate buffer containing L-alanine and α-oxoglutarate. ALT activity was measured by monitoring the concentration of pyruvate hydrazone formed with 2, 4 – dintrophenyl hydrazine. The absorbance of the sample was read against the reagent blank.

PRINCIPLE: α – oxoglutarate + L – alanine $\longrightarrow$ L – glutamate + Pyruvate.

Enzyme activity is expressed as a Standard International Unit (U/I).

B) Determination of Aspartate Amino Transferase (AST)

The blood serum was extracted into plain bottles after centrifugation of the blood samples at 3, 500 rpm for 10 minutes. AST activity was determined by the Colorimetric method using Randox test kits as described by Bergmeyer and Bernt (1974). Reagent blank was prepared with 0.5 ml of phosphate buffer containing L-aspartate and α-oxoglutarate and 0.1 ml of distilled water. The reagent was stirred and incubated for 30 minutes at 37^0C. After incubation, 0.5 ml of 2, 4 – dinitrophenyl hydrazine was added and allowed to stand for 20 minutes at 20^0C. The serum (0.1 ml) was then added to 0.5 ml of phosphate buffer as described above, 0.5 ml of 2,4 – dinitrophenyl hydrazine was also added to reagent blank and sample, respectively. The absorbance of the sample was read against the reagent blank after 5 minutes at 546 nm.

PRINCIPLE: α – oxoglutarate + L-aspartate $\longrightarrow$ L – glutamate + oxalocetate.

Enzyme activity is expressed as a Standard International Unit (U/I).

C) Determination of Alkaline Phosphates activity (ALP)

The ALP activity was determined by the spectrophotometric method according to Bergmeyer and Bernt (1974) using Randox test kits. The serum (0.02 ml) was added to 1.0 ml of reagent containing diethanol – amine buffer, pH 9.9, Magnesium Chloride ($Mg\ Cl_2$) and Substrate (p-nitrophenyl phosphate). The mixture produced was stirred and absorbance taken after 1, 2, and 3 minutes using a timer at 405 nm in a spectrophotometer. Change in absorbance taken after 2 and 3 minutes was used to determine the final absorbance of ALP. Enzyme activity was expressed as a Standard International Unit (U/I).

D) Determination of Serum Protein

The serum protein was estimated by the Biuret method (Layne, 1957) using Randox test kits. An aqueous sample containing about 1.5 mg protein is treated with an equal volume of 1 % biuret reagent (sodium or potassium hydroxide most often) followed by a few drops of aqueous copper (II) sulfate. The absorbance of the coloured mixture is then compared with standard curve to get the concentration of the serum protein.

Principle: cupric ions + alkaline + protein= coloured mixture (purple).

E) Determination of Reduced Glutathione (GSH)

The reduced glutathione (GSH) was determined by the colorimetric method as described by Ellman (1959). Tricarboxylic acid (3 ml) was added to the blood sample and centrifuged at 10, 000 rpm for 10 minutes. The supernatants (1.0 ml) after centrifugation was treated with 0.5 ml of Ellman's reagent (19.8 mg of 5,5 – dithiobisnitro benzoic acid in 10.0 ml of 0.1 % sodium nitrate and 3.0 ml of 0.2 M phosphate buffer, pH 8.0). The absorbance was read at 412 nm against the blank.

Enzyme activity is expressed as a decrease in the amount of Ellman's reagent in millimoles per minute.

GSH activity = $\frac{OD}{\Sigma} X \frac{V}{v} X 10^3 \mu$ mol/min

Where OD = absorbance of the sample

Σ = molar extinction coefficient (13, 600)

V= volume of reacting mixture (4.5 ml)

v= volume of Sample in the reaction mixture (0.1 ml)

3.2.7.6 Histopathology Studies

The internal organs (lung, liver, and kidney) of the rats were prepared for histopathology examinations using the method of Taylor *et al.* (2003). The histopathology was carried out by Dr. I. Irene., Department of Molecular and Anatomic Pathology, College of Medicine, University of Lagos, Idi-Araba and Mr. Samson Oyebadejo, Department of Clinical Pathology, Faculty of Basic Medical Sciences, College of Medicine, University of Lagos.

About 3-5 mm thick samples were cut from the selected organs of the rats for histological studies. The tissues were fixed using bound's fluid to preserve the original structures and shape of the tissues for easy thin section cut. The tissues were then dehydrated gradually through a series of increasingly concentrated ethanol/water mixture and finally in pure ethanol. The aim of dehydration was to remove water from the tissues to prevent putrefaction and to prepare the tissues for infiltration with an embedding medium which will not mix with water. Since alcohol does not mix with some of the common embedding media (for example, wax), it was replaced with Xylol. The tissues were then embedded in molten wax and allowed to set. Embedding allows thin sections of the tissues to be cut. Embedded tissues were sectioned using a microtome. About five (5) micrometers thick was cut from the wax-embedded tissues using a knife. The wax was dissolved away, and tissues partially dehydrated before staining. The tissues were then stained using mercury oxide at low concentrations. Staining allows contrast to be obtained between different structures because ordinarily, most biological structures are transparent. The stained

tissues on glass slides were covered tightly with cover-slips and viewed under a light microscope.

3.2.7.7 The DNA Purity of the Rats

The purity of the DNA of the exposed rats was determined by ultraviolet spectroscopy in the Department of Cell Biology and Genetics, University of Lagos.

A) Collection of Blood Pellets

Fresh blood samples were collected from the rats in small vials (sample bottles) and were kept temporarily in a freezer. The blood samples were spun at 5, 000 rpm for 10 minutes. The blood pellets were washed twice, and spun again as stated above in 1,000 µl phosphate-buffered saline (PBS). The blood pellets were transferred into an Eppendorf tube using a side mouth disposable pipette. The tube was spun at 10, 000 rpm for 5 minutes**.** The supernatants were removed and stored at -40°C before use.

B) Isolation of Blood DNA

The extraction of DNA from the blood pellets was carried out immediately to avoid degradation of the DNA from the samples. Isolation of DNA content of the blood samples of the rats was carried out using the protocol described by Dellaporta *et al.*, 1983. Blood pellet (200 µl) was each poured in already labeled (001 - 024) Eppendorf tubes. After this, 200 µl of 20 % Sodium dodecyl sulphate (SDS) was added to each sample and mixed thoroughly. The homogenized mixtures were then incubated at 65˚C in a heated bath and mixed intermittently 5 times for 30 minutes; the tubes were removed and allowed to cool at room temperature for 4 minutes. After cooling, 500 µl of ice-cold 5 M potassium acetate was added to each tube and mixed gently by inverting 5 times. The mixtures were then incubated on ice for 30 minutes and centrifuged with a refrigerated centrifuge at 12,000 rpm for 10 minutes at 4˚C. After centrifugation, the mixtures in the tubes separated into two; the solid part at the base (debris) and the liquid part which contains the DNA at the top (supernatant). The supernatant in each tube was carefully transferred into two

tubes per sample. Then, 1, 000 µl of ice-cold isopropanol was added and mixed by inverting gently 5 times till DNA strands visualized. The tubes were allowed to stand, and incubated at -20˚C in a freezer for 24 hours for complete precipitation. The DNA strands appeared as a white mass in the liquid mixture. After the appearance of the strands, the supernatants were poured away leaving the strands in the tubes. The last drops of isopropanol were removed by placing the tubes face down on paper towels for 1 hour. Afterwards, 70 % ethanol was added to the DNA strands, and it was centrifuged at 12, 000 rpm at 4˚C thereby washing the strands for 10 minutes. The ethanol was carefully discarded, and the last drops were removed by inverting the tubes for 10 minutes. After this, the tubes were laid flat on paper towels to allow the pellets dry completely for 4 hours. One hundred (100) µl of double distilled water was added to dissolve the DNA; this was kept in the refrigerator for further analysis.

C) Spectrophotometry

Spectrophotometry of the DNA of the exposed rats was determined using Biophotometer Plus by Eppendorf, A.G. Hamburg, Germany. The laboratory equipment was used to check the quality (purity) and quantity of the DNA isolated from the rats; the quantity in terms of the concentration of the DNA in nanogram per microlitre (ng μl^{-1}) and the quantity in terms of the absorbance of ultraviolet light through the curvette measured in Armstrong (Å). A prominent accessory is the curvette which houses the diluents and the DNA material. The equipment was powered on and scrolled to double-stranded DNA, set appropriately to the quantity of materials being tested. The diluents used to elute/dilute the DNA were also used to reduce its concentration in order to obey Beer-Lambert Law. The dilution is in ratio (DNA: diluents; 5µl: 95µl) or 10 times and the total solution makes 100 µl. However, before the reading was taken, the curvette was rinsed with the same diluents and standardized to spectrophotometer. The DNA was added and homogenized very well before the sample button is depressed, and the reading is taken for the sample. The result

was displayed on the liquid crystal display (LCD) for concentration (ng μl^{-1}), absorbance at different wavelengths simultaneously: 230*A*, 260*A*, 280*A* and ratio of 260*A* /280A.

3.2.7.8 Statistical Analyses

The Statistical Package for Social Sciences (SPSS) version 17 for Windows was used for all analyses. Comparison of data between the test and control groups was calculated using the Student's t-test. $p<0.05$ was considered statistically significant.

4.0 RESULTS

4.1 Acute Toxicity Test

The results of the acute toxicity test showed the plant extracts were nontoxic to the rats even at a dose of 2000 mg kg^{-1}. The general observations showed no mortality occurred 24 hours after administering the plant extracts. The rats that received roselle extract displayed a readiness to take more; they were licking the cannular used to administer the extract. The rats that received ginger, moringa, 'ugwu', and mixture extracts did not show any signs of illness.

4.2 Bioactive Screening of the Plant Extracts

4.2.1 Phytonutrient Analysis of the Plant Extracts

The phytonutrients found in the plant extracts are shown in Table 1. Roselle extract contains calcium, iron, zinc, magnesium, vitamins A, and vitamin C, while ginger extract has zinc, magnesium, vitamin A and vitamin C. Moringa, 'ugwu' and mixture extracts have all the tested nutrients.

4.2.2Phytochemical Screening of the Plant Extracts

The phytochemicals found in the individual plant extracts are shown in Table 2. Roselle extract contains alkaloids, tannins, glycosides, and reducing sugars, while moringa contains all the tested phytochemicals except flavonoids and phlobatanins. Ginger extract has glycosides, reducing sugars, saponins, and flavonoids, while 'ugwu' extract has all the phytochemicals except reducing sugars and phlobatanins. The mixture extract has all the tested bioactive compounds.

Table 1: The phytonutrients present in the plant extracts

Extract	Roselle	Moringa	Ginger	'Ugwu'	Mixture
Phytonutrient					
Calcium	+	++	-	+	+
Iron	+	++	-	++	++
Zinc	++	++	++	+	++
Magnesium	+	++	+	++	++
Vitamin A	++	+	+	+	+
Vitamin C	++	++	+++	+	++
Protein	-	++	-	++	++

Key: - = not present;

\+ = present in moderate amount;

++ = present in abundant amount.

Table 2: The phytochemicals present in the plant extracts

Extract	Roselle	Moringa	Ginger	'Ugwu'	Mixture
Phytochemical					
Alkaloids	+	+	-	+	+
Tannins	+	++	-	++	++
Glycosides	++	++	++	+	++
Reducing sugars	+	++	+	_	++
Saponins	-	+	+	+	+
Flavonoids	-	-	+	+	+
Phlobatanins	-	-	-	-	+

Key: - = not present;
+ = present in moderate amount;

++ = present in abundant amount.

4.3 Ameliorative Efficacy of the Plant Extracts on the Morphology, and Some Physical Characteristics of the Exposed Rats.

4.3.1 Efficacy of the Plant Extracts on Body Weight of the Exposed Rats

4.3.1.1The Wild Rats

Table 3 reveals the control 1, control 2, and test wild rats had body weight increase following treatment with the plant extracts for 180 days. However, a significant difference ($p< 0.05$) in body weight existed between the control 1, control 2 and test rats such that the weight increase mg kg^{-1} of the control 1 rats was 25, control 2 was 34, whereas the body weights increase of the wild rats treated with roselle, moringa, ginger, 'ugwu', and mixture extracts were 61, 72, 54, 66 and 83 mg kg^{-1}, respectively. Significant differences ($p<0.05$) were also observed in the test rats with the mixture of the plant extracts having the highest weight increase followed by moringa> 'ugwu'> roselle > ginger.

Figure 2 illustrates the percentage body weight increase of the wild rats treated with the plant extracts for 180 days. There was a significant difference ($p<0.05$) between the percentage weight gained by the test rats and control rats. A significant difference ($p<0.05$) was also noticed between the test rats such that the rats fed with mixture extract had the highest percentage weight gain, while the least were the rats fed with roselle extract.

4.3.1.2 The Albino rats

Table 4 shows both the control and test albino rats gained considerable weights during the 180 days of exposure. However, a significant difference ($p< 0.05$) in weight was observed between the control and test rats such that the weight increase in mg $kg^{-1}$of the control rats was 14.29, whereas the weights increase of the rats that were fed with roselle, moringa, ginger, 'ugwu', mixture extracts were 25.24, 29.61, 20.56, 28.94 and 34.89 mg kg^{-1}, respectively. Significant differences ($p< 0.05$) were also observed in the test rats with the

Table 3: Effects of plant extracts on body weight (g) of the wild rats

Day	0	30	60	90	120	150	180	Min. Wgt.	Max Wgt	Wgt. Increase
Exract										
Control 1	205^{a} ±7.63	206^{a} ±5.06	209^{a} ±4.61	213^{a} ±6.22	218^{a} ±3.61	222^{a} ±4.51	225^{a} ±4.62	202	227	25.0 ±5..32
Control 2	202^{a} ±6.58	205^{b} ±5.03	211^{a} ±5.30	216^{b} ±5.10	222^{a} ±2.00	231^{b} ±3.00	236^{a} ±5.56	202	238	34 ±4.52
Roselle	202^{a} ±4.65	211^{a} ±4.56	220^{a} ±3.00	229^{b} ±5.20	240^{b} ±4.18	252^{b} ±5.52	263^{b} ±3.51	201	266	61 ±4.21
Moringa	202^{a} ±5.51	215^{b} ±4.94	225^{a} ±4.36	237^{b} ±4.19	251^{a} ±4.73	261^{b} ±3.80	274^{b} ±5.62	198	280	72 ±1.23
Ginger	200^{a} ±5.77	209^{b} ±4.19	217^{b} ±4.53	224^{b} ±4.51	233^{b} ±3.15	242^{b} ±4.53	254^{a} ±4.53	195	256	54 ±4.51
'Ugwu'	202^{a} ±5.67	214^{b} ±6.25	223^{b} ±3.08	233^{b} ±4.08	248^{a} ±4.57	256^{b} ±5.64	268^{a} ±5.61	199	274	66 ±3.52
Mixture	201^{a} ±4.32	213^{b} ±4.20	225^{a} ±3.25	243^{b} ±4.67	257^{a} ±5.68	271^{a} ±5.89	284^{a} ±6.56	198	290	83 ±4.52

- Data are expressed as MEAN±SE
- Mean values in the same row with different superscripts 'a' and 'b' were significantly different at $p<0.05$
- Control 2 = Exposed wild rats fed with distilled water only.
- WGT = Weight

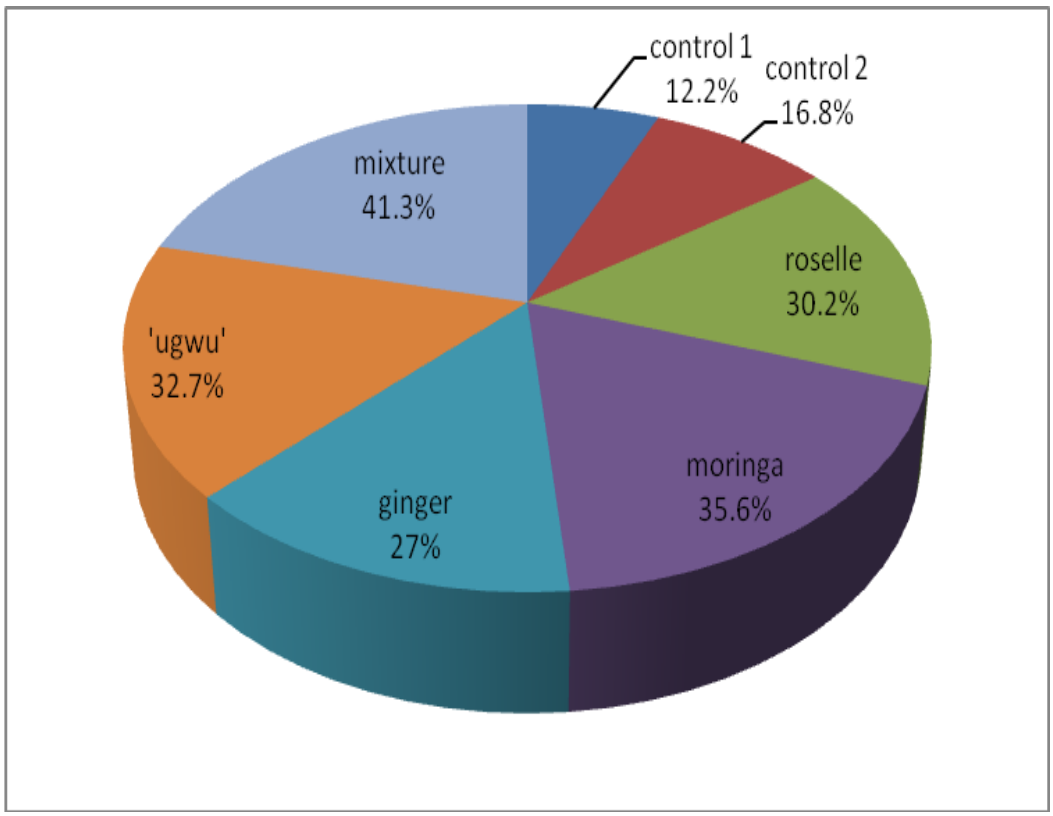

Figure 2: The percentage body weight increase of the wild rats fed with different plant extracts for 180 days.

Table 4: Effect of plant extracts on the body weight (g) of the exposed albino rats

Day	0	30	60	90	120	150	180	Min. Wgt.	Max. Wgt.	RGR	Wgt. Increase
Extract											
Control	190.42[a]	193.67[a]	198.07[a]	202.30[a]	207.83[a]	212.35[a]	217.60[a]	176.9	228.9	15.10	27.2
	±11.2	±9.6	±10.3	±9.39	±8.88	±10.23	±10.61			±3.4	±7.8
Roselle	185.82[a]	190.77[a]	199.42[a]	209.17[b]	215.15[b]	222.82[a]	232.73[b]	176.8	243.0	26.10	46.9
	±9.75	±8.12	±6.26	±6.76	±6.47	±5.91	± 7.78			±4.1	±6.98
Moringa	187.93[a]	196.60[b]	206.88 [a]	217.48[b]	226.48[a]	234.00[a]	243.48[b]	175.9	249.8	30.90	55.6
	± 9.57	± 7.83	±9.71	±6.11	± 8.21	±6.96	±7.78			±4.6	±6.90
Ginger	200.88 [a]	204.92[a]	213.55[b]	219.62[a]	227.35[b]	233.00 [a]	242.22[b]	192.3	249.9	23.00	41.3
	± 7.87	±5.82	±6.13	±6.31	±5.91	±7.38	±7.98			±3.2	±5.87
'Ugwu'	191.08 [a]	200.30[a]	207.42[a]	213.20[a]	222.98[a]	236.22[b]	246.35[a]	173.5	255.8	30.70	55.3
	±9.11	±8.75	±9.06	±10.5	±8.14	±7.56	±8.51			±5.1	±6.45
Mixture	188.60[a]	199.20[b]	209.92[a]	221.13[b]	231.58[a]	242.02[b]	254.37[a]	167.2	267.3	36.50	65.8
	11.91	±12.01	±13.18	±15.8	±12.9	±13.45	±12.01			±5.07	±6.34

- Data are expressed as MEAN±SE
- Mean values in the same row with different superscripts 'a' and 'b' were significantly different at $p<0.05$
- RGR = Relative Growth Rate

mixture of the plant extracts having the highest body weight increase of 34.89 mg kg^{-1}, followed by moringa, 29.61> 'ugwu', 28.84> roselle, 25.24 > ginger, 20.56 .

Figure 3 shows the relative growth rates of the exposed albino rats per day, where a significant difference ($p<0.05$) was observed between the control and test rats. The control rats had the relative growth rate of 15.1 %, while the rats that received extracts of roselle, moringa, ginger, 'ugwu', and mixture had relative growth rates of 26.1, 30.9, 23.0, 30.7 and 36.5 %, respectively.

4.3.2 Efficacy of the Plant Extracts on Some Physical Characteristics and appearance of the Exposed Rats.

4.3.2.1 The Wild Rats

The wild rats living around the cement factory showed no physical abnormality when compared with rats collected from cement dust-free zone (Plates 1 and 2).

4.3.2.2 The Albino Rats

Table 5 describes the effects of the plant extracts on some physical characteristics of the rats. A significant difference ($p<0.05$) exists between the physical characteristics of the control and test rats. Significant differences ($p<0.05$) were also observed in the physical characteristics of the test rats such that roselle had the highest death of 33.3 %, while the mixture of the plant extracts had the lowest death of 16.7 %. Moreover, the mixture of the plant extracts produced the highest average number of newborn of 14.0/litter, while ginger had the lowest average number of newborn of 8.0/litter. The highest offspring survival of 76.4 % occurred in the mixture rats, while roselle fed rats had the lowest offspring survival of 50.0 %. The rats that were administered with extracts of mixture, moringa, ginger and 'ugwu' were active with the mixture rats being the most active. However, the rats that were fed with roselle extract were not as active, while the control rats moved sluggishly.

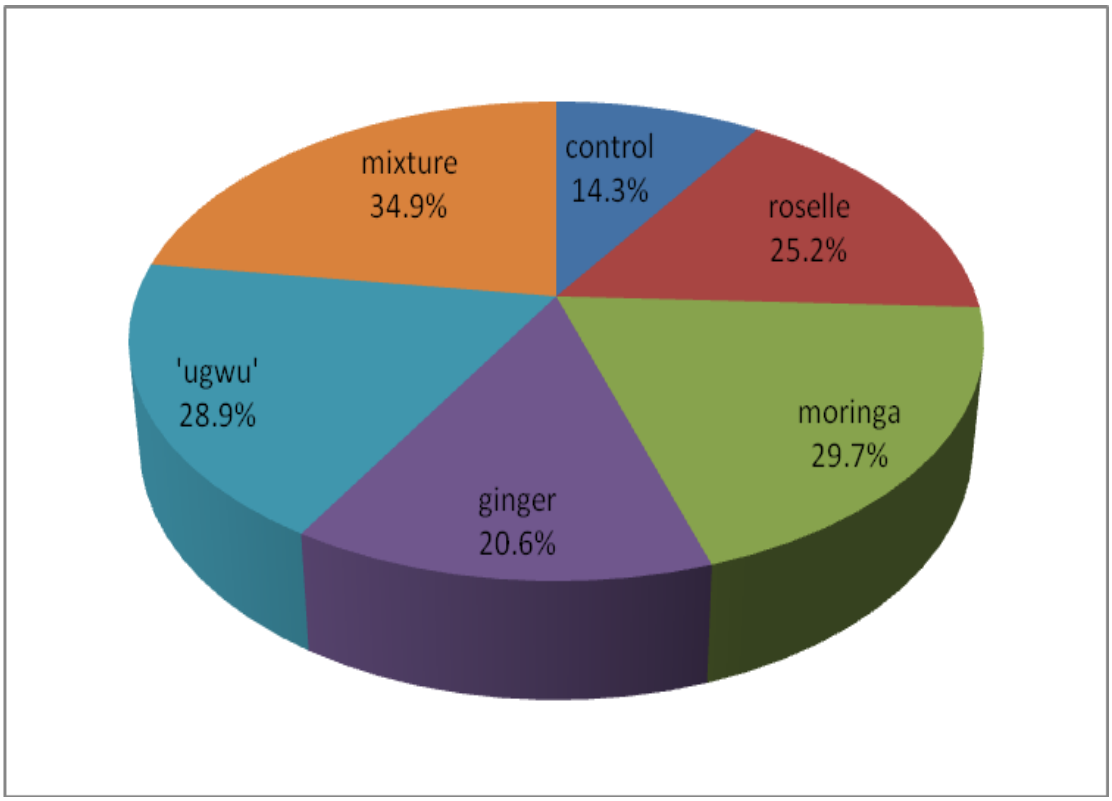

Figure 3: Relative growth rates of the exposed albino rats fed with different plant extracts for 180 days.

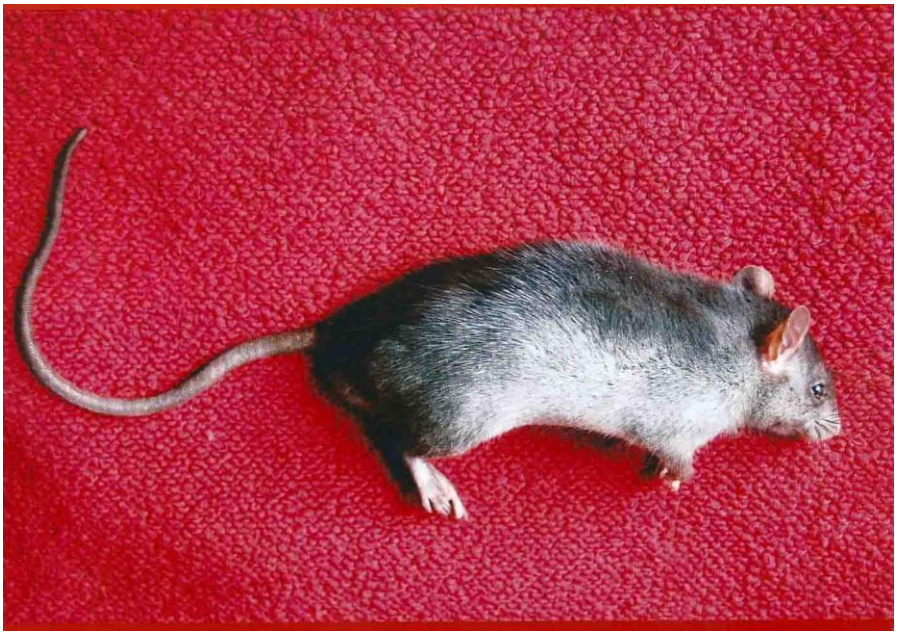

Plate 1: Wild rat at the cement dust-free zone.

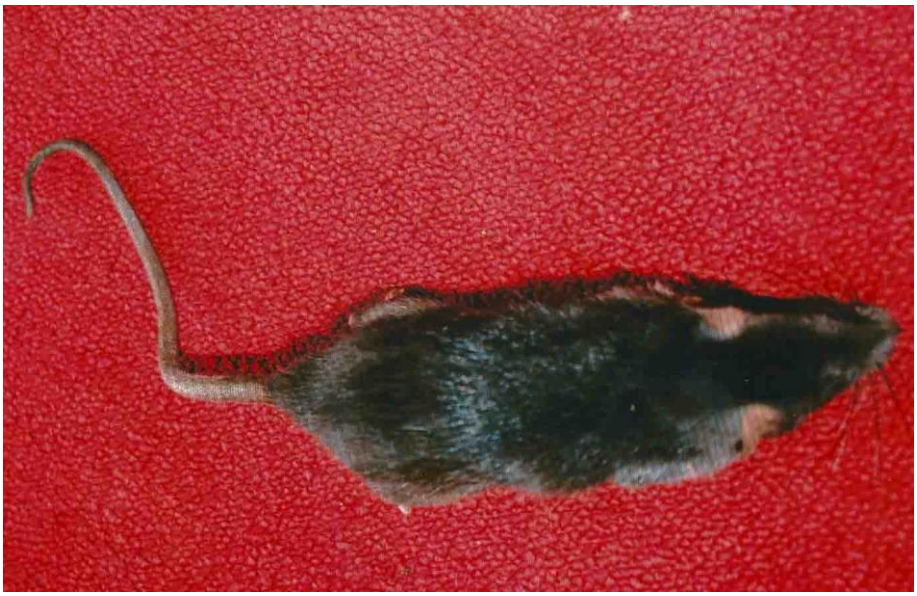

Plate 2: Wild rat at the cement factory

Table 5: Efficacy of the different plant extracts on some physical characteristics of the exposed albino rats

Physical characteristics	Death (%)	Ave. Number of Newborn per birth	Offspring survival (%)	Physical condition
Extract				
Control	58.3	6.0^{a} ±1.00	50.0	Sluggish
Roselle	33.3	8.33^{b} ±0.58	52.0	Partially active
Moringa	25.0	12.00^{b} ±1.00	75.8	Active
Ginger	41.7	8.0^{a} ±1.00	58.3	Active
'Ugwu'	25.0	11.0^{b} ±1.00	73.3	Active
Mixture	16.7	14.00^{b} ±1.00	76.4	Very active

- Mean values with different superscripts 'a' and 'b' from the control are significantly different at $P < 0.05$

Plates 3-9 show the effects of the plant extracts on the exposed albino rats. In term of external features, the control rats had total blindness and oral bruises, while the roselle fed rats had partial blindness and oral bruises. The moringa fed rats showed partial blindness and mild oral bruises, while the ginger fed rats had partial blindness and oral bruises. The rats that were administered the 'ugwu' and mixture extracts had total blindness and blood shot eyes. These symptoms were noticed after four weeks of exposure and there was no significant difference between the control and test rats.

4.4 Chemopreventive Efficacy of the Plant Extracts on Rats Exposed to Cement Dust.

4.4.1 The Wild Rats

Tables 6-10 show the levels of elements detected in the lungs of the wild rats inhabiting the cement factory before and after treatment with the different plant extracts. Significant differences ($p<0.05$) were noticed in the concentrations of elements reduced in the lungs of the rats after treatment with the different plant extracts for 180 days. In Table 6, roselle fed rats reduced the least concentration of calcium by 18.80 mg kg^{-1} while the rats administered with mixture extract reduced the highest concentration of calcium in their lungs by 34.90 mg kg^{-1}. The concentration of silicon reduced in the lungs of the rats that were fed with extract of roselle which was the least was 0.16 mg kg^{-1} whereas the rats that received ginger extract reduced the highest concentration of silicon by 0.31 mg kg^{-1} (Table 7). Furthermore, 1.48 mg kg^{-1} of aluminum was reduced in the lungs of the rats administered with extract of roselle while the rats fed with mixture extract reduced 2.54 mg kg^{-1} of aluminum (Table 8). Also, the concentration of chromium reduced in the lungs of the rats that received extracts of roselle was 0.28 mg kg^{-1} whereas the rats that received ginger extract reduced 0.42 mg kg^{-1} of chromium (Table 9). In Table 10, while roselle fed rats reduced the least value of lead by 0.36 mg kg^{-1}, the rats that were administered with mixture extract reduced the highest concentration of lead by 0.49 mg kg^{-1}.

Plate 3: The rat before exposure (day 0).

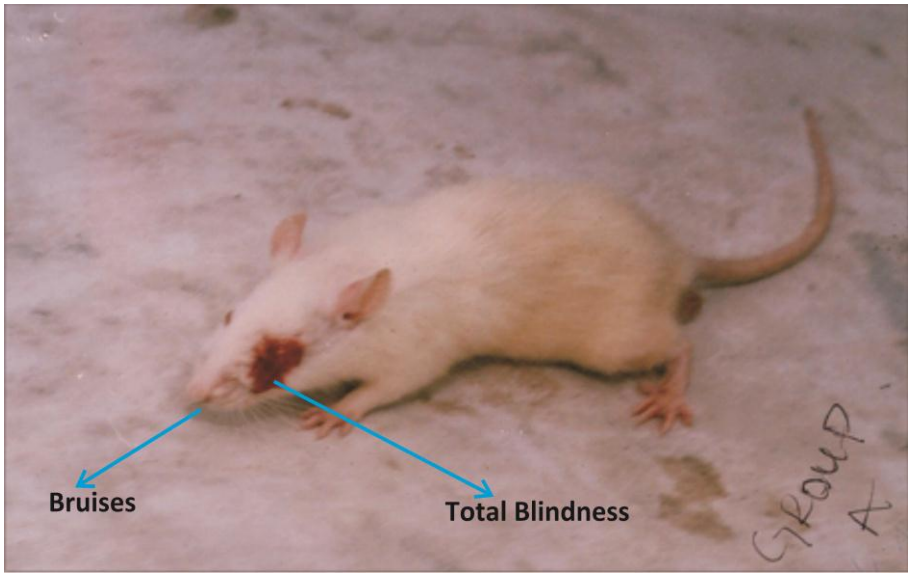

Plate 4: The control rat.

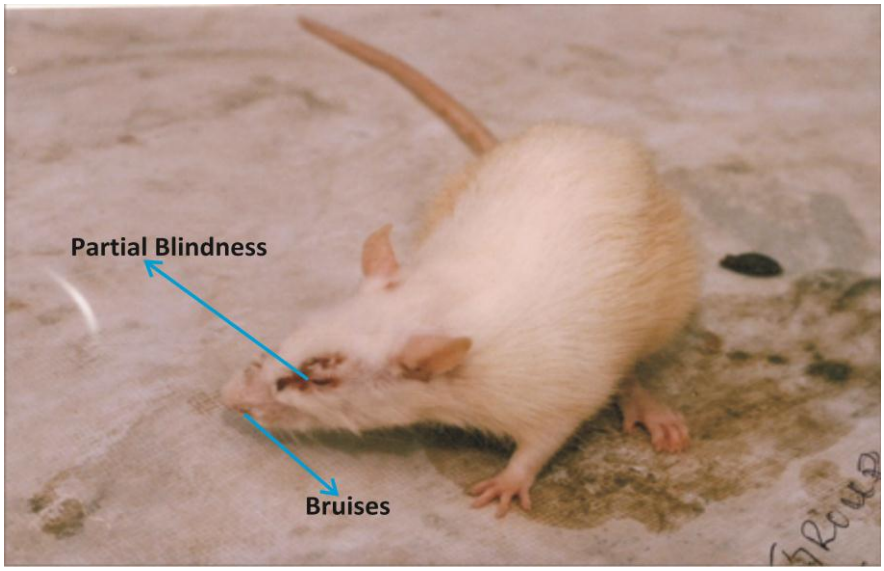

Plate 5: The rat fed with roselle extract.

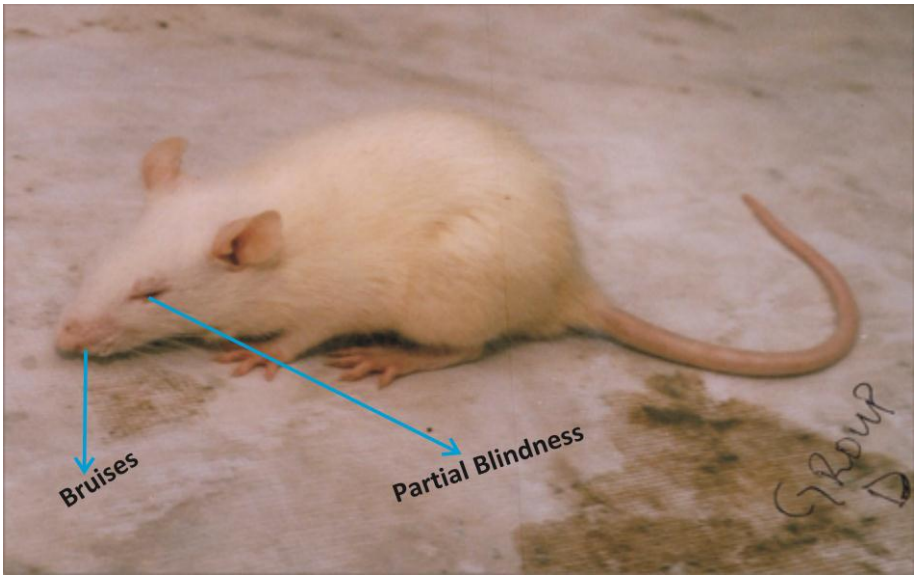

Plate 6: The rat fed with moringa extract.

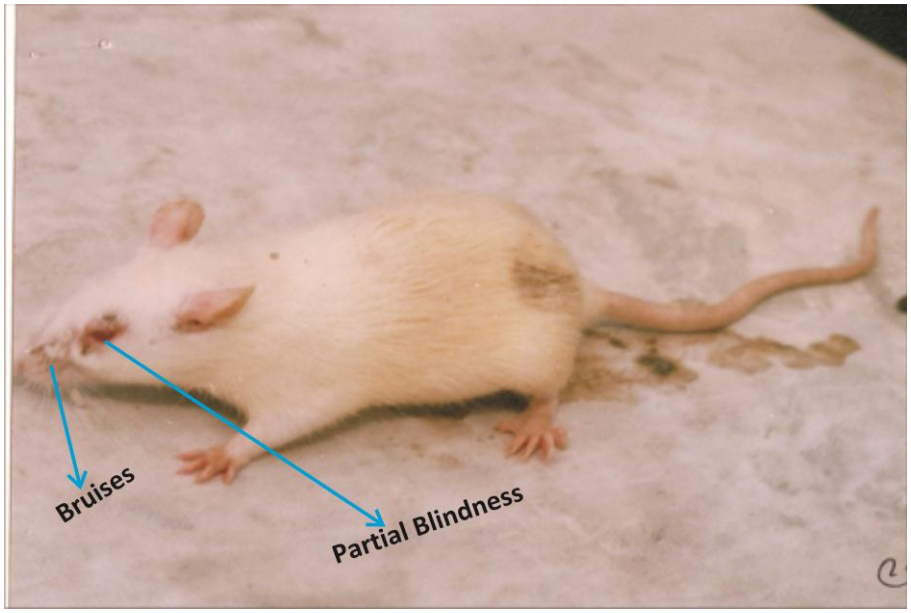

Plate 7: The rat fed with ginger extract.

Plate 8: The rat fed with 'ugwu' extract.

Plate 9: The rat fed with mixture extract.

Table 6: Level of calcium (mg kg^{-1}) detected in the lungs of the wild rats after treatment with different plant extracts

Day	0	60	120	180	Min Conc.	Max Conc.	Amount Reduced	OSHA Limit
Extract								
Control 1	10.00^{a}	10.10^{a}	10.1^{a}	10.32^{a}	9.98	10.3	0.03	8-10.5
	±0.067	±0.12	±0.20	±0.19			±0.01	
Control 2	49.9^{a}	46.5^{b}	44.0^{a}	39.6^{b}	39.21	50.22	10.3	8-10.5
	±0.30	±0.33	±0.81	±0.56			±1.1	
Roselle	50.3^{a}	43.1^{b}	36.8^{a}	31.5^{b}	32.30	49.32	18.8	8-10.5
	±1.01	±0.95	±1.53	±1.15			±1.2	
Moringa	49.8^{a}	40.3^{b}	33.2^{a}	26.7^{b}	24.22	50.6	23.1	8-10.5
	±1.20	±1.06	±1.79	±2.47			±2.0	
Ginger	49.2^{a}	38.5^{b}	28.6^{a}	19.4^{b}	16.32	50.22	29.8	8-10.5
	±1.65	±2.06	±3.13	±3.15			±2.2	
'Ugwu'	49.6^{a}	39.5^{b}	31.0^{a}	23.2^{b}	20.22	50.61	26.4	8-10.5
	±1.35	±1.11	±2.11	±2.60			±1.8	
Mixture	50.20^{a}	39.10^{b}	27.6^{a}	15.3^{b}	14.35	50.32	34.9	8-10.5
	±0.11	±0.95	±3.07	±0.98			±2.3	

- Data are expressed as Mean ± SE
- Mean values with different superscripts 'a' and 'b' along the same row are significantly different at $P < 0.05$
- Control 2= Exposed wild rats fed only with distilled water.
- OSHA = Occupational Safety and Health Administration

TABLE 7: Level of silicon (mg kg^{-1}) detected in the lungs of the wild rats after treatment with different plant extracts

Day	0	60	120	180	Min Conc.	Max Conc.	Amount Reduced	OSHA Limit
Extract								
Control 1	0.09^{a}	0.093a	0.097a	0.10^{a}	0.08	0.12	0.01	0.1
	±0.01	±0.025	±0.021	±0.017			±0.001	
Control 2	0.433^{a}	0.41^{a}	0.38^{b}	0.35^{a}	0.34	0.45	0.1	0.1
	±0.015	±0.015	±0.058	±0.01			±0.01	
Roselle	0.427^{a}	0.363^{b}	0.317^{a}	0.263^{b}	0.26	0.45	0.16	0.1
	±0.021	±1.53	±0.0058	±0.0058			±0.01	
Moringa	0.427^{a}	0.337^{b}	0.273^{a}	0.197^{b}	0.18	0.40	0.23	0.1
	±0.023	±0.0058	±0.021	±0.015			±0.02	
Ginger	0.437^{a}	0.323^{b}	0.253^{a}	0.17^{b}	0.15	0.46	0.27	0.1
	±0.021	±0.0058	±0.015	±0.02			±0.03	
'Ugwu'	0.423^{a}	0.34^{b}	0.27^{a}	0.21^{b}	0.26	0.45	0.21	0.1
	±0.025	±0.01	±0.01	±0.015			±0.02	
Mixture	0.433^{a}	0.30^{b}	0.213^{a}	0.13^{b}	0.11	0.44	0.26	0.1
	±0.01	±0.01	±0.015	±0.026			±0.03	

- Data are expressed as Mean ± SE
- Mean values with different superscripts 'a' and 'b' along the same row are significantly different at $P<0.05$
- Control 2= Exposed wild rats fed only with distilled water
- OSHA = Occupational Safety and Health Administration.

Table 8: Level of aluminum (mg kg^{-1}) detected in the lungs of the wild rats after treatment with different plant extracts

Day	0	60	120	180	Min Conc.	Max Conc.	Amount Reduced	OSHA Limit
Extract								
Control 1	0.0001^{a} ±0.000	0.00013^{a} ±0.000	0.0001^{a} ±0.0001	0.00013^{a} ±0.000	0.0001	0.0002	0.0001	5.00
Control 2	5.02^{a} ±0.01	4.91^{a} ±0.01	4.71^{a} ±0.01	4.45^{a} ±0.098	4.34	5.03	0.57 ±0.01	5.00
Roselle	5.02^{a} ±0.015	4.50^{b} ±0.06	3.98^{a} ±0.015	3.54^{b} ±0.036	3.51	5.03	1.48 ±0.03	5.00
Moringa	5.03^{a} ±0.07	4.30^{b} ±0.026	3.77^{a} ±0.11	2.99^{b} ±0.02	2.97	5.11	2.04 ±0.03	5.00
Ginger	5.03^{a} ±0.061	4.23^{b} ±0.032	3.52^{a} ±0.1	2.65^{b} ±0.425	2.16	5.10	2..38 ±0.04	5.00
'Ugwu'	5.04^{a} ±0.07	4.30^{b} ±0.032	3.68^{a} ±0.181	2.76^{b} ±0.379	2.32	5.12	2.39 ±0.05	5.00
Mixture	5.05^{a} ±0.067	4.11^{b} ±0.095	3.68^{a} ±0.095	2.51^{b} ±0.062	2.11	5.13	2.54 ±0.05	5.00

- Data are expressed as Mean ± SE
- Mean values with different superscripts 'a' and 'b' along the same row are significantly different at $P < 0.05$
- Control 2 = Exposed wild rats fed only with distilled water.
- OSHA = Occupational Safety and Health Administration.

Table 9: Level of chromium (mg kg^{-1}) detected in the lungs of the wild rats after treatment with different plant extracts

Day	0	60	120	180	Min Conc.	Max Conc.	Amount Reduced	OSHA Limit
Extract								
Control 1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.05
Control 2	0.56^{a} ±0.02	0.54^{a} ±0.01	0.51^{b} ±0.01	0.48^{a} ±0.01	0.47	0.58	0.08 ±0.01	0.05
Roselle	0.56^{a} ±0.0058	0.477^{b} ±0.015	0.35^{a} ±0.046	0.28^{b} ±0.026	0.25	0.56	0.28 ±0.03	0.05
Moringa	0.53^{a} ±0.021	0.31^{b} ±0.032	0.20^{a} ±0.042	0.12^{b} ±0.021	0.10	0.56	0.41 ±0.03	0.05
Ginger	0.51^{a} ±0.015	0.293^{b} ±0.021	0.16^{a} ±0.02	0.09^{b} ±0.01	0.08	0.52	0.42 ±0.03	0.05
'Ugwu'	0.52^{a} ±0.01	0.33^{b} ±0.015	0.017^{a} ±0.029	0.11^{b} ±0.01	0.10	0.53	0.41 ±0.04	0.05
Mixture	0.53^{a} ±0.02	0.23^{b} ±0.021	0.14^{a} ±0.042	0.08^{b} ±0.01	0.7	0.55	0.44 ±0.03	0.05

- Data are expressed as Mean ± SE
- Mean values with different superscripts 'a' and 'b' along the same row are significantly different at $P < 0.05$
- Control 2 = Exposed wild rats fed only with distilled water
- OSHA = Occupational Safety and Health Administration.

Table 10: Level of lead (mg kg^{-1}) detected in the lungs of the wild rats after treatment with different plant extracts.

Day	0	60	120	180	Min Conc.	Max Conc.	Amount Reduced	OSHA Limit
Extract								
Control 1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.05
Control 2	0.57^{a} ± 0.01	0.54^{a} ± 0.01	0.52^{a} ± 0.01	0.48^{a} ± 0.01	0.48	0.57	0.09 ± 0.01	0.05
Roselle	0.58^{a} ± 0.01	0.48^{b} ± 0.021	0.33^{a} ± 0.029	0.22^{b} ± 0.025	0.19	0.57	0.36 ± 0.02	0.05
Moringa	0.58^{a} ± 0.015	0.43^{b} ± 0.025	0.29^{a} ± 0.02	0.18^{b} ± 0.01	0.17	0.60	0.40 ± 0.03	0.05
Ginger	0.58^{a} ± 0.032	0.38^{b} ± 0.025	0.26^{a} ± 0.021	0.14^{b} ± 0.01	0.13	0.60	0.44 ± 0.04	0.05
'Ugwu'	0.58^{a} ± 0.01	0.040^{b} ± 0.035	0.29^{a} ± 0.015	0.17^{b} ± 0.026	0.15	0.59	0.42 ± 0.03	0.05
Mixture	0.59^{a} ± 0.01	0.39^{b} ± 0.01	0.25^{a} ± 0.035	0.10^{b} ± 0.006	0.10	0.60	0.49 ± 0.03	0.05

- Data are expressed as Mean ± SE
- Mean values with different superscripts 'a' and 'b' along the same row are significantly different at $P < 0.05$
- Control 2 = Exposed wild rats fed only with distilled water
- OSHA = Occupational Safety and Health Administration.

Figures 4-8 are graphical representations of the percentage concentrations of the toxic elements reduced in the lungs of the wild rats following treatment with the plant extracts for 180 days. The rats fed with the plant extracts had a significant ($p<0.05$) percentage of toxic elements reduction in their lungs compared with control 1 and control 2 rats that received distilled water only. Significant differences ($p<0.05$) were also noticed in the percentages of elements reduced by the rats fed with the plant extracts (except between ginger and 'ugwu') such that the mixture extracts had the highest percentage element reduction in all the tested elements, while the rats fed with roselle extract had the lowest percentage element reduction.

- ## 4.4.2 The Albino Rats

Tables 11-15 show the concentrations of the toxic elements accumulated in the lungs of the exposed albino rats. The test rats significantly ($p<0.05$) accumulated less toxic elements compared to the control rats that were administered distilled water only. Significant differences ($p<0.05$) were also noticed in the concentrations of elements accumulated in the lungs of the test rats. Mixture extract accumulated least concentrations and roselle fed rats accumulated highest concentrations of each tested element. Table 11 shows that roselle fed rats accumulated the highest concentration of calcium (31.3 mg kg^{-1}) while the rats administered with the mixture extract had the least concentration of calcium in their lungs (12.7 mg kg^{-1}). The concentration of silicon lodged in the lungs of the rats fed with extract of roselle had the highest value of 0.38 mg kg^{-1} whereas the rats that received the mixture extract accumulated least concentration of silicon with 0.10 mg kg^{-1}(Table 12). Furthermore, 2.5 mg kg^{-1} of aluminum was detected in the lungs of the rats administered with extract of roselle while the rats fed with mixture extract accumulated the least concentration of aluminum of 0.92 mg kg^{-1} (Table 13). Also, the concentration of chromium accumulated in the lungs of the rats that received extract of roselle was 0.36 mg kg^{-1} whereas the rats that received mixture extract accumulated 0.015 mg kg^{-1} of chromium (Table 14). In Table 14, while in roselle fed rats lead was the highest element accumulated (0.34 mg kg^{-1}) the rats that were administered mixture extract accumulated the least lead concentration of 0.12 mg kg^{-1}.

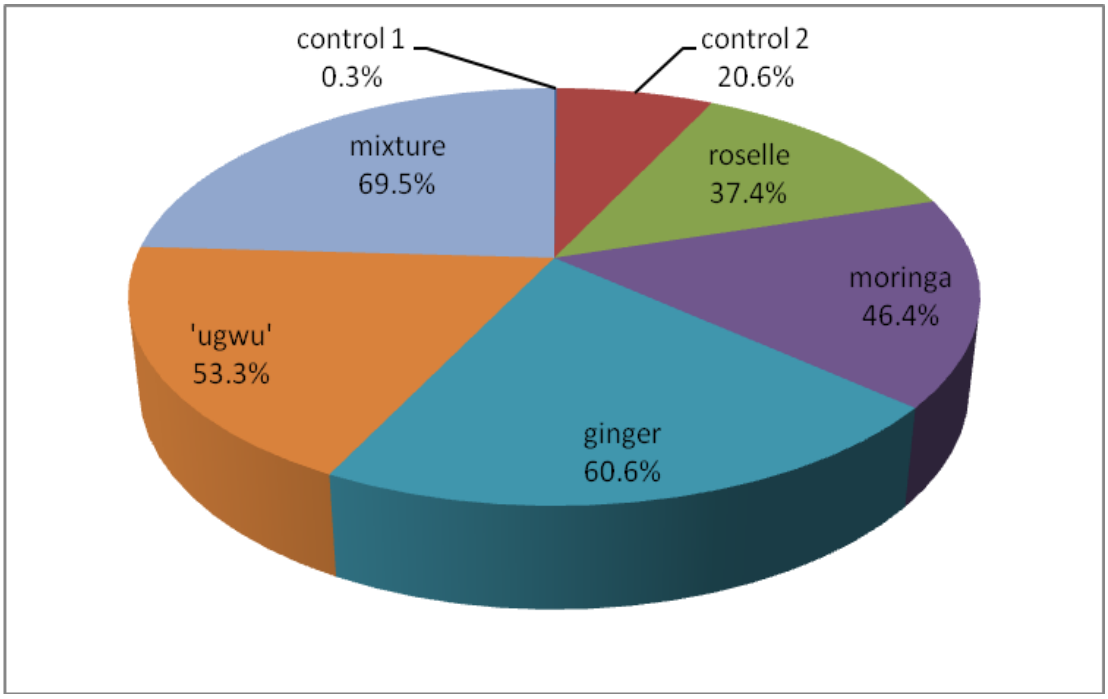

Figure 4: Percentage of calcium reduced (mg kg^{-1}) in the lungs of wild rats after feeding with different plant extracts for 180 days.

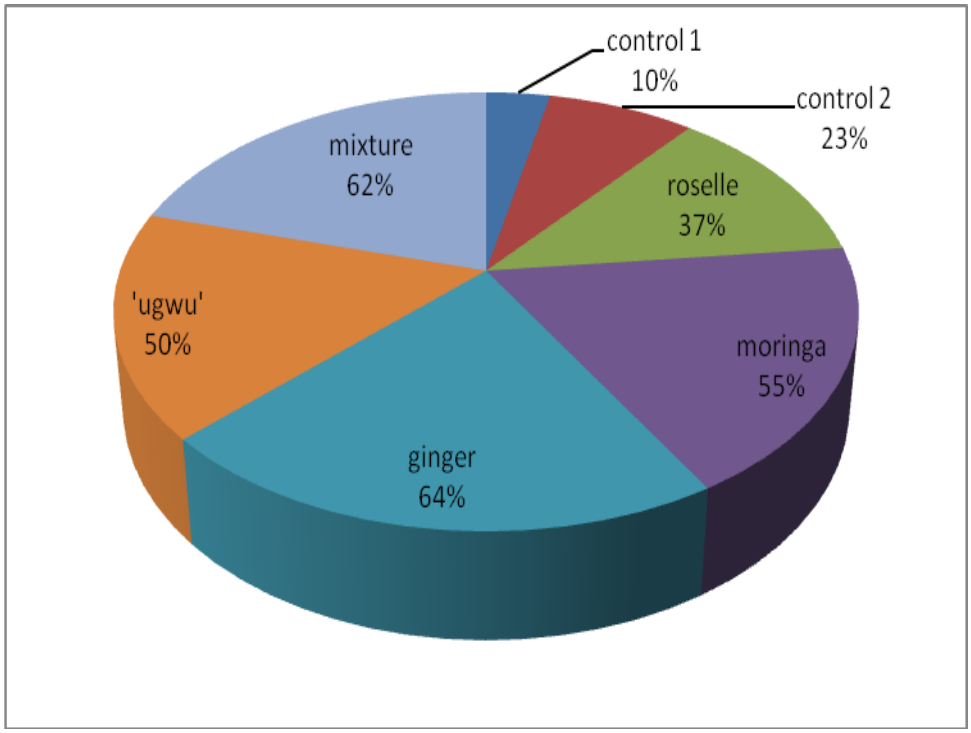

Figure 5: Percentage of silicon reduced (mg kg^{-1}) in the lungs of wild rats after feeding with different plant extracts for 180 days.

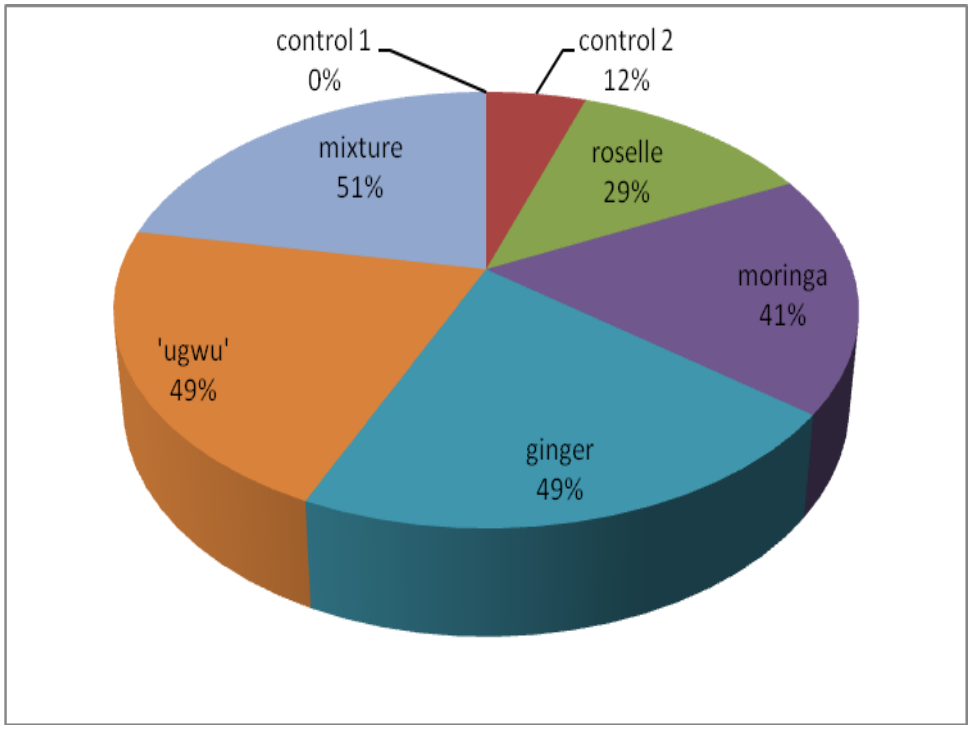

Figure 6: Percentage of aluminum reduced (mg kg^{-1}) in the lungs of wild rats after feeding with different plant extracts for 180 days.

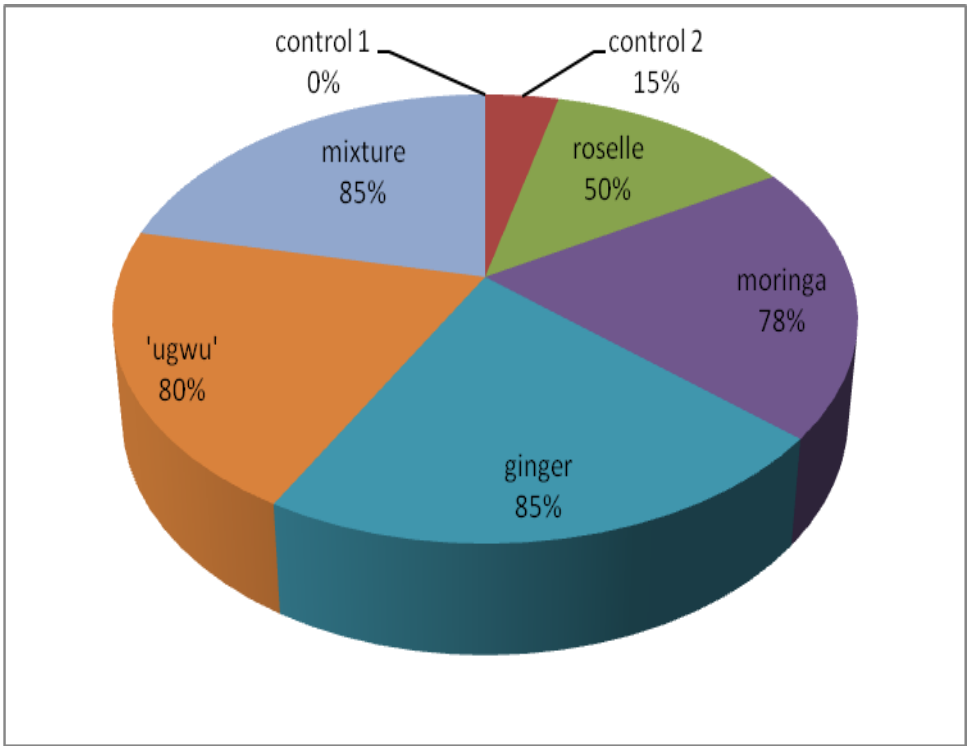

Figure 7: Percentage of chromium reduced (mg kg^{-1}) in the lungs of wild rats after feeding with different plant extracts for 180 days.

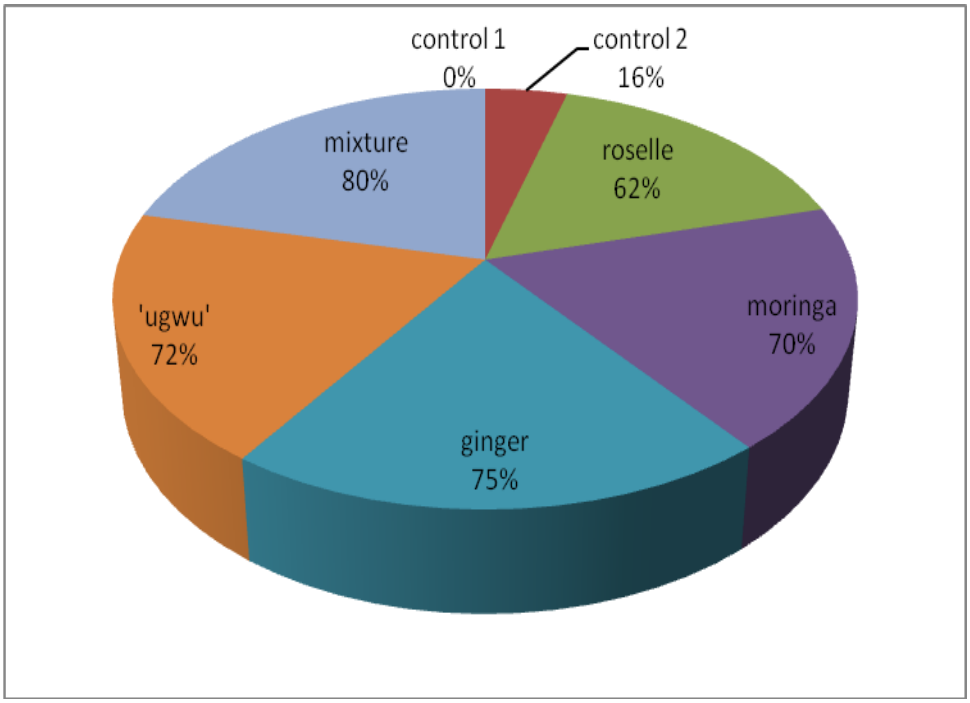

Figure 8: Percentage of lead reduced (mg kg^{-1}) in the lungs of wild rats after feeding with different plant extracts for 180 days.

Table 11: Level of calcium (mg kg^{-1}) detected in the lungs of the exposed albino rats treated with different plant extracts.

Day	0	60	120	180	Min. Conc.	Max. Conc.	Aver. Conc.	Amount Accumulated	OSHA Limit
Extract									
Control	9.93^{a}	29.5^{b}	44.1^{a}	60.4^{b}	9.83	62.05	36.5	50.50	8-10.5
	±0.16	±0.87	±1.78	±1.45				±4.6	
Roselle	9.73^{a}	21.0^{b}	32.5^{a}	41.0^{a}	9.65	42.21	26.1	31.30	8-10.5
	±0.08	±1.00	±1.99	±1.20				±3.5	
Moringa	9.94^{a}	19.2^{b}	29.5^{a}	38.20^{b}	9.91	39.21	24.3	28.30	8-10.5
	±0.11	±0.9	±0.58	±1.32				±3.1	
Ginger	9.88^{a}	12.8^{a}	15.80^{b}	29.7^{a}	9.82	30.81	17.3	19.82	8-10.5
	±0.20	±1.54	±1.68	±1.43				±2.7	
'Ugwu'	9.94^{a}	17.2^{b}	23.5^{a}	28.9^{b}	9.92	32.3	20.9	21.20	8-10.5
	±0.11	±0.90	±0.58	±1.44				±2.8	
Mixture	9.90^{a}	11.8^{a}	15.9^{a}	22.6^{b}	9.82	24.22	14.40	12.70	8-10.5
	±0.09	±0.25	±1.51	±1.90				±2.3	

- Data are expressed as Mean ± SE
- Mean values with different superscripts 'a' and 'b' along the same row are significantly different at $P < 0.05$
- OSHA = Occupational Safety and Health Administration

Table 12: Level of silicon (mg kg^{-1}) detected in the lungs of the exposed albino rats treated with different plant extracts.

Day	0	60	120	180	Min. Conc.	Max. Conc.	Aver. Conc.	Amount Accumulated	OSHA Limit
Extract									
Control	0.000	0.21^{a} ±0.01	0.37^{b} ±0.02	0.65^{a} ±0.05	0.000	0.70	0.3	0.65 ±0.08	0.1
Roselle	0.000	0.15^{a} ±0.03	0.24^{a} ±0.05	0.38^{b} ±0.06	0.000	0.47	0.2	0.38 ±0.07	0.1
Moringa	0.000	0.08^{a} ±0.06	0.21^{b} ±0.01	0.32^{a} ±0.06	0.000	0.32	0.2	0.32 ±0.06	0.1
Ginger	0.000	0.09^{a} ±0.006	0.16^{b} ±0.015	0.23^{b} ±0.02	0.000	0.25	0.1	0.23 ±0.05	0.1
'Ugwu'	0.000	0.08^{a} ±0.01	0.15^{b} ±0.01	0.23^{a} ±0.02	0.000	0.24	0.1	0.23 ±0.05	0.1
Mixture	0.000	0.0013^{a} ±0.006	0.0087^{b} ±0.06	0.10^{a} ±0.09	0.000	0.11	0.018	0.10 ±0.03	0.1

- Data are expressed as Mean ± SE
- Mean values with different superscripts 'a' and 'b' along the same row are significantly different at $P < 0.05$
- OSHA = Occupational Safety and Health Administration.

Table 13: Level of aluminum (mg kg^{-1}) detected in the lungs of the exposed albino rats treated with different plant extracts.

Day	0	60	120	180	Min. Conc.	Max. Conc.	Aver. Conc.	Amount Accumulated	OSHA Limit
Extract									
Control	0.000	0.39^{a} ±0.006	1.28^{b} ±0.05	3.78^{a} ±0.25	0.000	4.01	1.2	3.78 ±0.25	5.0
Roselle	0.000	0.17^{a} ±0.01	0.66^{b} ±0.06	2.54^{a} ±0.06	0.000	2.60	0.7	2.54 ±0.12	5.0
Moringa	0.000	0.16^{a} ±0.01	0.64^{b} ±0.02	2.43^{a} ±0.02	0.000	2.54	0.7	2.43 ±0.11	5.0
Ginger	0.000	0.021^{a} ±0.002	0.40^{b} ±0.01	1.40^{a} ±0.06	0.000	1.44	0.4	1.40 ±0.07	5.0
'Ugwu'	0.000	0.052^{a} ±0.01	0.39^{b} ±0.06	1.32^{a} ±0.07	0.000	1.38	0.4	1.32 ±0.08	5.0
Mixture	0.000	0.023 ±0.001	0.31^{a} ±0.002	1.33^{a} ±0.007	0.000	0.98	0.14	1.33 ±0.06	5.0

- Data are expressed as Mean ± SE
- Mean values with different superscripts 'a' and 'b' along the same row are significantly different at $P<0.05$
- OSHA = Occupational Safety and Health Administration

Table 14: Level of chromium (mg kg^{-1}) detected in the lungs of the exposed albino rats treated with different plant extracts.

Day	0	60	120	180	Min. Conc.	Max. Conc.	Aver. Conc.	Amount Accumulated	OSHA Limit
Extract									
Control	0.000	0.11^{a} ±0.01	0.35^{b} ±0.03	0.55^{a} ±0.03	0.000	0.55	0.20	0.55 ±0.06	0.5
Roselle	0.000	0.07^{a} ±0.01	0.27^{b} ±0.02	0.36^{a} ±0.02	0.000	0.37	0.20	0.36 ±0.05	0.5
Moringa	0.000	0.05^{a} ±0.006	0.24^{b} ±0.01	0.33^{a} ±0.01	0.000	0.33	0.10	0.33 ±0.04	0.5
Ginger	0.000	0.012^{a} ±0.006	0.069^{b} ±0.001	0.20^{a} ±0.01	0.000	0.21	0.10	0.20 ±0.02	0.5
'Ugwu'	0.000	0.017^{a} ±0.001	0.075^{b} ±0.005	0.27^{a} ±0.01	0.000	0.28	0.10	0.27 ±0.03	0.5
Mixture	0.000	0.001^{a} ±0.000	0.0013^{b} ±0.0004	0.15^{a} ±0.0007	0.000	0.017	0.0032	0.15 ±0.02	0.5

- Data are expressed as Mean ± SE
- Mean values with different superscripts 'a' and 'b' along the same row are significantly different at $P < 0.05$
- OSHA = Occupational Safety and Health Administration

Table 15: Level of lead (mg kg^{-1}) detected in the lungs of the exposed albino rats treated with different plant extracts.

Day	0	60	120	180	Min. Conc.	Max. Conc.	Aver. Conc.	Amount Accumulated	OSHA Limit
Extract									
Control	0.000	0.16^{a} ± 0.03	0.39^{b} ± 0.015	0.60^{a} ± 0.02	0.000	0.62	0.30	0.60 ± 0.09	0.5
Roselle	0.000	0.05^{a} ±0.006	0.24^{b} ±0.02	0.34^{a} ±0.02	0.000	0.35	0.20	0.34 ±0.06	0.5
Moringa	0.000	0.03^{a} ± 0.01	0.20^{b} ±0.01	0.29^{a} ±0.01	0.000	0.29	0.1	0.29 ±0.05	0.5
Ginger	0.000	0.012^{a} ±0.0006	0.065^{b} ± 0.006	0.18^{a} ±0.04	0.000	0.21	0.1	0.18 ±0.03	0.5
'Ugwu'	0.000	0.01^{a} ±0.001	0.066^{b} ±0.002	0.20^{a} ±0.01	0.000	0.23	0.1	0.20 ±0.03	0.5
Mixture	0.000	0.013^{a} ±0.002	0.015^{b} ±0.001	0.14^{a} ±0.01	0.000	0.15	0.08	0.12 ±0.02	0.5

- Data are expressed as Mean ± SE
- Mean values with different superscripts 'a' and 'b' along the same row are significantly different at $P < 0.05$
- OSHA = Occupational Safety and Health Administration

Figures 9-13 illustrate the percentage concentrations of the tested elements accumulated in the lungs of the exposed albino rats after 180 days of exposure. The percentages of elements accumulated by the test rats were significantly ($p<0.05$) low compared with control rats that received distilled water only. Significant differences ($p<0.05$) were also observed in the percentages of elements accumulated by the test rats such that the rats that received the mixture extract accumulated the least percentages of the tested elements, while roselle fed rats accumulated the highest in all cases.

4.5 Prophylactic Efficacy of the Plant Extracts on Haematological Parameters of the Exposed Rats.

4.5.1 The Wild Rats

Tables 16-19 show the rebuilding capacity of the plant extracts on the blood parameters of the wild rats collected from the cement factory. Significant differences ($p<0.05$) were observed in the blood parameters of the exposed wild rats before and after treatment with the different plant extracts for 180 days such that the PCV increase of the control 1 and control 2 rats that received distilled water only are 0.2 and 0.45 %, respectively. Whereas the PCV increase of the rats fed with roselle, moringa, ginger, 'ugwu' and mixture extracts are 4.89, 8.60, 4.59, 10.00 and 11.7 %, respectively (Table 16). Table 17 shows that the HB increase of the control 1 and control 2 rats are 0.1 and 0.28 g dl^{-1}, respectively, whereas the HB increase of the rats fed with roselle, moringa, ginger, 'ugwu' and mixture extracts are 1.25, 1.65, 1.81, 3.81 and 4.77 g dl^{-1}, respectively. Furthermore, 0.48, 0.60, 0.33, 0.72 and 0.77 $x10^{12}$ increase in RBC were recorded by the rats fed with roselle, moringa, ginger, 'ugwu' and mixture extracts, respectively, whereas 0.00 and 0.23 $x10^{12}$ were recorded by the control 1 and control 2 rats, respectively (Table 18). Table 19 reveals the WBC increase of the control 1 and control 2 rats are 67 and 493 mm^3, respectively, whereas the WBC increase of the rats fed with roselle, moringa, ginger, 'ugwu' and mixture extracts are 1217, 1103, 1233, 850 and 1050 mm^3, respectively.

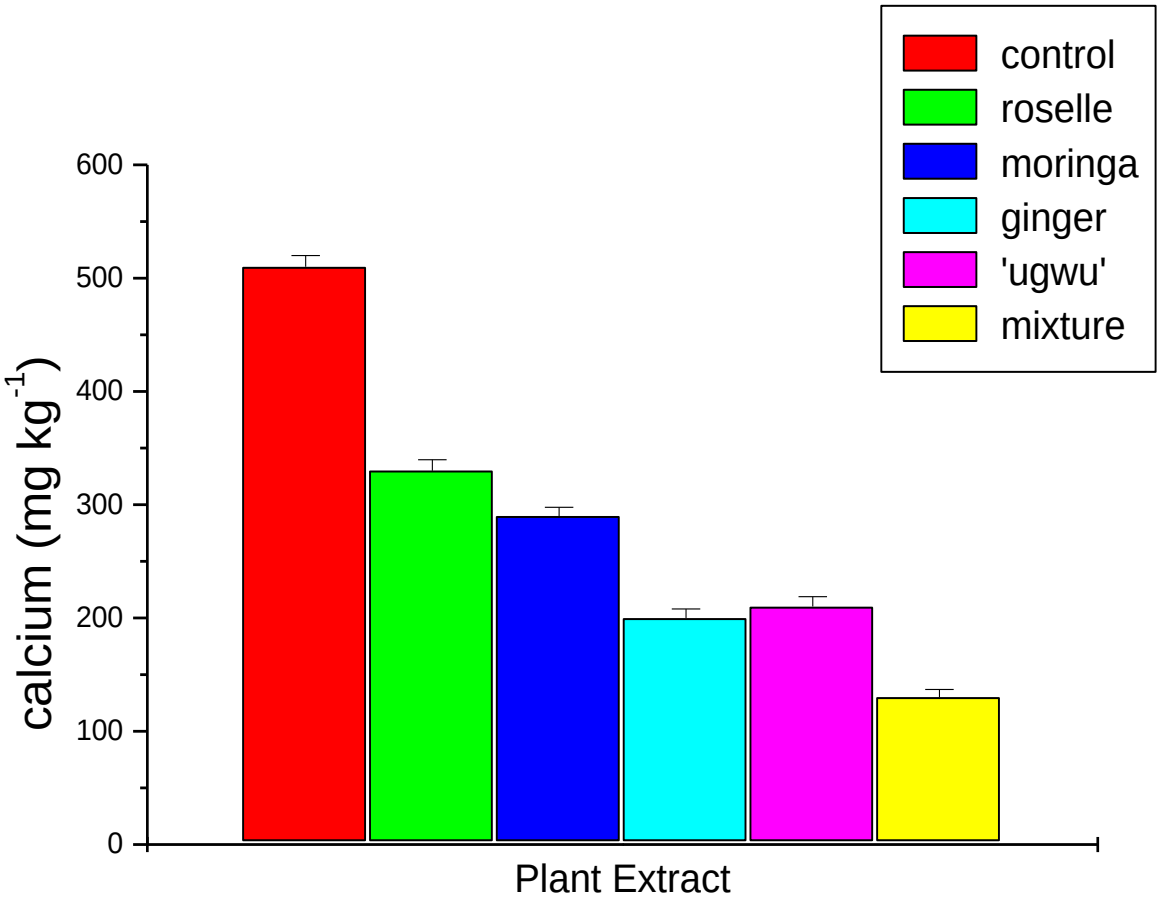

Figure 9: Percentage of calcium (mg kg^{-1}) accumulated in the lungs of the exposed albino rats fed with different plant extracts for 180 days.

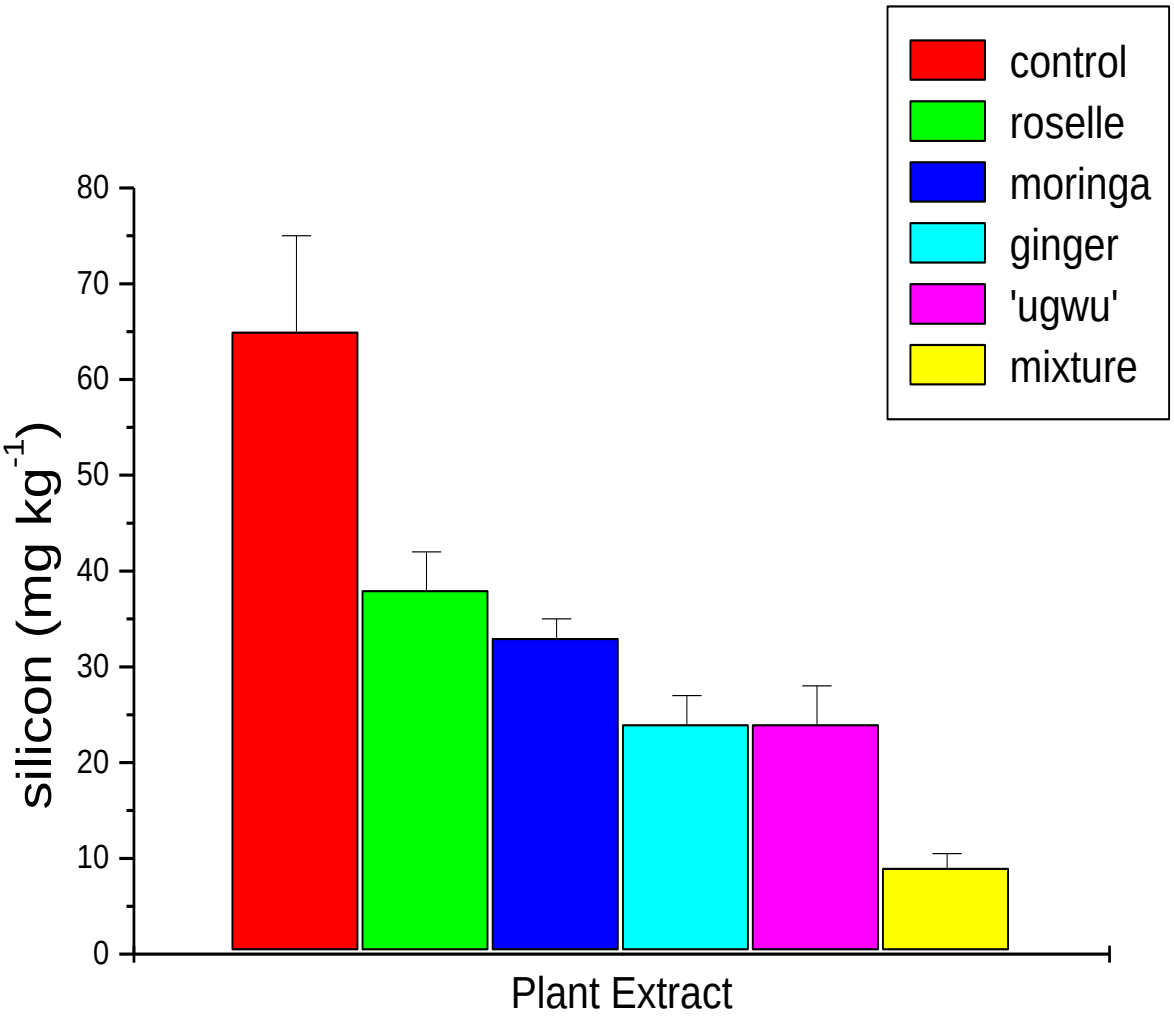

Figure 10: Percentage of silicon (mg kg^{-1}) accumulated in the lungs of the exposed albino rat fed with different plant extracts for 180 days.

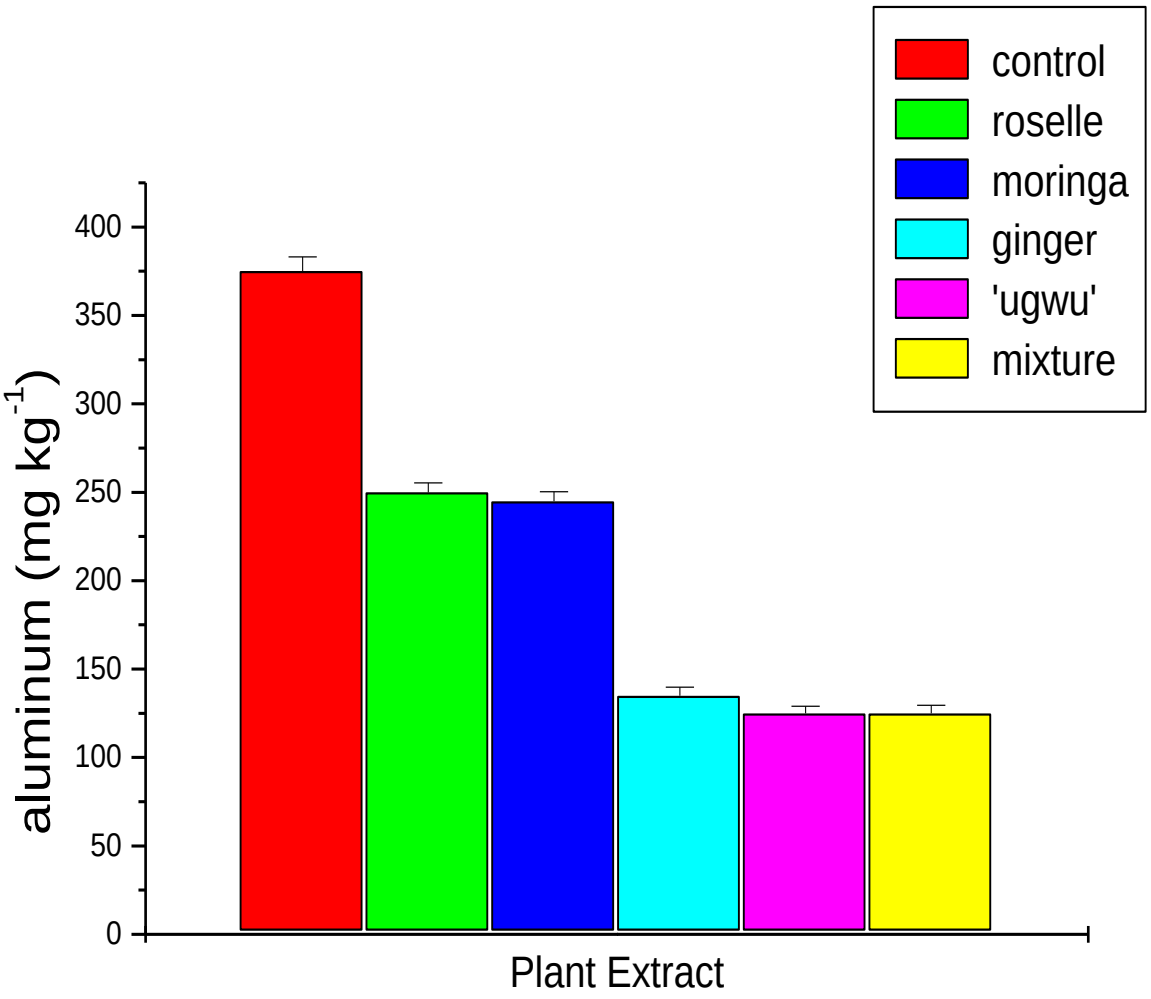

Figure 11: Percentage of aluminum (mg kg^{-1}) accumulated in the lungs of the exposed albino rats fed with different plant extracts for 180 days.

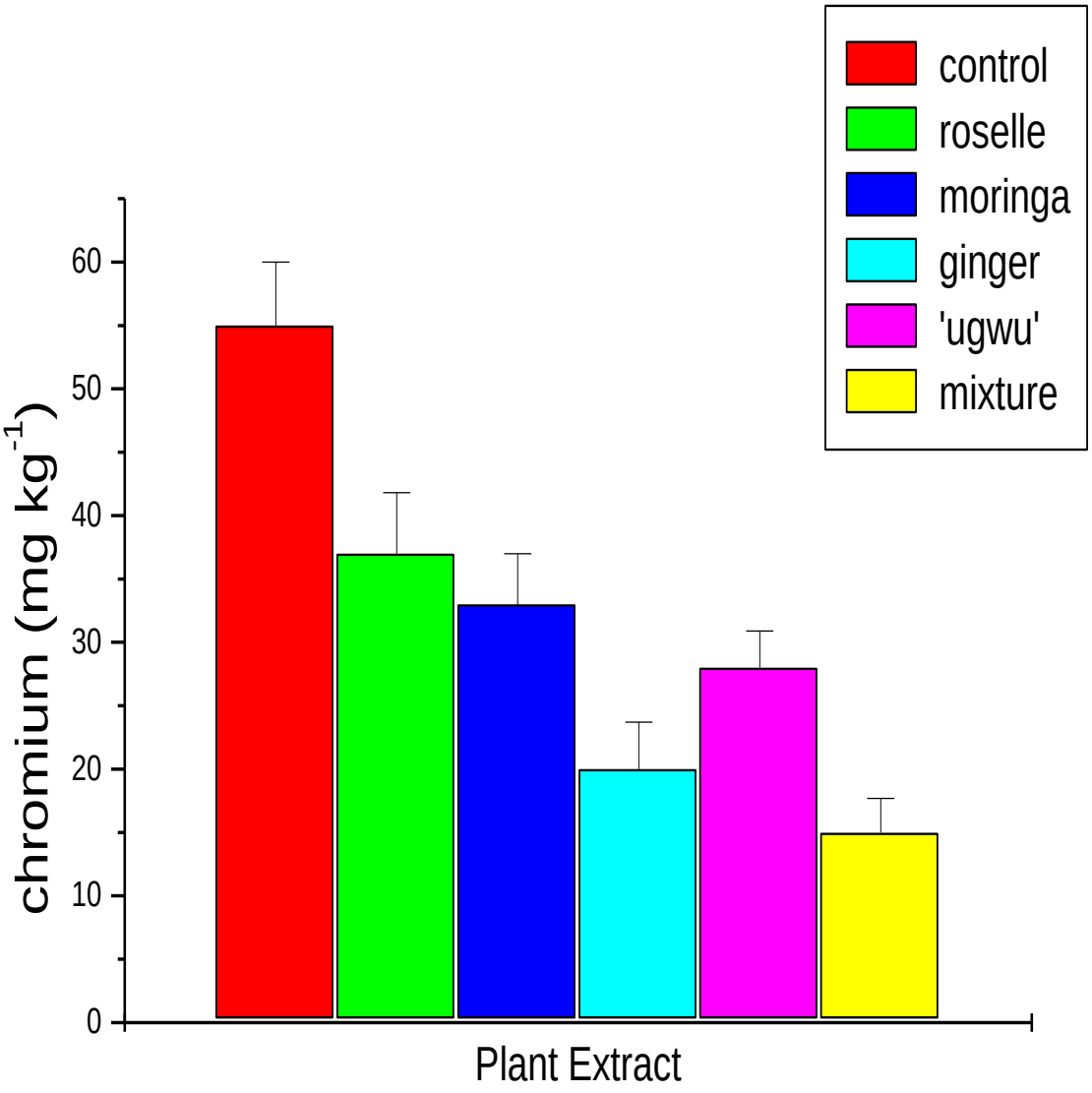

Figure 12: Percentage of chromium (mg kg^{-1}) accumulated in the lungs of the exposed albino rats fed with different plant extracts for 180 days.

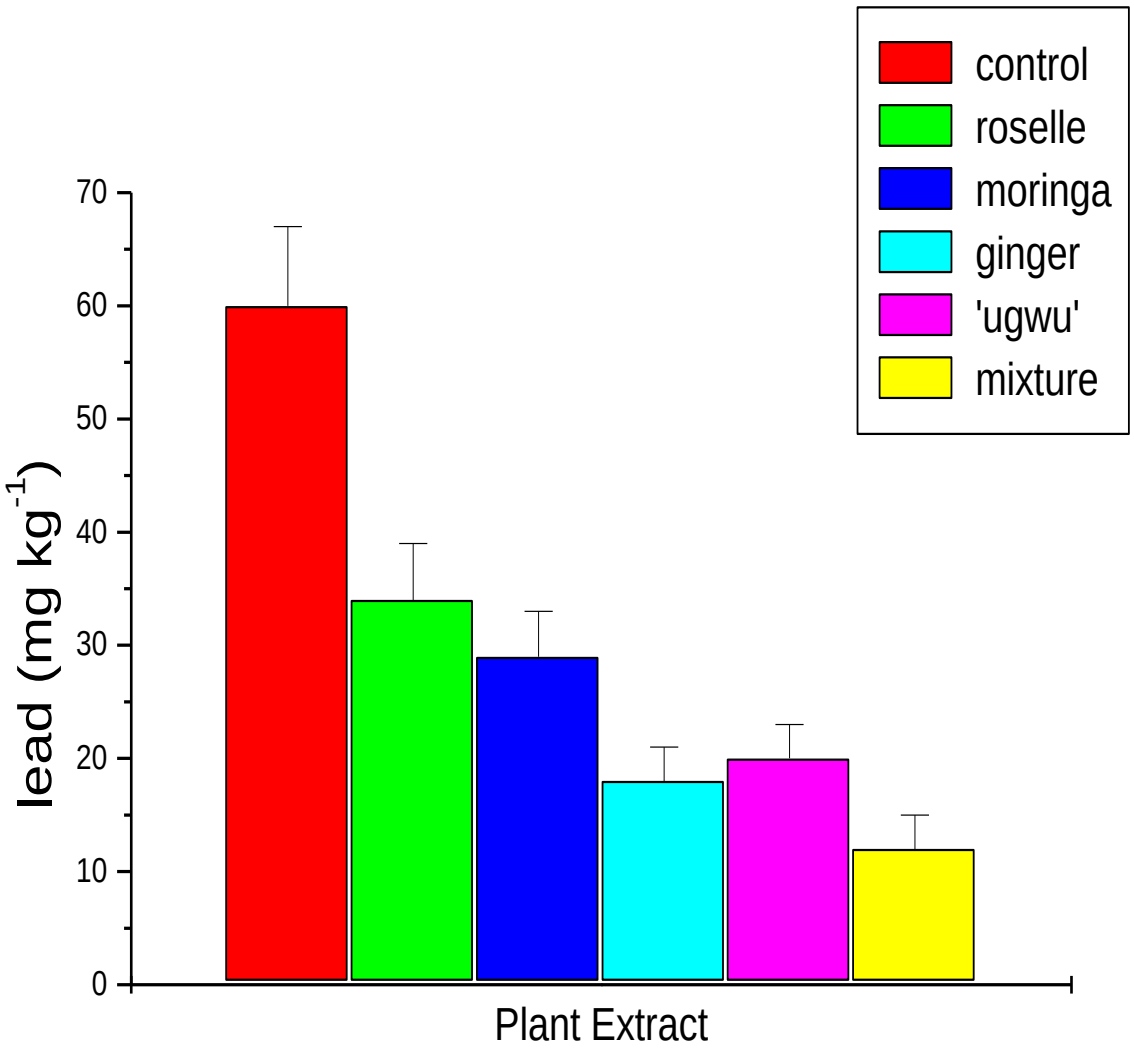

Figure 13: Percentage of lead (mg kg^{-1}) accumulated in the lungs of the exposed albino rats fed with different plant extracts for 180 days.

Table 16: PCV levels (%) of the wild rats treated with different plant extracts for 180 days

Day	0	30	60	90	120	150	180	Min. Val.	Max. Val.	Amount Increase
Extract										
Control 1	38.10[a] ±2.01	37.80[b] ±4.68	38.0[a] ±3.05	38.20[b] ±4.06	38.20[a] ±3.01	38.1[b] ±4.01	38.30[a] ±3.8	37.0	39.21	0.2 ±0.04
Control 2	26.35[a] ±4.07	26.50[b] ±3.10	26.60[b] ±4.53	26.62[b] ±3.02	26.70[a] ±3.51	26.73[b] ±4.12	26.80[a] ±4.01	26.22	26.80	0.45 ±0.05
Roselle	26.10[a] ±3.18	26.70[a] ±4.61	27.40[a] ±5.60	28.3[a] ±3.99	29.0[a] ±4.57	30.10[b] ±3.90	31.0[b] ±5.72	25.91	31.31	4.89 ±2.3
Moringa	26.00[a] ±1.02	28.10[b] ±2.49	29.4[a] ±3.27	30.90[b] ±2.49	32.60[a] ±3.50	33.90[b] ±4.29	34.60[b] ±4.37	25.31	34.96	8.60 ±2.5
Ginger	25.90[a] ±4.43	26.60[a] ±3.30	27.10[b] ±5.65	27.60[a] ±5.39	28.8[a] ±4.22	29.60[b] ±3.23	30.80[b] ±5.85	25.41	30.89	4.59 ±2.6
'Ugwu'	25.80[a] ±4.61	28.20[b] ±3.19	29.7[a] ±4.35	31.20[b] ±5.53	33.20[a] ±4.30	34.20[b] ±3.11	35.90[a] ±4.61	25.10	36.22	10.00 ±2.5
Mixture	25.80[a] ±4.58	28.20[b] ±3.31	30.20[a] ±5.05	31.90[b] ±4.35	34.0[a] ±6.72	35.70[b] ±4.55	37.50[a] ±4.61	25.11	38.21	11.7 ±3.1

- Data are expressed as Mean ± SE
- Mean values with different superscripts 'a' and 'b' along the same row are significantly different at $P < 0.05$.
- Control 2 = Exposed wild rats fed with distilled water only.

Table 17: The HB level (g dl^{1}) of the wild rats treated with different plant extracts for 180 days

Day	0	30	60	90	120	150	180	Min Value	Max Value	Amount Increase
Extract										
Control 1	13.1[a]	13.1[a]	13.2[a]	13.2[a]	13.2[a]	13.2[a]	13.2[a]	12.98	13.36	0.1
	±2.18	±3.17	±2.16	±4.18	±4.14	±3.14	±3.14			±0.09
Control 2	8.34[a]	8.36[a]	8.39[a]	8.46[b]	8.51[a]	8.56[a]	8.62[a]	8.32	8.59	0.28
	±2.02	±1.21	±2.11	±1.82	±2.42	±2.04	±1.02			±0.21
Roselle	8.35[a]	8.65[b]	9.17[a]	9.72[b]	9.92[b]	10.2[a]	10.60[b]	8.33	10.70	1.25
	±2.05	±1.15	±1.64	±2.17	±1.97	±2.14	±2.95			±0.48
Moringa	8.28[a]	9.18[b]	9.63[a]	10.3[b]	11.0[a]	11.30[b]	11.9[a]	7.89	11.99	1.65
	±1.37	±2.15	±2.08	±1.6	±2.61	±2.40	±3.11			±0.50
Ginger	8.49[a]	8.62[a]	9.03[b]	9.39[a]	9.62[b]	10.1[a]	10.3[b]	8.35	10.40	1.81
	±2.14	±2.20	±0.13	±0.21	±0.1	±0.11	±0.014			±0.53
'Ugwu'	8.61[a]	9.31[b]	9.96[a]	10.40[b]	11.00[a]	11.60	12.50[a]	8.35	12.51	3.81
	±2.27	±3.09	±2.58	±1.57	±3.11	±2.11	±2.6			±0.61
Mixture	8.23[a]	9.32[b]	10.0[a]	10.9	11.1a	11.90[b]	13.0[a]	7.99	12.99	4.77
	±1.21	±2.10	±2.05	+3.05	±3.13	±3.08	±3.01			±0.91

- Data are expressed as Mean ± SE
- Mean values with different superscripts 'a' and 'b' along the same row are significantly different at $P < 0.05$
- Control 2 = Exposed wild rats fed only with distilled water

Table 18: The RBC level (X 10^6/µl) of the wild rats treated with different plant extracts for 180 days

Day	0	30	60	90	120	150	180	Min Value	Max Value	Amount Increase
Extract										
Control 1	4.40^a	4.40^a	4.40^a	4.41^a	4.39^a	4.40^a	4.40^a	4.38	4.41	0.00
	±1.01	±1.11	±1.21	±1.00	±1.13	±0.01	±0.91			
Control 2	3.57^a	3.59^a	3.61^b	3.63^b	3.66^a	3.67^a	3.70^a	3.56	3.72	0.23
	±0.41	±0.51	±0.71	±1.10	±0.41	±0.82	±0.72			±0.19
Roselle	3.58^a	3.62^a	3.67^a	3.73^b	3.80^b	3.86^a	4.06^a	3.56	4.06	0.48
	±0.42	±0.43	±0.52	±0.52	±0.35	±0.75	±0.88			±0.31
Moringa	3.50^a	3.61^b	3.70^a	3.79^b	3.87^a	3.98^b	4.10^a	3.48	4.15	0.60
	±0.82	±0.52	±0.72	±0.82	±0.63	±0.71	±0.54			±0.32
Ginger	3.59^a	3.60^a	3.66^b	3.71^b	3.77^b	3.82^a	3.92^b	3.56	3.98	0.33
	±0.73	±0.96	±0.62	±0.73	±0.75	±0.82	±0.95			±0.31
'Ugwu'	3.50^a	3.63^b	3.72^a	3.84^b	3.95^a	4.11^b	4.23^a	3.51	4.25	0.72
	±0.64	±0.83	±0.71	±0.63	±0.53	±0.52	±0.73			±0.30
Mixture	3.55^a	3.65^b	3.76^a	3.88^b	4.07^a	4.19^b	4.32^a	3.57	4.36	0.77
	±0.95	±0.82	±0.72	±0.82	±0.57	±0.64	±0.55			±0.33

- Data are expressed as Mean ± SE
- Mean values with different superscripts 'a' and 'b' along the same row are significantly different at $P < 0.05$
- Control 2 = Exposed wild rats fed only with distilled water.

Table 19: The WBC level (mm^3) of the wild rats treated with different plant extracts for 180 days

Day	0	30	60	90	120	150	180	Min Value	Max Value	Amount Increase
Extract										
Control 1	4500[a]	4553[a]	4557[a]	4583[a]	4619[a]	4567[a]	4567	4500	4700	67
	±50	±50.3	±50.3	±28.9	±72.9	±57.7	±76.4			±16
Control 2	2200[a]	2300[a]	2400[a]	2483[a]	2547[a]	2623[a]	2693[a]	2100	2780	493
	±100	±100	±50	±104	±95.0	±80.0	±90.0			±54
Roselle	2200[a]	2367[a]	2533[b]	2780[a]	3000[b]	3217[a]	3417[b]	2100	3500	1217
	±100	±57.7	±57.7	±26.5	±100	±76.4	±76.4			±69
Moringa	2207[a]	2367[b]	2500[b]	2690[a]	2907[b]	3117[a]	3310[a]	2150	3400	1103
	±60.3	±76.4	±50	±50	±37.9	±104	±101			±70
Ginger	2217[a]	2450[b]	2657[a]	2800[a]	3083[a]	3333[a]	3450[a]	2150	3600	1233
	±76.4	±50	±50	±100	±126	±57.8	±80			±68
'Ugwu'	2367[a]	2453[a]	2534[a]	2692[a]	2737[a]	2950[b]	3217[a]	2200	3300	850
	±73	±50.3	±76.5	±47.5	±70.9	±50.0	±76.4			±45
Mixture	2250[a]	2533[b]	2770[b]	2980[b]	3170[b]	3384[a]	3600[b]	2200	3700	1050
	±75	±76.4	±197	±131	±81.9	±7.3	±100			±47

- Data are expressed as Mean ± SE
- Mean values with different superscripts 'a' and 'b' along the same row are significantly different at $P < 0.05$
- Control 2 = Exposed wild rats fed only with distilled water
- Negative control = Exposed wild rats fed only with distilled water

Figures 14-17 are graphical representations of the percentage increase in the haematological parameters of the wild rats after administering the plant extracts. There was a significant ($p<0.05$) high percentage increase in the haematological parameters of the test rats compared with the control rats that received distilled water only. Significant differences ($p<0.05$) were also noticed in the percentage increases of the haematological parameters of the test rats after administering the extracts.

4.5.2 The Albino Rats

Tables 20-23 show the bioprotective efficacy of the plant extracts on the blood parameters of the exposed albino rats where significantly ($P<0.05$) moderate to normal heath status was observed in the blood parameters of the test rats compared to the control rats. The PCV decrease of the control rats was 13 % whereas the PCV decrease of the rats fed with extracts of roselle, moringa, ginger, 'ugwu' and mixture are 5.30, 3.00, 5.80, 1.70 and 1.00 %, respectively (Table 20). Table 21 shows the HB decrease of the control rats was 4.48 while the HB decrease of the rats that received extracts of roselle, moringa, ginger, 'ugwu' and mixture are 1.92, 1.01, 2.20, 0.90 and 0.27 g dl^{-1}, respectively. Table 22 shows the RBC values ($x10^{12}$) of the exposed rats where the RBC decrease of the control rats was 0.84 whereas the RBC decrease of the rats fed with extracts of roselle, moringa, ginger, 'ugwu', and mixture are 0.52, 0.20, 0.46, 0.17 and 0.09, respectively. Moreover, the WBC increase of the control rats was 1594 mm^3 whereas the WBC increase of the rats that were fed with extracts of roselle, moringa, ginger, 'ugwu', and mixture are 672, 491, 272, 148, and 2.94 mm^3, respectively (Table 23).

Figures 18-21 are graphical representations of the percentage decrease in the blood parameters (PCV, HB, RBC and WBC) of the exposed albino rats treated with the plant extracts for 180 days. The percentage decrease in haematological parameters of the test rats were significantly ($p<0.05$) lower than the control rats that received distilled water only. The test rats fed with different plant extracts also differ significantly ($p<0.05$) in the percentage haematological decrease.

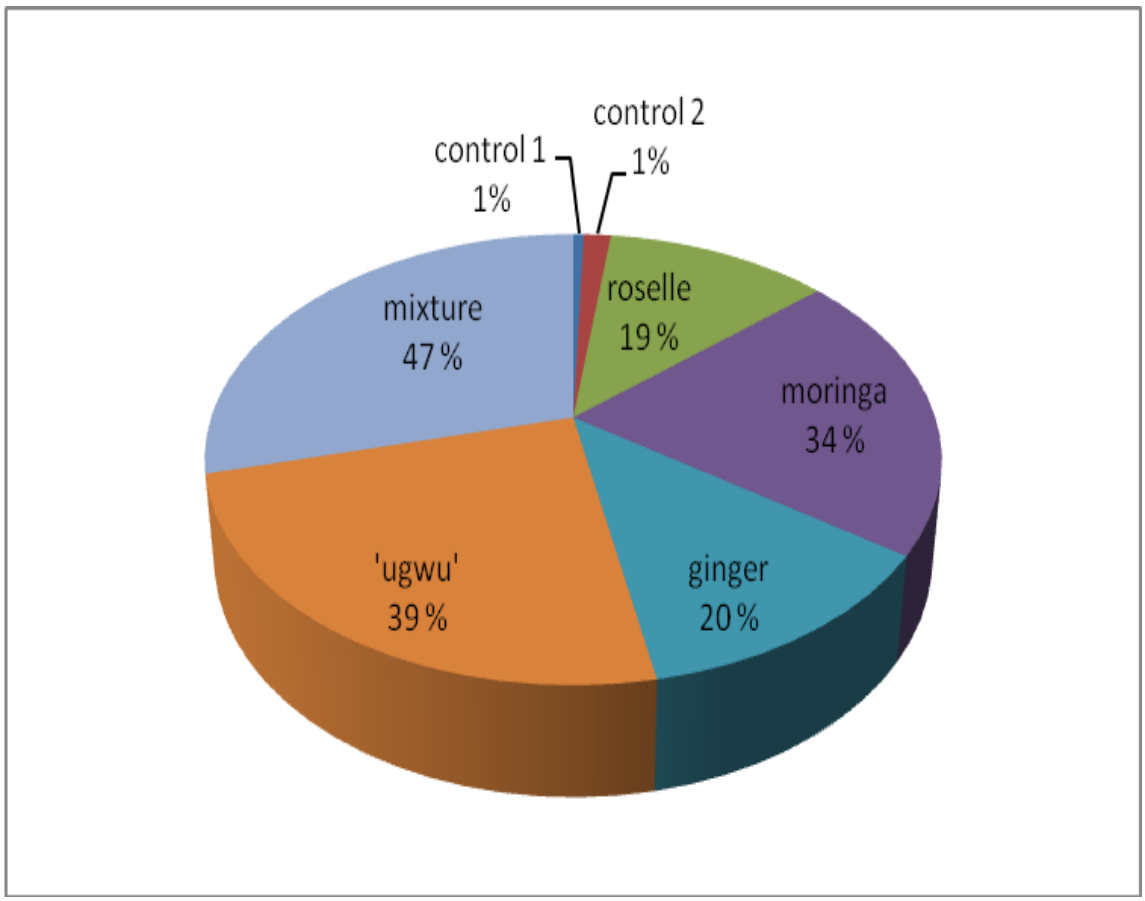

Figure 14: Percentage increase in PCV value of the wild rats after treatment with different plant extracts for 180 days.

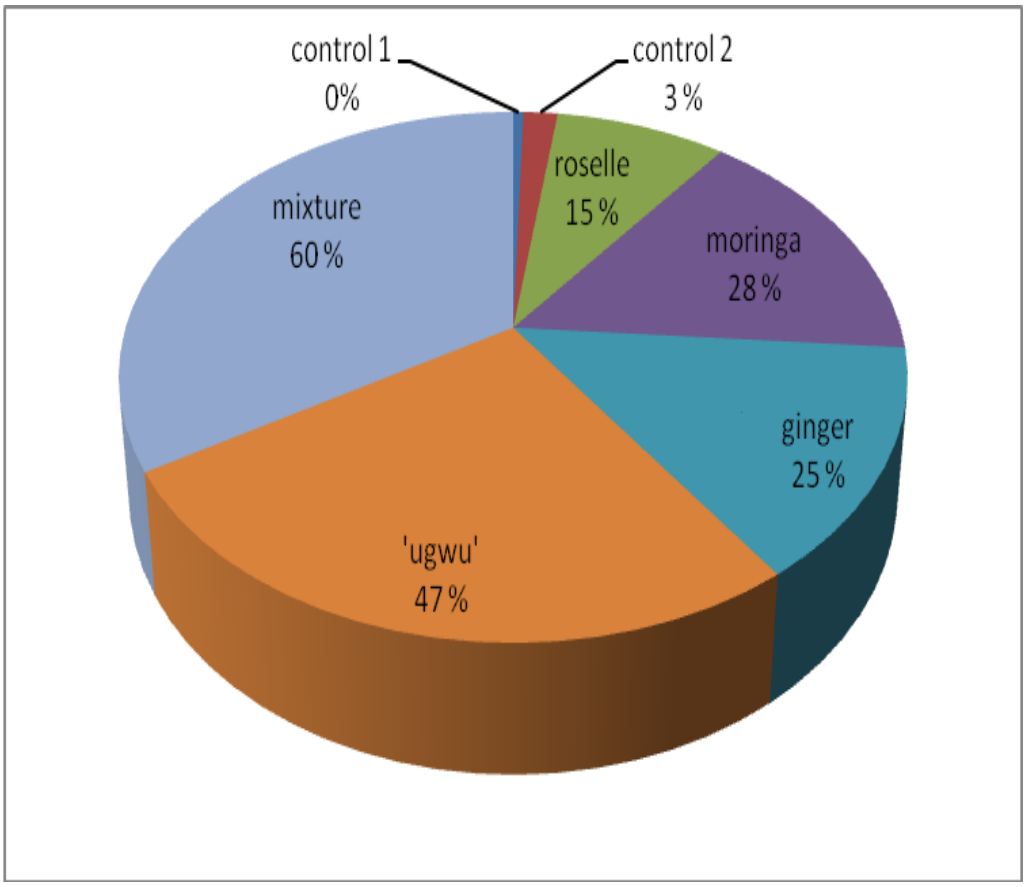

Figure 15: Percentage increase in HB (g dl^{1}) value of the wild rats after treatment with different plant extracts for 180 days.

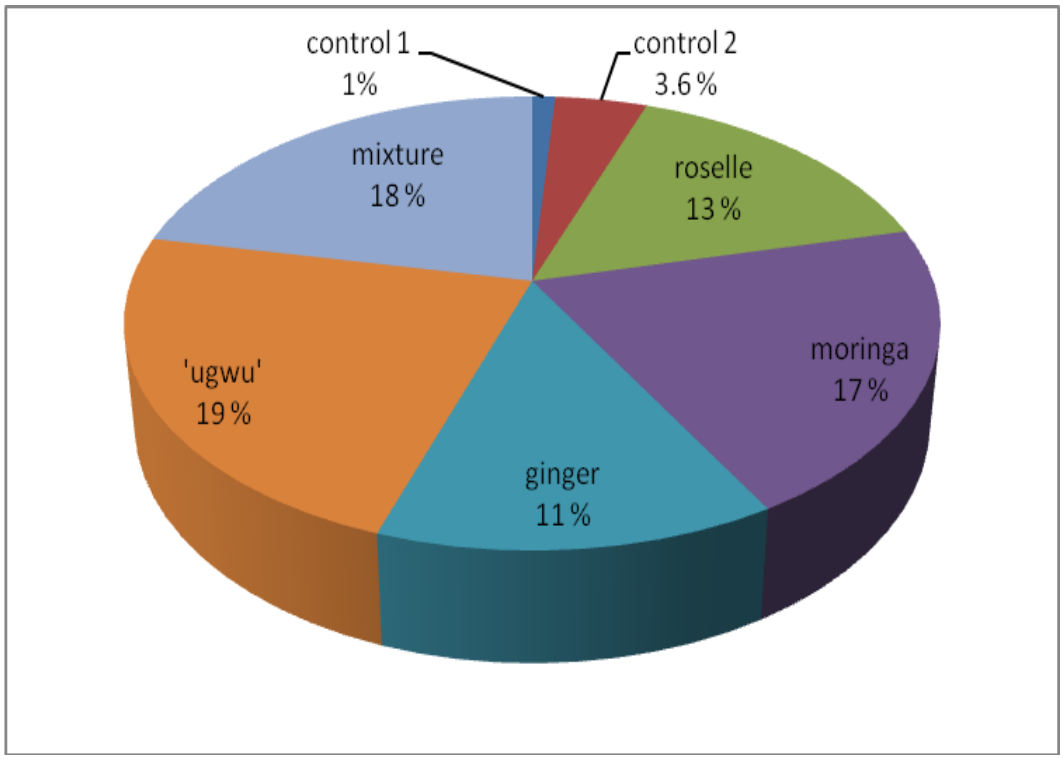

Figure 16: percentage increase in RBC (10^{12}) value of the wild rats after treatment with different plant extracts for 180 days.

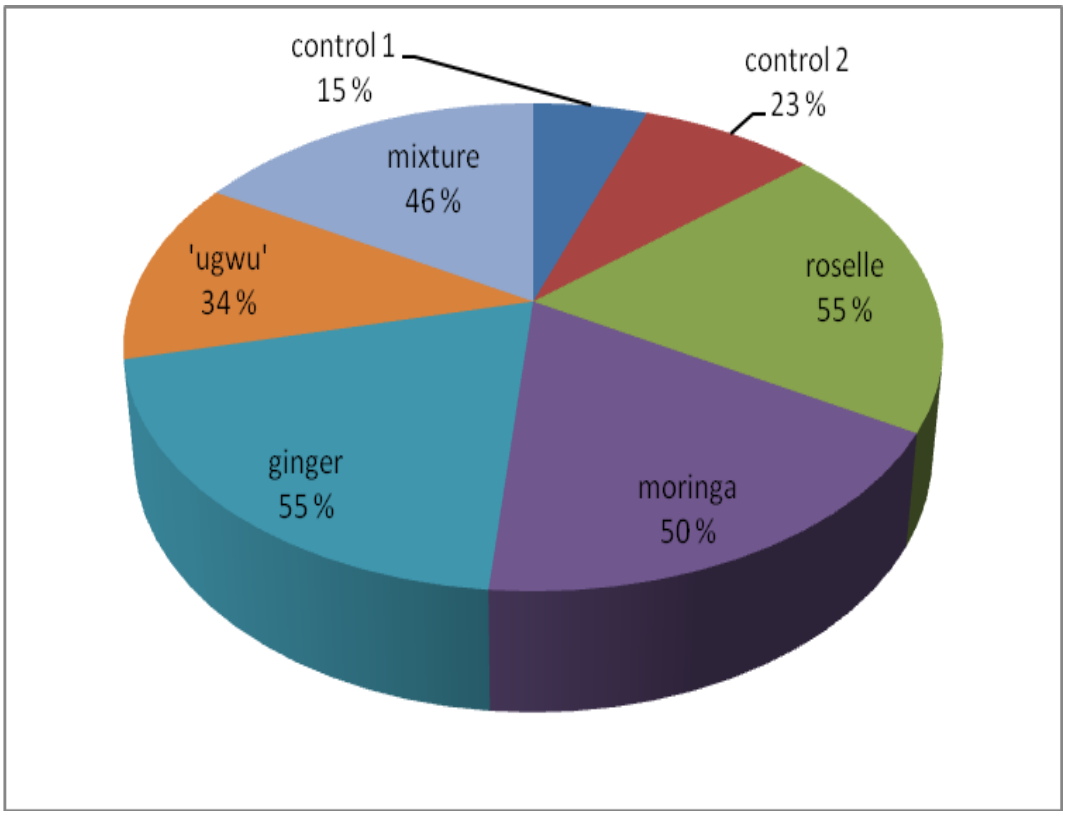

Figure 17: Percentage increase in WBC (mm^3) values of the wild rats after treatment with different plant extracts for 180 days.

Table 20: The PCV level (%) of the exposed albino rats treated with different plant extracts for 180 days

Day	0	30	60	90	120	150	180	Min. Value	Max. Value	Amount Decrease
Extract										
Control	39.10[a]	37.20[b]	35.50[a]	32.20[b]	30.40[a]	27.4[b]	26.60[a]	26.41	39.81	13.00
	±2.18	±3.12	±2.76	±2.11	±3.73	±4.10	±3.47			±0.44
Roselle	38.30[a]	37.70[a]	36.40[b]	35.0[a]	34.30[a]	33.20[a]	32.80[a]	32.21	39.21	5.30
	±3.86	±0.36	±3.42	±2.21	±3.47	±3.90	±2.72			±0.46
Moringa	39.00[a]	37.70[a]	37.50[a]	37.40[a]	37.00[a]	36.80[a]	36.00[a]	35.21	40.22	3.00
	±3.17	±3.63	±2.60	±2.58	±3.81	±3.54	±2.31			±0.43
Ginger	39.10[a]	37.50[b]	36.70[b]	35.20[a]	34.70[a]	33.60[b]	32.30[a]	32.20	39.50	5.80
	±3.62	±3.61	±2.48	±3.67	±2.36	±3.32	±3.11			±0..31
'Ugwu'	39.00[a]	38.10[a]	37.75	37.80[a]	37.20[a]	37.00[a]	36.30[a]	35.99	39.91	1.70
	±1.80	±2.13	±1.23	±3.24	±2.33	±2.58	±3.34			±0.43
Mixture	39.30[a]	39.20[a]	39.10[a]	38.90[a]	38.30[a]	38.70[a]	38.30[a]	37.22	39.91	1.00
	±3.56	±3.57	±2.48	±1.51	±2.60	±3.61	±2.61			±0.47

- Data are expressed as Mean ± SE
- Mean values with different superscripts 'a' and 'b' along the same row are significantly different at $P < 0.05$

Table 21: The HB level (g dl^{-1}) of the exposed albino rats treated with different plant extracts for 180 days

Day	0	30	60	90	120	150	180	Min. Value	Max. Value	Amount Decrease
Extract										
Control	13.20[a]	12.40[b]	11.80[a]	10.80[b]	9.50[a]	8.93[b]	8.72[a]	8.80	13.33	4.48
	±2.29	±2.43	±3.27	±2.05	±1.27	±0.86	±0.95			±0.06
Roselle	12.82[a]	12.40[a]	12.10[b]	11.71[a]	11.43[a]	11.12[a]	10.90[a]	10.80	13.1	1.92
	±2.10	±1.10	±2.14	±1.07	±1.16	±1.30	±1.23			±0.09
Moringa	13.03[a]	12.61[a]	12.53[a]	12.50	12.31[a]	12.29[a]	12.02[a]	12.10	13.40	1.01
	±2.39	±1.10	±1.20	±0.99	±0.97	±1.18	±1.10			±0.07
Ginger	13.01[a]	12.50[b]	12.21[b]	11.72[a]	11.60[a]	11.20[b]	10.81[a]	10.70	13.20	2.20
	±2.21	±1.21	±2.16	±0.92	±0.62	±1.01	±1.14			±0.03
'Ugwu'	13.00[a]	12.70[a]	12.61[a]	12.60[a]	12.40[a]	12.31[a]	12.10[a]	12.0	13.30	0.90
	±1.57	±1.04	±0.78	±0.88	±1.11	±1.20	±0.71			±0.06
Mixture	13.10[a]	13.10[a]	13.01[a]	13.00[a]	12.93[a]	12.90[a]	12.83[a]	12.40	13.30	0.27
	±1.18	±1.19	±2.16	±1.17	±1.20	±1.30	±0.92			±0.09

- Data are expressed as Mean ± SE
- Mean values with different superscripts 'a' and 'b' along the same row are significantly different at $P<0.05$

Table 22: The RBC level (X 10^6/µl) of the exposed albino rats treated with different plant extracts for 180 days

Day	0	30	60	90	120	150	180	Min. Value	Max. Value	Amount Decrease
Extract										
Control	4.30[a]	4.05[b]	3.88[a]	3.77[b]	3.64[a]	3.52[b]	3.46[a]	3.40	4.43	0.84
	±0.52	± 0.13	±0.93	±0.10	±0.56	±0.60	±0.32			±0.21
Roselle	4.32[a]	4.25[a]	4.16[a]	4.06[a]	3.97[a]	3.89[a]	3.79[a]	3.78	4.41	0.52
	± 0.39	± 0.36	±0.46	±0.37	±0.47	±0.52	±0.31			±0.11
Moringa	4.29[a]	4.26[a]	4.23[a]	4.19[a]	4.15[a]	4.12[a]	4.09[a]	4.04	4.40	0.20
	± 0.33	± 0.42	±0.51	±0.29	±0.37	±0.23	±0.34			±0.14
Ginger	4.31[a]	4.28[a]	4.22[a]	4.14[a]	4.03[a]	3.94[b]	3.85[a]	3.82	4.35	0.46
	± 0.64	± 0.36	±0.26	±0.46	±0.35	±0.44	±0.14			±0.11
'Ugwu'	4.31[a]	4.27[a]	4.23[a]	4.20[a]	4.18[a]	4.15[a]	4.14[a]	4.13	4.33	0.17
	± 0.52	± 0.53	±0.43	±0.63	±0.73	±0.62	±0.81			±0.10
Mixture	4.27[a]	4.26[a]	4.26[a]	4.23[a]	4.21[a]	4.19[a]	4.18[a]	4.12	4.32	0.09
	± 0.58	± 0.38	±0.48	±0.37	±0.57	±0.36	±0.55			±0.05

- Data are expressed as Mean ± SE
- Mean values with different superscripts 'a' and 'b' along the same row are significantly different at $P<0.05$

Table 23: The WBC level (mm^3) of the exposed albino rats treated with different plant extracts for 180 days

Day	0	30	60	90	120	150	180	Min. Value	Max. Value	Amount Increase
Extract										
Control	4833[a] ±99.1	4955[a] ±87.1	5137[a] ±106	5406[a] ± 183	5684[a] ±137	6100[a] ±133	6427[a] ±253	4735	6713	1594 ±121
Roselle	4862[a] ±204	4988[a] ±233	5061[a] ±201	5163[a] ±193	5307[a] ±162	5404[a] ±159	5534[a] ±107	4632	5501	672 ±59
Moringa	4884[a] ±174	4954[a] ±195	5296[a] ±632	5335[a] ±603	5344[a] ±604	5359[a] ±603	5375[a] ±600	4689	6058	491 ±58
Ginger	4767[a] ±96	4825[a] ±112	4850[a] ±133	4890[a] ±148	4920[a] ±147	4948[b] ±139	5039[a] ±133	4658	5146	272 ±41
'Ugwu'	4845[a] ±104	4884[a] ±100	4910[a] ±105	4933[a] ±103	4932[a] ±102	4969[a] ±104	4993[a] ±100	4743	5098	148 ±29
Mixture	490[a] ±134	493[a] ±136	496[a] ±148	4980[a]± 148	500[a] ±150	5018[a] ±150	508[a] ±145	4751	5161	189 ±31

- Data are expressed as Mean ± SE
- Mean values with different superscripts 'a' and 'b' along the same row are significantly different at $P<0.05$

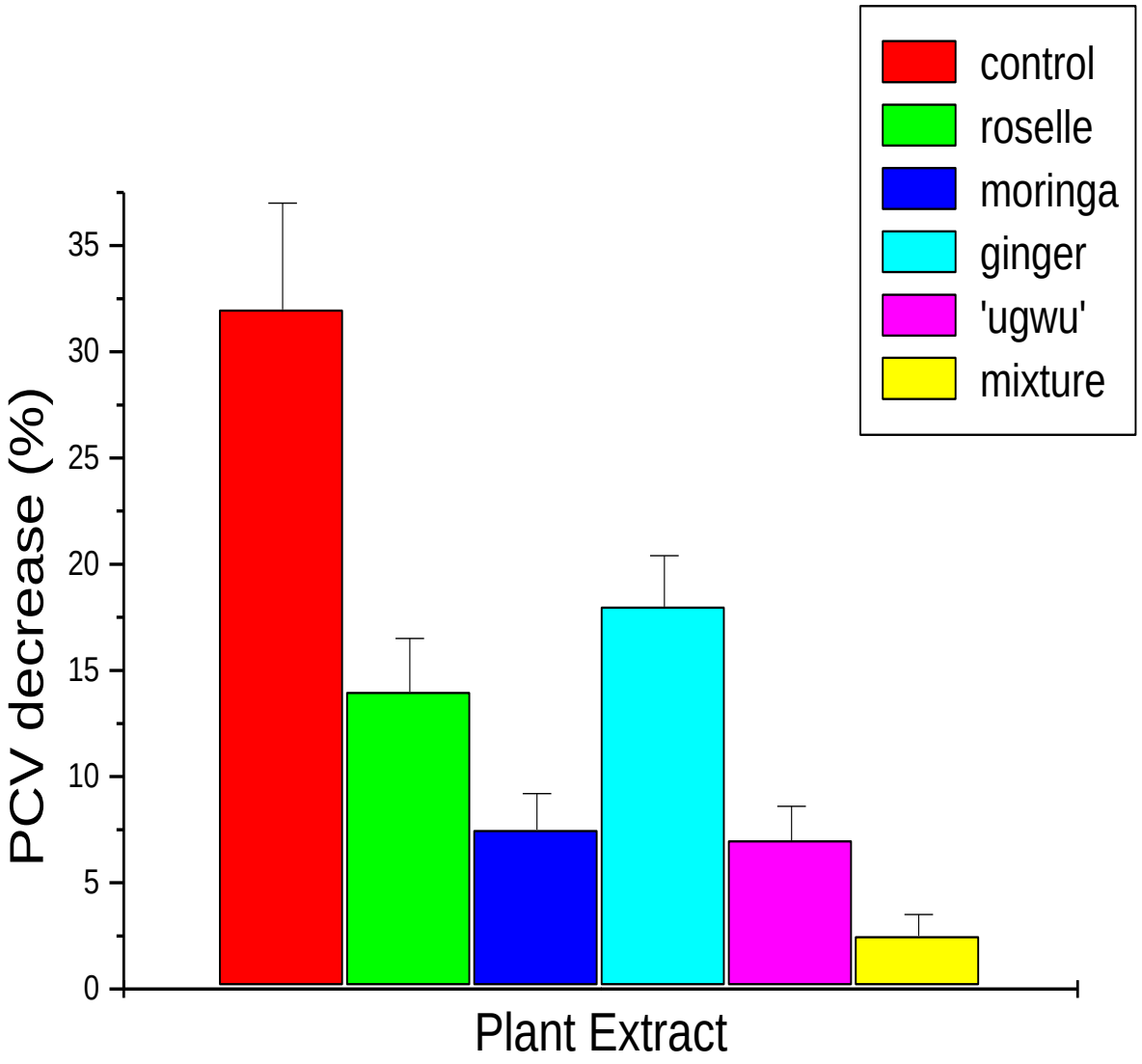

Figure 18: The percentage PCV decrease of the exposed albino rats administered different plant extracts for 180 days

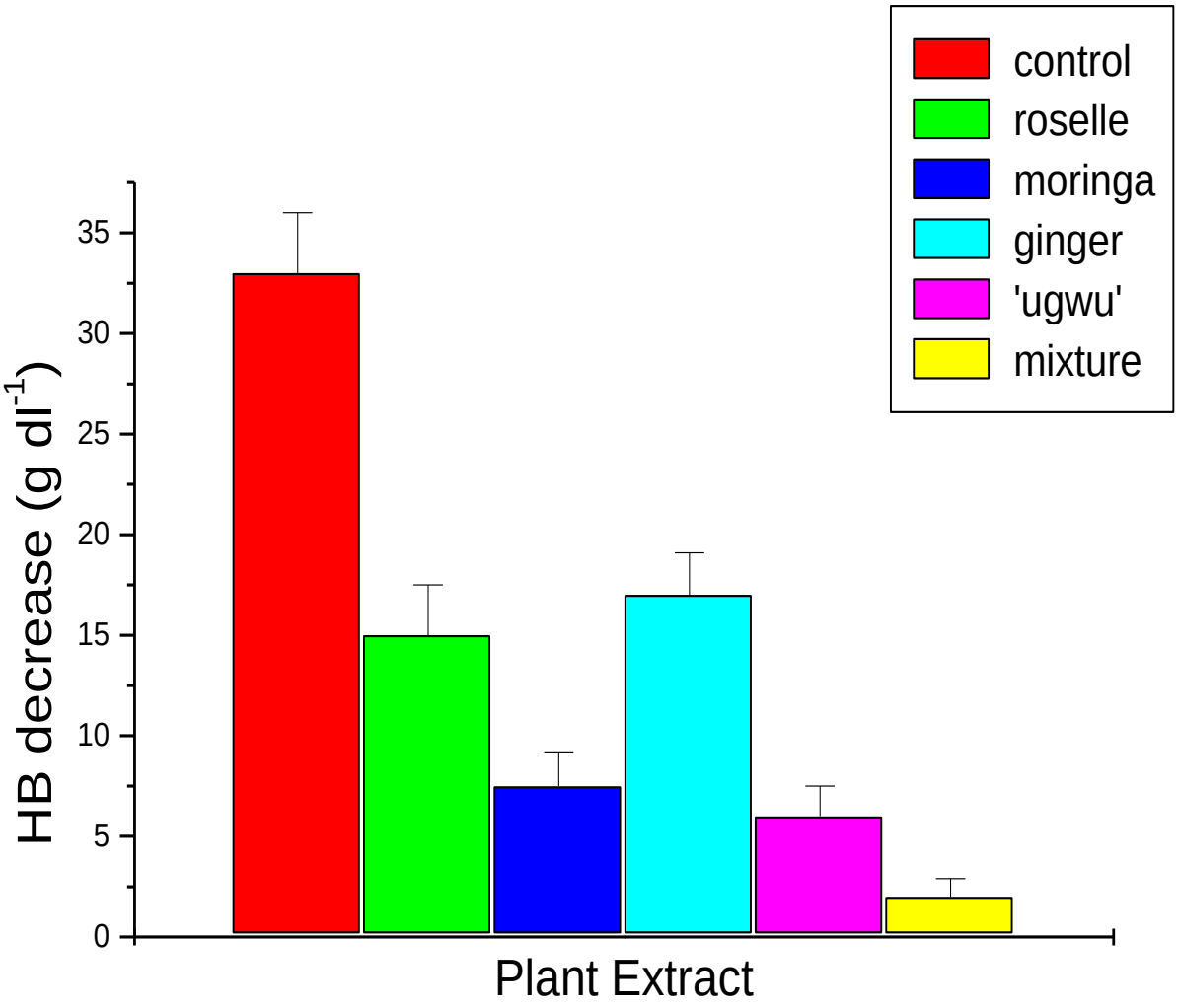

Figure 19: The percentage HB (g dl^{-1}) decrease of the exposed albino rats administered different plant extracts for 180 days

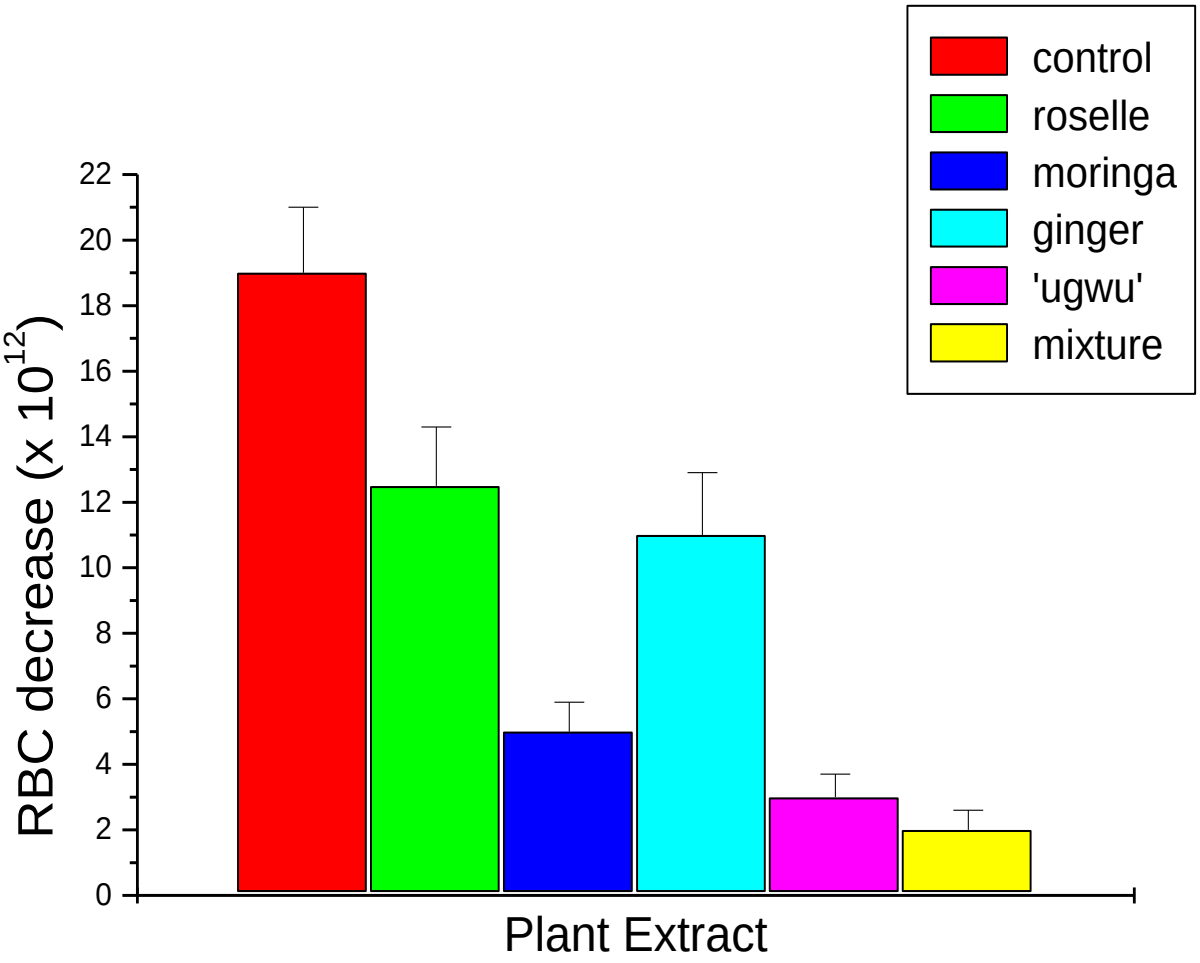

Figure 20: The percentage RBC (10^{12}) decrease of the exposed albino rats administered different plant extracts for 180 days.

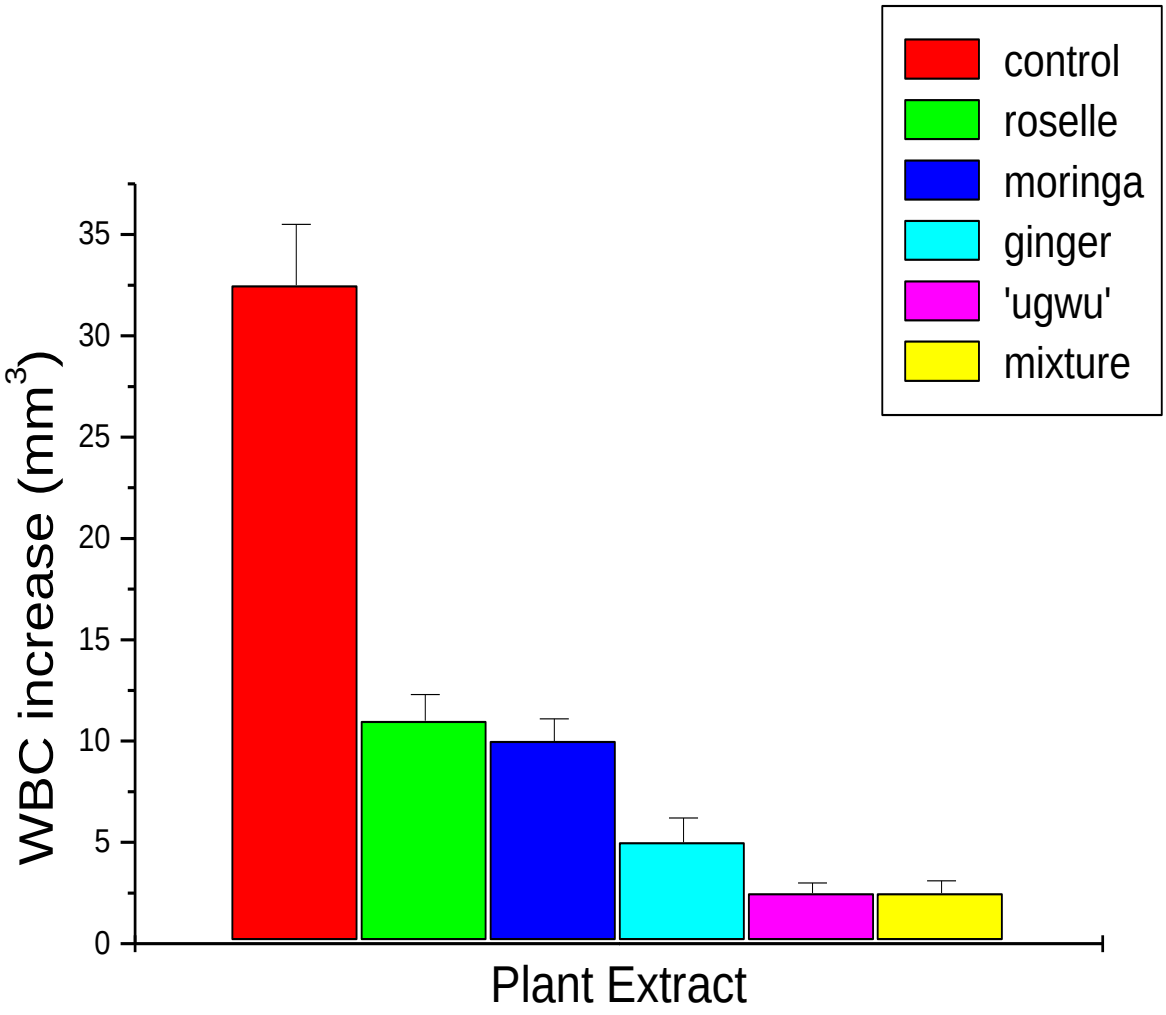

Figure 21: The percentage WBC (mm^3) increase of the exposed albino rats administered different plant extracts for 180 days.

4. 6 Efficacy of the Plant Extracts on the Biochemical Parameters of Rats Exposed to Cement Dust.

4.6.1 The Wild Rats.

Tables 24-28 show the rebuilding efficacy of the plant extracts on the biochemical parameters of the wild rats. The plant extracts significantly ($p<0.05$) normalized the biochemical parameters of the test rats compared to the control 1 and control 2 rats that were fed with distilled water only. Table 24 shows both the control 1 and control 2 rats had 1.3 and 8.3 u l^{-1} ALT decrease, respectively, whereas the rats fed with roselle, moringa, ginger, 'ugwu', and mixture extracts had 16.1, 20.2, 22.6, 22.5 and 26.8 u l^{-1} ALT decrease, respectively. The AST decrease in the control 1 and control 2 rats are 0.9 and 9.7 u l^{-1}, respectively, whereas the rats administered with roselle, moringa, ginger, 'ugwu', and mixture extracts had AST decrease of 18.0, 20.9, 22.4, 18.8 and 23.8 u l^{-1}, respectively (Table 25). Table 26 shows the ALP decrease of the control 1 and control 2 rats are 0.7 and 23.7 u l^{-1}, respectively, while the ALP decrease of the rats fed with roselle, moringa, ginger, 'ugwu', and mixture extracts are 45.8, 56.8, 59.5, 55.2 and 60.9 u l^{-1}, respectively. Table 27 reveals the serum protein increase of the control 1 and control 2 rats are 0.03 and 0.14 g dl^{-1}, respectively, whereas the serum protein increase of the rats that were administered with extracts of roselle, moringa, ginger, 'ugwu' and mixture are 0.42, 0.64, 0.36, 0.99 and 0.70 g dl^{-1}, respectively. The GSH increase of the control 1 and control 2 rats are 0.5 and 0.6 u l^{-1}, respectively, while the GSH increase of the rats that were fed with extracts of roselle, moringa, ginger, 'ugwu' and mixture are 2.7, 4.0, 3.2, 4.1 and 4.1 u l^{-1}, respectively (Table 28). Significant differences ($p<0.05$) were also noticed in the biochemical parameters of the rats fed with the different extracts.

Figures 22-26 illustrate the percentage rebuilding efficacy of the plant extracts on the biochemical parameters (ALT, AST, ALP, Serum protein and GSH) of the wild rats treated with the plant extracts for 180 days. The test rats had significantly ($p<0.05$) higher percentage rebuilding efficacy compared with the control. Also, at the end of the treatment, significant differences ($p<0.05$) were observed in the percentage rebuilding efficacy of the test rats

TABLE 24: The ALT level (U/L) of the exposed wild rats treated with different plant extracts for 180 days

Day	0	90	180	Min. Value	Max. Value	Amount Decrease	RD L Range
Extract							
Control 1	25.4[a] ±2.3	25.2[a] ±2.4	24.1[a] ± 2.1	23.1	26.5	1.3 ±1.1	10 – 40
Control 2	46.4[a] ±4.3	43.2[a] ±4.4	38.1[a] ± 5.1	36.1	48.5	8.3 ±2.9	10 – 40
Roselle	47.4[a] ±4.4	40.3[b] ±4.7	31.3[a] ±4.0	28.7	48.7	16.1 ±3.1	10 – 40
Moringa	46.5[a] ±3.9	38.4[b] ± 4.4	26.3[b] ±4.6	24.4	47.9	20.2 ±2.5	10 – 40
Ginger	45.1[a] ±3.3	33.1[b] ±3.5	22.5[b] ±4.0	20.3	46.9	22.6 ±2.5	10 – 40
'Ugwu'	47.3[a] ± 5.1	37.9[b] ±4.0	24.8[a] ±4.4	22.1	48.3	22.5 ±2.4	10 – 40
Mixture	46.5[a] ±3.2	33.5[b] ±3.5	19.7[a] ±5.6	17.9	47.8	26.8 ±2.5	10 – 40

- Data are expressed as Mean ± SE
- Mean values with different superscripts 'a' and 'b' along the same row are significantly different at P <0.05
- Control 2 = Exposed wild rats fed only with distilled water
- RDL = Randox Laboratory Services, UK

TABLE 25: The AST level (U/L) of the exposed wild rats treated with different plant extracts for 180 days

Day	0	90	180	Min. Value	Max. Value	Amount Decrease	RD L Range
Extract							
Control 1	21.4[a] ±2.1	21.3[a] ±2.2	20.5[a] ±2.0	18.6.	23.1	0.96 ±0.43	10 – 34
Control 2	55.2[a] ±6.3	47.4[a] ±5.2	45.5[a] ±4.1	43.3	57.0	9.7 ±1.9	10 – 34
Roselle	56.1[a] ±5.0	46.5[b] ±6.1	38.1[a] ±3.4	37.8	57.6	18.0 ±2.9	10 – 34
Moringa	57.3[a] ±6.4	43.2[b] ±4.7	36.4[a] ±4.6	34.9	58.1	20.9 ±3.0	10 – 34
Ginger	56.5[a] ±4.2	41.1[b] ±4.1	34.1[a] ±5.8	33.2	57.8	22.4 ±2.4	10 – 34
'Ugwu'	55.8[a] ±4.3	43.1[b] ±6.0	37.0[a] ±5.0	35.5	56.9	18.8 ±3.1	10 – 34
Mixture	56.3[a] ±4.0	38.5[b] ±5.2	32.3[a] ±5.3	30.1	58.3	23.8 ±3.4	10 – 34

- Data are expressed as Mean ± SE
- Mean values with different superscripts 'a' and 'b' along the same row are significantly different at; P <0.05.
- Control 2 = Exposed wild rats fed only with distilled water
- RDL = Randox Laboratory Services, UK.

Table 26: The ALP level (U/L) of the exposed wild rats treated with different plant extracts for 180 days

Day	0	90	180	Min. Value	Max. Value	Amount decrease	RDL Range
Extract							
Control 1	100.6[a] ±10.13	100.3[a] ± 9.00	99.9[a] ± 8.81	97.5	103.8	0.7 ±0.2	44 – 147
Control 2	200.7[a] ± 14.23	189.3[a] ±13.25	177.0[a] ±15.71	164.3	202.6	23.7 ±2.1	44 – 147
Roselle	201.6[a] ± 15.07	185.5[a] ± 15.5	155.8[b] ±15.36	152.8	203.9	45.8 ±2.5	44 – 147
Moringa	202.6[a] ± 15.86	155.9[b] ±14.16	145.8[a] ± 18.00	140.5	204.8	56.8 ±3.8	44 – 147
Ginger	202.5[a] ± 10.00	151.7[b] ±11.16	143[a] ± 14.21	137.9	203.6	59.5 ±3.7	44 – 147
'Ugwu'	199.8[a] ± 12.45	150.3[b] ±18.42	144.6[a] ± 13.21	138.1	202.5	55.2 ±4.6	44 – 147
Mixture	201.5[a] ± 13.43	148.4[b] ±14.11	140.6[a] ±14.01	135.4	204.2	60.9 ±4.4	44 – 147

- Data are expressed as Mean ± SE
- Mean values with different superscripts 'a' and 'b' along the same row are significantly different at P <0.05.
- Control 2 = Exposed wild rats fed only with distilled water.
- RDL = Randox Laboratory Services, UK.

Table 27: The serum protein level (g dl^{-1}) of the wild rats treated with different plant extracts for 180 days

Day	0	60	90	180	Min Value	Max Value	Protein Increase	RDL Range
Extract								
Control 1	6.88^{a} ±0.06	6.89^{a} ±0.01	6.88^{a} ±0.02	6.91^{a} ±0.01	6.81	6.92	0.03 ±0.001	6.5-8.5
Control 2	5.90^{a} ±0.01	5.92^{a} ±0.02	5.95^{a} ±0.05	6.04^{a} ±0.014	5.89	6.06	0.14 ±0.015	6.5-8.5
Roselle	5.90^{a} ±0.002	5.96^{b} ±0.02	6.09^{a} ±0.07	6.32^{a} ±0.07	5.90	6.38	0.42 ±0.024	6.5-8.5
Moringa	5.89^{a} ±0.01	6.03^{b} ±0.05	6.14^{a} ±0.03	6.53^{b} ±0.06	5.88	6.58	0.64 ±0.031	6.5-8.5
Ginger	5.89^{a} ±0.02	5.95^{a} ±0.04	6.04^{a} ±0.10	6.25 ±0.06	5.87	6.32	0.36 ±0.027	6.5-8.5
'Ugwu'	5.90^{a} ±0.01	6.06^{a} ±0.02	6.19^{b} ±0.02	6.89^{b} ±0.02	6.66	6.70	0.99 ±0.042	6.5-8.5
Mixture	5.90^{a} ±0.06	6.06^{a} ±0.02	6.19^{b} ±0.02	6.60^{a} ±0.05	5.89	6.66	0.70 ±0.029	6.5-8.5

- Data are expressed as Mean ± SE.
- Mean values with different superscripts 'a' and 'b' along the same row are significantly different at $P < 0.05$
- Control 2 = Exposed wild rats fed only with distilled water.
- RDL= Randox Laboratory Services, UK.

Table 28: The GSH level (U/L) of the exposed wild rats treated with different plant extracts for 180 days

Day	0	90	180	Min. Value	Max. Value	% GSH Increase	RDL Range
Extract							
Control 1	6.0[a]	6.2[a]	6.5[a]	5.9	6.7	0.5	1-10
	±1.5	± 1.6	±1.4			± 0.15	
Control 2	3.10[a]	3.3[a]	3.7[a]	2.85	3.9	0.6	1-10
	± 1.2	± 0.9	± 0.8			±0.33	
Roselle	3.0[a]	4.1[b]	5.7[a]	2.89	6.1	2.7	1-10
	± 1.1	± 0.8	± 0.8			±0.66	
Moringa	2.9[a]	4.8[b]	6.9[a]	2.82	7.3	4.0	1-10
	± 0.3	± 1.1	± 1.9			±0.76	
Ginger	3.0[a]	4.2[b]	6.2[a]	2.92	6.7	3.2	1-10
	± 0.2	± 1.2	± 1.3			±0.90	
'Ugwu'	2.8[a]	4.6[b]	6.9[a]	2.71	7.0	4.1	1-10
	± 0.1	± 1.1	± 1.6			±0.78	
Mixture	3.1[a]	4.6[b]	7.2[a]	2.91	7.4	4.1	1-10
	± 0.7	± 1.1	± 0.7			±0.74	

- Data are expressed as Mean ± SE;
- Mean values with different superscripts 'a' and 'b' along the same row are significantly different at $P < 0.05$;
- Control 2 = Exposed wild rats fed only with distilled water.
- RDL = Randox Laboratory Services, UK.

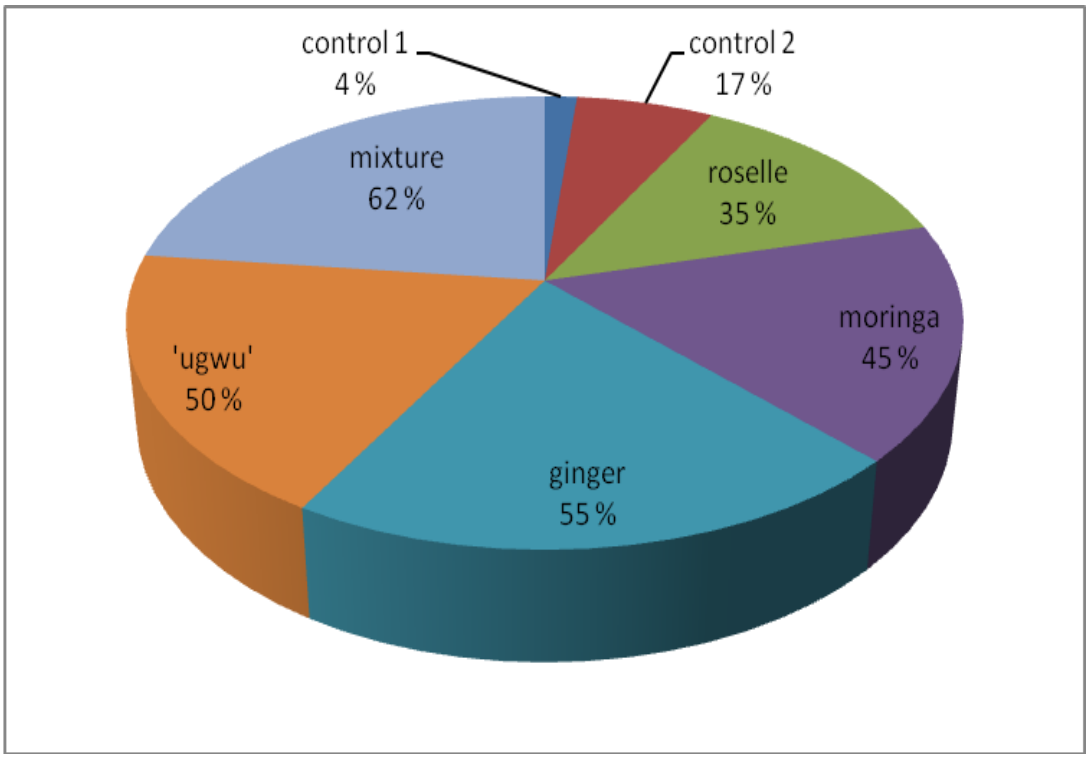

Figure 22: Percentage ALT decrease (U/L) of the wild rats after treatment with the plant extracts for 180 days.

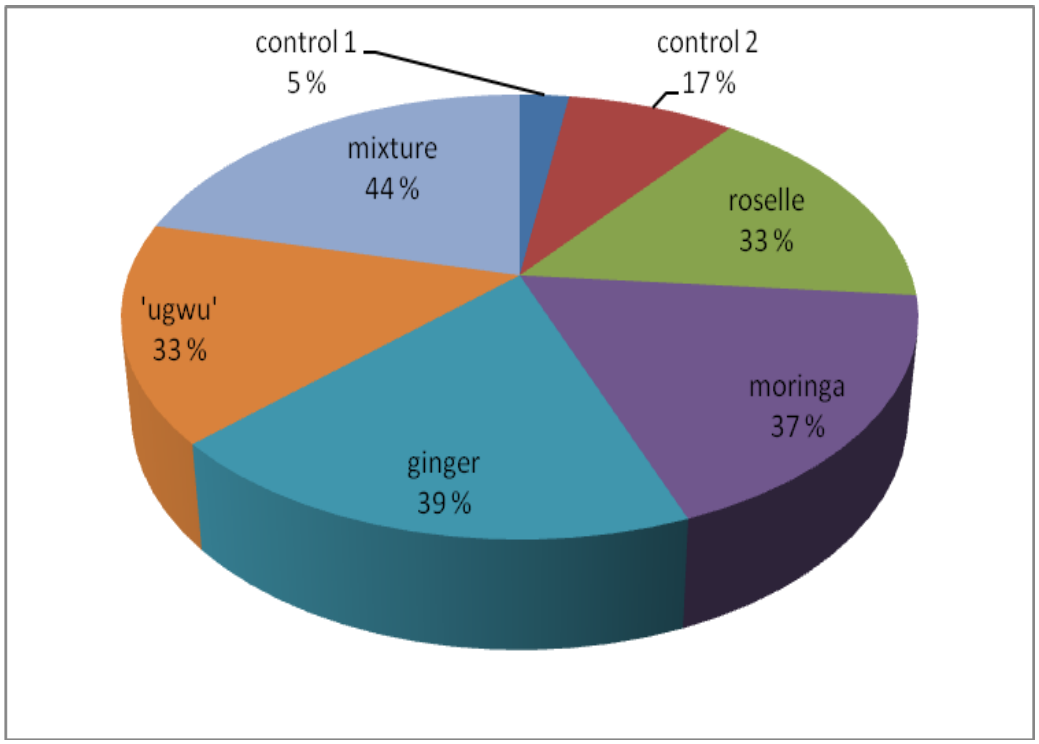

Figure 23: Percentage AST decrease (U/L) of the wild rats after treatment with the plant extracts for 180 days.

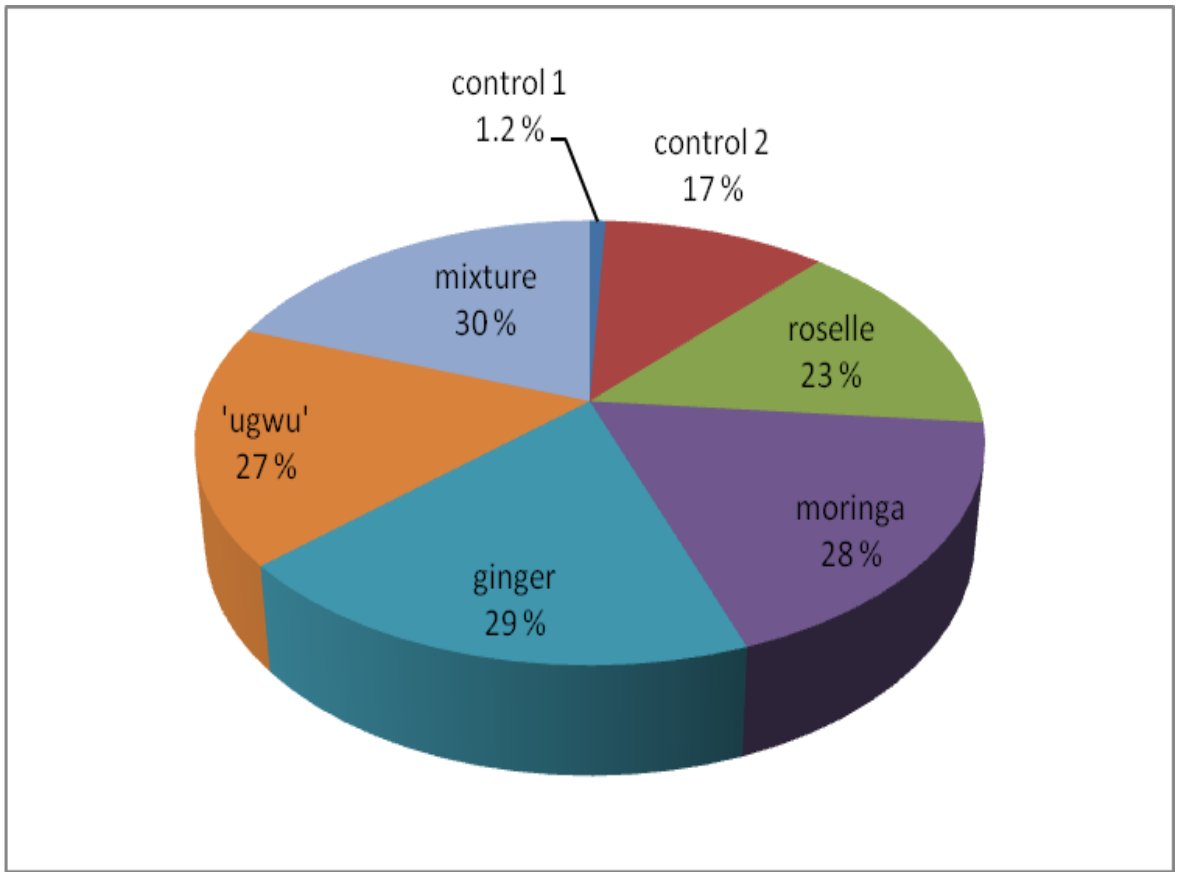

Figure 24: Percentage ALP decrease (U/L) of the wild rats after treatment with the plant extracts for 180 days.

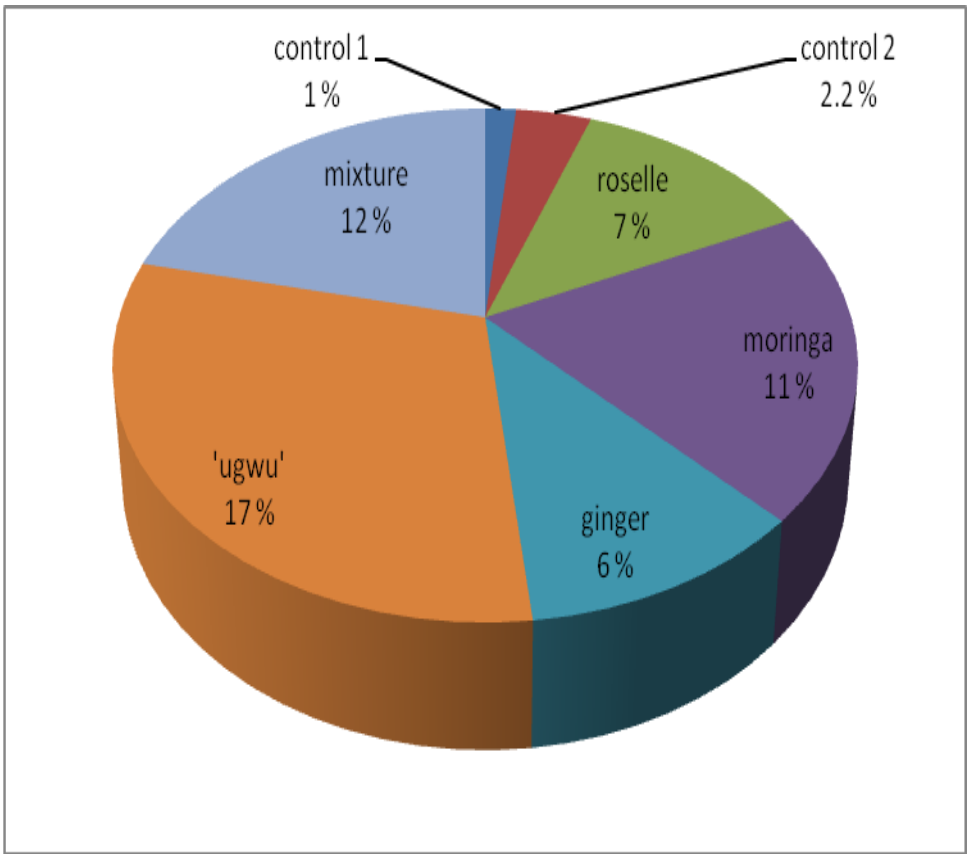

Figure 25: Percentage serum protein increase (g dl^{-1}) of the wild rats after treatment with the plant extracts for 180 days.

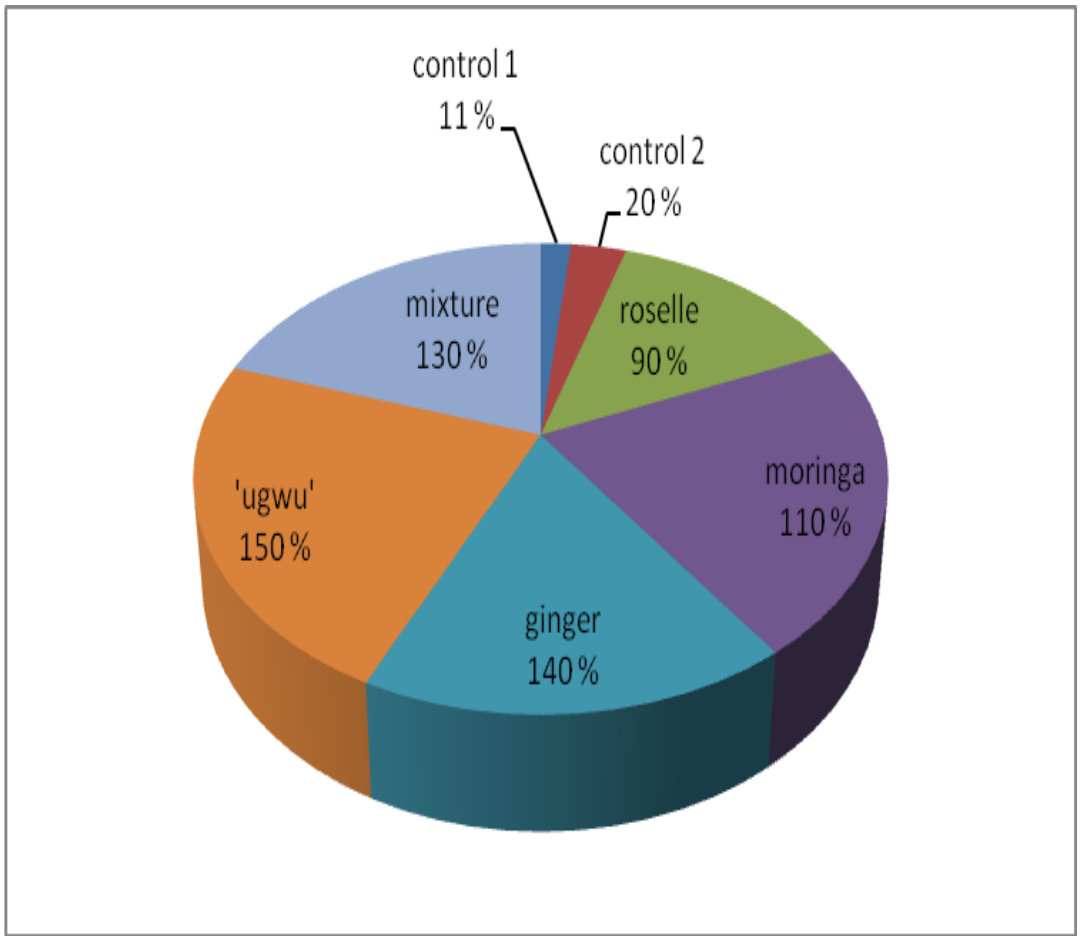

Figure 26: Percentage GSH increase (U/L) of the wild rats after treatment with the plant extracts for 180 days.

4.6.2 The Albino Rats.

Tables 29-33 show the bioprotective efficacy of the plant extracts on the biochemical parameters of the exposed albino rats. The test rats showed moderate to mild levels of the biochemical parameters compared to the control rats. Table 29 shows the control rats had an18.2 u l^{-1} ALT increase, whereas the rats fed with roselle, moringa, ginger, 'ugwu', and mixture extracts had 12.9, 9.9, 6.2, 7.1 and 4.6 u l^{-1} ALT increases, respectively. The AST increase in the control rats is 16.2 u l^{-1}, whereas the rats administered with roselle, moringa, ginger, 'ugwu', and mixture extracts had AST increases of 14.2, 10.1, 7.4, 10.2 and 7.9 u l^{-1}, respectively (Table 30). Table 31 shows the ALP increase of the control rats is 125.3 u l^{-1}, while the ALP increases of the rats fed with roselle, moringa, ginger, 'ugwu', and mixture extracts are 45.7, 27.3, 35.0, 43.0 and 24.6 u l^{-1}, respectively. Table 32 shows the serum protein decrease of the control rats is 0.97 g dl^{-1}, whereas the serum protein decrease of the rats that were administered with extracts of roselle, moringa, ginger, 'ugwu' and mixture are 0.84, 0.15, 0.79, 0.21 and 0.04 g dl^{-1}, respectively. The GSH decrease of the control rats is 2.40 whereas the GSH decrease of the rats fed with roselle, moringa, ginger, 'ugwu' and mixture extracts are 1.3, 0.9, 06, 0.9 and 0.5 u l^{-1}, respectively (Table 33). Significant differences ($p<0.05$) were also noticed in the biochemical parameters of the rats fed with the different extracts.

Figures 27-31 are graphical representations of the percentage bioprotective efficacy of the plant extracts on albino rats exposed to cement dust for 180 days. The test rats had a significant ($p<0.05$) higher percentage of bioprotective efficacy compared to the control. Significant differences ($p<0.05$) were also observed in the percentage bioprotective efficacy of the test rats.

Table 29: The ALT level (U/L) of the exposed albino rats treated with different plant extracts for 180 days

Day	0	90	180	Min. Value	Max. Value	Amount Increase	RDL Range
Extract							
Control	25.3[a] ±2.1	31.1[b] ±4.5	43.5[a] ±5.1	23.1	45.5	18.2 ±3.0	10 – 40
Roselle	27.4[a] ±3.3	30.6[b] ±4.04	40.3[a] ±5.5	25.7	43.6	12.9 ±2.2	10 – 40
Moringa	23.5[a] ±2.9	27.3[a] ±4.4	33.4[b] ±4.6	22.4	35.1	9.9 ±1.5	10 – 40
Ginger	26.4[a] ±3.3	30.6[a] ±3.5	32.6[a] ±4.0	24.3	34.9	6.2 ±0.9	10 – 40
'Ugwu'	26.6[a] ±2.1	30.5[a] ±4.0	33.7[a] ±4.4	24.1	35.0	7.1 ±2.3	10 – 40
Mixture	25.5[a] ±3.2	27.9[a] ± 4.5	30.1[a] ± 5.6	24.1	29.0	4.6 ±2.2	10 – 40

- Data are expressed as Mean ± SE
- Mean values with different superscripts 'a' and 'b' along the same row are significantly different at P <0.05
- RDL = Randox Laboratory Services, UK.

Table 30: The AST level (U/L) of the exposed albino rats treated with different plant extracts for 180 days

Day	0	90	180	Min. Value	Max. Value	Amount Increase	RD L Range
Extract							
Control	26.1[a] ± 4.3	35.8[b] ±5.2	42.3[a] ±5.1	25.2	43.1	16.2 ±1.8	10 – 34
Roselle	25.9[a] ±5.0	30.2[b] ±6.1	40.1[a] ±4.4	24.9	39.2	14.2 ±1.8	10 – 34
Moringa	26.3[a] ±5.4	28.9[a] ±4.7	36.4[b] ±4.6	25.1	37.0	10.1 ±1.7	10 – 34
Ginger	27.5[a] ±4.2	30.8[a] ±5.1	34.9[a] ±4.8	26.0	35.4	7.4 ±1.1	10 – 34
'Ugwu'	25.8[a] ±5.3	28.1[a] ±6.0	36.0[b] ±5.0	24.8	37.8	10.2 ±1.9	10 – 34
Mixture	26.4[a] ±4.0	28.1[a] ±5.0	34.3 [a] ±5.3	25.7	35.3	7.9 ±2.1	10 – 34

- Data are expressed as Mean ± SE
- Mean values with different superscripts 'a' and 'b' along the same row are significantly different at; P <0.05.
- RDL = Randox Laboratory Services, UK.

Table 31: The ALP level (U/L) of the exposed albino rats treated with different plant extracts for 180 days

Day	0	90	180	Min. Value	Max. Value	Amount Increase	RDL Range
Extract							
Control	53.7[a] ± 3.21	89.3[b] ± 1.15	179.0[a] ± 21.7	48.4	188.2	125.3 ±18.1	44 – 147
Roselle	57.3[a] ± 4.04	73.3[a] ± 15.5	103[a] ±15.3	55.5	110	45.7 ±9.3	44 – 147
Moringa	55.7[a] ± 5.68	62.3[a] ± 4.16	83.0[b] ± 8.74	49.0	88.9	27.3 ±5.8	44 – 147
Ginger	53.0[a] ± 1.00	64.7[b] ± 1.15	88[b] ± 4.58	50.1	95.3	35 ±6.1	44 – 147
'Ugwu'	53.0[a] ± 2.65	62.3[b] ± 2.52	96.0[a] ± 1.51	49.2	101.2	43 ±9.7	44 – 147
Mixture	54.1[a] ± 3.25	63.7[b] ± 1.53	78.7[a] ± 3.23	51.6	87.3	24.6 ±4.6	44 – 147

- Data are expressed as Mean ± SE
- Mean values with different superscripts 'a' and 'b' along the same row are significantly different at $P < 0.05$.
- RDL = Randox Laboratory Services, UK.

Table 32: The serum protein level (g dl^{-1}) of the exposed albino rats treated with different plant extracts for 180 days

Day	0	60	90	180	Min. Value	Max. Value	Protein Decrease	RDL Range
Extract								
Control	6.84[a] ±0.10	6.39 [a] ±0.78	6.28[a] ±0.04	5.87 [a] ±0.03	6.03	6.91	0.97 ±0.23	6.5-8.5
Roselle	6.84 [a] ±0.12	6.57[a] ±0.16	6.42[a] ±0.27	6.00[a] ±0.04	6.10	6.93	0.84 ±0.12	6.5-8.5
Moringa	6.78 [a] ±0.15	6.73[a] ±0.14	6.72[a] ±0.12	6.63[a] ±0.04	6.55	6.95	0.15 ±0.09	6.5-8.5
Ginger	6.85[a] ±0.11	6.62[a] ±0.10	6.49[a] ±0.08	6.06[a] ±0.03	6.03	6.94	0.79 ±0.19	6.5-8.5
'Ugwu'	6.83[a] ±0.14	6.76[a] ±0.11	6.74[a] ±0.09	6.62 ±0.04	6.62	6.98	0.21 ±0.07	6.5-8.5
Mixture	6.75[a] ±0.06	6.73[a] ±0.07	6.72[a] ±0.08	6.71[a] ±0.05	6.63	6.81	0.04 ±0.01	6.5-8.5

- Data are expressed as Mean ± SE
- Mean values with different superscripts 'a' and 'b' along the same row are significantly different at $P<0.05$
- RDL = Randox Laboratory Services, UK.

Table 33: The GSH level (U/L) of the exposed albino rats treated with different plant extracts for 180 days

Day	0	90	180	Min. Value	Max. Value	Amount Decrease	RDL Range
Extract							
Control	5.10[a] ±1.2	3.8[b] ± 0.9	2.7[a] ± 0.8	2.65	5.15	2.40 ± 0.43	1-10
Roselle	4.9[a] ± 1.1	4.0[b] ± 0.8	3.6[a] ± 0.8	3.59	5.10	1.32 ± 0.38	1-10
Moringa	4.8[a] ± 0.9	4.3[a] ± 1.1	3.9[a] ± 0.9	3.89	5.13	0.9 ± 0.30	1-10
Ginger	4. 8[a] ± 0.8	4.6[a] ± 1.2	4.2[a] ± 1.1	4.10	5.11	0.6 ± 0.26	1-10
' Ugwu'	5.0[a] ±0.8	4.6[a] ± 1.3	4.1[a] ± 1.4	4.14	5.15	0.9 ±0.28	1-10
Mixture	4.9[a] ±1.3	4.6[a] ±1.2	4.4[a] ± 0.7	4.50	5.12	0.5 ±0.24	1-10

- Data are expressed as Mean ± SE
- Mean values with different superscripts 'a' and 'b' along the same row are significantly different at P <0.05;
- RDL = Randox Laboratory Services, UK.

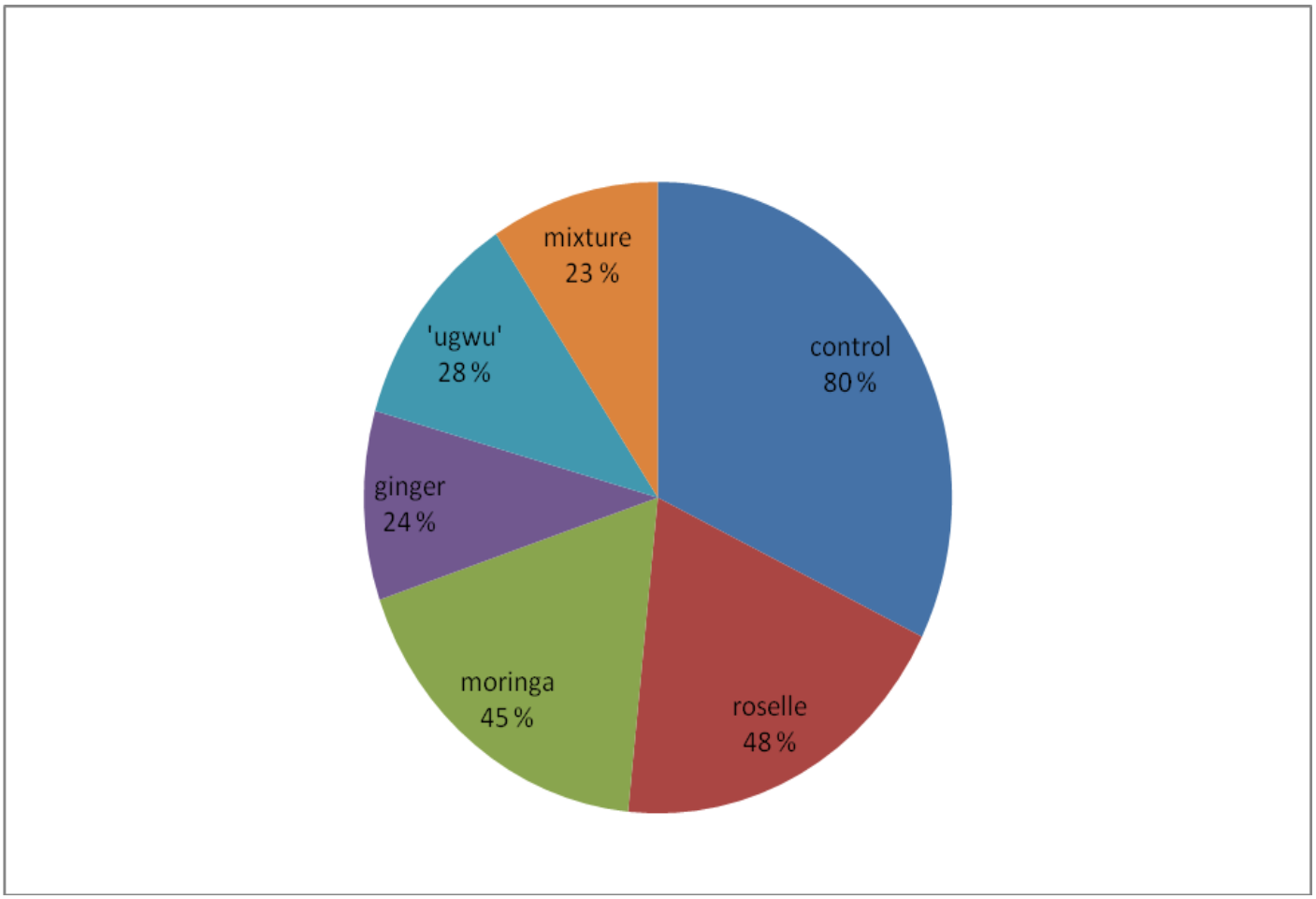

Figure 27: Percentage ALT increase (U/L) of the exposed albino rats treated with the plant extracts for 180 days.

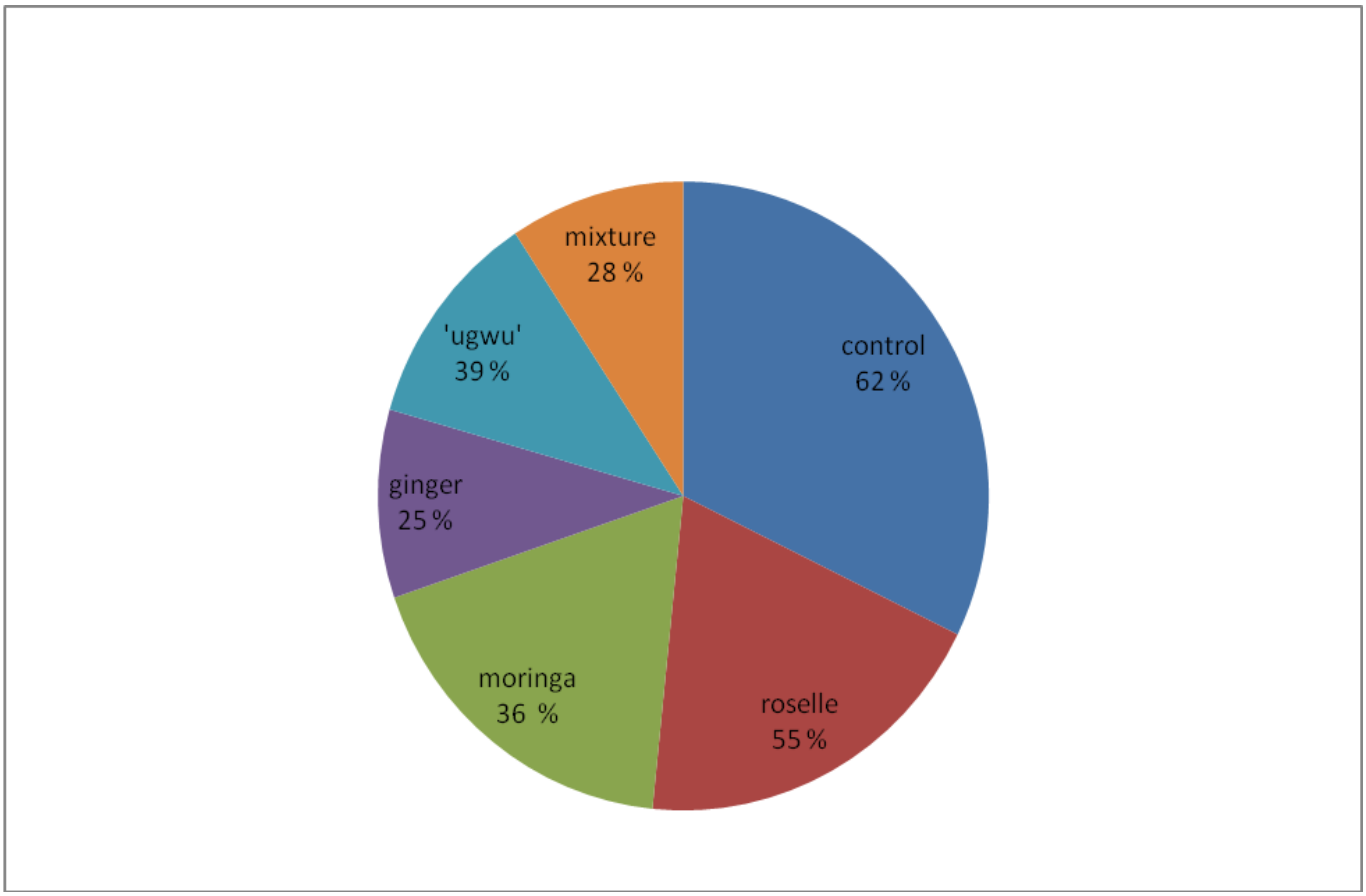

Figure 28: Percentage AST increase (U/L) of the exposed albino rats treated with the plant extracts for 180 days.

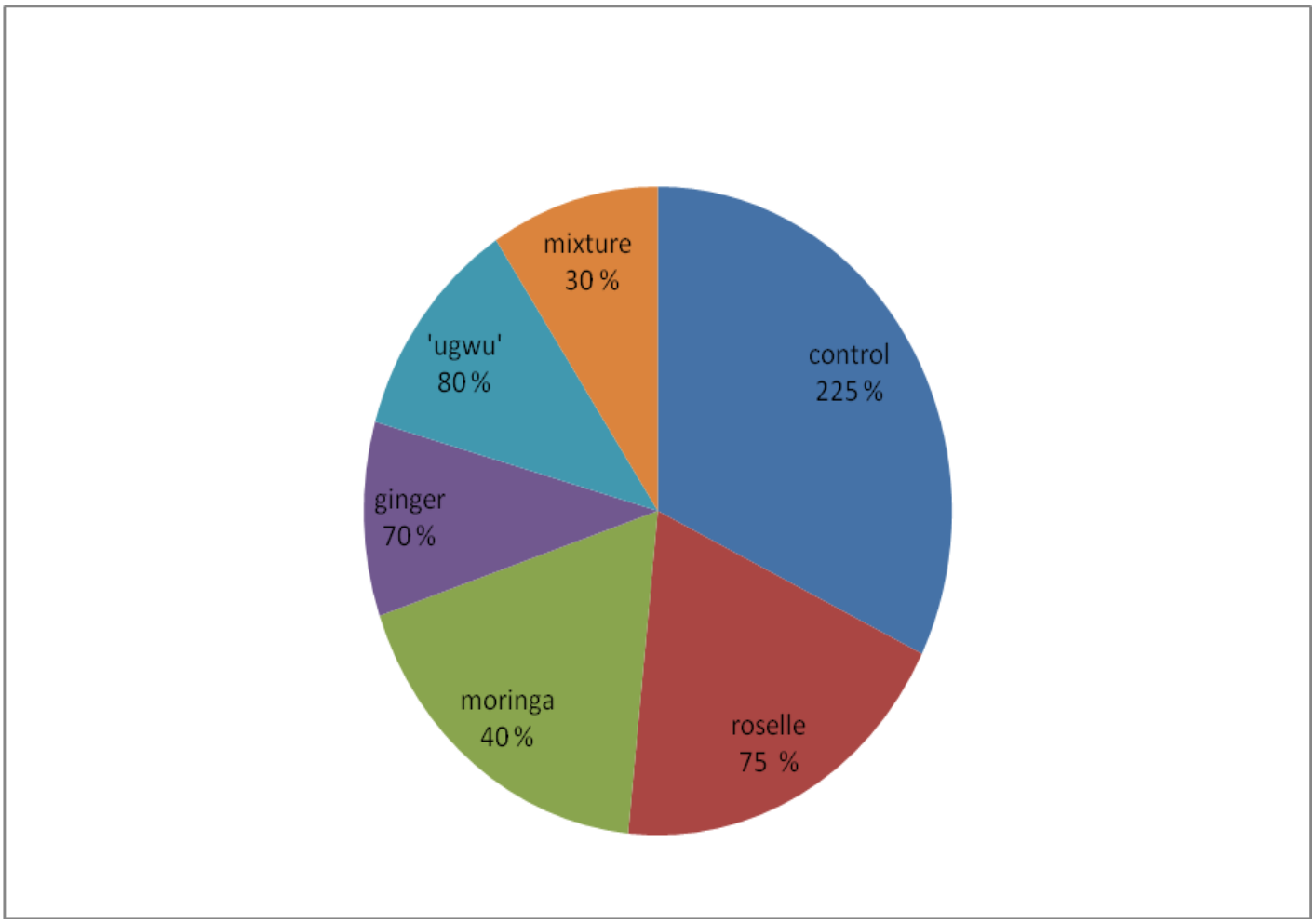

Figure 29: Percentage ALP increase (U/L) of the exposed albino rats treated with the plant extracts for 180 days.

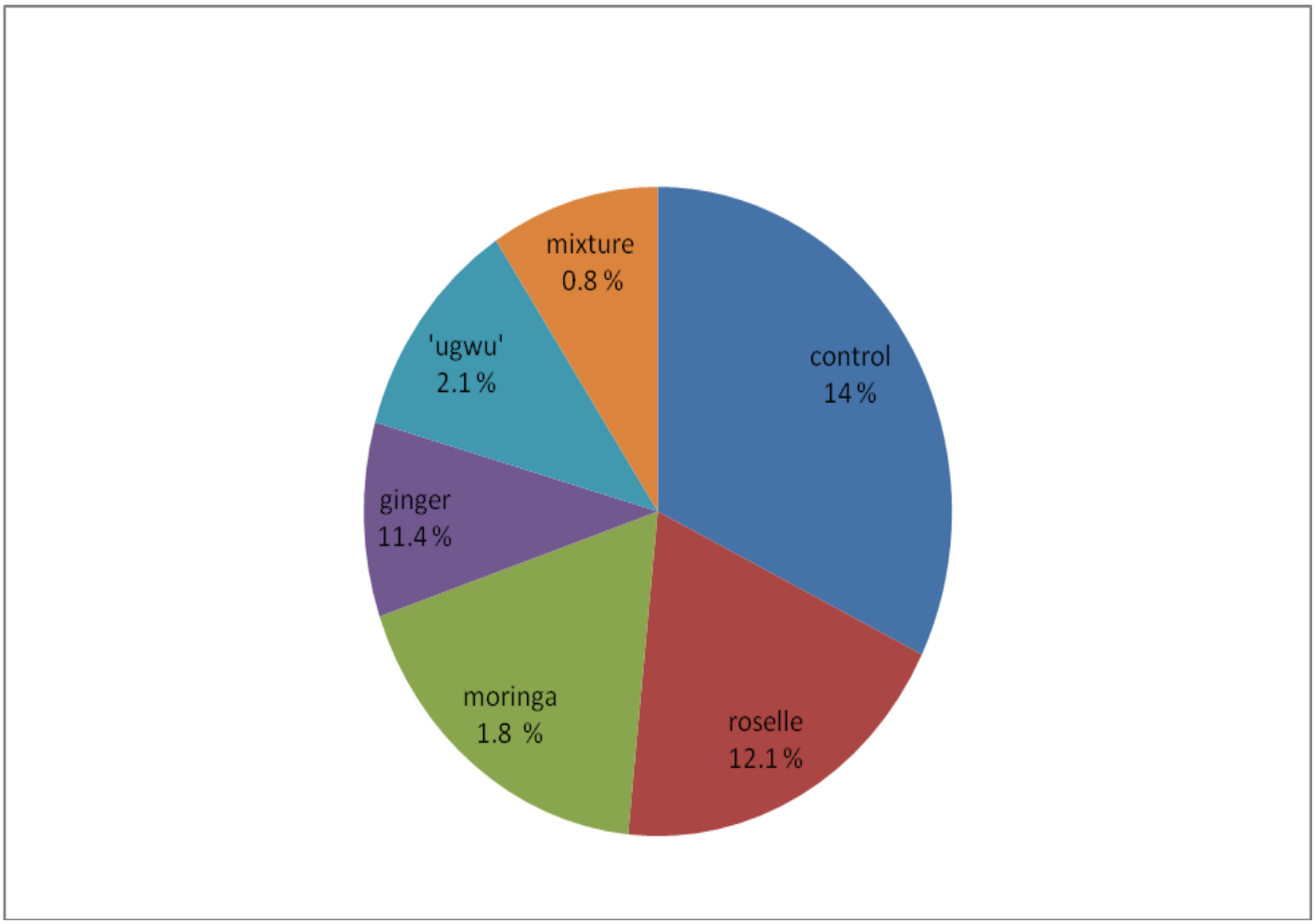

Figure 30: Percentage serum protein decrease (g dl $^{-1}$) of the exposed albino rats treated with the plant extracts for 180 days.

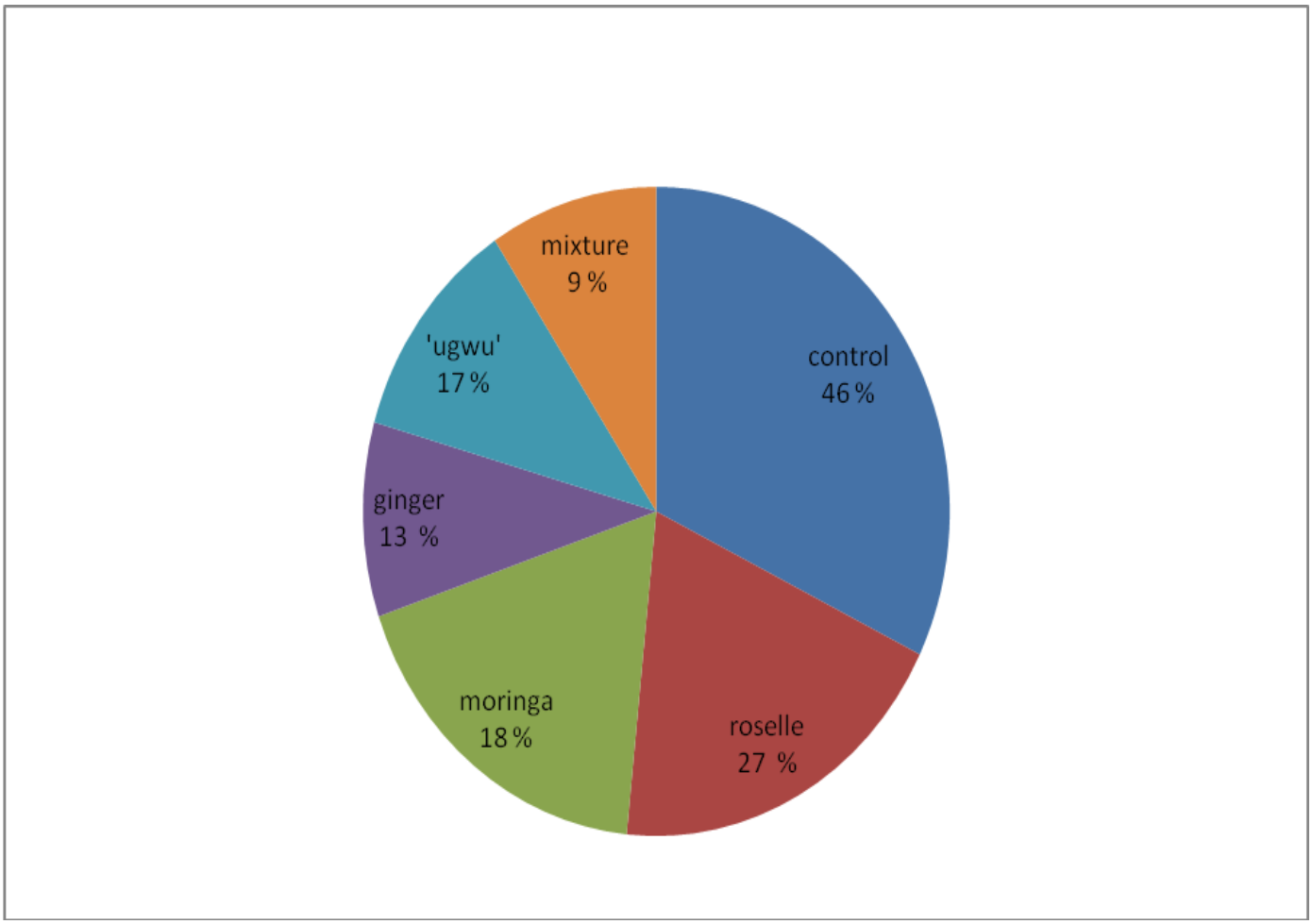

Figure 31: Percentage GSH decrease (U/L) of the exposed albino rats treated with the plant extracts for 180 days.

4.7 Histopathological Studies of the Rats

4.7.1 The Wild Rats

Plates 10-17 show the rebuilding efficacy of the different plant extracts on the damaged lung tissues of the wild rats inhabiting the vicinity of the cement factory. The lung tissues of the wild rats living around the cement factory revealed severe inflammation, vascular congestion, congested alveolus, and severe fibrosis (Plate 11). Severe fibrosis was also noticed in the rats following treatment with distilled water (Plate 12). After administering the different plant extracts to the rats for 180 days, significant improvements were noticed in the lung tissues of the exposed wild rats such that the rats that were fed with roselle, moringa, ginger, 'ugwu and mixture extracts revealed congested alveolus and moderate inflammation, moderate inflammation, mild inflammation, mild vascular congestion and mild inflammation (Plates 13, 14, 15, 16 and 17) respectively.

Plates 18-25 show the liver tissues of the wild rats before and after treatment with the different plant extracts. The liver tissues of the wild rats living within the vicinity of the factory showed vascular congestion, which was also observed in the rats following treatment with distilled water (Plates 19 and 20). However, this histological problem was not noticed in the liver tissues of the rats after administering the different plant extracts (Plates 19-25).

Plates 26-33 show the histological conditions of the kidney tissues of the wild rats before and after administering the different plant extracts. Severe inflammation and heavy pigmented areas were observed in the kidney tissues of the wild rats inhabiting the vicinity of the cement factory (Plate 27). After administering distilled water only to the control wild rats, they had inflammation (Plate 28). However, no traces of the histological conditions were observed in the rats that received the plant extracts (Plates 29-33).

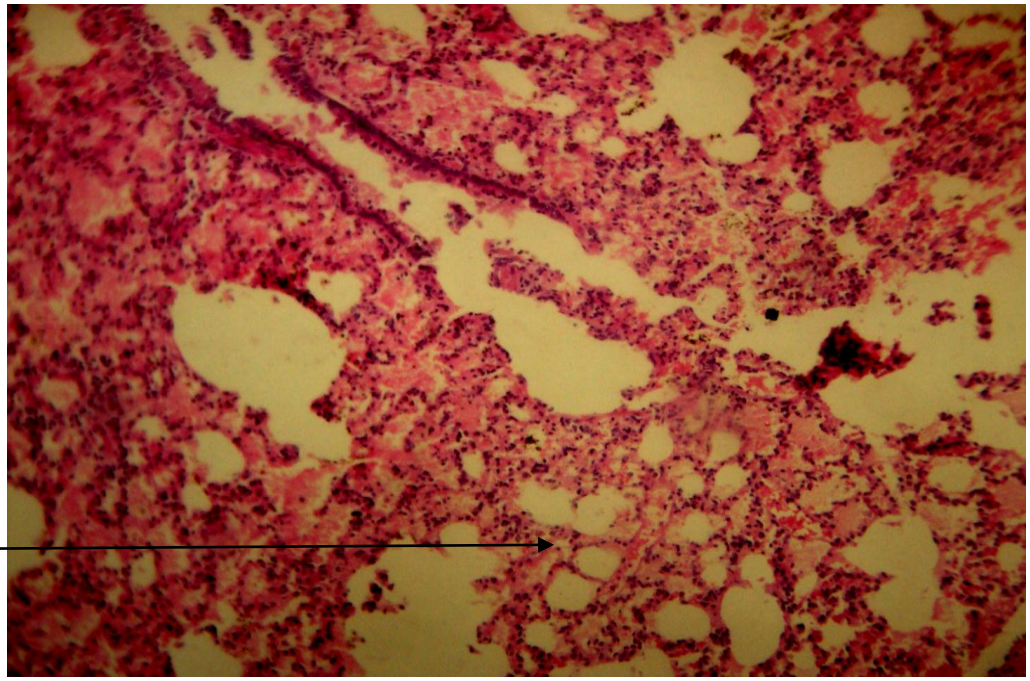

Plate 10: Photomicrograph of the lung tissues of the wild rat at the cement dust-free zone (× 400)

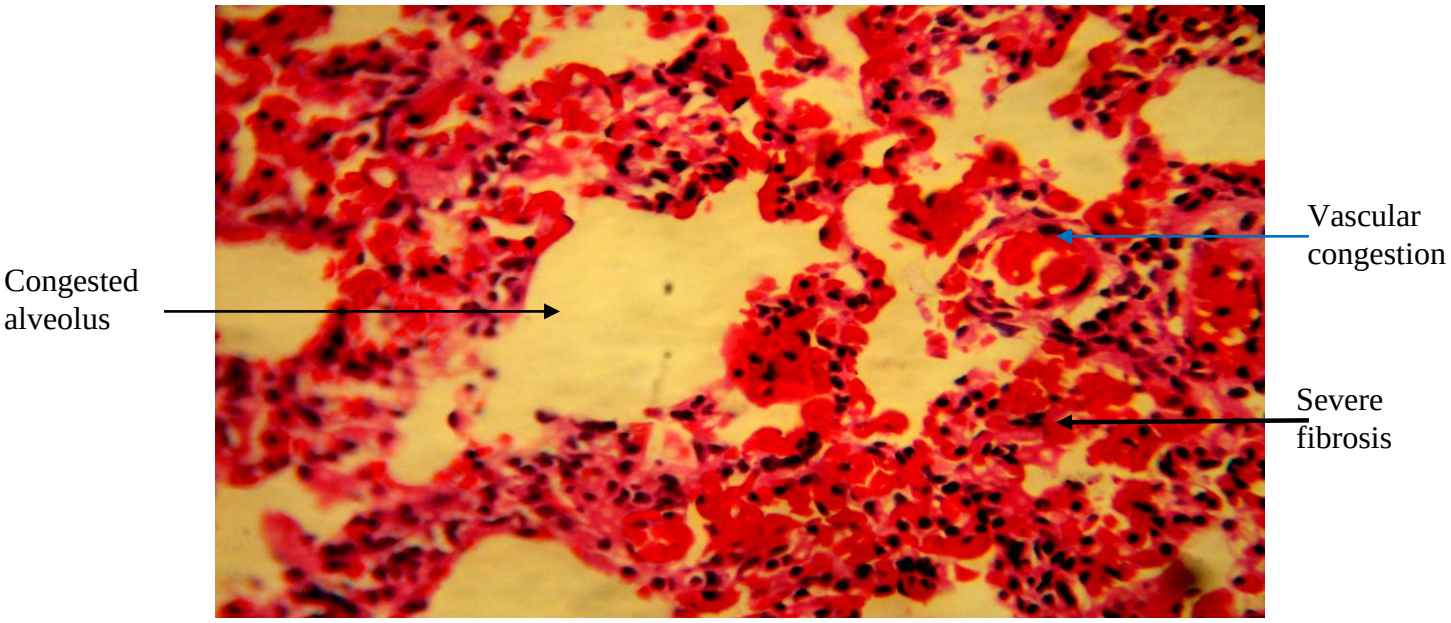

Plate 11: Photomicrograph of the lung tissues of the wild rat before administering the plant extract (X400).

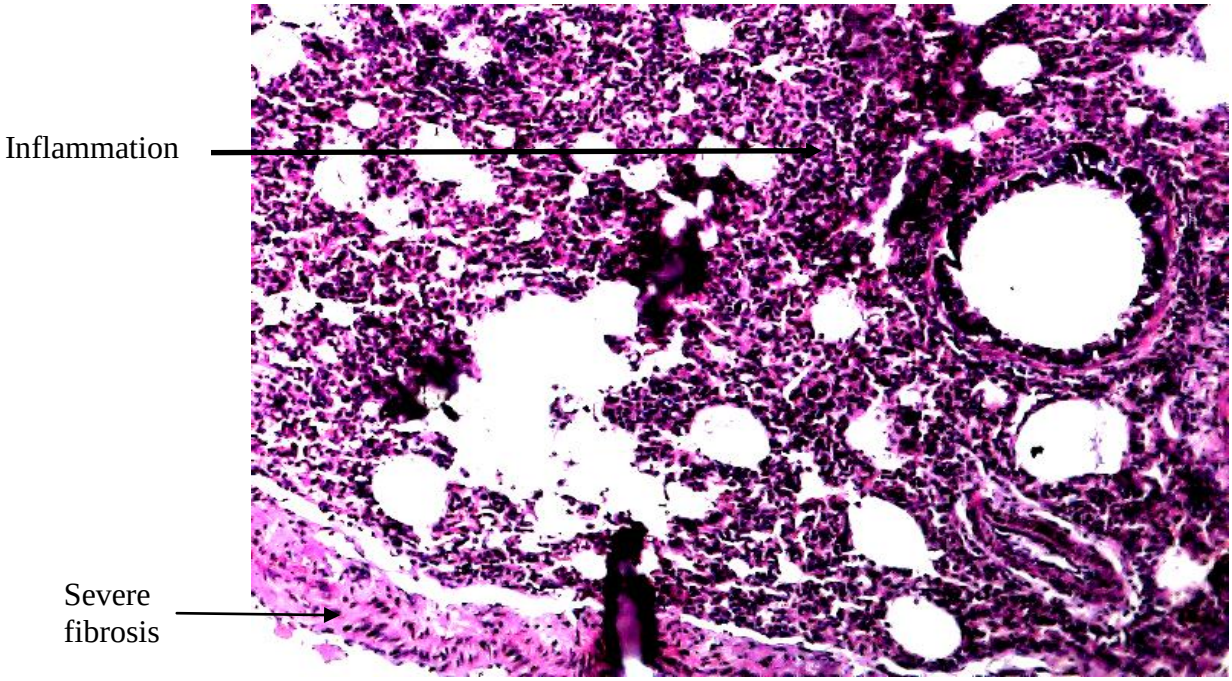

Plate 12: Photomicrograph of the lung tissues of the control rats fed with distilled water (x 400)

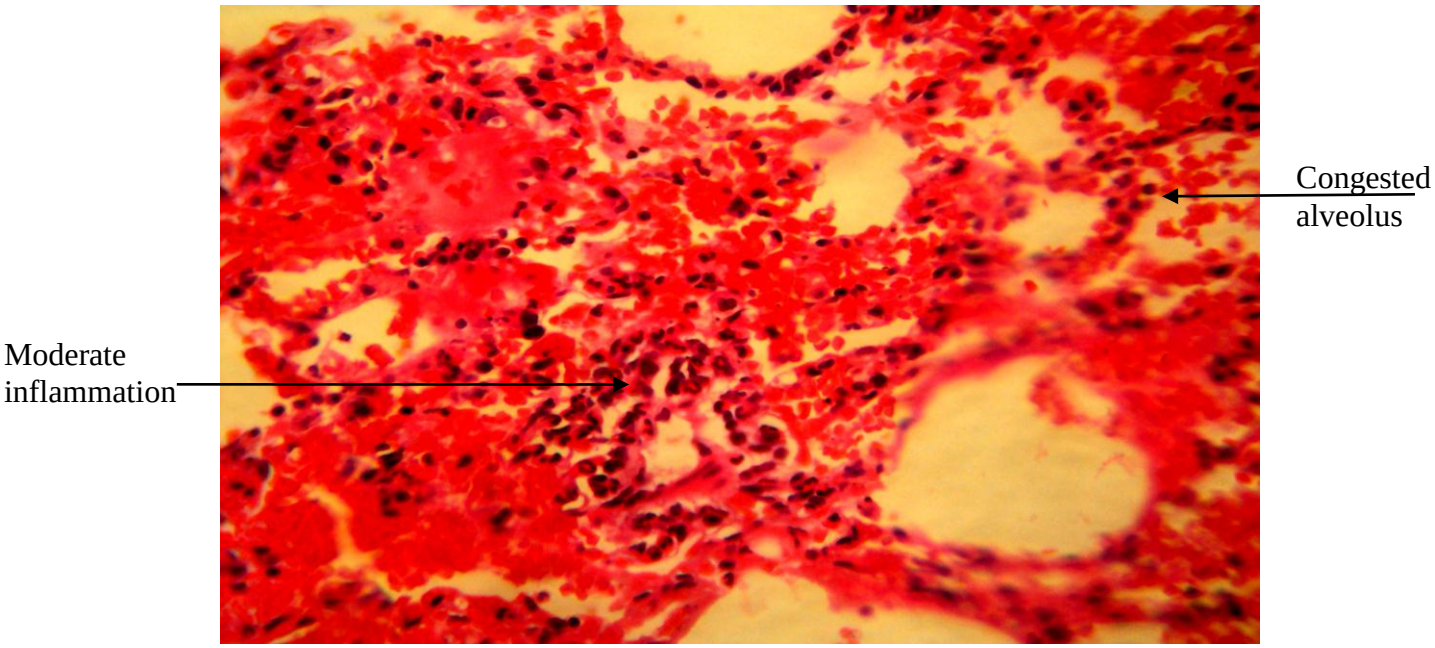

Plate 13: Photomicrograph of the lung tissues of the wild rat fed with roselle extract (X400).

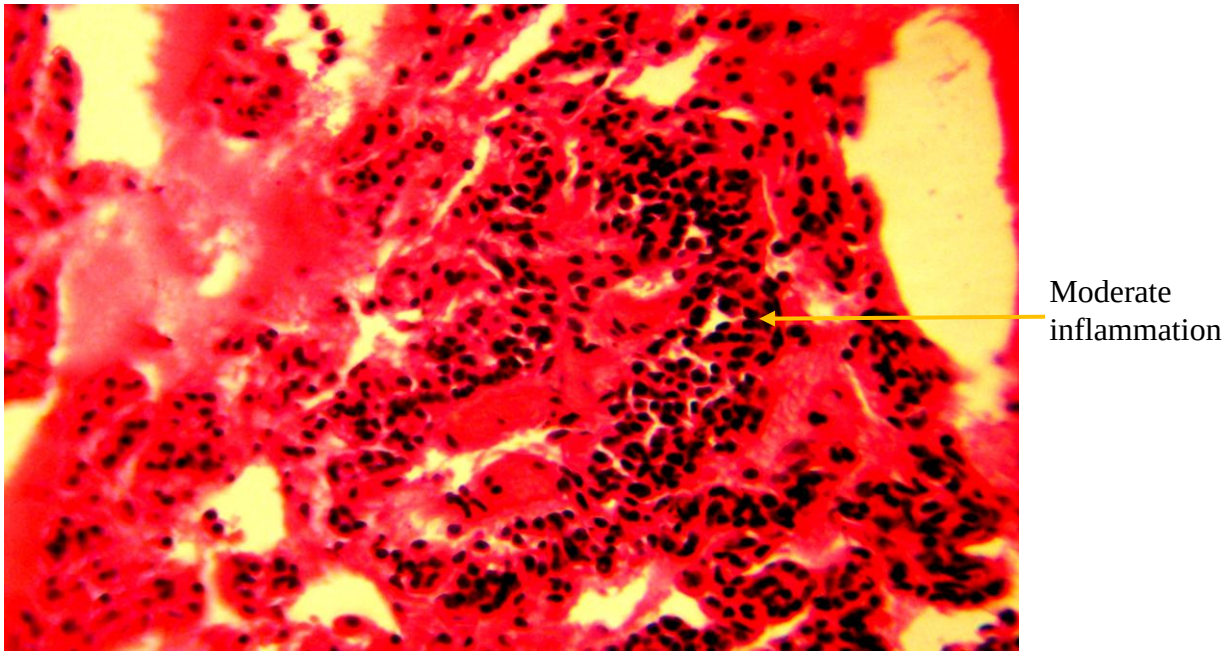

Plate 14: Photomicrograph of the lung tissues of the wild rat fed with moringa extract (X400).

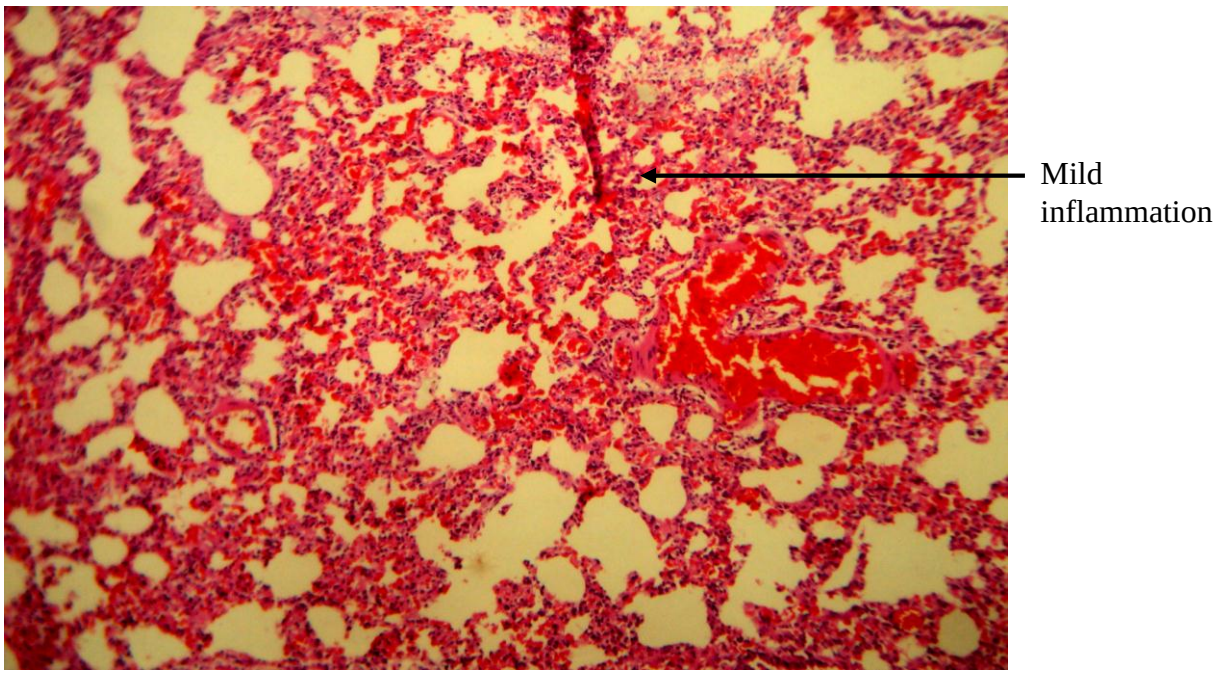

Plate 15: Photomicrograph of the lung tissues of the wild rat fed with ginger extract (X400).

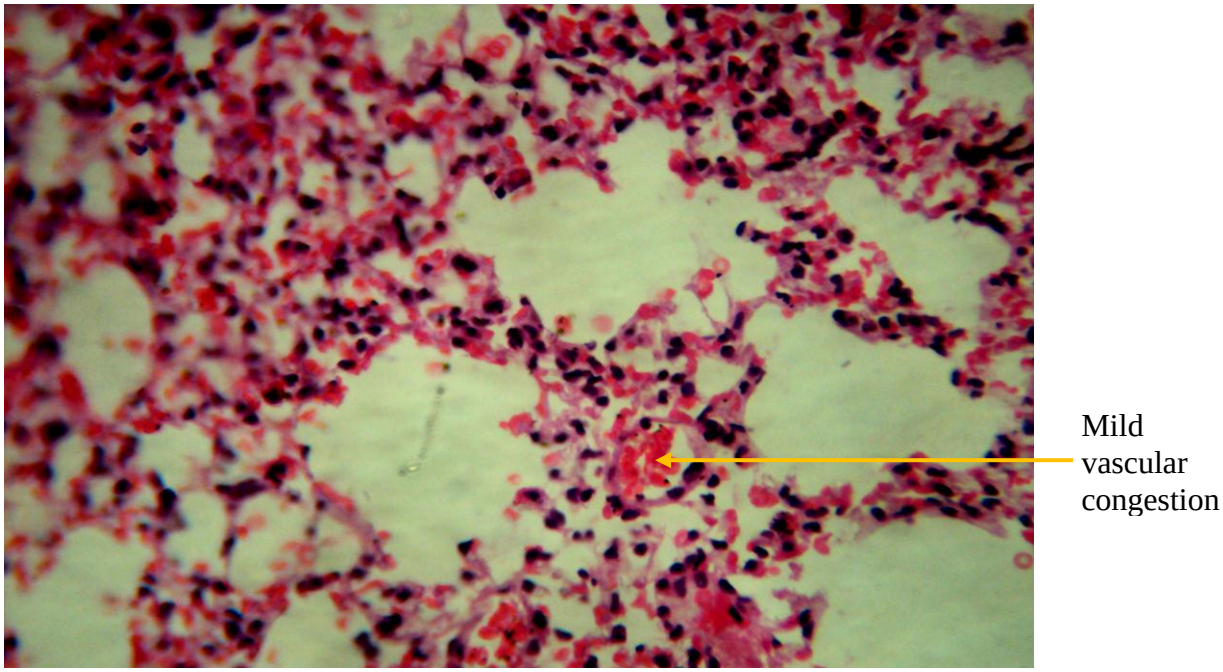

Plate 16: Photomicrograph of the lung tissues of the wild rat fed with 'ugwu' extract (X400).

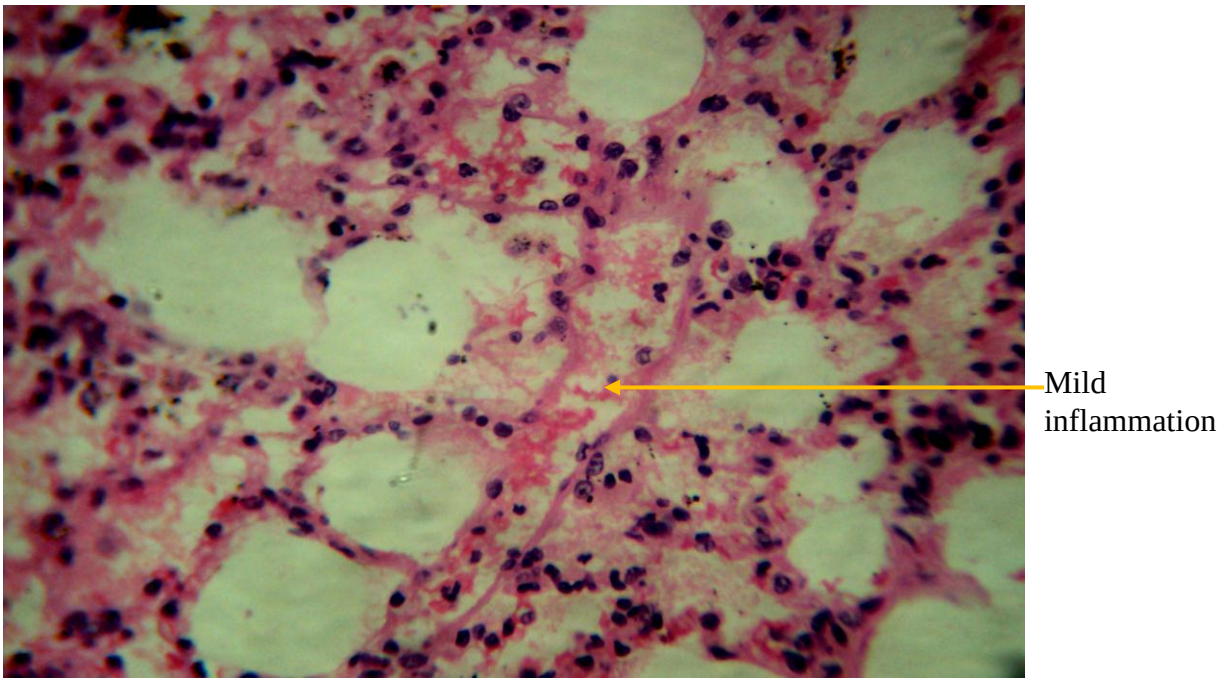

Plate 17: Photomicrograph of the lung tissues of the wild rat fed with mixture of extracts (X 400).

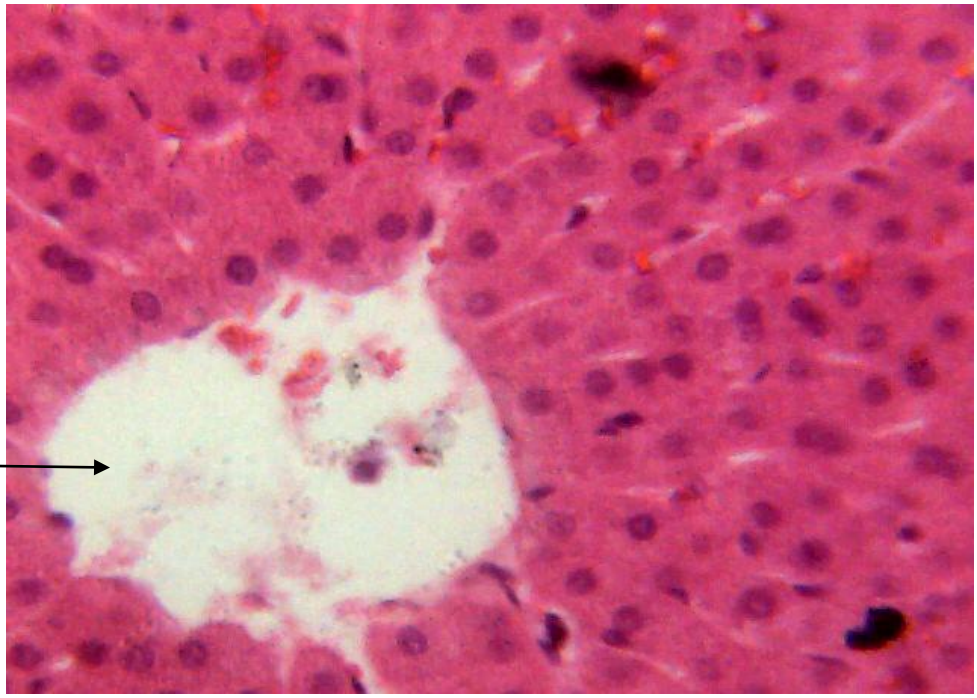

Plate 18: Photomicrograph of the liver tissues of the wild rats at the cement dust-free zone (X 400)

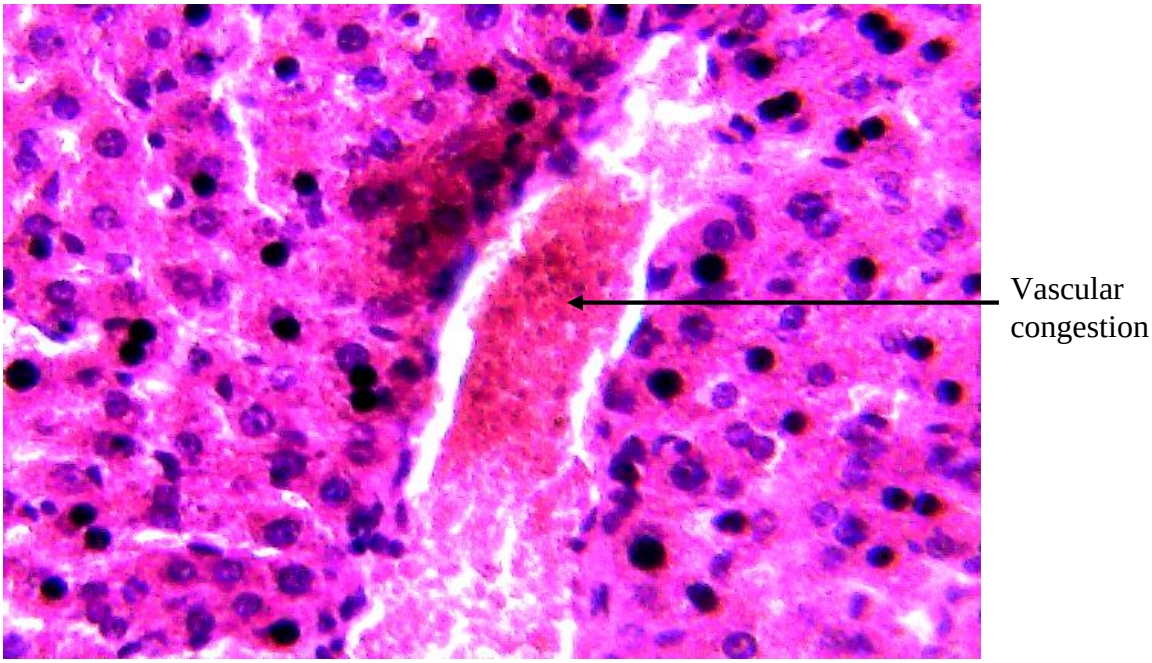

Plate 19: Photomicrograph of the liver tissues of the wild rat before treatment with the plant extract (X400).

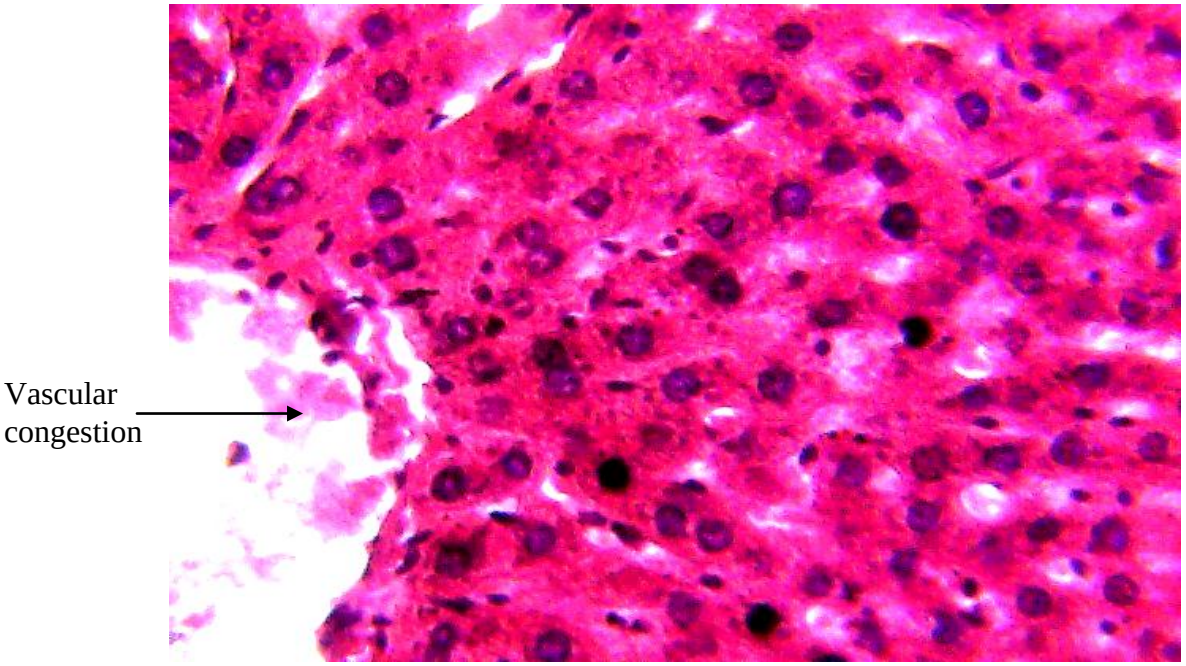

Plate 20: Photomicrograph of the liver tissues of the control rat fed with distilled water (X 400).

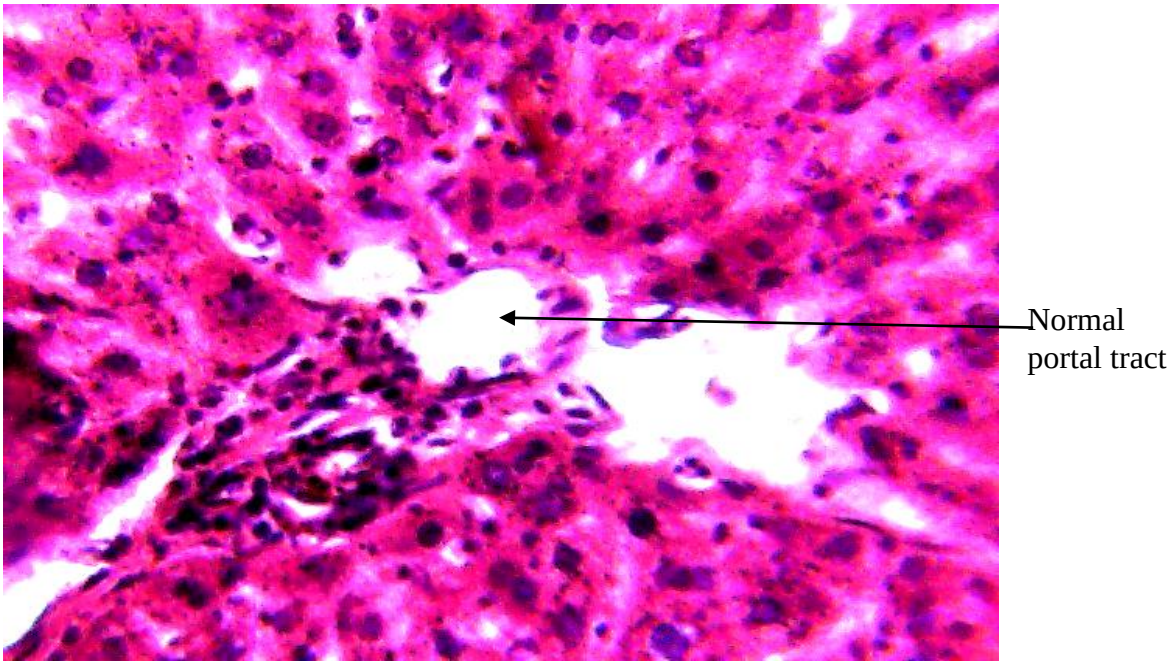

Plate 21: Photomicrograph of the liver tissues of the wild rat fed with roselle extract (X400).

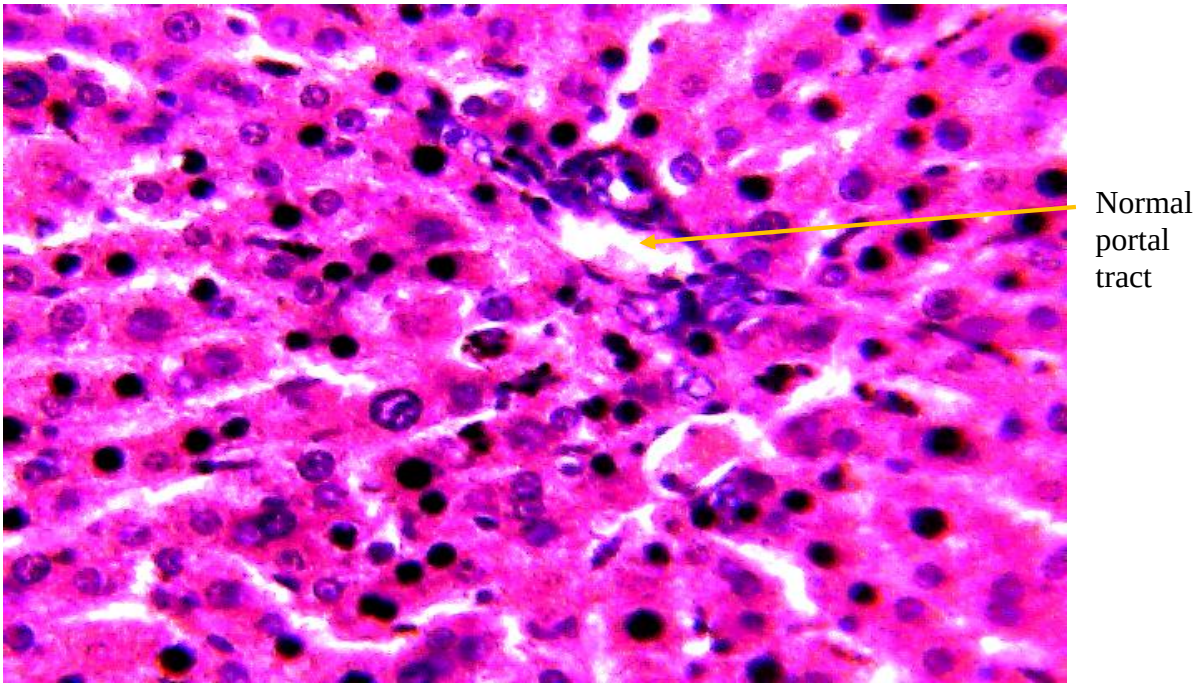

Plate 22: Photomicrograph of the liver tissues of the wild rat fed with moringa extract (X 400).

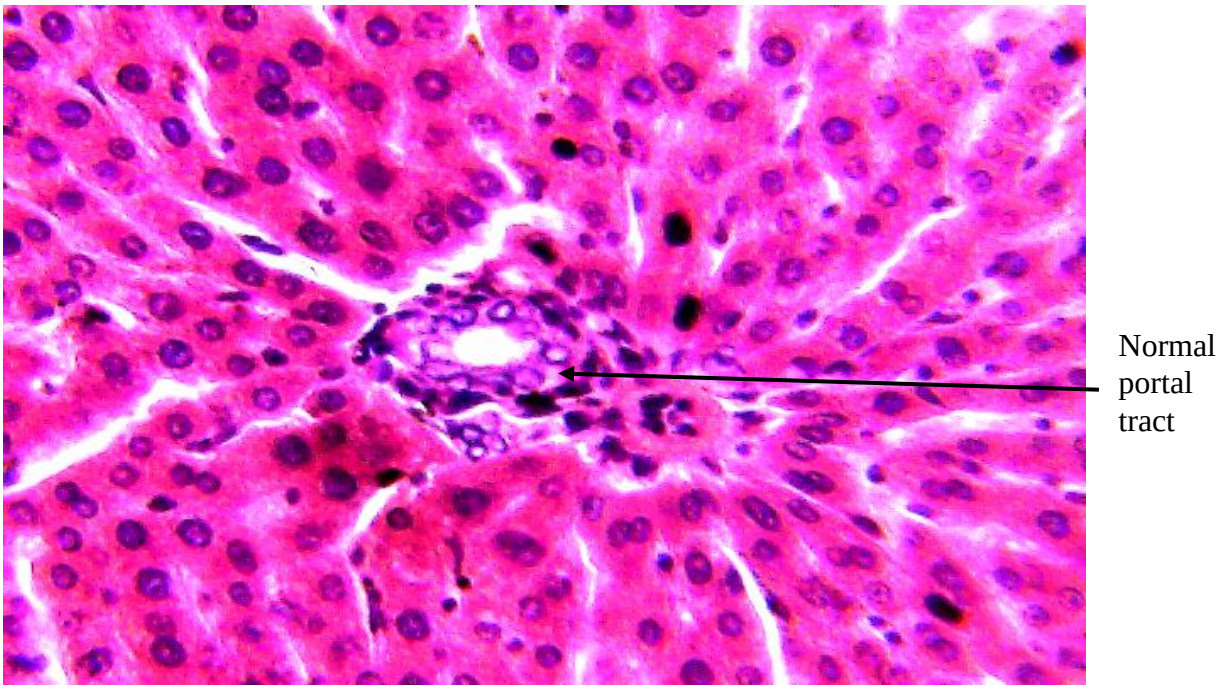

Plate 23: Photomicrograph of the liver tissues of the wild rat fed with ginger extract (X400).

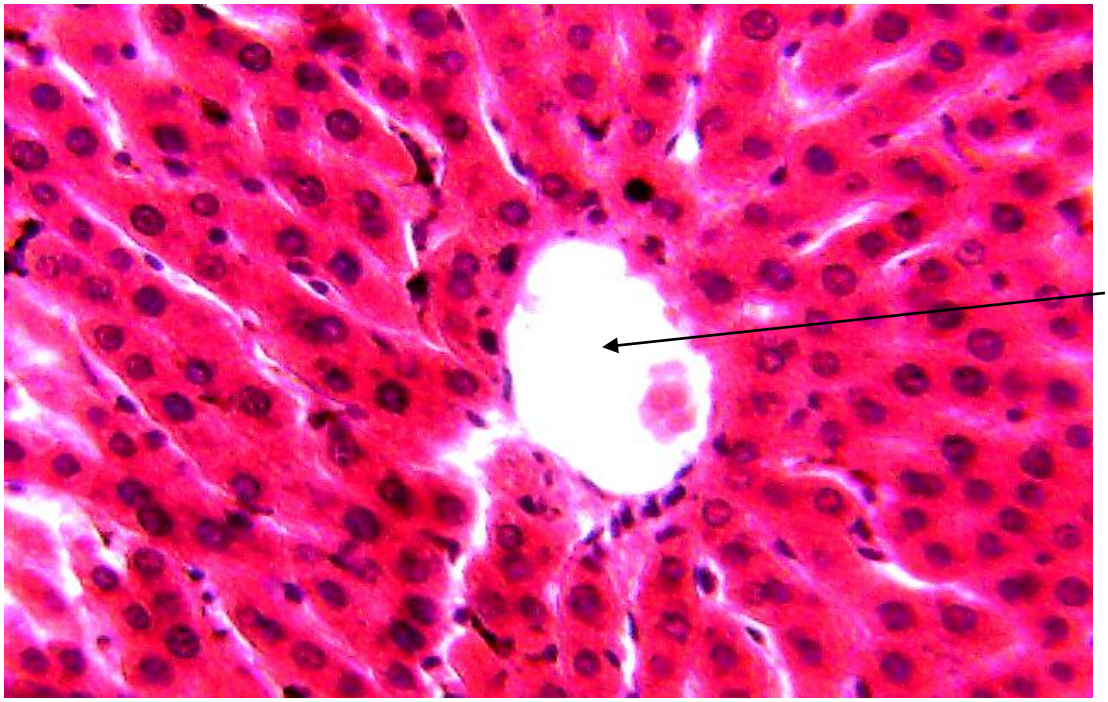

Plate 24: Photomicrograph of the liver tissues of the wild rat fed with 'ugwu' extract (X400).

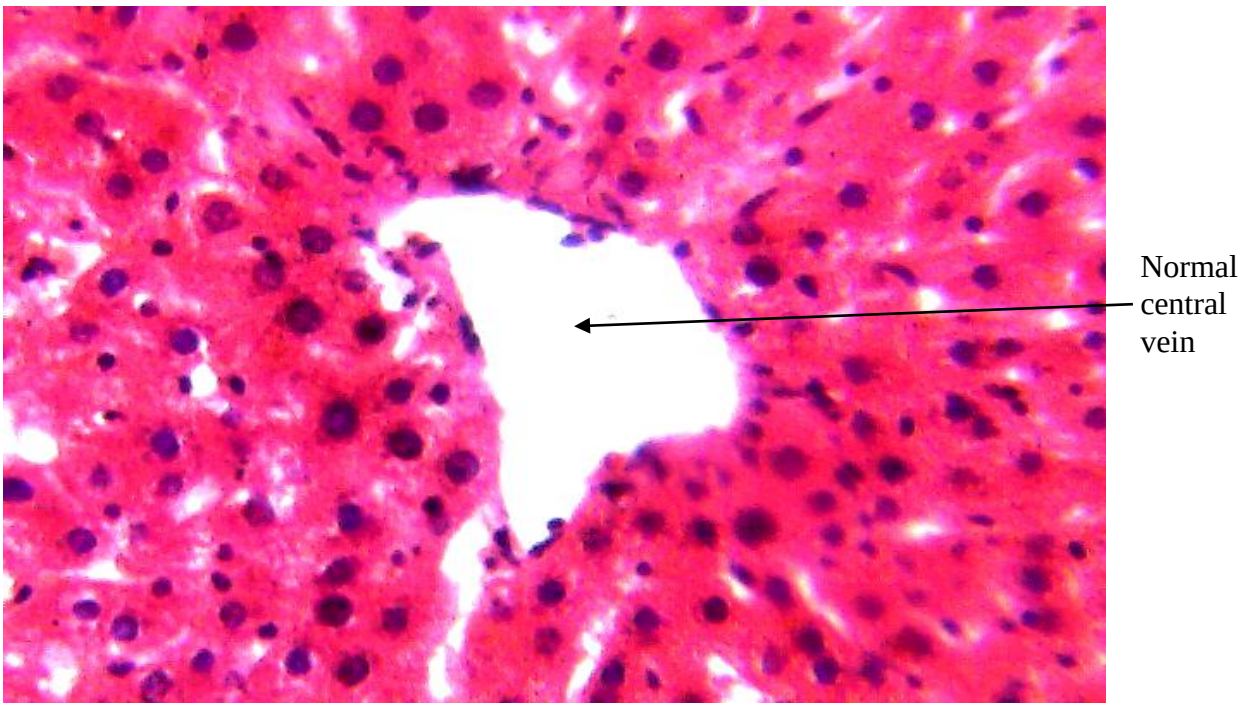

Plate 25: Photomicrograph of the liver tissues of the wild rat fed with mixture extract (X400).

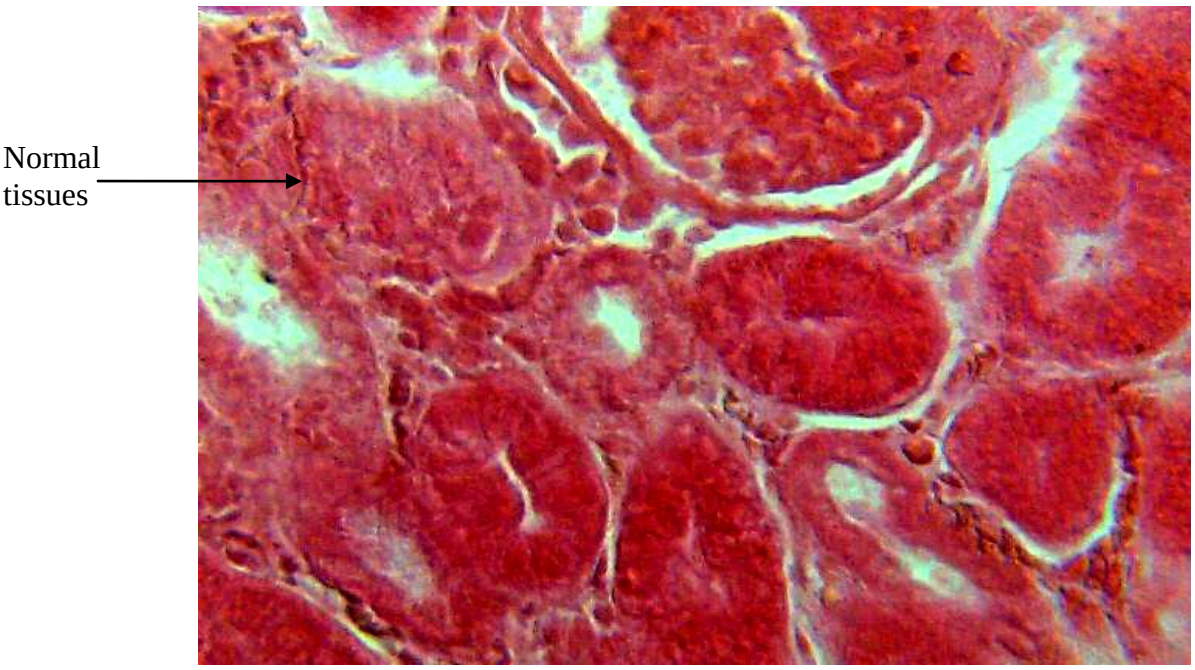

Plate 26: Photomicrograph of the kidney tissues of the wild rat at the cement dust-free zone (X400).

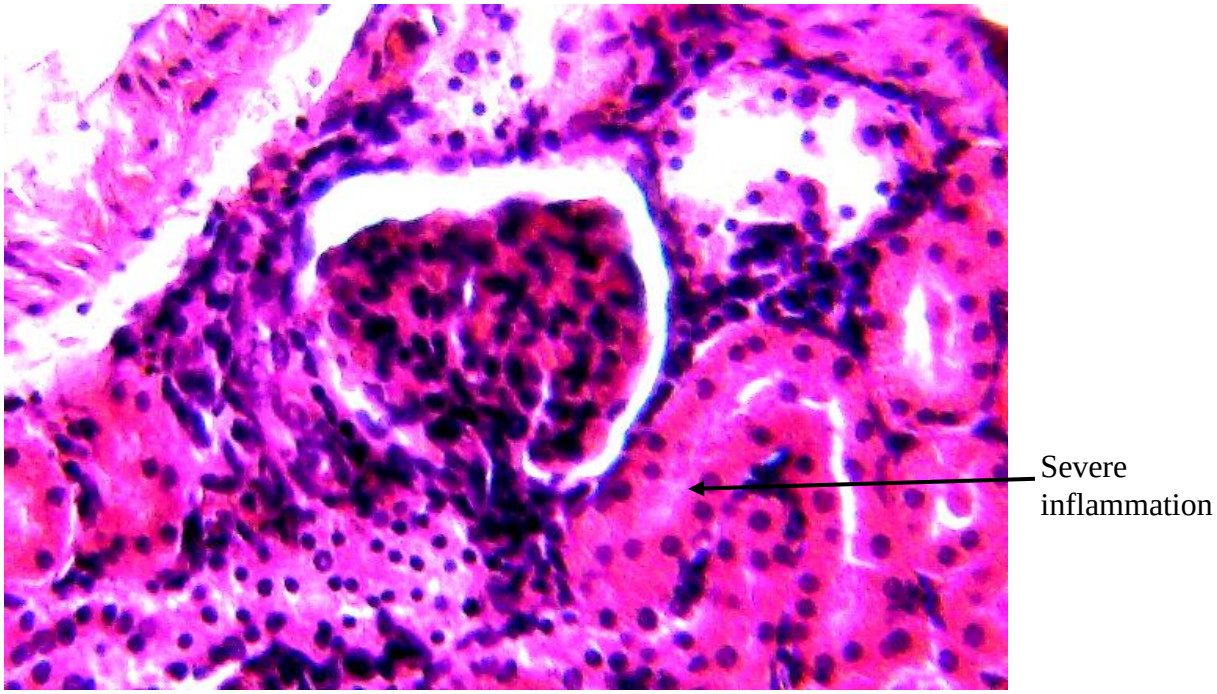

Plate 27: Photomicrograph of the kidney tissues of the exposed wild rat before treatment with the plant extract (X400).

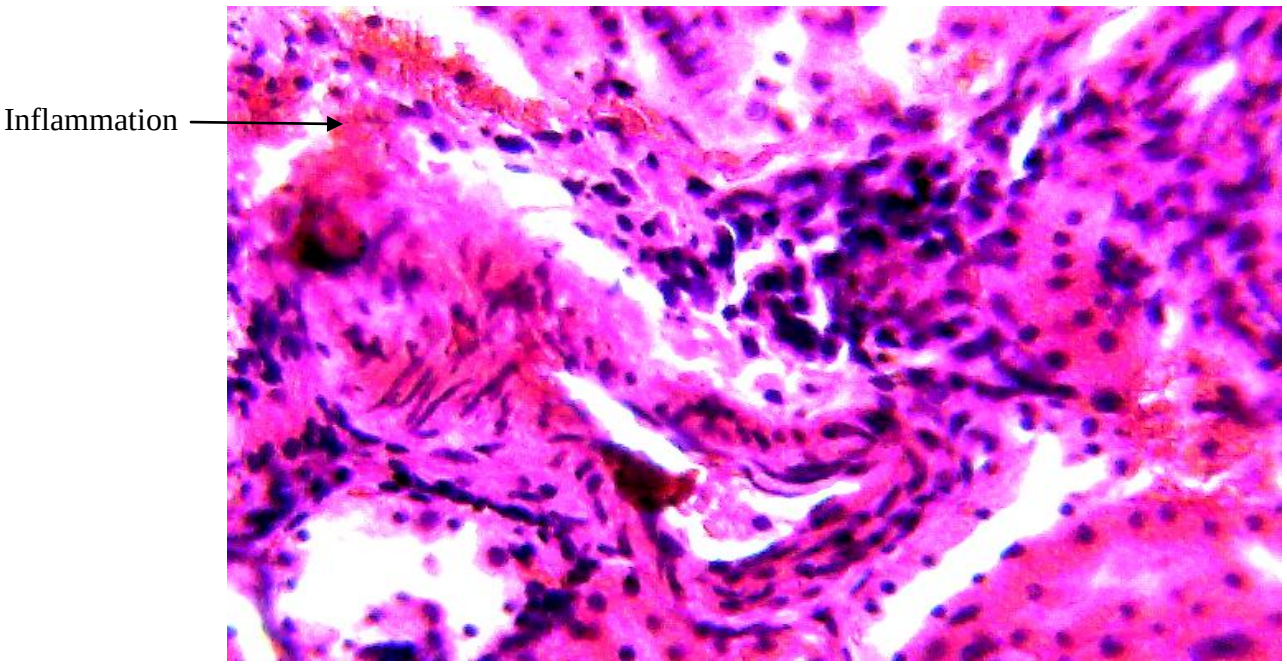

Plate 28: Photomicrograph of the kidney tissues of the control wild rat fed with distilled water (X400).

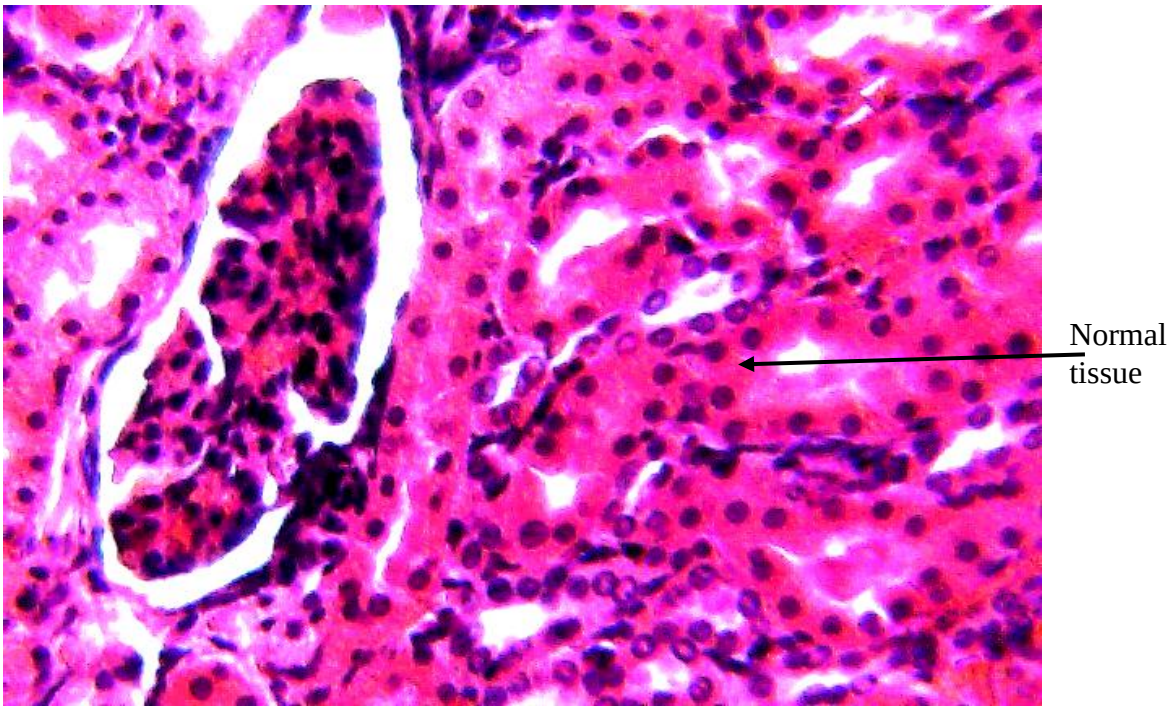

Plate 29: Photomicrograph of the kidney tissues of the wild rat fed with roselle extract (X 400).

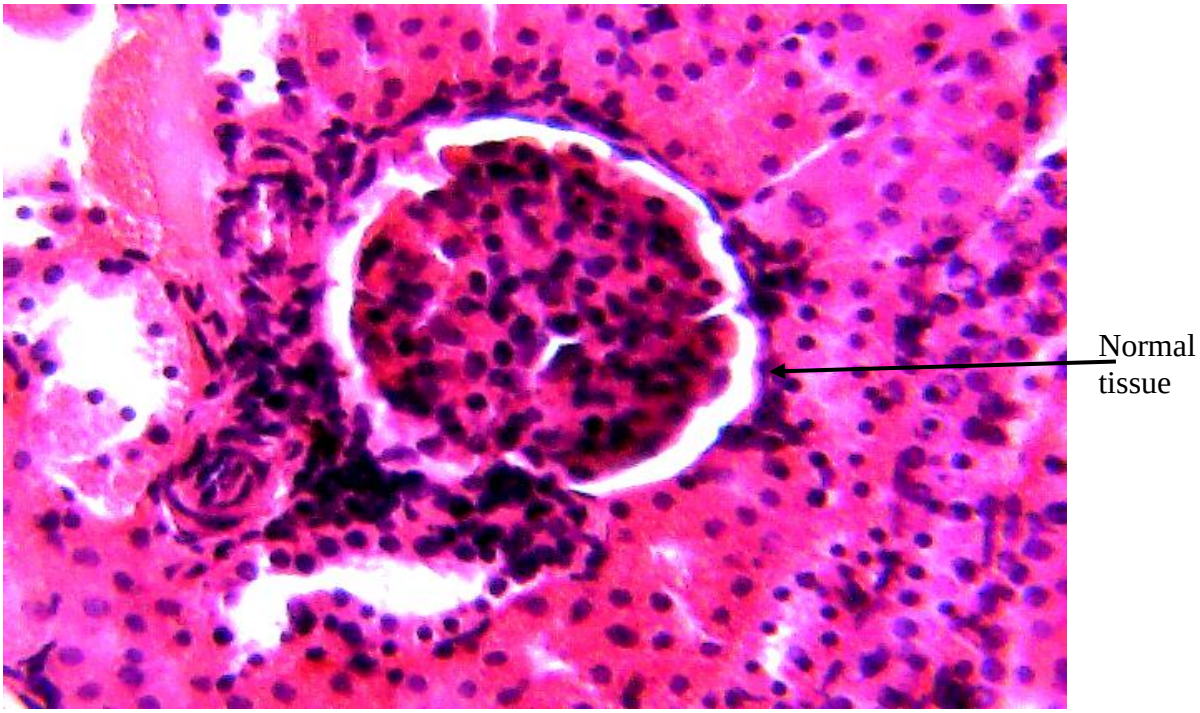

Plate 30: Photomicrograph of the kidney tissues of the wild rat fed with moringa extract (X400).

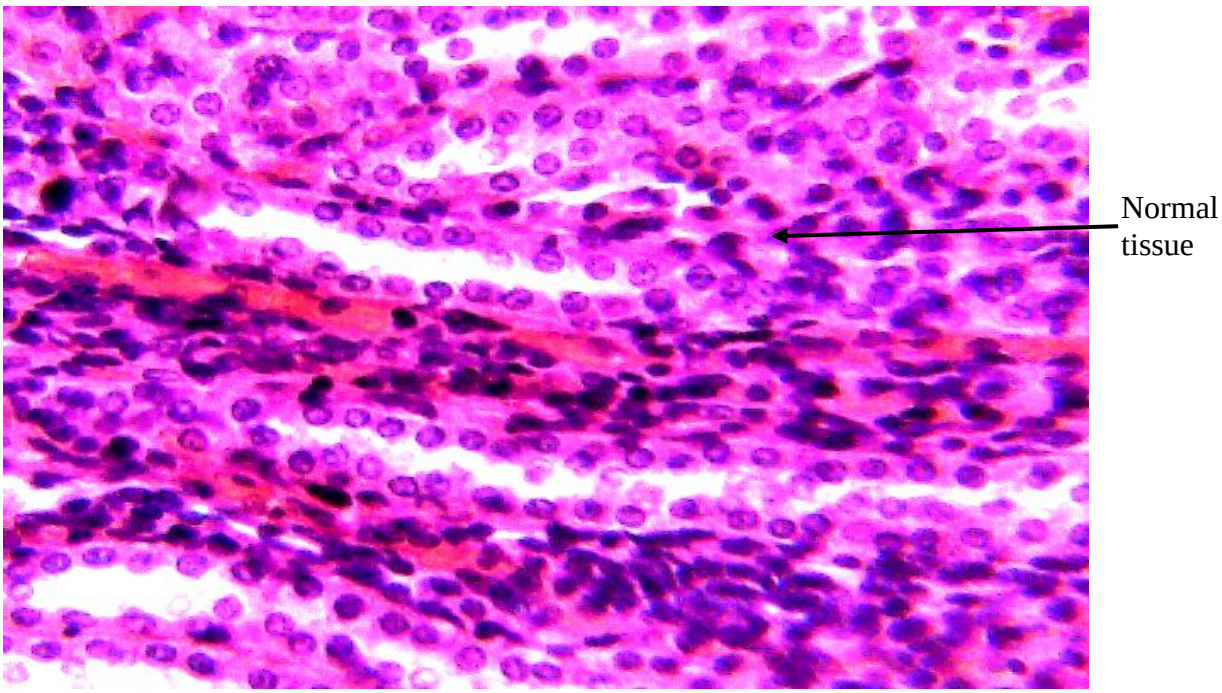

Plate 31: Photomicrograph of the kidney tissues of the wild rat fed with ginger extract (X400).

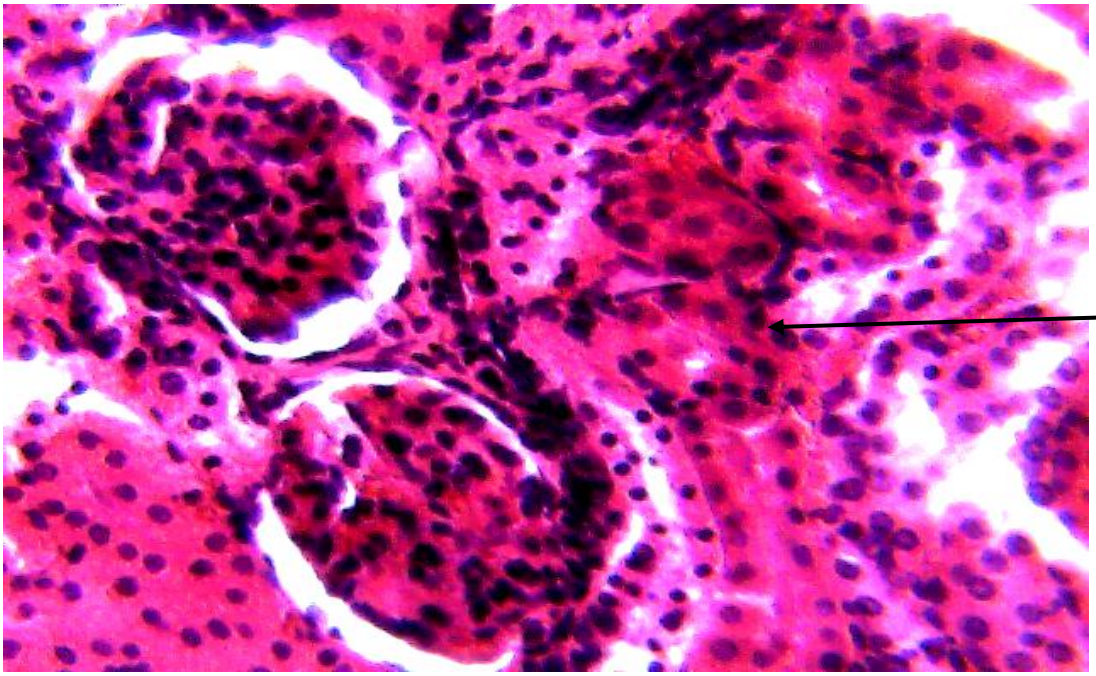

Plate 32: Photomicrograph of the kidney tissues of the wild rat fed with 'ugwu' extract (X400).

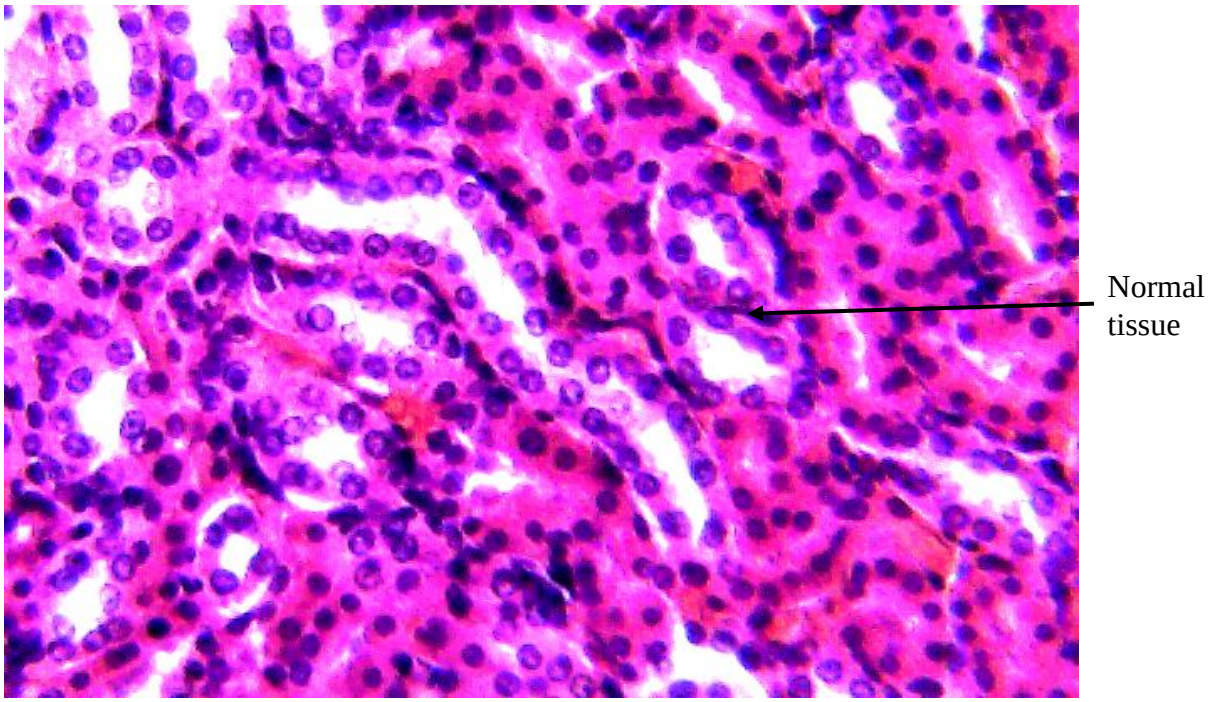

Plate 33: Photomicrograph of the kidney tissues of the wild rat fed with mixture extract (X 400).

4.7.2 The Albino Rats

Plates 34-40 show the bio-protective efficacy of the plant extracts on the lung tissues of the albino rats exposed to cement dust. The lung tissues of the albino rats before exposure showed normal alveolus and bronchus (Plate 34). After exposure to cement dust, the control rats revealed severe interstitial fibrosis and cellular debris (Plate 35). Moderate fibrosis was observed in the lung tissues of the albino rats treated with roselle and moringa extracts (Plates 36 and 37), respectively. The rats that were fed with extracts of ginger, 'ugwu', and mixture extracts had mild septal fibrosis (Plates 38, 39 and 40), respectively.

Plates 41-47 show the bioprotective efficacy of the plant extracts on the liver tissues of the albino rats exposed to cement dust for 180 days. Plate 41 showed the liver tissues of the rats before exposure showing normal hepatocyte, normal portal tracts, and normal cental vein. The control rats that received distilled water only showed severe vascular congestion (Plate 42). The rats that were fed with roselle extract showed normal hepatocyte, and mild vascular congestion (Plate 43). The rats that received moringa, ginger, 'ugwu' and mixture extracts showed no abnormality (Plates 44, 45, 46 and 47), respectively.

Plates 48-54 show the bio-protective efficacy of the plant extracts on the kidney tissues of the albino rats exposed to cement dust for 180 days. Plate 48 showed the kidney tissues of the rats before exposure showing normal glomerulus, normal interstitial, and normal tubules. The control rats that received distilled water only showed severe interstitial inflammation and heamorrhage (Plate 49), while the rats that were fed with roselle extract had mild inflammation (Plate 50). However, no abnormality were observed in the rats that were given ginger, 'ugwu' and mixture (Plates 51, 52, 53 and 54), respectively.

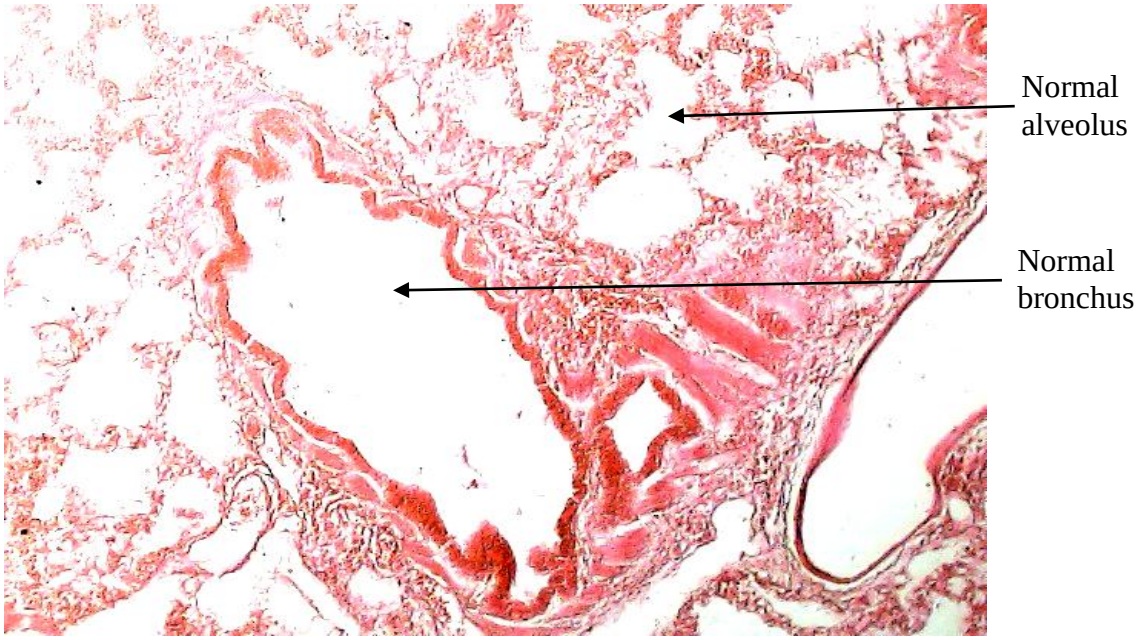

Plate 34: Photomicrograph of the lung tissues of the albino rats before exposure (X 400).

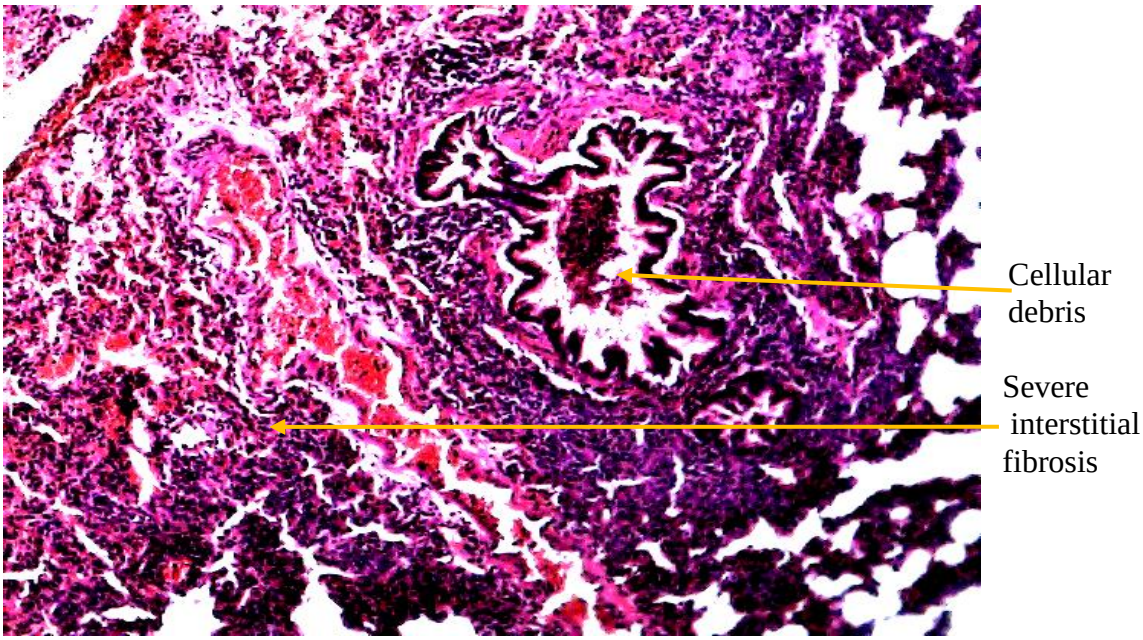

Plate 35: Photomicrograph of the lung tissues of the control albino rats after exposure to cement dust(X400).

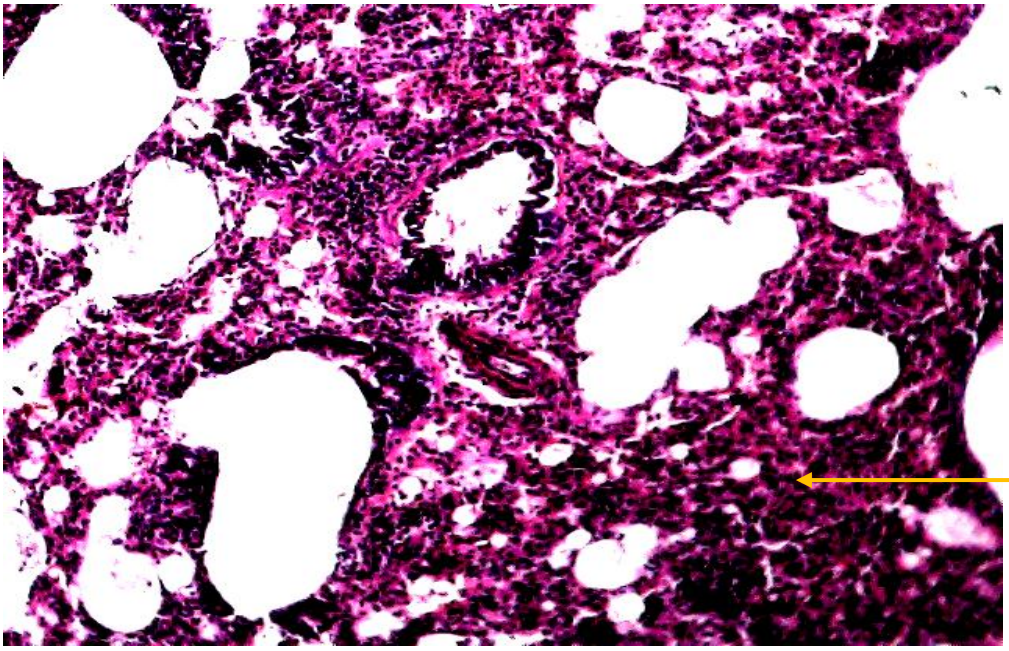

Plate 36: Photomicrograph of the lung tissues of the exposed albino rats fed with roselle extract (X 400).

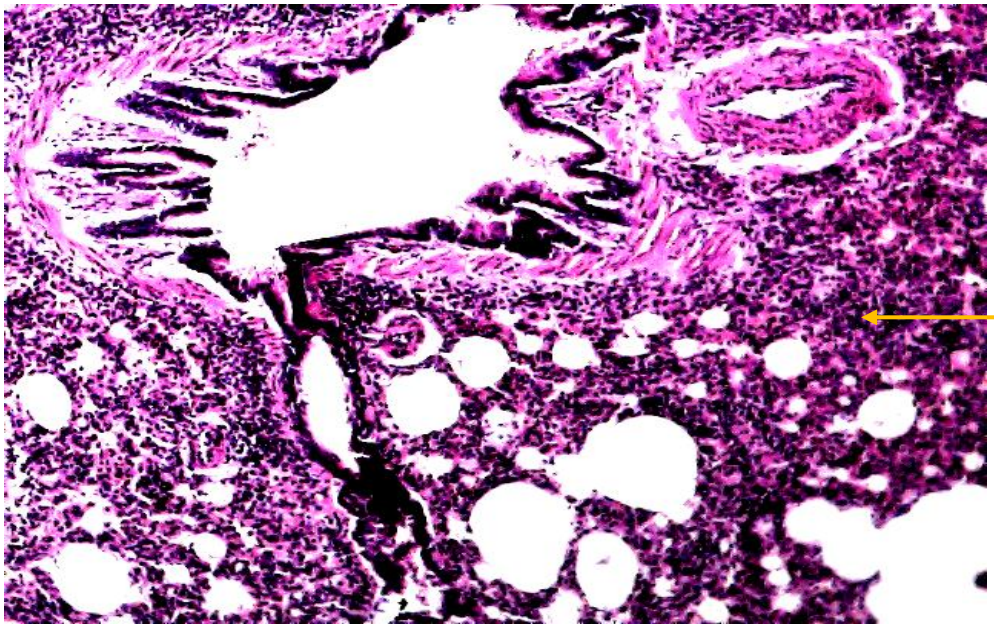

Plate 37: Photomicrograph of the lung tissues of the exposed albino rats fed with moringa extract (X 400).

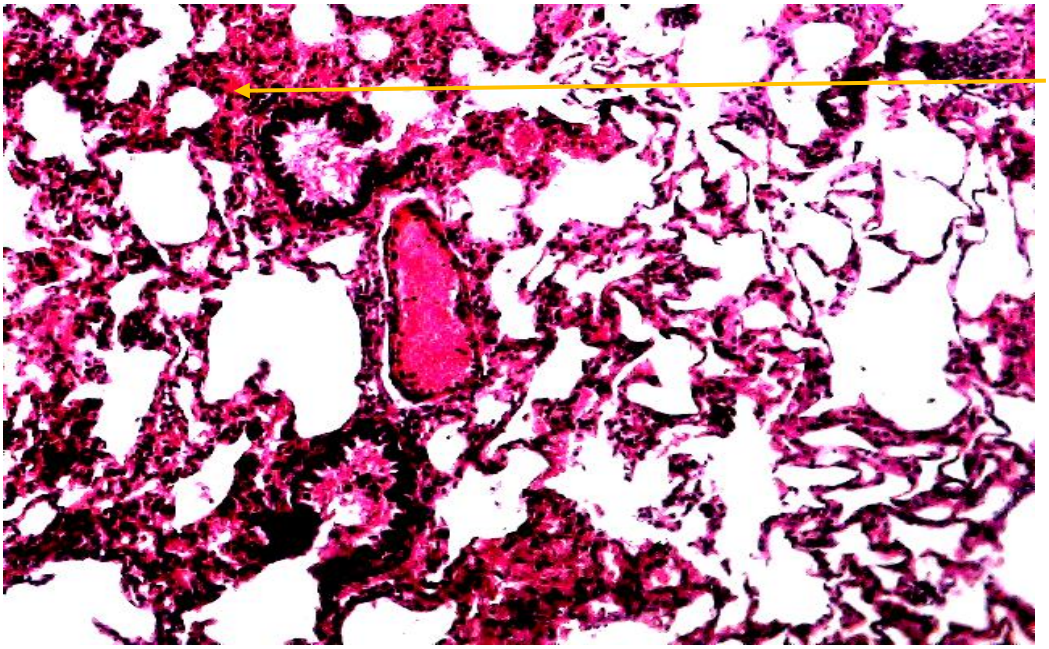

Plate 38: Photomicrograph of the lung tissues of the exposed albino rats fed with ginger extract (X400).

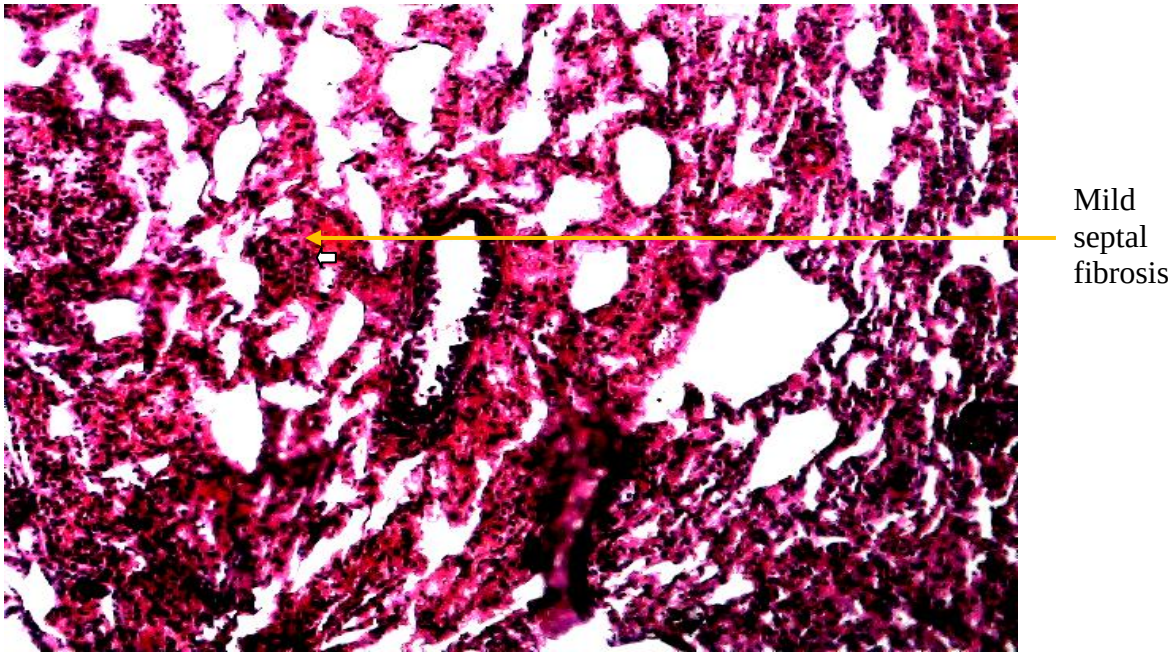

Plate 39: Photomicrograph of the lung tissues of the exposed albino rats fed with 'ugwu' extract (X400).

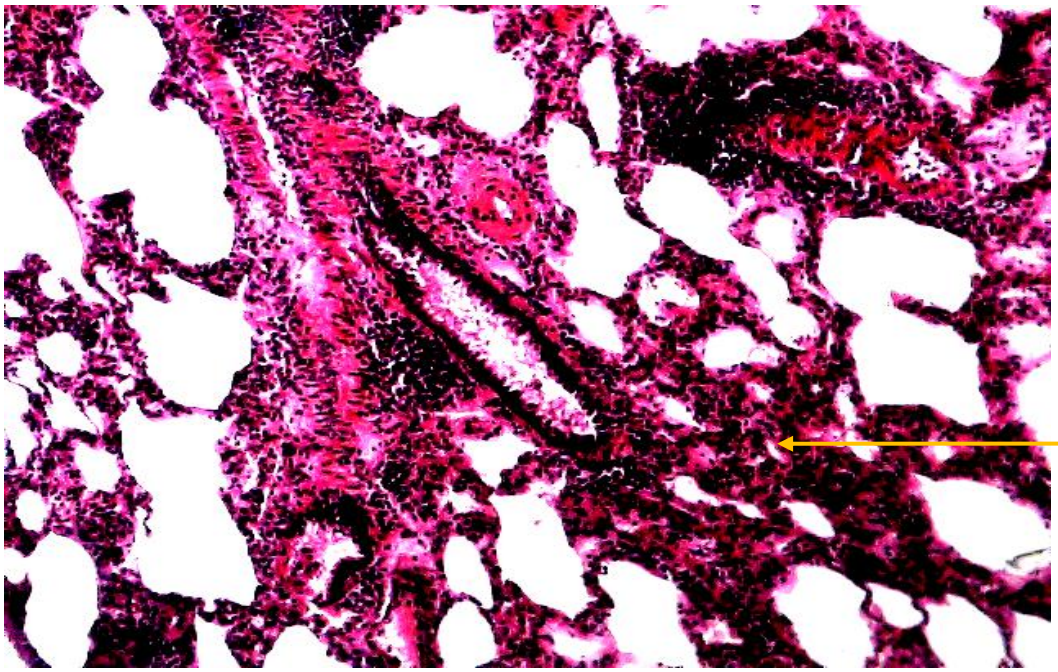

Plate 40: Photomicrograph of the lung tissues of the exposed albino rats fed with mixture of the extracts (X400).

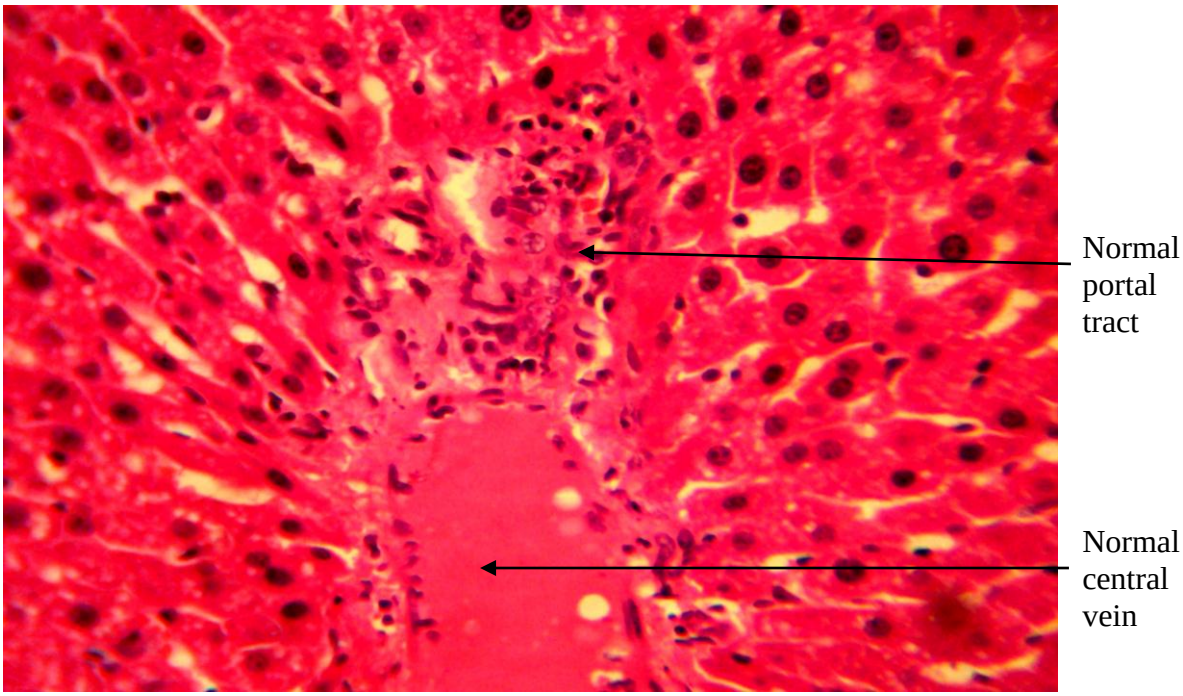

Plate 41: Photomicrograph of the liver tissues of the albino rats before exposure (X 400).

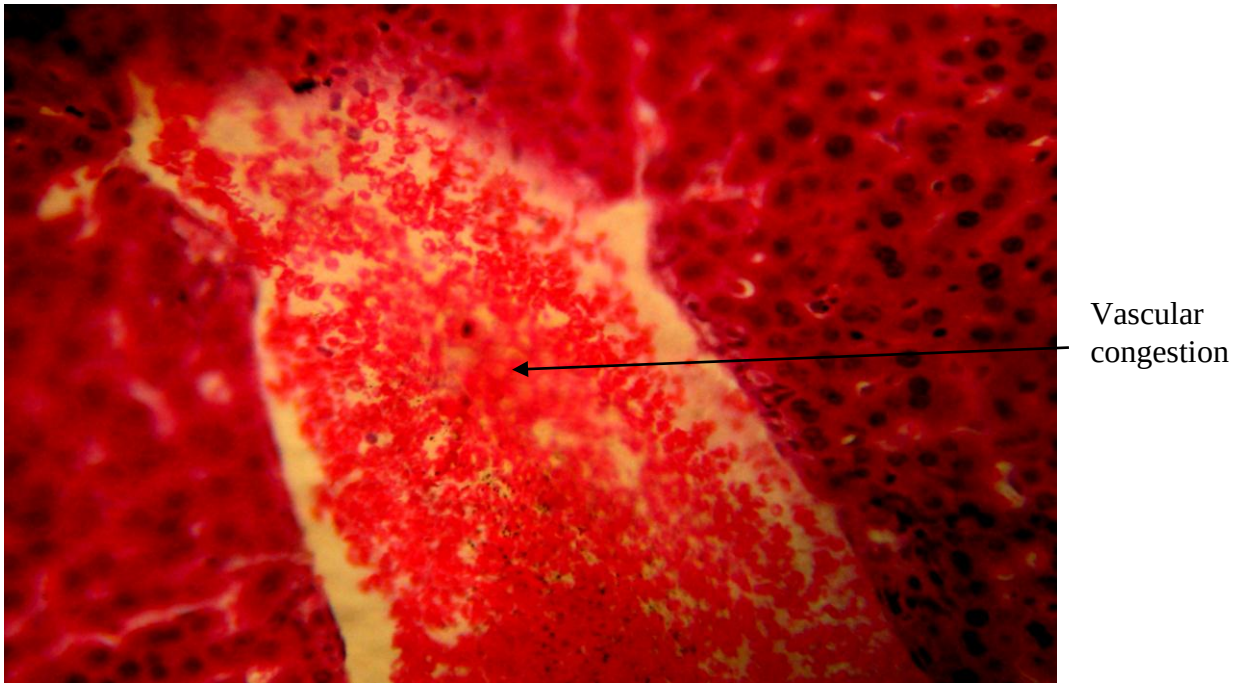

Plate 42: Photomicrograph of the liver tissues of the control albino rats at the end of exposure (X400).

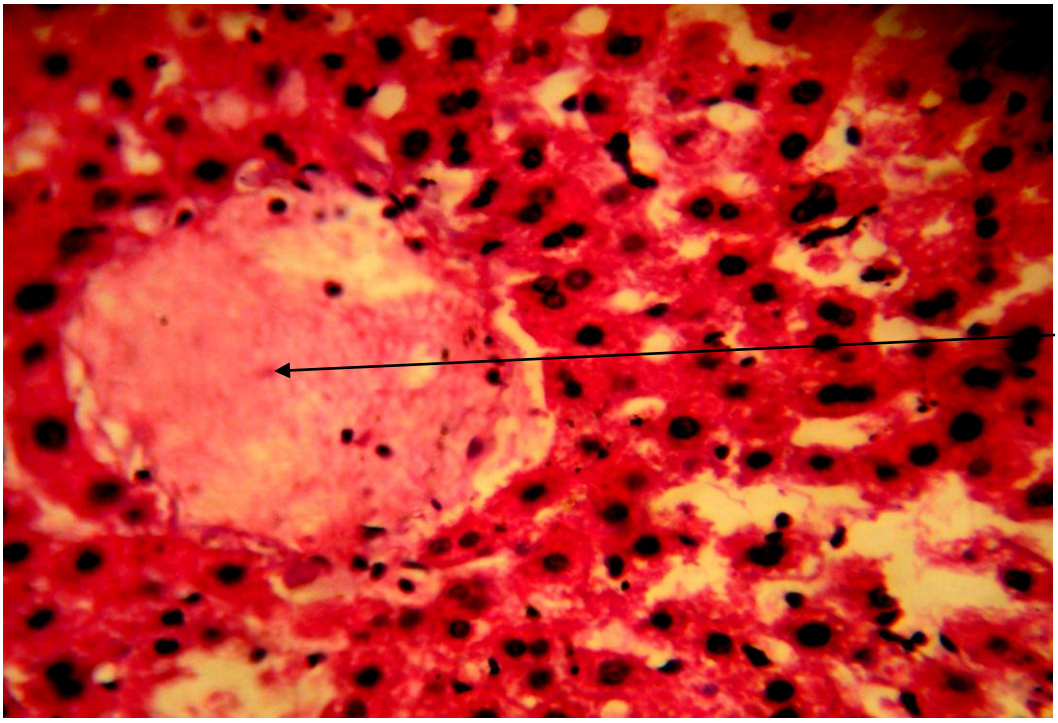

Plate 43: Photomicrograph of the liver tissues of the exposed albino rats fed with roselle extract (X400).

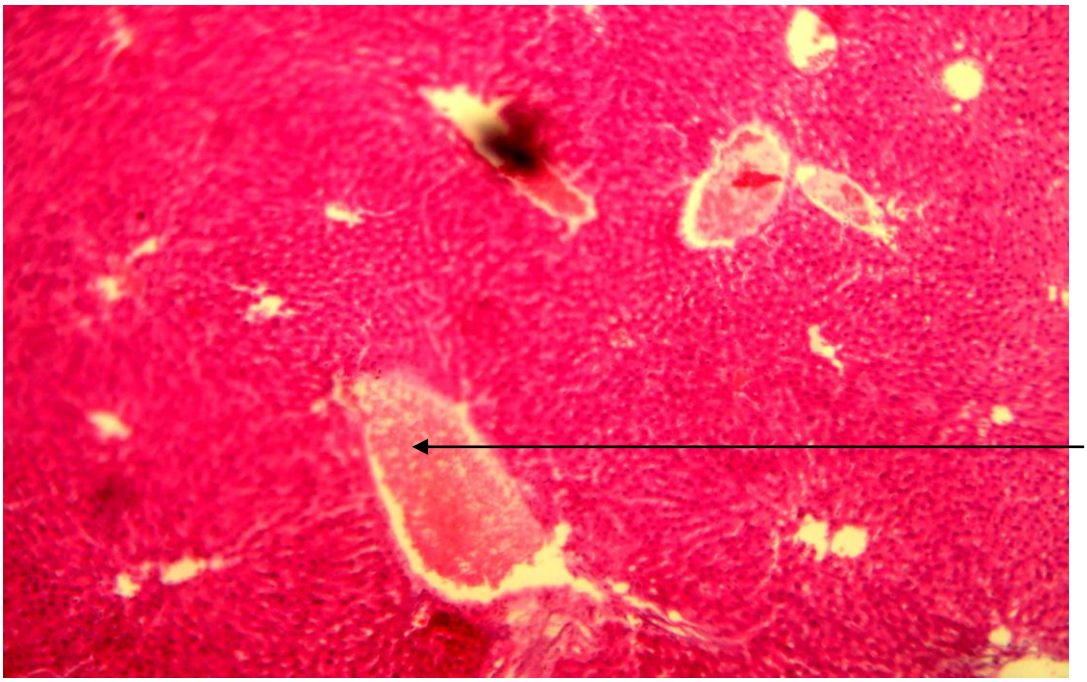

Plate 44: Photomicrograph of the liver tissues of the exposed albino rats fed with moringa extract (X400).

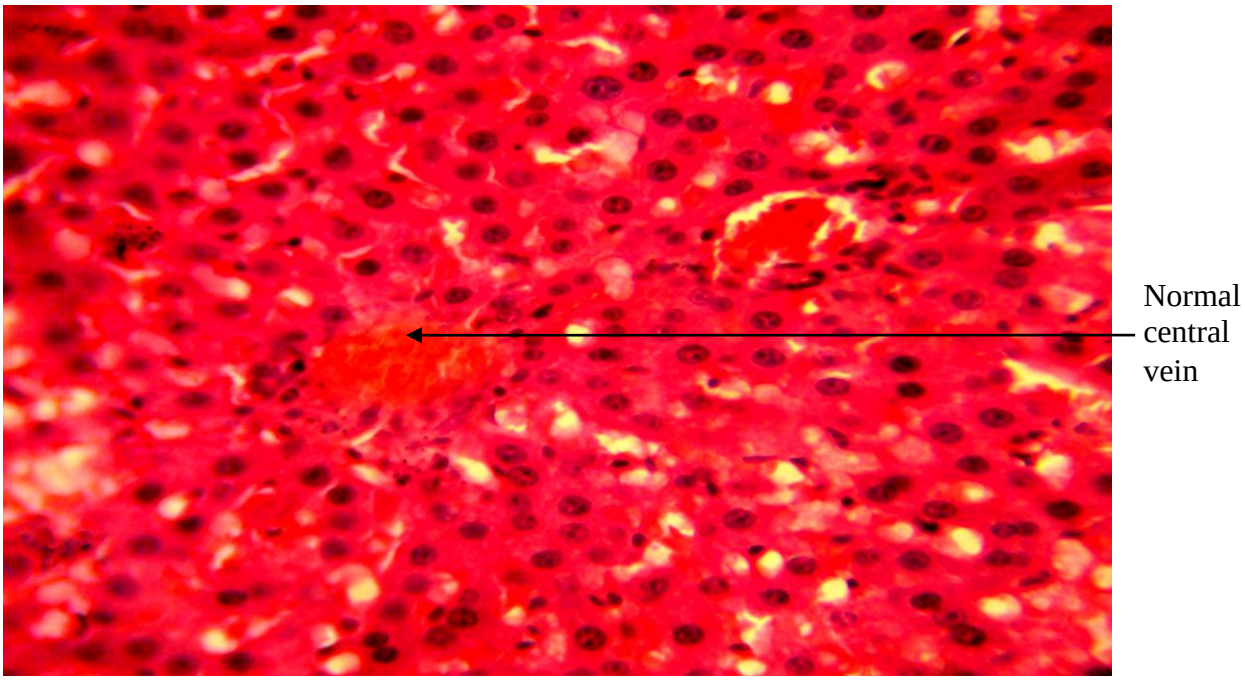

Plate 45: Photomicrograph of the liver tissues of the exposed albino rat fed with ginger extract (X400).

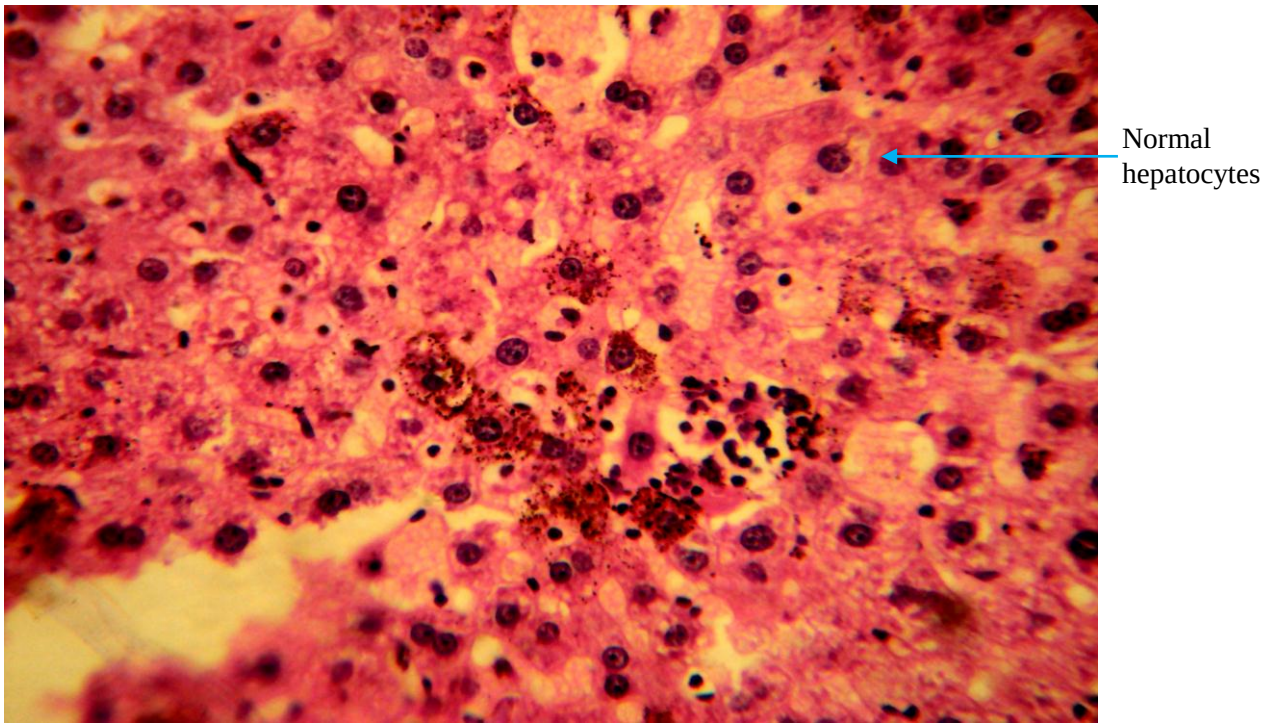

Plate 46: Photomicrograph of the liver tissues of the exposed albino rats fed with 'ugwu' extract (X400).

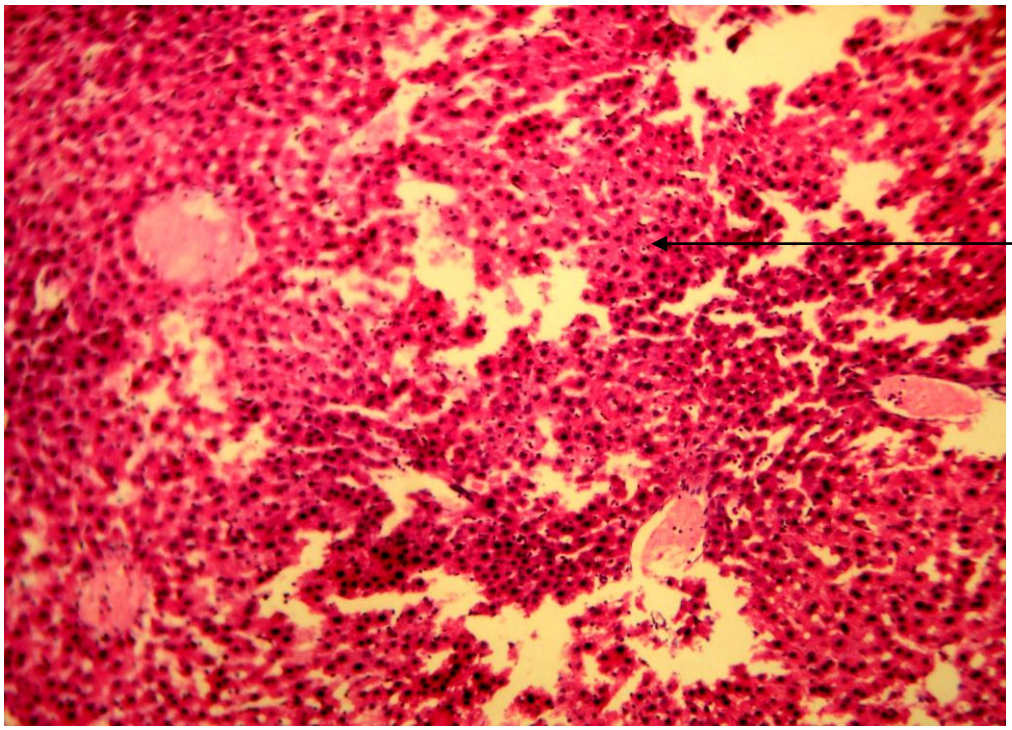

Plate 47: Photomicrograph of the liver tissues of the exposed albino rats fed with mixture extract (X400).

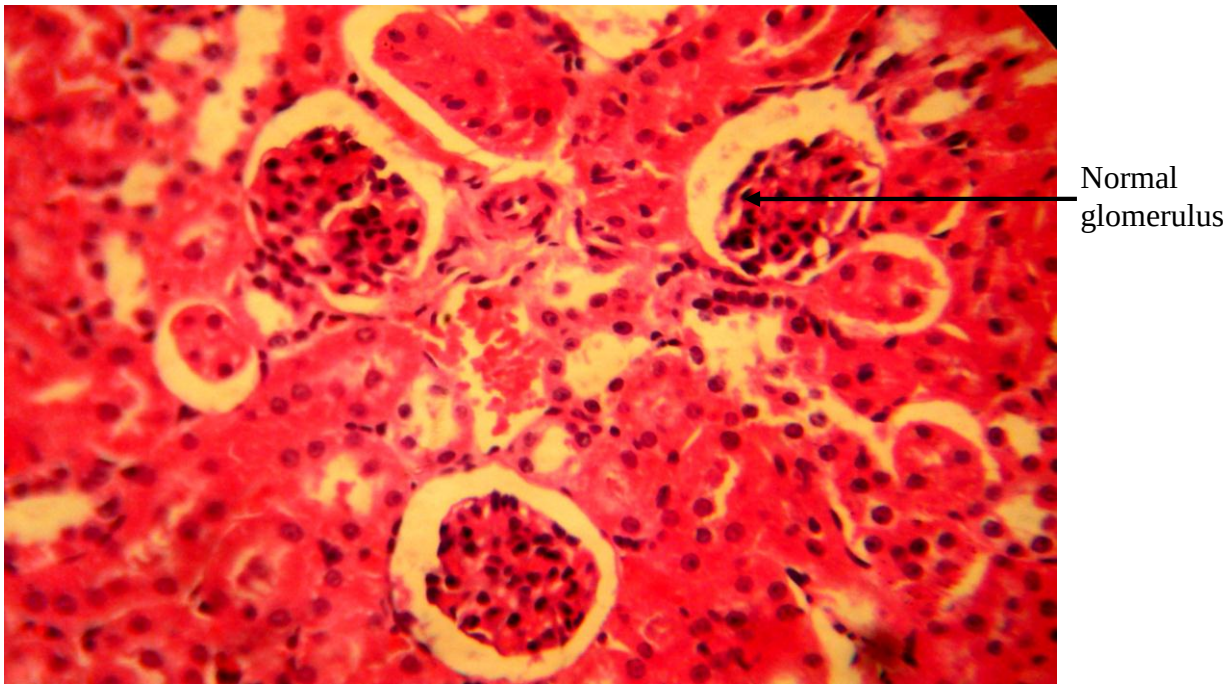

Plate 48: Photomicrograph of the kidney tissues of the albino rats before exposure (X400).

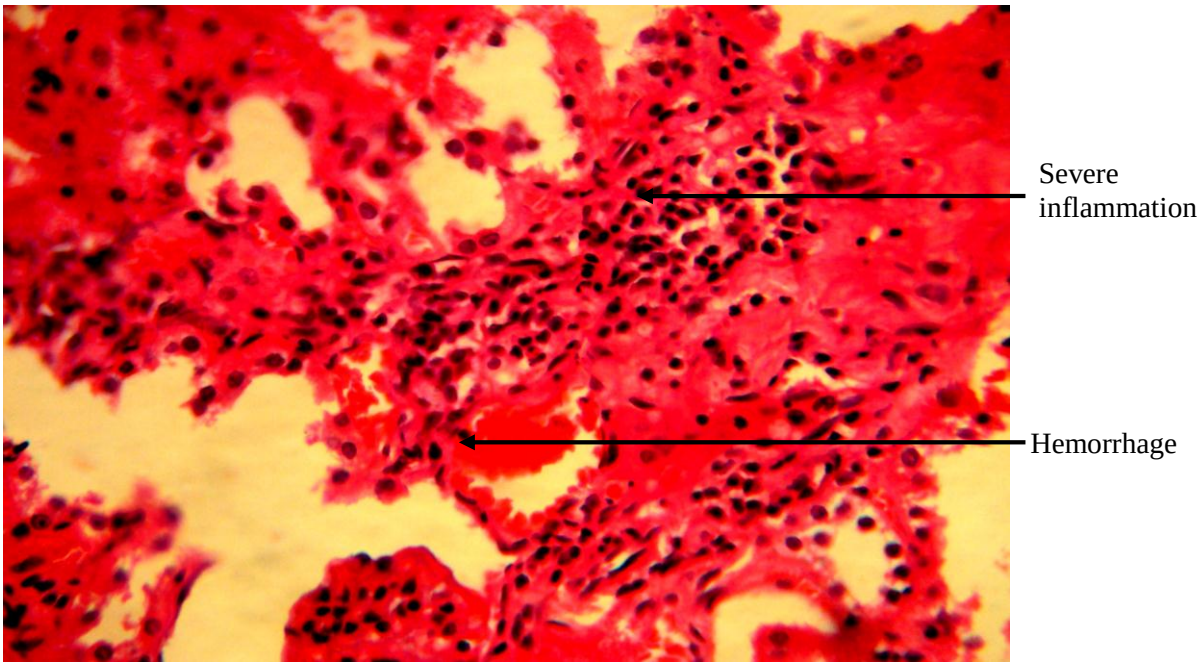

Plate 49: Photomicrograph of the kidney tissues of the control albino rats at the end of exposure (X400).

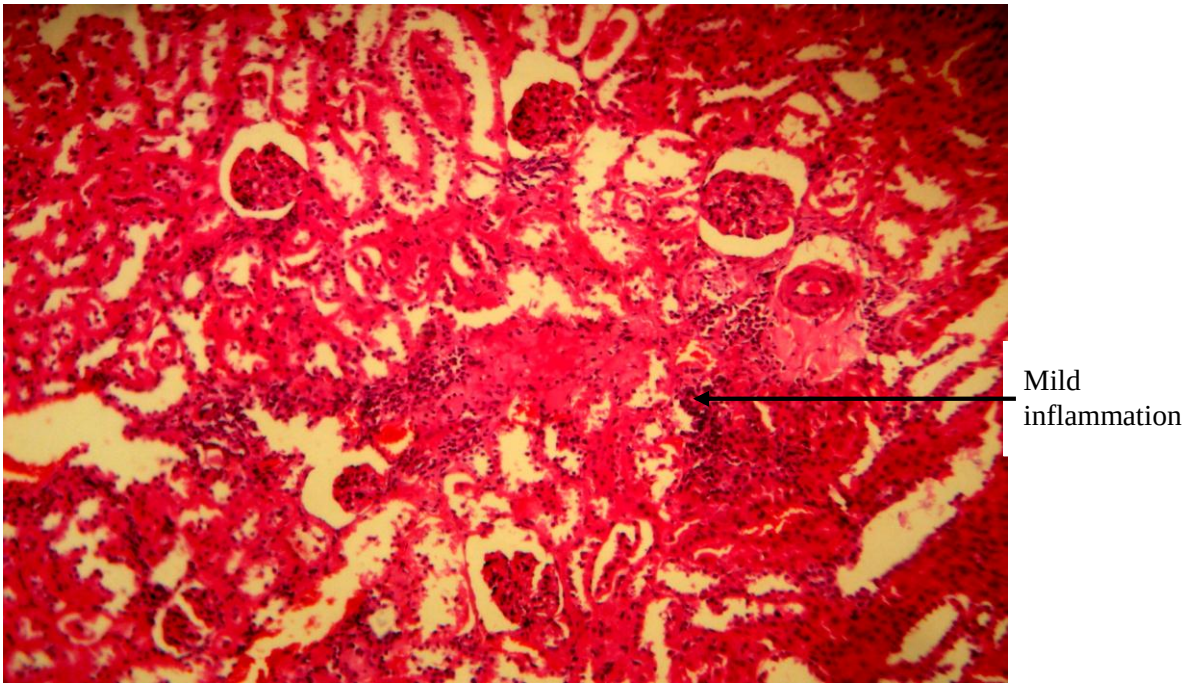

Plate 50: Photomicrograph of the kidney tissues of the exposed albino rats fed with roselle extract (X400).

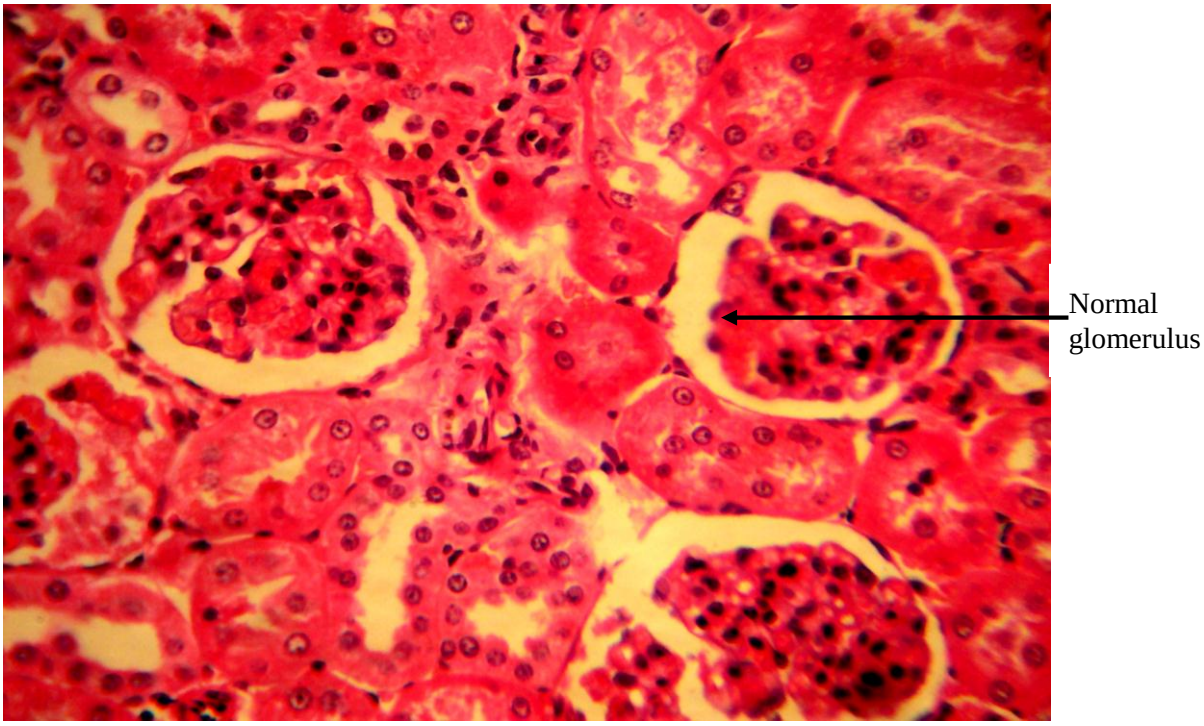

Plate 51: Photomicrograph of the kidney tissues of the exposed albino rats fed with moringa extract (X400).

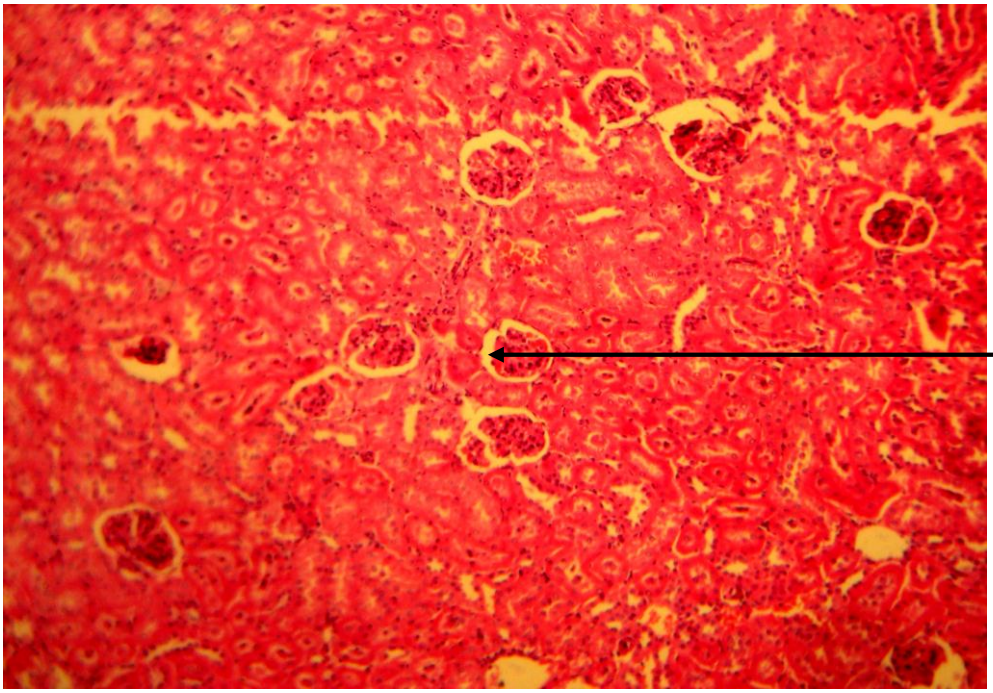

Plate 52: Photomicrograph of the kidney tissues of the exposed albino rats fed with ginger extract (X400).

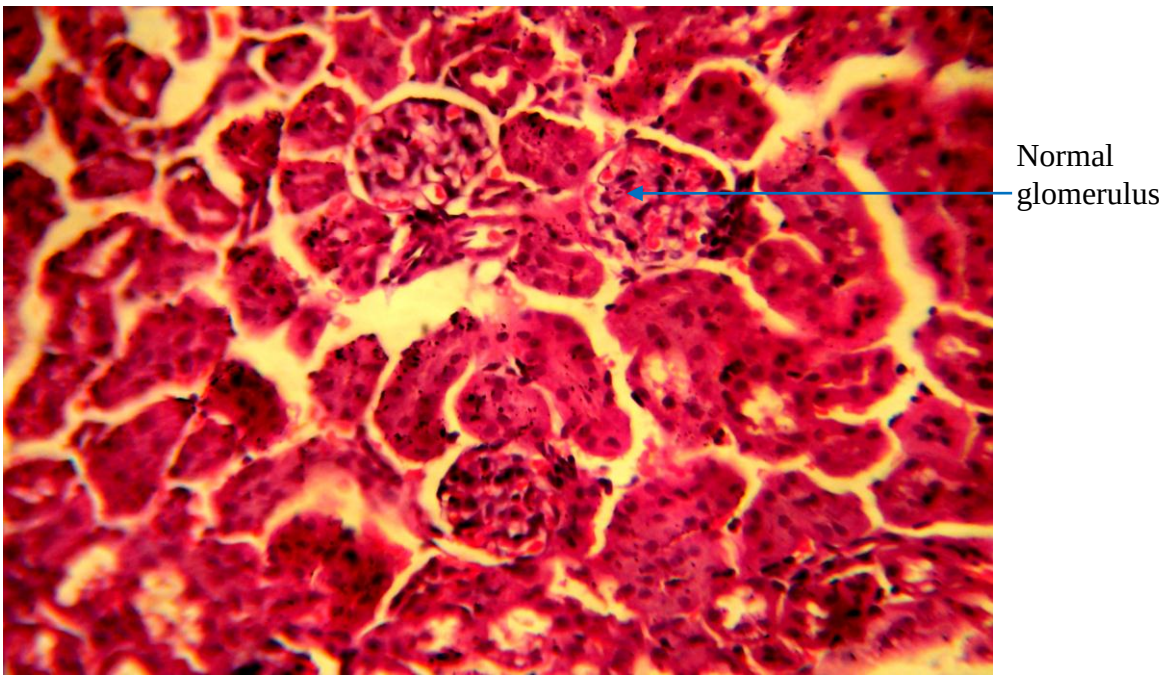

Plate 53: Photomicrograph of the kidney tissues of the exposed albino rats fed with 'ugwu' extract (X400).

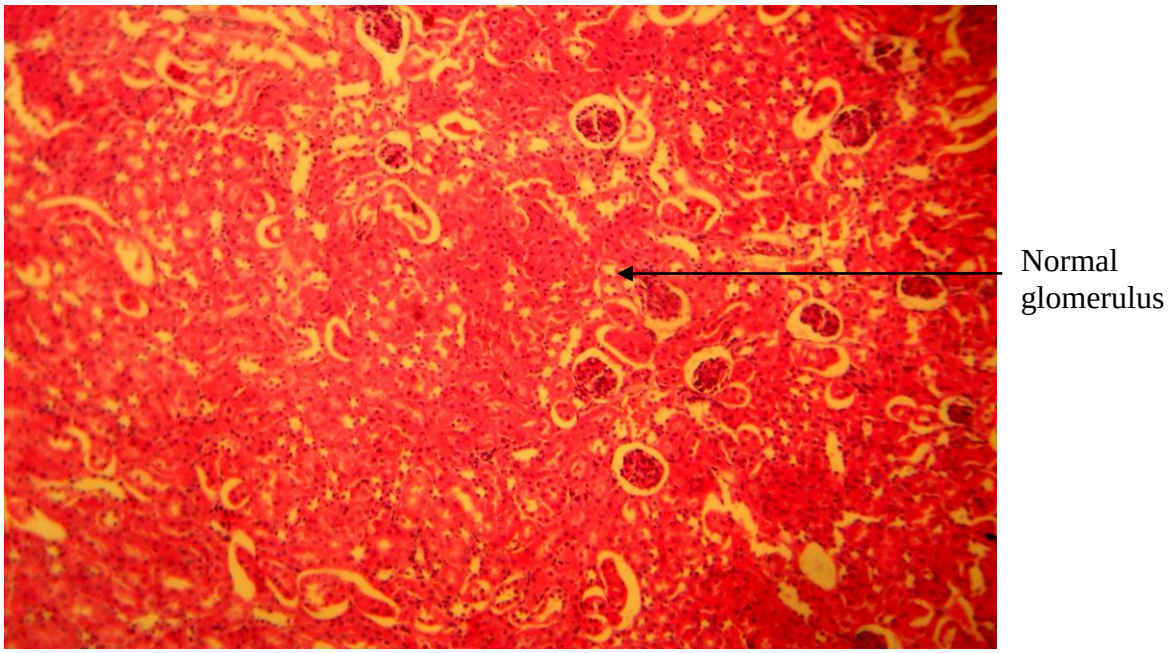

Plate 54: Photomicrograph of the kidney tissues of the exposed albino rats fed with mixture extract (X400).

4.8 Effects of the Plant Extracts on DNA Purity of the Rats Exposed to Cement dust.

4.8.1 The Wild Rats

Table 34 shows the DNA purity or absorbance at 260/280 of the wild rats following treatment with the plant extracts. The absorbance of the wild rats treated with the plant extracts were significantly (P>0.05) higher than the absorbance of DNA of rats that received distilled water only. The absorbance of the control 1 rats was 1.65; control 2 was 1.39, while the absorbance of the rats that were fed with extracts of roselle, moringa, ginger, 'ugwu' and mixture extracts are 1.43, 1.51, 1.63, 1.52 and 1.60, respectively. Furthermore, significant difference (P>0.05) were also observed in the absorbance of the rats fed with the different plant extracts.

Figure 32 illustrates the mean purity or quality of DNA of the wild rats after treatment with the plant extracts for 180 days. The mean purity of the test rats were significantly ($p<0.05$) higher than the control rats that received only distilled water. Significant differences ($p<0.05$) were also observed in the mean purity of the test rats.

4.8.2 The Albino Rats

Table 35 shows the effects of the plant extracts on the DNA purity of the exposed Albino rats. The purity of the DNA of the control rats at the end of the exposure was significantly compromised and had fallen below standard after 180 days of exposure. Although the purity of the DNA of the rats treated with the plant extracts at the end of the exposure fell below the 0 day values, the values were within the normal range (1.50-2.0). Significant differences ($p<0.05$) were observed between the optical density (A260/280) of the control and test rats.

Figure 33 is a graphical representation of the mean purity of the DNA of the exposed albino rats treated with the plant extracts for 180 days. The mean purity of the test rats were significantly ($p<0.05$) higher than the control. Significant differences ($p<0.05$) were also observed in the mean purity of the test rats.

Table 34: The DNA purity of the wild rats.

Parameter	Concentration (ng μl^{-1})	A260	A280	A260/280	P – Value
Extract					
Control 1	2.11 ± 0.91	0.028 ± 0.001	0.018 ± 0.006	1.65 ± 0.078	
Control 2	6.21 ±1.82	0.031 ±0.002	0.023 ±0.001	1.39 ±0.61	0.0009*
Roselle	4.21 ±1.25	0.022 ±0.012	0.016 ±0.001	1.43 ±0.01	0.0010*
Moringa	3.32 ±0.73	0.018 ±0.002	0.012 ±0.001	1.51 ±0.11	0.0622**
Ginger	2.31 ±0.22	0.029 ±0.002	0.018 ±0.001	1.63 ±0.13	0.0736**
'Ugwu'	3.42 ±0.93	0.031 ±0.014	0.021 ±0.016	1.52 ±0.11	0.0585**
Mixture	2.35 ±0.53	0.048 ±0.001	0.030 ±0.002	1.60 ±0.16	0.0724**
Rat baseline	7.56 ±2.51	0.052 ±0.007	0.039 ±0.003	1.30 ±0.021	0.0001*

- Values were expressed as MEAN ± SE
- When absorbance (A) at 260/280 is between 1.5 – 2.0 = Normal values, below 1.5 and above 2.0 = abnormal values
- When (*$p<0.05$): Significant from control and when (**$p>0.05$): Not significant from control.
- Control 2 = Exposed wild rats fed only with distilled water.

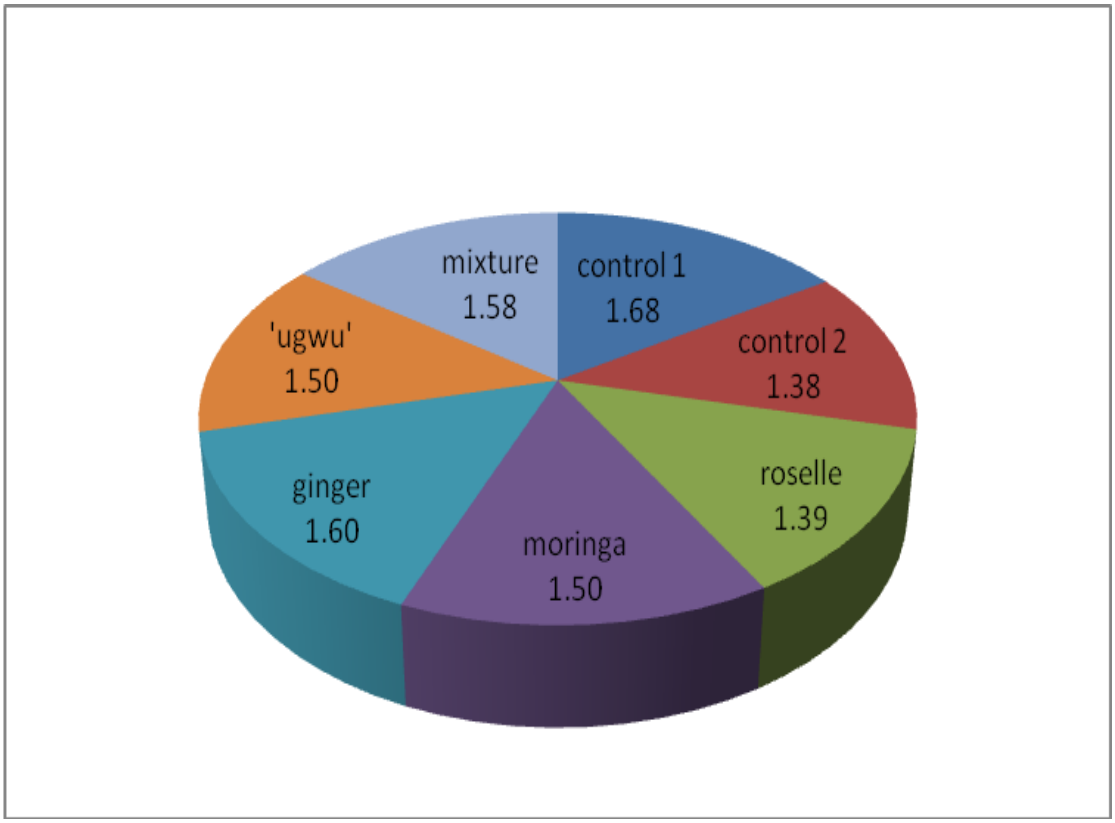

Figure 32: The mean purity or absorbance (A) of the DNA of the wild rats following treatment with the plant extracts.

TABLE 35: The DNA purity of the exposed albino rats.

Parameter	Concentration (ng μl^{-1})	A260	A280	A260/280	P – Value
Extract					
Control	7.67	0078	0.064	1.22	
	± 0.11	± 0.01	± 0.06	± 0.078	
Roselle	2.67	0.026	0.017	1.53	0.009**
	±1.53	±0.02	±0.006	±0.082	
Moringa	6.00	0.069	0.047	1.47	0.007**
	±1.73	±0.01	±0.002	±0.061	
Ginger	3.3	0.03	0.023	1.55	0.002**
	±2.52	±0.02	±0.04	±0.115	
'Ugwu'	4.33	0.044	0.028	1.59	0.012**
	±1.53	±0.02	±0.02	±0.122	
Mixture	2.33	0.078	0.64	01.59	0.002**
	±1.53	±0.07	±0.06	±0.036	
Rat	1.33	0.012	0.009	1.87	0.0001**
baseline	±0.58	±0.008	±0.0001	±0.061	

- Values were expressed as MEAN ± SE
- When absorbance (A) at 260/280 is between 1.5 – 2.0 = Normal values, below 1.5 and above 2.0 = abnormal values
- When (*p<0.05): Significant from control and when (**p>0.05): Not significant from control.

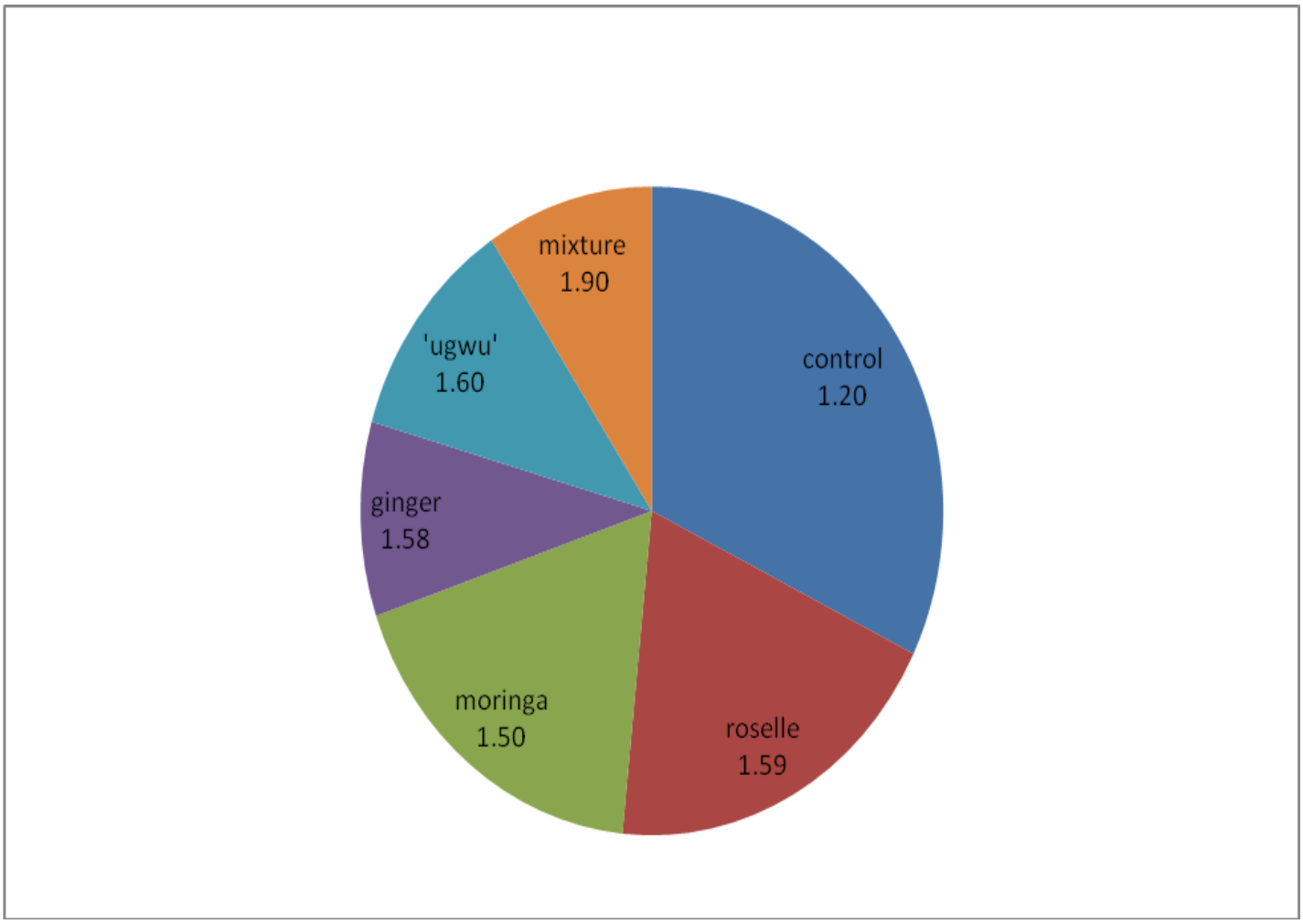

Figure 33: The mean purity or absorbance (A) of the DNA of the exposed albino rats treated with the plant extracts for 180 days.

4.9 Exposure Effect of the cement Plant

Elemental analysis of Shagamu cement dust shows it contained calcium, silicon, aluminum, chromium and lead in high concentrations (Table 36). The concentrations of the toxic elements in cement dust detected in the lungs of the exposed rats increased significantly ($p<0.05$) with closeness to the cement factory and length of exposure (Table 37). At 250 m from the cement factory, the concentrations of calcium, silicon, aluminum, chromium and lead detected in the lungs of rats exposed to cement dust are 66.9, 0.97, 2.81, 0.53 and 0.61 mg kg^{-1}, respectively. The rats that were placed at 1 km from the cement factory had 62.83, 0.53, 2.56, 0.31 and 0.49 mg kg^{-1} of calcium, silicon, aluminum, chromium and lead, respectively, in their lungs. The concentrations of 58.31, 0.30, 0.21, 0.06 and 0.07 mg kg^{-1} of calcium, silicon, aluminum, chromium and lead, respectively, were found in the lungs of the rats that were exposed to cement dust at 2.5 km from the cement factory. At 5 km from the cement factory, the concentrations of calcium, silicon, aluminum, chromium and lead detected in the lungs of rats exposed to cement dust are 17.20, 0.21, 0.15, 0.04 and 0.03 mg kg^{-1}, respectively. The concentrations of calcium, silicon, aluminum, chromium and lead in the lungs of the rats that were placed at 6 km from the cement factory are 8.30, 0.0013, 0.0013, 0.000 and 0.000 mg kg^{-1}, respectively.

Table 36: Elemental analysis of Shagamu cement dust

Element	Cement Chemist Notation	Mass %
Calcium Oxide CaO	C	50-64 %
Silicon Oxide SiO_2	S	21-25 %
Aluminum Oxide $A1_2O_3$	A	10-11 %
Chromium Oxide	Cr	7-10 %
Lead Oxide	**Pb**	**6-10 %**

Table 37: Variation in exposure to cement dust in relation to closeness to the cement factory.

Element	Calcium	Silicon	Aluminum	Chromium	Lead	Mean Weight Increase
Location						
250 m	66.90	0.97	2.81	0.53	0.61	82.5
	±6.5	±0.21	±1.22	±0.18	±0.17	±10.1
1km	62.83	0.53	1.56	0.31	0.49	98.4
	±5.32	±0.20	±1.5	±0.11	±6.16	±11.2
2.5 km	58.31	0.30	0.21	0.06	0.07	106
	±5.41	±0.92	±0.81	±0.001	±0.002	±13.3
5 km	17.20	0.21	0.15	0.04	0.03	118.2
	±2.81	±0.08	±0.01	±0.002	±0.003	±16.1
6 km	8.30	0.043	0.0013	ND	ND	126.7
	±1.8	±0.002	±0.003			±15.5

- Data are expressed as Mean ± SE
- ND= Not detected.

5.0 DISCUSSION OF RESULTS

5.1 Phytonutrient and Phytochemical Screening (Bioactive Compounds) of the Plant Extracts

Phytonutrients and phytochemicals are nutrients and biologically active compounds, respectively, present in plants. These nutrients and chemicals have been shown by scientists to be necessary for sustaining human life (Harper, 2011). The phytonutrients and phytochemicals found in the food plants could be linked with the overall improved health status of the exposed rats following treatment with the plant extracts. Laboratory studies have shown that phytonutrients and phytochemicals in fruits and vegetables may reduce the risk of cancer, heart diseases and other illnesses, possibly due to dietary fibers, polyphenol, antioxidants and anti-inflammatory effects (USFDA, 2009). The antioxidants in the tested plant extracts could have prevented cell and tissue damage processes of the toxic elements in cement dust while the nutrients in the plant extracts actively involved in cell rebuilding activities.

5.2 Ameliorative Efficacy of the Plant Extracts on Morphology, and some Physical Characteristics of the Rats Exposed to Cement dust

The high weight increase noted in the test rats compared with control rats could be attributed to the antioxidant and cell rebuilding activities of some chemicals and nutrients in the plant extracts. Phytochemical analysis of the plant extracts showed the plants contained glycoside and saponin, both of which could have increased the body weight of the rats. George *et al*. (2002) reported that glycosides and saponins increased the feed intake and growth of experimental animals. Okwu (2005) also reported that glycoside indirectly increases the levels of calcium in animals, which specializes in blood and bone formation leading to body weight increase. The food plants also contain essential nutrients such as calcium, magnesium, iron, sodium, potassium and zinc, all which could have contributed to the body weight of the

exposed rats. Adedapo *et al.* (2009) observed increase in the weight of mice administered with the extracts of moringa. Moreover, increase in weights of rats and birds fed with 'ugwu' diets have been reported by Fasuyi and Nonyeren (2007), and Iweala and Obidoa (2009).

The low fertility and birth rates of the control rats that were administered with distilled water only may be due to the destruction of their sperm cells, eggs and reproductive systems by the toxic elements in cement dust. Several studies on rats and other rodents indicated that blood lead concentrations above 30-40 mg dl^{-1} were associated with impairment of spermatogenesis and reduced concentrations of androgens (Apostoli, 1998). Studies have also shown that the majority of infertility, birth defects and aborted pregnancies that happened in the United States in the 90s were due to exposure to heavy metal (ATSDR, 1999). The high fertility and birth rates of the rats fed with the plant extracts compared with the rats that were administered distilled water alone may be attributed to the scavenging activities of various antioxidants such as flavonoids, tannins, and saponin found in the plant extracts. It could also be the results of the replenishing activities of the phlobatanins and alkaloids detected in the plant extracts. Moringa has been reported by Adedapo *et al*. (2009) and Cajuday and Pocsido (2009) to improve sexual activity in rats by promoting testosterone production. Salman *et al.* (2008) also reported an improvement in sperm count and quality in rats following treatment with 'ugwu' extract. Alkaloids and phlobatanins detected in the plant extracts have been identified in increased sexual activity in rats (George *et al*., 2002; Okwu, 2004). Alkaloids are aphrodisiac (Harisaranraj *et al*., 2009) while phlobatanins can synthesis sex hormones (Okwu, 2001; Edeoga *et al*., 2005).

The partial and total blindness, as well as oral bruises and eye inflammation, observed in all the rats exposed to cement dust could have been caused by the toxic substances detected in cement dust. Hazardous substances in cement dust such as silica, mercury and lead have been reported to cause vision problems (RMC, 2001). The ineffectiveness of the plant extracts to mitigate these health problems could be because the extracts were administered orally and not

topically. However, more work is needed in this direction to know the veracity of this explanation.

The low death and high offspring survival rates of the rats fed with the plant extracts may be attributed to the prophylactic action of the phytoconstituents. Phytochemicals such as the flavonoids, saponins, glycosides, tannins and alkaloids found in the plant extracts could have worked for the overall well-being of the exposed rats. These antioxidants could have protected the cells, tissues and organs of the rats from oxidative damage caused by toxic elements in cement dust with resultant decrease in death rate, and high offspring survival rate. Also, the essential nutrients in the plant extracts were actively involved in cell rebuilding processes, resulting in improved health status of the exposed rats. A research has identified phytochemicals in the reduced mortality rates observed in people consuming high levels of plant-based foods (Arts and Hollman, 2005). Alkaloids are strong antioxidants which can improve physiological activities of animals resulting in improved health status and low death rate (Harisaranraj *et al*., 2009).

5.3 Chemopreventive Efficacy of the Plant Extracts on Rats Exposed to Cement dust

The low concentrations of the toxic elements accumulated in the lungs of the exposed rats treated with the plant extracts compared with the control rats that received distilled water only could be the result of scavenging and chemopreventive activities of various antioxidants found in the plant extracts. For example, the roselle extract contained alkaloids and tannins, which might have been involved in removing the toxic elements from the exposed rats. The antioxidants in moringa that may likely have helped in chemoprevention include tannins and saponins. Ginger contained antioxidants such as flavonoids, saponins, and tannins, which could have been involved in chemoprevention. The ‘ugwu’ extract contained free-radical scavenging properties such as flavonoids, tannins, and saponins. *Azadirachta indica* plant containing

saponins, tannins and flavonoids has been shown to prevent accumulation or remove toxic elements from the body (Krishnaiah *et al.*, 2008).

5.4 Bioprotective Efficacy of the Plant Extracts on Haematological Parameters of Rats Exposed to Cement dust

The low blood parameters of the wild rats living around the cement factory and the exposed albino rats treated only with distilled water was a sign of microcytic and hyprochromic anaemia. The fall in the blood parameters showed that cytotoxic interaction exit between the blood of the exposed rats and the toxic elements in cement dust. Lead and aluminum present in the cement dust are known to alter haematological system of animals including humans (ATSDR, 2005). The improved blood parameters of the wild rats after treatment with the plant extracts and fairly normal blood parameters of the exposed albino rats treated with the plant extracts may be credited to the effects of the phytoconstituents with their attendant antioxidant and haematinic properties. The plant extracts contained blood purifiers and blood-forming nutrients and chemicals such as calcium, zinc, magnesium, ascorbic acid, saponins, alkaloids, glycosides, and reducing sugars, all of which could have worked together and increased the haematological parameters of the exposed rats. The terpenes and ascorbic acid found in the food plants have been shown to function as antioxidants, protecting blood and other body fluids from assault by free-radicals caused by toxic substances in the body (Poornima and Ravishankar, 2009). Saponins, also detected in the plant extracts, has been shown by Krishnaiah *et al*. (2008) as blood purifier, eliminating toxic substances and cholesterol from the blood. Fasoyiro *et al*. (2005) reported that food plants rich in minerals and nutrients like calcium, zinc, potassium, sodium, magnesium may boost blood volume of animals including humans.

5.5 Bioprotective Efficacy of the Plant Extracts on Biochemical Parameters of Rats Exposed to Cement dust

The abnormal levels observed in the liver enzymes, Alanine amino transferase (ALT), Aspartate amino transferase (AST) and Alkaline phosphates activity (ALP) of the exposed rats could have stemmed from liver damage caused by toxic elements in the cement dust. These enzymes are mostly found in the liver cells, which release them into the blood stream when there is injury (Dan, 2011). Moderate to mild levels observed in the test rats compared to the control rats may be owing to the scavenging and antioxidant activities of flavonoids, tannins, glycosides, saponins, reducing sugar, and phlobatanins found in the plant extracts. All these phytochemicals could have protected the liver tissues from free-radicals damage, and worked for the overall well-being of the rats. Hepatoprotective effects of 'ugwu' plants have been reported by Iweala and Obidoa (2009). Janakat and Nassar (2010) also reported the aqueous extract of *Terfezia claveryi* almost normalized the effect of carbon tetrachloride (CCl_4) on liver function enzymes of albino rats as a result of the high antioxidants present in the plant. Milk thistle (*Silybum marianum*), containing flavonoids, has demonstrated the ability to normalize liver enzyme levels in participants whose liver had been damaged by toxic chemicals (Steven, 2011).

The reduction observed in the metabolic enzymes, serum protein and glutathione (GSH), of the exposed rats could be due to renal excretion, impaired protein synthesis or liver damage by the toxic elements in the cement dust. Glutathione is the most powerful internal antioxidant and liver protector but can be depleted by large amounts of toxic element in the body (Dan, 2011). The improvements observed in the serum protein and GSH of the exposed rats following treatment with the plant extracts may be the effects of the bioprotective and cell rebuilding activities of the plant extracts. Salman *et al*. (2008) and Shirin-Adel and Prakash (2010) observed that ginger plant contain crude protein known as *Silymarin*, which could have boosted the serum protein of the exposed rats. Food plants containing phytochemicals such as

flavonoids have been reported to increase the levels of serum protein and glutathione in infants fed (Warwick *et al*., 2012).

5.6 Cell Rebuilding Efficacy of the Plant Extracts on Internal Organs (Lung, Liver and Kidney Tissues) of Rats Exposed to Cement dust

The marked histological damage observed in the lung, liver, and kidney tissues of the wild rats inhabiting the cement factory and the exposed albino rats treated only with distilled water showed deleterious interactions between the tissues and the toxic elements in the cement dust. Some elements found in the lung tissues of the exposed rats are suspected to be involved in the pathogenesis of the histological damage. Calcium was found in the tissues of the exposed rats in excess amounts, which could have induced toxicity. Fan *et al*., (2007) stated that although calcium is important in metabolism, excess amounts can cause brain damage. Silicon, aluminum, and chromium compounds, also found in the tissues of the exposed rats in high concentrations have been implicated in silicosis, increased risk of cancer, and tissue damage (Hughes *et al*., 2001; ATSDR, 2010). The marked improvements observed in the damaged tissues of the wild rats following treatment with the plant extracts and the moderate to mild histology of the exposed albino rats administered with the plant extracts may be the result of the chemopreventive and cell rebuilding activities of antioxidants and nutrients such as flavonoids, glycosides, tannins, saponins, ascorbic acid, zinc, and magnesium found in the plant extracts. Flavonoids in *Azadirachta indica* leaves have been reported to prevent or neutralize free-radicals and toxic elements, which attack the cells and tissues of animals and damage it (Krishnaiah *et al*, 2008). Saponins in plant extracts have been shown to help humans prevent or fight tumor cells, particularly lung and blood cancers caused by toxic substances (Barakat *et al*., 1993). Ascorbic acid is a strong antioxidant which activates the functions of all the cells, protects and removes toxic substances from the body and intervenes in the regeneration of damaged tissues (Poornima and Ravishankar, 2009). The presence of tannins

and terpenoids in *Hibiscus rosa-sinensis* has been explained for its involvement in tissue healing and cell regeneration processes (Nayak *et al*., 2007; Okwu and Josiah, 2006).

5.7 Bioprotective Efficacy of the Plant Extracts on the Purity of the DNA of Rats Exposed to Cement dust.

The low purity of the DNA of the wild rats living around the cement factory and exposed albino rats treated only with distilled water suggested that the integrity of the DNA of the exposed rats have been compromised by the toxic elements in the cement dust. Exposure of experimental animals to heavy metals ions has been reported by Shao (2010) to lead to DNA damage and DNA repair inhibition. The improved DNA purity of the exposed wild rats after treatment with the plant extracts and moderate to normal DNA purity of the exposed albino rats treated with the plant extracts could be the results of the prophylactic and chemopreventive activities of the phytochemicals present in the plant extracts. The phytochemical screening of all the plant extracts revealed saponins, flavonoids and tannins, which could have involved in chemopreventive and bioprotective activities. In the last few decades, several studies suggest that regular consumption of fruits, vegetables and spices have health benefits including risk reduction of developing DNA problems (Terry *et al*., 2001). Much of the protective effects have been attributed to phytochemicals such as flavonoids, terpenes and alkaloids present in plants, which have ability to scavenge free radicals from the body (Barth *et al*., 2005).

5.8 Exposure Effects of the Cement Plant.

The levels of toxic elements detected in the lungs of the exposed rats at the factory are very high, as they all exceeded regulatory standard. The concentrations of the detected toxic elements increased with duration of exposure, and closeness to the cement factory. The rats felt the impact of the cement dust pollution till about 5 kilometers radius of the factory. The high levels of the elements detected showed the cement plant seriously polluted the environment. The high level of pollution confirms the assertion of Bilen (2010) that cement production is one of the main sources of environmental pollution. The high concentrations of the toxic

elements further show that control strategies for prevention of dust release by cement plants have not been effective in the Cement Company. Fell *et al*. (2003) reported that in advanced countries such as United States and United Kingdom, control-strategies for preventing dust release by machinery enclosure, local exhaust ventilation, work automation, and great diligence in maintenance of machinery have been carried out. These, presumably have led to less dust exposure.

5.9 SUMMARY OF FINDINGS AND CONCLUSION

OBJECTIVES	SUMMARY OF FINDINGS
To determine the phytochemicals (bioactive Compounds) present in the plant extracts.	1. The roselle extract contained glycosides, tannins, reducing sugar, and alkaloids. 2. The moringa extract revealed glycosides, tannins, saponins, reducing sugar, and alkaloids. 3 The ginger extract had flavonoids, glycosides, saponins, and reducing sugar. 4 The 'ugwu' extract contained flavonoids, glycosides, tannins, saponins, and alkaloids.
To evaluate the ameliorative efficacy of the plant extracts on morphology, and some physical characteristics of the rats	1. The plant extracts increased the body weights of the exposed rats and there was a significant difference ($p<0.05$) between the weight gained by the control and test rats. Significant differences ($p<0.05$) also existed in the body weight gained by the test rats. Order of effectiveness: mixture> moringa>ugwu>roselle>ginger. 2. The plant extracts increased the fertility and offspring survival rates of the exposed rats, and lowered death risk. 3. The exposed rats had bruises around their mouths, while some had partial blindness, others had total blindness. This implies that the plant extracts could not proffer prophylactic role on the external features of the rats.

OBJECTIVES	SUMMMARY OF FINDINGS
To assess the chemopreventive efficacy of the plant extracts in exposed rats	1. The plant extracts reduced accumulation of toxic elements in the rats' tissues. Order of effectiveness: mixture> ginger >'ugwu'>moringa>roselle.
To evaluate the bioprotective efficacy of the plant extracts on haematological parameters of the exposed rats	1. The test rats showed moderate to normal haematological parameters compared with the control rats. This implies that the plant extracts contain antioxidants and are haematinic. Order of effectiveness: mixture>'ugwu'> moringa>roselle>ginger.
To assess the bioprotective efficacy of the plant extracts on biochemical parameters of the exposed rats.	1 The test rats showed moderate to normal biochemical parameters compared with the control rats. The plant extracts contain antioxidants, which prevented damage to liver enzymes (ALT, AST and ALP) and boosted metabolic enzymes (Protein and GSH). Order of effectiveness: mixture>ginger>moringa<'ugwu'>rosel le>.
To assess the cell-rebuilding efficacy of the plant extracts on the lung, liver, and kidney tissues of the exposed rats	1. The plant extracts protected and repaired damaged cells and tissues in the exposed rats. Order of effectiveness: mixture>ginger>'ugwu'>moringa>rosel le.
To evaluate the prophylactic and bioprotective efficacy of the plant extracts on the purity of the DNA of the exposed rats	1 The DNA of the exposed rats treated with the plant extracts were purer than the DNA of the rats that received distilled water only. Order of effectiveness: mixture>'ugwu'>ginger>roselle>morin ga.

5.10 CONCLUSION

This study has shown that phytonutrients and phytochemicals could help ameliorate the impacts of cement dust on rats living around the cement factory. Inhabitants around cement plants should therefore be advised on the importance of including food plants containing these phytonutrients and phytochemicals in their diets.

5.11 RECOMMENDATION AND FUTURE RESEARCH

It is advisable that people should not reside within 6 km radius of the cement factory. Workers in the cement company should be advised to take roselle, moringa, ginger, and 'ugwu' in their diets daily. More research needs to be done to evaluate ameliorative potentials of some other food plants on people living around cement plants.

5.12 CONTRIBUTION TO KNOWLEDGE

- The food plants enhanced some physical characteristics (for example; weight, fertility and offspring survival rates), and lowered death rate of the exposed rats. Hence, the food plants can be used in animal husbandry.

- The food plants can be used to prevent accumulation of toxic elements in the body or it can be used as detoxifiers in cement dust polluted environments to clean up the body.

- The food plants are bioprotective and haematinic and can be used in the management of anaemic conditions caused by exposure to cement dust.

- The food plants can prevent and repair cell and tissue damage caused by exposure to cement dust.

Appendix 1

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Table 37: Typical Composition of Cement Kiln Dust

Element	Cement Chemist Notation	Mass %
Calcium Oxide CaO	C	61-67 %
Silicon Oxide, SiO_2	S	19-23 %
Aluminum Oxide, $A1_2O_3$	A	2.5-6 %
Ferric Oxide, Fe_2O_3	F	0-6 %
Sulfate	S	1.5-4.5 %

(Source: Hewlett, 1998)

Appendix 11

PLATE 52: The Roselle Plant (*Hibiscus sabdariffa*)

Appendix 1I1

PLATE 53: The Moringa Plant (*Moringa oleifera*)

Appendix 1V

PLATE 54: The Ginger Root (*Zingiber officinale)*

Appendix V

PLATE 55: The 'Ugwu' Plant (*Telfairia occidentalis*).

Appendix VI

PLATE 50: A Wild rat (*Rattus rattus*)

Appendix VII

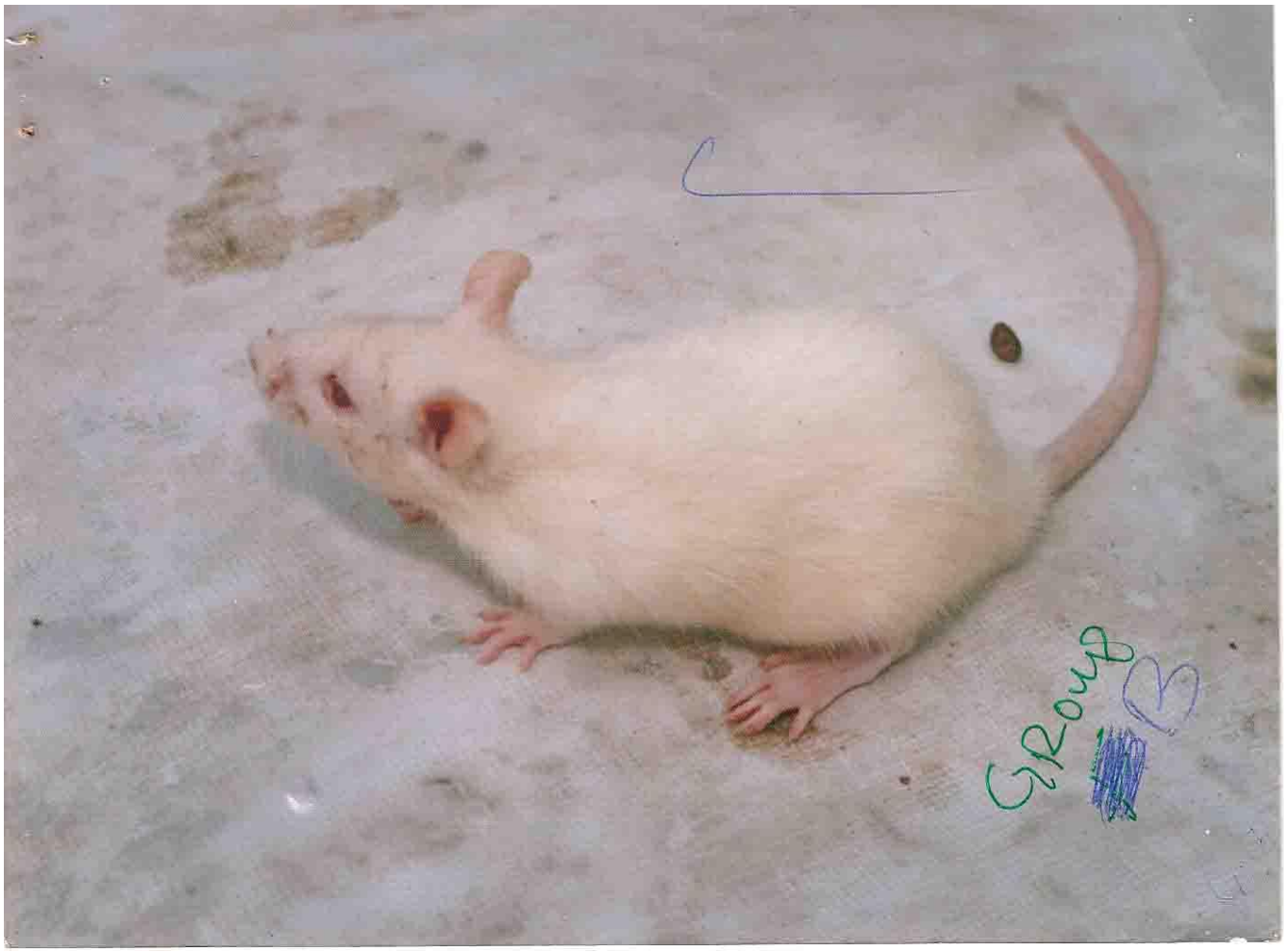

PLATE 51: Albino rat (*Rattus norvegicus*)

Appendix VIII

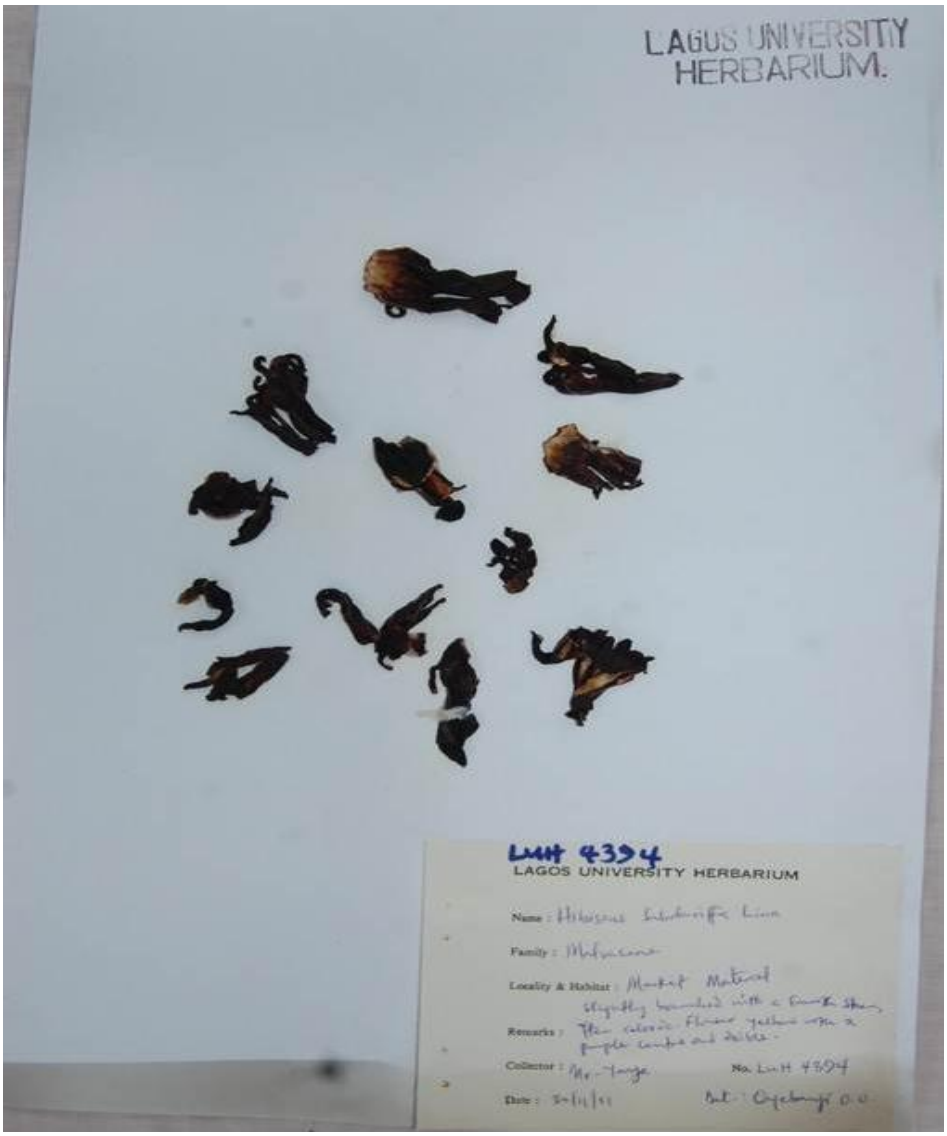

Plate 56: Roselle (Herbarium Sample).

Appendix IX

Plate 57: Moringa (Herbarium Sample).

Appendix X

Plate 58: Ginger (Herbarium Sample).

Appendix XI

Plate 59: 'Ugwu' Leave (Herbarium Sample).

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