KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY
COLLEGE OF ART AND BUILT ENVIRONMENT
FACULTY OF ART

EXPLORING THE POTENTIAL OF *AZADIRACHTA INDICA* EXTRACTS FOR PRESERVATION OF SYMPODIAL BAMBOO

BY
BARFO BOATENG
(B. A. Integrated Rural Art and Industry)

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DECLARATION

I hereby declare that this submission is my own work towards the Maters of Philosophy degree in Integrated Art and Industry, and that, to the best of my knowledge, it contains no material previously published by another person nor material which has been accepted for the award of any other degree of the University, except where due acknowledgment has been made in the text.

Barfo Boateng (PG 1874714)	……	……..……
Student Name & ID.	Signature	Date.

Certified by

DR Rudolf Steiner	……	……..……
Supervisor's Name	Signature	Date

Certified by:

Dr. Rudolf Steiner	……	……..……
Head of Department	Signature.	Date.

ABSTRACT

Due to the high amount of starch and sugar in the *Bambusa vulgaris,* it makes it easy for pests, fungi, borers and other biodegrading organisms to attack the bamboo making it less durable and unattractive for production of any artifact by the local craftsmen. (Baah, 2001). Bamboo is a renewable natural resource that is woody, precious, physically powerful and exceptionally fast- growing grass. Bamboo plays an important role in the world's economy; however, in Ghana, most bamboo industries use chemical preservative which are toxic example dusban, an imported and expensive product for the preservation of bamboo which has ripping effects on the users of bamboo products and the environment as a whole. Ghana Standard Board and other environmental protection agencies are preaching for the use of biological and organic means of preservation of bamboo and other woody materials so as to protect our lives and planet earth. Neem plant (A***zadirachta indica),*** as some people call the "the village pharmacy" because of its ability to treat certain illnesses in both humans and animals, again as pesticides and mosquito repellant. This study has experimented the potential of neem leave extracts in the production of preservative in preserving *Bambusa vulgaris* in Ghana coupled with other traditional methods of preserving bamboo and also to make it environmentally friendly method of preservation.

B.B

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CHAPTER ONE

INTRODUCTION

1.1 Overview

This chapter presents the conceptual frame work of the study and the philosophy upon which the entire research is built. Methodically, it is the sum up of the study background, problem statements, study objectives, research questions, delimitation and limitation, importance of the study, definition of key terms and finally arrangements of the rest of the chapters.

1.2 Background to the Study

Bamboo is a material with numerous uses such as building, furnishing and fencing. Although this non-timber forest product is a good material, its traditional use has been restricted to the construction of temporary structures and is used where cheap and inferior materials are needed.

Due to the depleting wood resources in most Ghanaian forests, attentions have been drawn to bamboo, a material that is renewable, environmentally friendly and widely available. Bamboo grows rapidly and adapts to most climatic situation and possesses features that are of better quality compared to other plants species.

The bamboo plant is a renewable natural resource and plays an important role in the world's economy; however, bamboo is used mainly for fencing and in places where low graded material is required in construction firms. There has been a strong conviction that bamboo has strong and versatile natural use but comes with shorter life span due to the attack by pests and wood degrading organisms.

1.3 Statement of the Problem

Bambusa vulgaris is specie of bamboo, which is common in Ghana and can easily be cultivated in our locality. It has within it some substances example starch, wax, gammy substance and lignin material, which give strength to the bamboo. (Lipangile and Mandemla, 2001)

Due to the high amount of starch and sugar in the *Bambusa vulgaris*, it makes it easy for pests, fungi, borers and other biodegrading organisms to attack the bamboo culm making it less durable and unattractive for production of any artifacts by the local craftsmen. (Baah, 2001)

Bambusa vulgaris is yellow in colour with longitudinal green stripes running from node to node. It is very light in mass. It is relatively big in size which makes it good for furniture construction for both indoor and outdoor use. It is found around the compounds of most organization as part of ornamental plants grown to improve the aesthetic appearance of their surroundings.

Again, since craftsmen in the bamboo industry work with inorganic, imported and expensive preservative which poses more threat to the user and the environment, Odei (2004) asserted that such chemicals are toxic and causes many problems to the craftsman and users of the bamboo product preserved with such chemicals therefore suggested that research into other alternative organic preservatives which will be easily accessible and available, human and environmentally friendly.

Therefore, there is the need to research into plant extracts that has the potentials of preserving *Bambusa vulgaris* in the Ghanaian bamboo industry, which is readily available

and accessible and does not pose any threat to the craftsmen, his customers and the entire environment.

1.4 The Purpose of the Study

The purpose of this study is to experiment with the potential of extracts from neem leaves (*Azidirachta indica*) for the preservation of *Bambusa vulgaris* in Ghana.

1.5 Objective of the Research

The researcher set the following objectives to guide him arrives at an appreciable conclusion on the project;

1. To identify and study the traditional methods of bamboo preservation.
2. To identify the active ingredient in neem plant as potential material for bamboo preservation.
3. To apply and test the efficacy of neem leave extract as preservative on *Bambusa valgaris.*

1.6 Importance of the Study

This research work will provide alternative organic means of preserving bamboo, which is easily processed, accessible, and less costly to the craftsman in the bamboo industry.

Again, the research work will limit the use of inorganic, imported, expensive and toxic chemicals, which are harmful to the user and the environment as a whole. Furthermore, it will also provide simple step-by-step procedure in acquiring the preservative from the neem plant for the preservation of *Bambusa vulgaris*.

In furtherance to this, when craftsmen in the bamboo industry use locally available alternative material, which is less costly, easily accessible and it involves simple procedures in getting the preservative, it will boost the production of bamboo works in the local industry which will results in more money to the craftsmen since they are assured of injecting small money into production.

Again, bamboo producer's and buyer's safety, together with the environment will be protected.

Lastly, this research work will provide vital information on using extracts from plants and other traditional methods for the preservation of bamboo and serve as a reference material for bamboo craftsmen, students, researchers, lecturers and other people in the bamboo industry.

1.7 Research Questions

- What are some of the traditional methods of preservation of bamboo?
- What is the active insecticidal or fungicidal ingredient in neem plant that has the potentials of preserving of bamboo?
- How can the neem leave extract be applied and its efficacy tested on *Bambusa vulgaris?*

1.8 The Scope

The assessment and execution of this research was not laboratory based but detailed desktop studying, physical observation and interviewing of professionals in the bamboo industry.

Again, *Bambusa vulgaris* was the specie of bamboo used for the research work, obtained from KNUST in Kumasi, Ghana.

Lastly, neem leaves were the main active material used for the research, which was obtained from KNUST in Kumasi, Ghana.

1.9 Delimitation

The study is limited to the use of extracts from neem leaves for the preservation of lathed and carved bamboo (*Bambusa Vulgaris*).

1.10 Definition of Terms

Preservation: Protecting bamboo or bamboo works from pests, borers and termites that would cause its current quality or condition to deteriorate.

Biological control: it is the process of minimizing termite, pest, fungi and borers that attack the bamboo plants with the use of other microorganisms.

Preservative: it is the extract from neem leave that has the ability to protect bamboo from harm, decay or spoilage.

Potency: the strength of neem leaves extract that is effective and strong to achieve the required results in the preservation of bamboo.

Efficacious: the power or ability of the preservative to produce desired results.

Hazard: toxic chemicals that are potentially very dangerous or giving unwanted outcome to human being and the environment.

Toxic: chemicals containing a poisonous element that can cause serious harm or death to the user of such chemical.

Pounding: to beat neem leave into a pulp or powder with repeated heavy blows in a mortar

Durability: ability of the bamboo product to last for a longer period without damage or attack.

Herbs: medicinal plant from the neem plant that does not produce woody stems.

Filter: porous material used for straining pounded neem leaves.

Craftsman: the one who makes decorative or practical objects skillfully by hand with bamboo.

Medicinal: neem leave extract having the properties to treat illness or capable of treating illness

Prehistoric: relating to the period before history was first recorded in a written document.

Enzyme: composite substance formed by living cell which is a bio-chemical catalyst

Catalyst: a matter which can increase the rate at every chemical reaction without altering its original form or shape

Leach: to remove soluble components from a solid mixture by the use of a solvent

Microorganism: a tiny organism like pests, fungi, virus, bacterium or protozoan that can be seen under a microscope

Termite: a light-colored social insect that forms large colonies that live in warm or tropical region, feed on bamboo materials and are highly destructive to trees and bamboo substances.

Laminate: to put together pieces of bamboo to create a long lasting object

Sliver: a thin piece of bamboo that has been split, cut or broken off

Culm: the jointed hollow stem of a bamboo or similar plant

Infest: to live or cover the surface or inside of the bamboo culm.

Gummy substance: a sticky thick solution, that flows slowly in a fresh bamboo that makes it easy to be attacked.

1.11 Organization of the Rest of the Text

Chapter one talks about the introduction of the whole report. This describes the problem and its setting, and the objectives. The rest are limitations, delimitation, and importance of the study, definitions of terms and arrangement of the text.

Chapter two reviews the related literature. It consists of the review of methods of bamboo preservation in some selected cultures.

Chapter three also deals with the methodology employed for the project. These include sampling techniques applied in data collection from the field and the general procedures in the execution of the project.

Chapter four discusses the results and findings of the study and the final chapter talks about summary, conclusions, and recommendations and followed by list of references.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

2.1 Overview

The preservation of bamboo has been on topical area of research. Different views and methods have been documented in the literature reviewed in this chapter. Bamboo is an outstanding material for innumerable applications ranging from handicrafts and utility items to industrial products and structural components of bridges and buildings. With such extensive applicability, it offers incredible source of revenue potential for rural and urban communities and business opportunities for industry. Although the advantages of bamboo are well known, its wider exploitation is disadvantaged by its receptiveness to natural degradation, like weakening of wood. Deterioration of bamboo can be disallowed from beginning to end through appropriate and safe treatments during storage, processing and use. Although such practices have been in use for some time, relevant information on the various preservation procedures is not adequately available.

From compiled notes on bamboo, Baah (2001 p1) said that "there is hardly any rival to bamboo in the plant kingdom" According to him, from ancient times, bamboo has been linked to human livelihood, fulfilling needs for furniture, entertainment, housing and food in some cultures.

Addai (2003 p.5) confirms the fact that "Bamboo is a grown grass belonging to the family called *Grannae* and occurs in two main ecological forms -monopodial and sympodial Bamboo". He further stated that they grow in the temperate climate and in the subtropics and tropics.

From the report published by the International Network for Bamboo and Rattan (INBAR) (1998), it was stated that, compared with other woody plants, bamboo is a fast growing plant. It was reiterated that it takes between forty to sixty days for bamboo to reach a maximum height. Examples of some giant bamboo was stated to have reached a height of thirty to thirty-six meters and could survive all kinds of conditions.

2.2 Species of Some Bamboo around the World

According to the International Network for Bamboo and Rattan (1998: P.3) about 1300 species of bamboo have been identified worldwide. These include, *Bambusa atra, Bambusa bambos, Bambusa vulgaris, Bambusa balcooa, Bambusa multiplex, Bambusa bambos, Bambusa blumeana, Bambusa burmanica, Bambusa amahussana Bambusa forbesii, Bambusa heterostachya, Bambusa polymorpha, Bambusa vulgaris var vita, Bambusa tuldoides and Bambusa tulda.*

Other species are the *Cephalostachyum, Dendrocalamus, Dinochloa, Gingantochloa, Kinabuluchloa, Melacalamus, Melocanna, Nastus, Neohouzeaua, Phyllostachys,*

2.3 Ghanaian Bamboo Species

The local species of bamboo in Ghana as indicated by Baah (2001) numbered seven. They include; *Bambusa pervariabilis, Bambusa vulgaris, Dendrocalamus strictus, Bambusa arundinacea, Bambusa multiplex, Bambusa bambos* and *Bambusa var vitata.* In the midst of these, *Bambusa vulgaris* is native to Ghanaian environment.

Plate 2.1: *Bambusa vulgaris var vitatta*
(Source: Researcher's Field Work)

Bambusa vulgaris is extensive in Ghana and can be easily propagated or cultivated. A study conducted on this particular bamboo shows a very low opposition to biological corrupting agents or pests and fungi. Although like all other bamboo varieties *Bambusa vulgaris* has within its structure starch, wax, gum and lignin which gives strength to the material, the presence of sugar makes the material defenceless, since the sugar content is on the elevated side making the bamboo sweet and attractive to pest. This particular bamboo is yellow in colour with longitudinal green stripes running from node to node. It is very light in mass. It is found around the compounds of most organization as part of ornamental plants grown to improve the aesthetic appearance of their surroundings.

Plate 2.2: *Bambusa bambos*
(Source: Researcher's Field Work)

Bambusa bambos or *Bambusa arundinacea* is an accepted one of the bamboos that have some level of opposition to pest attack. Studies conducted on this material show its ability to grow straight and are preferred by most craftsmen for the making of artefacts. Compared to vulgaris this variety does well under proper management. *Bambusa bambos* are found around water bodies and are very good material for construction. Its sugar content is very low. Because of its comparatively bigger size, it allows for processing and lamination into boards for panelling and joinery.

Plate 2.3: *Bambusa vulgaris*
(Source: Researcher's Field Work)

2.4 Traditional Uses of Bamboo in Ghana

According to Baah (2001), because of bamboo seemingly short life range, bamboo is, customarily, and normally utilized in production of products that are less durable.

Bamboo culms, split or entire culm, make it easier to build fence wall protection, kitchens and bathrooms in rural settlement and lower income communities. Bamboo culms have been split into pieces that are used to roof house and could last for a span of more than two years. Parts and the entire bamboo culms are used to make benches in public places and mostly under shades for relaxation. Painstaking work, for example, spatulas, wooden spoons and other kitchen wares are produced using the split bamboo culms. Most of these

products do not last, because the preservative treatment given is not adequate or not preserved at all.

The ribs of huge, imperial (royal) umbrellas are produced using parts of the full-grown culms. Steiner (2001) clarified that on most farms, bamboo is utilized to reinforce plantains, as climbing streak for yam vines, as tool handles, as beams for roofing farm hurts, storage barns and as defensive fencing material around farms and homes against pest and animals that may destroy farm crops.

Steiner (2016) in a communication, fish farmers on Lake Volta likewise utilizes it to trap fish. In one strategy, bit of bamboo are woven into a trap-net into which the fishes are baited or trapped. In another technique, bits of culms with the nodes in place toward one side and the flip side open are suspended under the water to give false haven to the fishes. The fishes swim into the culms however can't swim in reverse out of them. Canoe workers additionally use the long, thin posts to push canoe (kayaks) over shallow waters or rivers.

Flutes are produced using the little culms of around 25 mm diameter. The famous Ghanaian performer, the late Dr. Ephraim Amu is outstanding for his bamboo flute display. Culms are sliced to different sizes and the stomachs are expelled. These are beaten softly against a level stone surface to create an assortment of musical sounds

2.5 Non-Traditional Uses

Steiner (2016) in a personal interview opined that, in recent years in the building and construction industry, wawa poles that were once used as props for scaffolding and for casting concrete flooring have become scarce and expensive and have been replaced with bamboo culms.

In the craft industry whole and split culms are carved into various decorative items. In the furniture industry bamboo culms are complemented with timber wood for the manufacture of furniture. In more recent years the technique of splitting the culms of Bambusa vulgaris into slivers for various uses is becoming a novel practice.

Bamboo slivers are being used to weave baskets and basketry-related products. Splits and slivers are bonded together by means of glue to form laminated ply bamboo that can be used for most purposes for which timber wood is required.

2.6 Traditional Methods of Preservation of Bamboo

Traditional methods are ways that indigenous people have developed over the years in giving preservative treatment to their local bamboo for use in housing, fencing and other forms of construction.

Addai (2003) said at Apeadu Kokobin in the Asukwa East district of Ashanti, bamboo for housing is cut fresh and buried in swamps of water for at least three days, they are then carried home and kept in the kitchen as over ceiling for smoking and drying. This makes the bamboo unattractive to pest. Steiner (2016) in a personal communication noted that, at Binsri in the Adansi West District, before bamboo is used to construct any structure, special concoctions are prepared from selected leaves. The concoctions Steiner (2016) explained are used to paint the ends of the bamboo that will be buried in the earth or make contact with the earth. He further opined that the earth surrounding the bamboo is mixed with a residue of the concoctions. This is done to keep pests from approaching the bamboo benches constructed in their compounds. The name of the leaves, he said were not disclosed He said that the leaves were poisonous and no animal fed on them. The dried

form of these leaves is burnt in pots to expel mosquitoes and other crawling insets found in homes.

Addai (2003), again observed that, at most pottery producing and sales points like Nfensi, a pottery village on the Kumasi, Sunyani road, a potter who displays his wares on a table constructed with bamboo, said that he used dirty engine oil to paint the bamboo and also mixed the surrounding earth with dirty engine oil and kerosene before fixing the bamboo in the ground. He further stated that when DDT (dichlorodiphenyltrichloroethane) is added to the engine oil before using it on the bamboo, the bamboo stays for a very long time especially when used for roofing. He further explained that raffia fronds are fibrous and can be impregnated with D.D.T. quite easily, so when used in combination with bamboo, the bamboo is protected from pest infestation.

Generally, bamboo is said to have a normal life span of one to three years. Jayantti and Follete (1998) assert that non-chemical treatment of bamboo preservation also called conventional treatments are broadly utilized by countryside's and may be attempted devoid of the operations of any unique, advanced or sophisticated machine.

Traditional methods used differ from place to place, but all aim at giving preservative treatment to the bamboo. Gnanaharan and Mosteiro (1997) contend that in Japan, one of the traditional methods used includes extraction of sticky substances and decrease in the starch substance of the bamboo. They contended that the motivation behind expelling the sticky substances is to accomplish even colour, while the expulsion of the starch decrease later attacks by fungi and microorganism.

In the extraction of the gummy substances from the bamboo, Gnanaharan and Mosteiro explained that the Japanese use the wet and dry methods. In the desiccated method or process, green bamboo is uniformly heated at 120 degrees Celsius. These, they said, causes the gummy substances and water to emerge on the surface and they are wiped off with a dry cloth. In the wet process, the bamboo is kept immersed in boiling water within one and two hours, and the surface wiped with dry cloth.

In India, Gnanaharan and Mosteiro (1997) asserted that, the method widely practiced is the immersion of the bamboo in water for a period of 90 days.

2.7 Chemical Treatment Methods of Bamboo

Compared with the traditional methods for preservation, the application of chemicals for the preservative treatment of bamboo and other woody materials are more efficient in giving fortification in opposition to biological preservative treatments. Nonetheless, chemical preservatives are perpetually toxic and extreme concern must be taken when using and disposing of chemicals.

The following chemical treatment methods are described by Jayanetti and Follette, (1998):

a. Butt treatment
b. Glue- lime treatment
c. Pressure treatment
d. Boucherie method
e. Modified Boucherie method
f. Open tank method for cold soaking
g. Hot and cold bath process

2.7.1 Butt Treatment

Jayanetti and Follette (1998) explained that the butt ends of newly harvested bamboo culms with branches and leaves unbroken are placed in preservatives in container. This process although slow is used for the treatment of short culms. The bamboo culms that are prepared are submerged in a solution of water-soluble preservatives and it is left for some days. This allows for transfer of chemical preservatives into the structure of the culms. The preservative in the drum is refilled regularly in order to maintain the desired strength.

2.7.2 Glue- Lime Treatment

Addai (2003) agreed with Jayanetti and Follette (1998) in stating that the glue- lime preservation is specific to the manufacture of bamboo board and involves the addition of sizeable amount preservatives to the glue within the period of manufacturing.

2.7.3 Boucherie Method

Addai (2003) emphasized that, with the boucherie technique of treatment, it requires the bamboo culms to be in the fresh green state. The water transporting part of the bamboo culm is penetrated entirely with preservative fed in by the magnitude of container placed at a higher level than the bamboo culm through pipes into its base end. Bamboo culms are fixed firmly to tubes by rubber covering and clamped. This is more appropriate for younger culms with high moisture content.

According to Bindish, Muther, and Ratra (1998) the modified Boucherie method involves the introduction of a pneumatic force pump over the preservative fluid within a tank by the

support of pumped air. Addai (2003) further asserts that it is feasible in the direction of treating bamboo with mixture of preservatives in addition to fire retardant substance.

2.7.4 Hot and Cold Bath Process

Addai (2003) contended that in this method the bamboo culm is submerge in a tank with preservatives, which is then with intense heat directed on the bamboo, with the support of steel coils in a boiler. The temperature is then regulated to about 80-100 degrees Celsius, left in that temperature for within 35-45 minutes and permitted to reach its coolness.

2.7.5 Open Tank Method

The open tank treatment method is economical, simple and provides good effective protection for the bamboo. Jayanetti and Follette (1998) indicated that bamboo culms which have been primed to a normal dimension, are soaked in a water soluble preservation within a period of 3-5 days. The preservation solution penetrates the bamboo culm from end to end and other sides by process of diffusion. Penetration of preservatives is better in immature bamboo culms; these can be twisted and folded for the production of bag handles and other artifacts.

Ubidia (2002) confirmed the practices of the indigenous people of Latin America in the preservation of bamboo. Ubidia said from her personal experience, in the period when the moon appears to be in a semi-circular form, some of the cavities in the nodes and internodes in the bamboo culm seem to lose more water. She also confirmed that within this period, the bamboo culms turn to lessen in its water content which makes it shrink and become less attractive to pest or any microorganism to attack them that will cause decay.

Ubadia said, in Columbia the preservation of bamboo is done in the bamboo plantations or forest, in the following manner:

1. The bamboo is harvested in advance
2. The bamboo is cut on the first knot without cavities.
3. It is left at the place of cutting on the tree stump of its base, on a stone or on a brick as vertical as possible leaning on or supported by the neighboring bamboos their branches and leaves on for two to three weeks.
4. The bamboo is placed horizontally and the branches and leaves cut off.

Ubidia argued that, bamboos preserved this way have a characteristic colour and a strong smell of alcohol.

According to Lipangile and Mandemla (2001) without preservation bamboo is a useless material. They said *Bambusa vulgaris* is prone to rapid decay because it constitutes large amounts of sugar and starch, which attracts attack by termites, fungi rot and post powder beetle. Lipangile and Mandemla (2001) said that, there are several known preservation techniques, which are applicable, depending on the types of bamboo to be treated, climatic conditions and nature of decaying organisms. They affirmed that, the principal bamboo decaying organisms in Ghana are termites, post powder beetles and fungi rot. For this, the most effective proposed treatment of bamboo to be used is the chemical methods.

According to Ubidia (2002), in her investigations, she observed that direct heating of the bamboo and the drying process increases the molecular cohesion which improves the hardness of the bamboo as well as increases the resistance to attack by insects and microorganisms.

Preserving or treating bamboo with water or any liquid with much more concentrated alcohol content happens to be much efficient, except that it is applicable to smaller objects. Ubidia (2002) asserts that, the high content of alcohol in a liquid is a natural preservative that destroys fungus and microorganisms, and it prevents moths and other insects infesting the bamboo. According to Odei (2004) in possessing bamboo for the production of baskets, culms after splitting were steeped in water for three days. In certain instances, prepared strips were rather steeped in water.

The rationale for this water treatment was to leach out the sugar and the starch which render the bamboo susceptible to the attack of insects. Odei again confirmed that, another preservative treatment that should be done to avoid the use of toxic chemicals is salt treatment. Odei said, this is done by boiling strips and nodes of bamboo in water containing two tea spoonful of salt per a liter for thirty minutes. This treatment is carried out for strips to be used for making household items such as fruit baskets, napkin rings, etc. In this, salt is used instead of toxic preservatives, because the items to be made are food related.

In the treatment of bamboo, Odei (2004) insisted that it is better to first remove the epidermal layer to allow easy penetration of preservatives. She further stressed the removal of the inner lumen because that is the part of the bamboo that the insects and borers attack. Bamboo preservation is so essential since the natural durability of the bamboo cannot be relied on. From the information gathered from the various authors, it is evident that, the service life of the bamboo can be improved upon by either the traditional methods of preserving bamboo, or by the chemical preservative treatment described by Jayanetti and Follette, or the combination of the two.

2.8 Preservatives

Preservative is a constituent of an organic substance, which is added to edibles, for example, nourishment, drinks, medications, organic specimens, makeup, paints, wood, and numerous items to anticipate deterioration by irresistible development or by undesirable natural changes. Generally, she observed that preservation is done in two main methods, chemical and physical (Nutrition Department Manual, 2016).

Chemical treatment she said involves adding chemical compounds to products. Physical preservation also involves procedures, for example, refrigeration or drying. Preserving food reduces the danger of food borne diseases, reduce microbial decay, and protect hygienic attributes as well as nutritious feature. Some considerable methods of preservation treatments incorporate lack of moisture, refrigeration and freeze-drying. Chemical substances as well as physical preservation methods can combine.

In the field of plant technology, Steiner (2015) in a personal communication explained that materials like wood, weeds and grass are treated with compounds that prolong the life of the plant. These include salt; chemicals like borax and chloropryrofous based chemicals.
In another personal communication with Steiner (2016) he said to prevent degradation by bacteria Antimicrobial preservatives can be applied, this method he expounded is the most widely recognized customary and ancient way of protection equivalent to pickling and including honey to forestall microorganism development by adjusting the pH level. The most normally used antimicrobial additives are lactic corrosive nitrates and nitrites, he concluded. The precise methods of these chemical compound ranges on or after restraining development of the microscopic organisms to the reserve of particular enzymes.

2.9 History of Preservatives

According to Professor Matilda Steiner (2016) in an interview said preservatives have been used since prehistoric times. In ancient Egypt preservatives were used to embalm dead bodies of kings and important royals. Smoked red meats for instance have phenols, also different chemicals substances that impede waste. Protection of nourishments (food) and materials has developed extraordinarily for some years and has been dynamic within the enhancing food and material security. Uses of preservative other than the normal paints, normal traditional oils, and salts and so forth within food and on materials started in nineteenth century, however it was not across board until twentieth century.

However, the use of food preservative incredibly relies on the nation. Various developing nations that do not have strong government laws to manage groceries additives confront both hazardous levels of preservatives in food and complete prevention of foods that are viewed as not natural. Nations like Egypt and the Roman Empire have likewise demonstrated in case studies chemicals and organic additives.

Plate 2.4: Neem Tree Used as Wind Break and to Create Shade
(Source: Researcher's Field Work)

2.10 The Concept of Neem Tree as Valuable Plant

The neem plant (*Azadirachta indica*) happens to be a tropical evergreen plant, which originated from India and is additionally located within other Asian countries.

According to Horsbrugh (2006), within India, neem plant is known as "the village pharmacy" owing to its therapeutic adaptability, furthermore it has been employed as a part of Ayurvedic pharmaceutical for over 3,000 years because of its therapeutic attributes. Again neem is called "arista" in Sanskrit a word that signifies 'unblemished, wonderful and everlasting'. The plants leave, seeds and bark contain compounds which demonstrated to be effective for antipyretic, antiviral, antifungal, antiseptic anti-inflammatory as well as anti-ulcer use. The Sanskrit named the plant "nimba" originated from the expression 'nimbati syasthyamdadati' which imply 'to provide great wellbeing'.

2.10.1 Neem Twig

Burnell (1996) and affirmed by Dr. Steiner in a discussion that, the twigs of neem tree are also used as toothbrushes in India and Africa specifically Ghana. At the present time toothpastes which have neem extracts are considered highly well for the human teeth and are also accessible commercially.

2.10.2 The Neem Plant Extracts (Leaves and Seeds)

The neem (leaves and seeds) extracts noticed to contain spermicidal and along these lines research is being conducted scientifically to develop contraceptives scientifically. The neem plant produces anti-inflammatory, hurt easing, fever reducing compounds that can help in the mending cuts, smolders, ear infections, sprains and cerebral pains, and in addition fevers (Gupta, 2000).

2.10.3 Neem Bark and Root

Randhawa and Parmar (1996) asserted that, the neem plant bark and roots additionally have therapeutic properties. Bark and roots in powdered state are likewise used to control insects and ticks on favorite animals in the homes. Neem tree has anti- bacterial properties that assist in battling against skin diseases, for example, skin inflammation, psoriasis, scabies, dermatitis, and others. Neem extracts again helps in treating diabetes, AIDS, cancer, coronary illness, herpes, hypersensitivities, ulcers, hepatitis and a several other ailments.

The recent documentation by Gupta (2000) on neem plants said the leaves, fruits, seeds, oil, roots and bark are noted for their profitable restorative values. Those advantages were recorded in an old document called 'Carak-Samhita' along with 'Susruta-Samhita', these books were establishment on the Indian system of ordinary treatment of ailments, Ayurveda. Neem plant is having garlic-like scent, and also a sharp taste. Most parts of neem tree have numerous utilizations, which appropriately gives neem its name in Sanskrit-"sarva roga nivarini", signifying 'the healer of all diseases'. Most essential documents recorded exploit the services of different parts of plant, which include;

2.10.4 Neem Oil

According to Shettepa et al, (2010), the neem oil is obtained from the seeds of the neem plant and has insecticidal and restorative properties owing to this it has been utilized for treating various ailments for a number of years as pest control, beautifying agents, pharmaceuticals, and others.

2.10.5 Neem Seedcake

Again, Gupta (2000) opines that, the neem seedcake (residue of neem seeds after oil extraction) is utilized for soil reconsideration, which gives the soil natural matter as well as bringing down its nitrogen losses by a process called nitrification. Again it works effectively as nematicide.

The neem oil and other neem extracts are used to manufacture health and beauty care products. Some of such products are soaps, bath powders, shampoos, lotions and creams,

toothpastes, neem leaf capsules to increase immunity and as a skin purifier, insect repellents, pet care products, etc.

Neem extracts have been approved by the U.S. Environmental Protection Agency for use on food crops. It has been proven in various researches that neem is non-toxic and beneficial insects, birds or humans and protects food crop from more than 150 costly pests. The neem plant is a fast growing tree that more often than not achieves a structural height of about 10-30 meters high, and in an exceptionally great condition can grow up to approximately 45-50 meters. Generally speaking, it is an evergreen tree; however, under bad conditions, for example, expanded arid periods, it may shed a large portion of its foliage. The branches spread broadly. Genuinely, thick crown is roundish or oval and may achieve a breadth 13-25 meters in old standing varieties.

The storage compartment is moderately short, straight and may achieve girth of about 1.5-3.5 meters. The bark is hard fissured or textured and whitish-gray to brownish-red. The sapwood is grayish-white and the heart wood reddish.

Root structure of neem tree involves a strong taproot and all around made flat roots. Side surface of the roots may achieve more than 17 meters long. Vesicular-Arbuscular Mycorrhiza (VAM) is associated with the rootlets masterminded neem as a significantly VAM dependent plant species.

2.11 The Neem Leave

Ganguli, (2002) opines that, the leaves are pinnate and unpaired 25-35 centimeters long and the medium to darker green leaves, which number up to about 20-30 are around 4-9 centimeters long. The terminal leaves are mostly absent. The petioles are short; the young

leaves are reddish to purplish in colour. The shape of the matured leaflets is mostly asymmetric and the margins are dentate with exception of the base of the basiscopal half, which is strongly reduced and wedge-shaped. The state of grown leaves is pretty much kilter.

Normal hybrid involving *Azadirachta indica* and *Azadirachta siamensis*, originate from Thailand around where several kinds mature collectively, they have in-between spot, about the form and uniformity of the leaves.

2.12 Compounds in Neem Plant

According to Ganguli (2002) and confirmed by Cloyd (2015) asserted that, the neem seed, leave, bark and root contain a complex secondary metabolite azadirachtin. People in the scientific field believe that there are more compounds yet to be identified and documented in the neem. Those compounds may include; calcium, phosphorus, iron, thiamine, nicocin, vitamins, chloriphyle, and many more.

Other compounds found in neem plant are classified according to Cloyd (2015) as;

- Azadirachtin – insect repellent, anti-feedant, anti-hormonal, insect growth regulator.
- Salanin – insect repellent
- Gedunin – vasodilator, anti-malaria and anti-fungal.
- Ninbidol – anti- tubercular, anti- protozoan, anti-pyretic.
- Sodium nimbinate – diuretic, spermicide, anti-arthritic.
- Nimbin – anti-pyretic, anti-histamine, anti-fungal, anti-inflammatory.
- Quercetin – anti-protozoal.

- Nimbidin – anti-bacterial, anti-ulcer, analgesic, anti-arrhythmic, anti-fungal.

2.13 Scientific Classification of Neem

Cloyd (2015) stated that, the neem plant has been classified scientifically as;

Family – Meliceae

Species – A. indica

Genus – Azadirachta

Kingdom – Plantae

Order – Sapindales

Division – Magnoliaphyta

Binomial name – Azadirachta indica

2.14 Geographical Location of Neem

According to Horsbrugh (2006), Neem tree is a local plant of Asian continent mostly around the Indian sub-continent, which generally or fairly spread across, in a general sense in the dry tropics and sub-tropical, Americas, Africa, South Pacific islands and Australia. Around the Indian area it is found in various cities. Within Myanmar the plant is mostly found and extremely normal in the middle region of the state

Around South Pacific area the neem plant can be found around Fiji Island. In Australia the plant was at first presented around 50-65 years back. Also at Indonesia, the neem tree can be found generally around low lying eastern and on the northern part of Java and around the Frier Islands along the East Bali, Sumbawa and Lombok. Again around Philippines it was found around seventies as well as eighties century. Moreover, in the Republic of

China, the neem plant was cultivated on the sub-tropical Island of Hainan and Southern China. Within Nepal the neem plants were sighted in the Southern, low lying zones in Tarai local. For Sri Lanka the plants were boundless around the Northern Island.

Also in Iran, the neem plants develop beside the coast through to Chat el Arab located at Iraq, around the Arabian Peninsula. In Qatar and Abu Dhabi the neem tree was cultivated in water system utilizing desalted sea water beside roads and along parks. Sizeable neem farms were planted along Arafat fields near Makkah in other to give shady and resting place to Muslims who travel to Makkah.

An unavoidable utilization of synthetics in our everyday life be it agriculture, clothing, conservation or medicinal services is currently clearing way to like or develop a taste for ecological goods. Most cities, universally, are now a days tend to have strong conviction and depend much on forest innovation apart from any other time while the appearance of current scientific knowledge. period within which the reliance on manufactured substance form chemicals within the early stages and middle twentieth century compelled union on more up to date chemicals as a panacea for all maladies and diseases. The traditionalist state of mind of a few communities, who relied upon raw or natural goods with reference to manufactured or artificial ones, were regularly attributed to backwardness.

Plate 2.5: Neem and the Environment
(Source: Researcher's Field Work)

(Govt. of India, 1996) stated, blissfully, modern communities now a days find themselves bamboozled in the web they have created willingly to regress to natural ways of remedying situation.

For it is in line with these that the neem plant has aligned rebound and guarantees to seize the focal point of the state in the impending years.

Shettepa et al (2010), the neem plant is greatly gainful to redeem the earth of any contamination; since its in-florescence is purifying with its fluffy peaks hurling fifty feet into the sky, the neem plant is a veritable plant "Kalpataru" for providing healthy environment or surroundings. As compared to other plants, neem exhale oxygen and keeps its oxygen level adjusted in the air.

Similar to other trees, the neem plant provides other ecological advantages, for example, it controls flooding, minimizes the rate at which the soil erodes and helps with the reduction of salivation. The neem prevents ecological crises in most Asian countries especially India and various tropical countries as it is effectively utilized to support restoration of the corrupted environment and mistreated terrains.

The neem plant is profoundly prescribed to support the reforestation of the semi-parched areas in Asian Regions, Sub-Saharan District and Central America. The plant is to a greater extent valuable in municipal forestry as it is having momentous capacity to resist atmospheric and water contamination and in addition high temperature. The tree also helps in reestablishing as well as keeping top soil's richness which will help making agro-forestry reasonable and profitable.

The neem plant is a natural assert of keeping the environment safe and clean. For most towns, urban communities and also in farms, the plant is helpful and serves as windbreak, source of shade. As a result of the plant's numerous benefits, it is now a normal practice in most countryside in India to at least have a neem tree planted within the compound or outside of the houses. The plant is additionally viewed as one of the important forest products within India and the neighboring states.

According to Govt. of India (1996), the magical plant has powerful insect control and restorative attributes. Most importantly, substances produced to control pests using the plant's extracts are more secured comparing it with other synthetic pests control substances. The reactions to the use of synthetic pesticides are frequently worrisome. It causes ecological problems and is extremely dangerous to individual life. Because of these

results, there have been extreme quests to secure more or produce pesticides that are eco-friendly.

Pests controlling substances produced by using neem extracts are very good because they are products from natural source. Its products are biodegradable and non-hazardous because it does not create any ill-effect to people and other creatures; it has no lingering impact on horticulture for this reason neem is carefully considered as the best alternative to dangerous pesticides.

Through the push for feasible horticulture as well as natural cultivating, utilization of plant based-products as pesticides has procured more significance. The neem plant is an exceptionally reasonable possibility for environment-accommodating, safe horticulture advancement. Cloyd (2015) asserted that, Azadirachtin can be utilized as a part of farming and general wellbeing because of its eco-friendly nature. Utilization of neem extracts for plant protection will decrease the attention on hazardous pest controlling substances and in this way help promote better farming practices and contributing our quota in protecting the environment since synthetic pesticides are major source of health related issues or problems. With the use of bio-pesticides, farmers will avoid health risks which frequently occur both in the developed and developing nations.

2.15 Natural Services Neem Provides

The neem tree among Indian societies has been positioned higher to 'Kalpavriksha' which is a fanciful and wish-satisfying tree. To 'Sharh-e-Mufridat Al-Qanoon, the neem tree has been named 'Shajar-e-Mubarak', meaning ‘the favored plant or the blessed tree', as a result

of its exceedingly gainful properties. Although investigative studies are needed, neem is presumed to filter air and nature of poisonous components (Gupta, 2000).

According to Department of Land Resource Management in document (2015), in the midst of hot summer in northern parts of Indian sub-continents, the temperature condition under the neem tree is about 10° C not exactly as the surrounding temperature; about 5 air-condition systems working together may work productively and economically as a fully developed or grown neem. Reclamation of polluted soils as well as its extreme utilization of such wastelands would be recovered through neem since it has another quality or benefits as an ecological panacea. Around 10 years prior, about 45,000 neem plants were cultivated on more than 15 kms on the areas of Arafat toprovide canopy to pilgrims during hajj. Neem plantation has noticeably affected the zone's micro climate, micro flora, sand soil and micro fauna properties, and when fully developed would give canopy to about 3 million pilgrims or travelers (Ahmed, 1995). It has become an old conviction that neem tree growing inside the house can keep the encompassing air clean of contamination and along these control ecological contamination. Likewise, hanging neem twigs on the entryway of a house is said to offer protection against contamination and infection.

The neem tree is not just lovely to take a glance at, giving greatness and quietness, additionally it serves as a refuge to numerous gainful living beings, bats, feathered creatures, honey bees, arachnids, and so on. Honeycombs built up on top of the neem tree are uniquely liberated from the galleria wax moth invasion. Various types of flying creatures and natural product eating birds and bats manage to survive on the sugary juicy fruit for ready food, while certain rodents specifically eat the seed, affirming the plant's wellbeing to warm-blooded creatures. Horsbrugh, (2006), the debris of falling leaves

enriches soil fertility and the organic content on the soil. Just little has been shown about the mycorrhizal relationship amongst neem tree, bacterial and parasitic endophytes, yet the neem tree is by all accounts a living microcosm.

The lasting and evergreen neem tree can survive for about 100 to 300 years, if not felled. Indeed, some preservationist appraisal of the 'ecological service of the plant' accounted for US $ 12 every month, which would give an astounding estimation of US $ 28,000 to 38,000 to its life span. Other monetary employments of neem and the advantages inferred, for example, honey biomass generation, timber and seed are substantial and irrefutable.

2.16 Forestation of Neem and Agro-Forestry Service

The neem tree is an exceptionally significant agro-forestry species in Africa, Australia, Asia and it is also getting to be well known in humid parts of America and parts of the Middle-East. As solid, adaptable tree and multitask able tree, it's best for reforestation courses and also meant for restoring debased, dry as well as semiarid lands. In the period of an extreme dry season around Tamil and Nadu (1999), observed that neem tree became luxurious, whilst some plants dried off.

Plate 2.6: Neem in Reforestation
(Source: Gupta, 2000)

The neem plant is helpful as windbreaks and in the various regions where we have low precipitation as well as high wind speeds. According to (Benge, 1989) around the area of Majjia Valley within Niger, more than 600 kilometers as wind breaks contained twofold columns of neems which have been grown to give protections to millets of about 30% expansion in areas of small piece of grains. Again the neem tree serving as wind breaks on small scale farms have additionally been planted beside sisal cultivated area in the coastal towns of Kenya. Larger scale neem tree plantations have also been commenced around Kwimbas Afforestation System in Tanzania.

Along the country stretch starting from Somalia towards Mauritiania, the neem trees have been planted to stop the Sahara Desert from expanding. Again, as neem trees are favored tree planted along roadside, within business sectors as well as close residences in view of

the shade it gives. Be that as it may, the plants are specifically been planted within blended places. They were not accidental event when Emperor Ashoka, a powerful leader of prehistoric India, during the third century BC, ordered his people to plant the neem tree down ceremonial as well as superhighway and streets alongside different perennials plants such as Tamarind, Madhuca longifolia var. latifolia Tamarindus indica and others.

The neem tree has all the great properties intended for other societal forestry plans. The neem plant is a brilliant plant species designed for silvipastoral schemes including creation forage and vegetables. Be that as it may, as indicated in some reports from (Radwanski and Wickens 1981) the neem cannot be cultivated in the midst of agrarian yields because of its forceful propensity. Others are of the view that the plant can be grown in the mix of organic products, for example, cassava, cotton, sesame, hemp, sesame, peanuts, sorghum, bean and so on, especially when the neem tree is still in the maturing state. The plant may also be cut to ease shades in addition to give grub and to give mulch too. Recently, tissue culture and biotechnology ought to create a conceivable atmosphere in other to choose neem phenol type with alluring tallness and form to be used in inter-cropping as well as different forestry methods. All the allopathic impacts of the neem tree on other crops, assuming such, should be examined.

2.17 Neem Biomass

Fully developed neem tree may yield between 20 to 150 tons dried out biomass, dependent on precipitation, location qualities, space, eco-type or its genotypes. In relation to the leaves comprises almost half of its biomass, the food and timber make up about one

quarter each. Enhanced organization of the neem tree can produce a harvest of approximately 13.6 cubic meter of superb strong wood (Ahmed, 1995).

The neem timber is very hard and moderately substantial and has religious connotation around some areas in India. The timber seasoned nicely, aside it's ending parts slitting. As long-lasting as well as termite resistance, the neem tree is exploited for fencing, beams for construction, furnishings and others. Presently there is developing business sectors in other parts of the Europe designed for light-shaded neem timber for the production of house furnishings (H. Schmutterer). Strong pole woods are particularly imperative in the advancing nations; the neem's capacity to sprout subsequent to felling and to re-grow, it is a safe haven in the wake of pollarding creating an exceedingly suited pole generation or manufacturing (National Research Council 1992). The neem plant develops quickly and is a high-quality source of fire wood and fuel, its charcoal has averagely high calorific significance.

2.18 Azadirachtin, Active Ingredients in Neem that Fight Termites, Fungi and Insects

According to Cloyd (2015), azadirachtin is the key or active insecticidal ingredient found in neem plant. Naturally occurring substance which belong to the organic molecules class known as tetrachortieterpenoids. It is also similar to insect hormones referred to as "ecdysones" in structure which control the process of metamorphosis as the insect moves from larvae to pupa and adult.

Azadirachtin function as an ecdysone blocker which prevent insect's molt that is breaking their life cycle. The residual insecticidal activities are noticeable in 7-10 days or longer depending on the rate or mode of application and the insects.

Cloyd (2015) opined that, the active ingredient in neem is used to control aphids, thrips, whiteflies, beetles, fungus gnats, caterpillar, mushroom flies, mealybugs, leafminers, gypsy moth and others on grains, greenhouse crops and ornamentals.

Azadirachtin being the active ingredient in the neem plant varies from 0.2 – 6.2 % although water extracts are effective as pesticides. Neem compounds are not highly soluble in water. It is one of the first active ingredient isolated from neem and has proved to be the plants main agent for battling insects. It appears to cause about 90% effectiveness in dealing with most pests. It does not kill insect immediately instead it repels and disrupt their growth and reproduction. Research for the past 20 years has shown that it is one of the most potent organic growth regulator and feeding deterrents ever gotten.

Frimpong (2017), also asserted in an interview that, the azidirachtin has not gotten what we call the knockdown effect but rather it repels and prevent them from feeding (molting). It deforms the insects' wings, legs and the parts that helps it to move or reproduce.

2.19 Mode of Application

Neem extracts can be applied in many ways; some refined ways for examples are spray, drenches or diluents in irrigation water. Again, they can be applied to plant through injection or topical application either as dust or spray. More so, they can be added to bait to attract insects and sometimes they are burned example neem leaves, seed and dry neem cake as ingredient in some mosquito coils (Nisbet, 2000).

2.20 Moisture Content of Bamboo

Baah (2001), stated that bamboos are normally attacked by insects and fungi when the tissues are having sufficient water content. At least it should be above fibre saturation point of about 20 – 22 %.

The moisture content maybe high in processed bamboo culms, this is because they may have been seasoned improperly or seasoned insufficiently. Water in-take in bamboo occurs through the ends with their metaxylem vessels and it is much lesser through the nodes. It is sometimes easier for the water content to rise through the inner culms. Because of this point the inner part of the culms are easily attacked than the outer part due to the nutritious parenchyma in the bamboo culm per its high moisture content.

2.21 Insects

They are the by far the largest hexapod invertebrate in the athropod phylum. The class Insecta, or insects, are the Arthropoda that have three pairs of legs, body which is divided into three regions (head, thorax, and abdomen), one pair of antennae and, usually, wings. Other Arthropoda classes have more than three pairs of legs and only one or two body regions, and they never have wings. Other common classes of Arthropoda are Crustacea (such as sowbugs, crayfish, crabs), Diplopoda (millipedes), Chilopoda (centipedes), and Arachnida (such as spiders, ticks, mites, scorpions).

2.22 Primary Pest

According to Xu Changtang (2003), bamboo products or culms are easily attacked by powder post beetles. They are mostly *Dinoderus celluris, Lyctus spp, Dinoderus brevis* and

Dinoderus minutus. They normally attack the fresh cut or felled bamboo culms due to its high presence of sugary content in the parenchyma. When the bamboo culm is subjected to traditional treatment method like soaking the culm in running water or muddy area, it reduces the starchy or sugary content and makes it susceptible to beetle and termite attack (Addai, 2003).

Liese (1997) opined that, when bamboo culms are allowed to stand straight or lean against a wall for some times, they mostly become brittle and biological work against termite and beetle attack.

2.23 Dinoderus minutus and Dinoderus spp

Adult *Dinaderus minutus* and *Dinaderus spp* only attack felled bamboo culms through its wounds, cut-ends and cracks and along the longitudinal tunnels in the bamboo culm and renders the portion which has been attacked form powdery substances on the surfaces. The powder comes from the holes created by the adult beetles. The amount of beetles present in the culm determines the number of holes that will be created on the bamboo rendering it useless (Xu Changtang, 2003).

Nair et al. (1983) indicated that beetle attack in storage yards is extremely unpredictable and the borer's occurrence is apparently not related to season, but to the quality of bamboo and how it is seasoned or preserved.

Again, Mathew and Nair (1990) also reported that most finished products of woody materials especially bamboo example flower vas, mats, curtain, baskets, desk organizers and other wall hanging are mostly destroyed by powder-post beetles *Dinoderus minutus*

and *Dinaderus minutus spp* but evidence on the extent of loss suffered is yet to be available.

2.24 Phytosanitary Control

Xu Changtan (2003), phytosanitary pests in other countries are easily transported from one country to another through the international trade of woody materials like bamboo. In many ports, these beetles are thoroughly checked and if any slight hint of this pest is found, the whole products are carefully scrutinized and treated with all the seriousness it deserves. The imported woody materials and the container are treated by the country's pest control unit using heating and fumigation.

2.25 Physical and Biological Control of Bamboo

After harvesting the bamboo culm, it is then subjected to physical and biological treatment to render it resistant to borers and fungi attack. The traditional and method is to immerse the culm into water or placed them in running water or soak them in muddy area, this method is suitable to reduce the starchy content in bamboo but according to Baah (2001), the treatment takes longer period and leave some black spots or the whole bamboo culm is blackened.

Heating the bamboo culm using fire, boiling it in water or exposing it to direct sunlight in hot season for a period can also kill bamboo borers and destroy their eggs, larvae, pupae and the adult beetles. (Yao Kang et al, 2000)

CHAPTER THREE

METHODOLOGY

3.1 Overview

This chapter talks about the various methods employed by the researcher in finding information for this project work. However, there are many research approaches in this chapter. These include qualitative research design, library research, population of the study, sampling and sample technique, research instrument, primary and secondary data, and data collection procedures. This chapter also deals with the activities and techniques employed in the execution of the project.

3.2 Research Design

There seem to be numerous research methods that could have been adopted for usage in this research work but the descriptive and experimental methods of the qualitative research paradigm were adopted to bring together data for the study. The descriptive research method and experimental methods were adopted based on a work done earlier by Steiner (2006). The descriptive method was used to describe the entire research and the experimental research method was used for formulating the processes of extracting the preservatives from plants for the preservative treatment of Sympodial bamboos. This also goes to conform to a similar design developed by Ahmed (2017) in the execution of a similar project.

3.3 Descriptive

The descriptive research according to (Glass and Hopkins, 2010) involves gathering of data that describe event, activities and arrange, tabulate, depict and describe the data collected.

Leedy (2005) opines that, descriptive research deals with the condition that demands the observation technique as primary means of gathering data and describe the techniques observed.

The descriptive research was chosen because the researcher describes the step-by-step procedure and techniques in the execution of the project. Some bamboo processing factories and local craftsmen were also visited to carefully observe the procedures in preserving the bamboo.

3.4 Experimental Research Design

The experimental research is a scientific and systematic inquiry or approach which seeks to investigate a relationship between variables where there is priority given to time and consistency. In experimental research, the investigator manipulates several independent variables to determine the effects on the dependent variables. There are basically three characteristics that describe experimental research; manipulation, controlled and observation. (Leedy and Ormond, 2005)

This project also moves in the same line to experiment the potential of the neem plant leave for the preservation of bamboo. The researcher was able to experiment the potentials of neem leave extract for the preservation of bamboo with time and consistency as stated

above which also provided systematic and logical method in answering questions related to this project.

3.5 Library Research

Libraries visited plays an important role in research, hence the libraries visited include;

1. Kwame Nkrumah University of Science and Technology Main Library
2. Faculty of Art Library- KNUST
3. The African Virtual University Library Center, KNUST
4. Virtual Libraries of Distance Learning On the Internet.
5. Research Commons - KNUST

3.6 Population of the Study

Population concept is fundamental to both descriptive and analytical research. For the purpose of this study the researcher considered population as group of persons having information on bamboo preservation. Within this context, senior officers of bamboo industries, plant operating staff of bamboo industries and bamboo craft workers, bamboo researchers or students, and bamboo teachers in some visual art teaching schools are considered to constitute a population.

The population was later sub-divided into three categories comprising:

(A) Senior officers of institutions and teachers of bamboo craft

(B) Technicians of Bamboo industries and research institutions.

(C) Artisans working in bamboo.

Table 1: Target Population

Category	**Number**
A	5
B	26
C	10
Total	**41**

The potential population for this research project was forty one (41respondents) made up of the senior officers in institutions or establishments, field technicians working in institutions and establishments and Artisans working in bamboo.

The criteria for the selection of population were as follows:

1. Only senior officers of institutions and teachers of bamboo art were selected.
2. He or she must be involved in the processing and preservation of bamboo in a factory, or research institution, with working experience of at least five years.
3. He or she should be a bamboo craftsman with at least five years of working experience.

Table 2: Accessible Population

CATEGORY	**NUMBER**
A (LAYER 1) Senior officers/ Teachers of bamboo craft	3
B (LAYER 2) Technicians of Bamboo industries and research institutions.	18
C (LAYER 3) Artisans working in bamboo.	8
TOTAL	**29**

3.7 Sampling Strategy

The Stratified Random sampling technique helped the researcher to sub divide the population into smaller homogeneous group so as to get more exact representation. It

reduced biases and allowed the researcher to generalize his finding to the entire population. This method was in this manner used to choose the sample of 29 (70%) of the whole population of 41. The researcher considered 70% of the target population as an adequate figure since the aggregate number of respondents in this project was forty one (41).

3.8 Justification of Sample Picked / Selected

Based upon the above information, the researcher considered a sample of 29 (70%) to be a representation of the total population of forty one (41). The twenty nine (29) became accessible population. In spite of the fact that this specimen constitutes a homogeneous population, every class is not the same as the other.

The significance of the above classification is that it would decide the legitimacy of information gathered from the specimen chose. It is expected that the factory information from the manager of the plant should not be so different from that given by technicians operating the plant and should be comparable to information received from Artisans working in bamboo.

The Stratified Random sampling technique employed by the researcher, sub divides the population into smaller homogeneous groups keeping in mind the end goal to get more precise representation. This reduced predisposition and permitted the researcher to generalize his finding to the whole population.

3.9 Primary Data

The researcher used the descriptive and experimental research methodologies for the project or research. The primary data were solicited from the senior officers of the

institutions and establishments. These comprise managers of bamboo factories their deputies, heads of research institutions at Council for Scientific and Industrial Research (CSIR), craftsmen in the bamboo industry and lecturer and teachers of bamboo art and technology from K N U S T, Kumasi.

3.10 Secondary Data

The Secondary data were composed mostly from documentary sources (books, publications, periodicals, charts, brochures and thesis). In all the various areas visited, efforts were made to collect the necessary data. Data collected from technicians and artisans were all assembled, analyzed and used where necessary for the project.

3.11 Data Collection Instruments

The data collection instruments were interview and observations which were used to gather data from respondents, with reference to the preservation methods adopted for preserving bamboo and the operation of the components of plant for giving the preservative treatment to bamboo.

3.12 Interviews Conducted

Formal interviews were also carried out. The interview was significant to the research because it was the chief data gathering device used aside observation. In this, respondents were willing to talk to the researcher and to give out information relevant to the study. Respondents in the entire category were visited and interviewed and was conducted at

different work places of all the respondents using tape recorders. The medium of communication for the interview was English and Twi.

3.13 Observation

On the spot observation of preservation and preparatory treatment of the bamboo was conducted by the researcher at all the preservation points visited by the researcher. These were done to enable the researcher see, understand, and document the processes adopted at the various preservation points.

3.14 Data Collection Procedure

Several data were gathered from various sources and were grouped into two main areas; Primary data and secondary data.

Primary data were collected through interviews, discussions and observation from the senior officers in the bamboo industry, technicians and lecturers from KNUST, researchers from Council for Scientific and Industrial Research (CSIR) and craftsmen in the local industry while the secondary data were collected or gathered from books, magazines, periodicals, journals and internet.

3.15 Data Collection for Objective One

To identify and study the traditional methods of bamboo preservation.

The main purpose of this objective is to identify and study the traditional methods of preserving bamboo as existed in my locality and other areas. The researcher based on already documentation regarding the traditional methods of bamboo preservation from

journals, unpublished thesis, internets and books. Again, lecturers and local bamboo craftsmen were visited to observe and interview them to have a clearer view on the traditional bamboo methods of preservation.

3.16 Data Collection for Objective Two

To identify the active ingredient in neem plant as potential material for bamboo preservation.

The purpose of this objective is to identify the active ingredient inhabited in the neem plant leave that makes it possible to battle insects, borers and other biodegrading organisms. The researcher visited Council for Scientific and Industrial Research (CSIR) at Kwadaso in Kumasi, Ghana. Again, some Agro Chemical industries in Ghana example *Dizengoff Ghana* were also visited interviewed and had discussions with Senior Researchers in the institutions to ascertain the active ingredient in the neem leave that can be a potential for preserving bamboo. Once again the researcher relied on information from journals, books and internet regarding neem plant and its active ingredients inherent in them to battle biodegradable organisms.

3.17 Data Collection for Objective Three

To apply and test the efficacy of neem leave extract as preservative on Bambusa valgaris.

For the purpose of this objective, the researcher depended on the information and knowledge acquired from observation and interviews and also documentations from books, journals and internet on the application of extracts for the purposes of preservation and its workability. He again painstakingly harvested and processed some neem leaves to acquire

the extracts for the preservation of *Bambusa vulgaris*. The step-by-step procedures learnt from the observations and interviews from senior researchers and local bamboo craftsmen in the preservation of bamboo were followed to apply the neem leave extract and tested its efficacy on the *Bambusa vulgaris*.

3.18 General Procedures in Executing the Project

The simple soaking, boiling and coating the surface of bamboo among the traditional method were adopted for the preservative treatment with neem extract. This is made uncomplicated to allow everybody read, comprehend and track the procedures as used within the preservative treatment of bamboo. Preservation of bamboo culm is made both in a boiler or place for stacking, or in a diffusing trough. This particular process embraces diffusion, coating the surfaces with the help of brush and boiling in extracts produced out of neem leaves. This process is very essential in giving preservative treatment to bamboo and the process has been designed to solve the existing problem of ecologically unfriendliness, and the health hazards related to bamboo preservation measures and the incapability of some well-preserved bamboo repelling pest and fungi outbreak.

3.19 Harvesting, Preparation of Neem Leaves and Preservation of Bamboo

Neem trees are very scarce in Ashanti region, although the plant does well in the tropics of Africa and Ghana for that matter. In Ghana, Neem trees are abundant in Greater Accra and certain parts of Eastern and Volta regions but scatted in some areas in Ashanti regions. On the KNUST campus, Neem can only be found in very few locations. On the Okodee road Neem can be found 150 meters from the University press and some few scattered locations

on the ridge road. Out of KNUST campus, neem can be found at the Emina hospital junction, directly in front of the Roman Catholic Church.

At the Emina hospital junction, several little branches of the neem were cut and put in a sack for transporting to the project site where they were washed thoroughly with water. Woody parts of the material harvested were taken out of the material stuck to ensure that the leaves are the main material under consideration.

Plate 3.1: Neem leaves after washing.
(Source: Researcher's Field Work)

Activity 1: Pounding of Neem Leaves and Soaking of *Bambusa vulgaris* for Twenty Days

The epidermis of *Bambusa vulgaris* were removed by turning on the lathe turning machine and carvings done on the bamboo before preserving to allow the preservative to enter all parts of the bamboo for proper preservation to take place and also to avoid any further cut or carving on the bamboo after preservation. This process was applicable to all the samples of *Bambusa vulgaris* used for the experiments.

Several kilograms of neem leaves were harvested and washed in a bath of water. 12 kilograms was pounded in a metal mortar with a metal pestle. The pounding was done until the leaves were torn into tiny leafy sheets. The pounded leaves were soaked for 24 hours with 12 liters of water. After the 24 hours of soaking, the soaked pounded leaves was stirred and sieved through a 60mm wire mesh sieve into a bucket with the capacity to hold 15 liters of liquid. Samples of seasoned split *Bambusa vulgaris*, was submerged in the neem extract, which is the liquid that was strained off the soaked pounded leaves and was kept submerged in the liquid extract for 20 days. After the seventh day the bamboos were taken out of the neem extracts and dried in the air or sunlight.

Plate 3.2: Pounding of the Neem
(Source: Researcher's Field Work)

Plate 3:3: *Bambusa vulgaris* in Neem Leaves Extract
(Source: Researcher's Field Work)

Activity 2: Pounding and Sieving of Neem Leave

Several kilograms of neem leaves were harvested and washed in a bath of water. 12 kilogram mass was pounded in a metal mortar with a metal pestle. The pounding was done until the leaves were torn into tiny leafy sheets. The pounded leaves were soaked for 24 hours with 12 liters of water. After the 24 hours of soaking, the soaked pounded leaves was stirred and sieved through a 60mm wire mesh sieve into a bucket with the capacity to hold 15 liters of liquid.

Plate 3.4: Neem Extract in a Bowl
(Source: Researcher's Field Work)

Activity 3: Pounding of Neem Leave and Soaking of Bamboo Culm in Extract for Forty Days

Several kilograms of neem leaves were harvested and washed in a bath of water. 12 kilogram mass was pounded in a metal mortar with a metal pestle. The pounding was done until the leaves were torn into tiny leafy sheets. The pounded leaves were soaked for 24 hours with 12 liters of water. After the 24 hours of soaking, the soaked pounded leaves was stirred and sieved through a 60mm wire mesh sieve into a bucket with the capacity to hold 15 liters of liquid. Samples of *Bambusa vulgaris,* was submerged in the neem extract, which is the liquid that was strained off the soaked pounded leaves and was kept submerged in the liquid extract for 40 days. After the 40th day, the bamboos were taken out of the neem extracts and dried in the air or sunlight.

Plate 3.5: A Decorated Bamboo Vas Placed in Neem Preservatives
(Source: Researcher's Field Work)

Activity 4: Soaking of *Bambusa vulgaris* in Extract for Sixty Days

Several kilograms of neem leaves were harvested and washed in a bath of water. 12 kilogram mass was pounded in a metal mortar with a metal pestle. The pounding was done until the leaves were torn into tiny leafy sheets. The pounded leaves were soaked for 24 hours with 12 liters of water. After the 24 hours of soaking, the soaked pounded leaves was stirred and sieved through a 60mm wire mesh sieve into a bucket with the capacity to hold 15 liters of liquid. Sample of *Bambusa vulgaris*, was submerged in the neem extract, which is the liquid that was strained off the soaked pounded leaves and was kept submerged in the liquid extract for 60 days. After the 60th days, the bamboos were taken out of the neem extracts and dried on the sun. R. Gnanaharan and Mosteiro (1997) in an illustrated manual explain that, in some cultures, bamboo is submerged in streams and ponds for 100 days and this helps the bamboo to leach out most of its soluble sugars, which they believe are part of the principal food of the degrading agents of the bamboo. It was established that water could facilitate leaching out of soluble sugars through osmosis, which presupposes that liquid neem extract will do both leaching out of soluble sugars and then preserve and protect the bamboo against pest infestations. In view of the 30, 40 and the 60 days submersion all to ascertain the effectiveness of the neem extract as suitable for the preservative treatment of bamboo.

Plate 3.6: *Bambusa vulgaris* Soaked in Neem Leave Extract for sixty days
(Source: Researcher's Field Work)

Activity 5: Pounding of Neem Leave and Boiling of Bamboo Culm in the Extract

12 kilograms of neem leaves were pounded in a metal mortar with a metal pestle. The pounding was done until the leaves were torn into tiny leafy sheets. The pounded leaves were soaked for 24 hours with 10 liters of water. After the 24 hours of soaking, the soaked pounded leaves was stirred and poured into a bucket with the capacity to hold 20 liters of liquid. Samples of *Bambusa vulgaris* were submerged in the neem extract and salt, and this was brought to boil for 2 hours on a high pressure gas burner. After boiling, the bamboos were taken out of the neem extracts and dried in the air or sunlight. It was boiled to help loosen the fibres for easy absorption of the preservative and also to destroy an already existing degrading organism in the bamboo.

Jayanetti and Follett (1998) affirmed that since there is the lack of any toxic constituents, bamboo culm forms an already food supply for array of organisms. They said that significant amount of starchy substances in green bamboo makes it more attractive to borer beetles. They asserted that soluble sugar forms the principal nutrients for degrading

organisms and if these can be decreased from the culm, the risk of decay will be extensively reduced. The use of chemicals was an alternative that was encouraged by researchers and interviewees for the project.

Plate 3.7: Boiling of the *Bambusa vulgaris* with Salty Water on a High Pressure Gas Stove (Source: Researcher's Field Work)

Activity 6: Pounding of Neem Leave and *Bambusa vulgaris* Coated with Extract

12 kilograms of neem leaves were pounded in a metal mortar and a metal pestle. The pounding was done until the leaves were torn into tiny leafy sheets. The pounded leaves were soaked for 24 hours with 10 liters of water. After the 24 hours of soaking, the soaked pounded leaves was stirred and poured into a bucket with the capacity to hold 20 liters of liquid. The epidermis of *Bambusa vulgaris* were removed by turning on the lathe turning machine and some were made into flower vases. A 15 cm brush was used to coat the surface of the bamboo vases with the neem extract. This particular technique was described by a local bamboo craftsman who produces bamboo furniture as surface coating or application of the extract with the help of a painting brush. Preservation of bamboo by

painting with neem extracts was another method which was considered to test the efficacy of neem as a material for preservation.

Plate 3.8: Preservation of Vases using Neem Leave Extracts to Coat the Surface *Bambusa vulgaris*
(Source: Researcher's Field Work)

3.20 Tests Conducted on Preserved Bamboo

After the six activities of preservation with neem extracts, tests were conducted on the samples of *Bambusa vulgaris*. They were subjected to pest infestation to test for the efficacy of the neem extract for the preservation of bamboo.

Plate 3.9: Exposure of Treated split *Bambusa vulgaris* to Termites.
(Source: Researcher's Field Work)

Samples of the *Bambusa vulgaris* were exposed to termites, to test the efficacy of the neem extract over four weeks. This was met by intermittent watering by the rain which helped to create an abode for the termites around the bamboo.

Through physical observation at the Renewable Natural Resource termite prone site at KNUST, it was observed that several woody materials on the site have being attacked by termites and insects giving an indication that the place is termite infested area.

According to (Mochiah, 2017), several thousands to millions of termite are expected to attack a material to ascertain that the place is termite prone area.

Again, some of the treated bamboos were also placed together with already infested bamboos in a borer prone area to test the efficacy of the preservative on the *Bambusa vulgaris* for three weeks. According to Frimpong (2017) an entomologist from CSIR, it is believed that since the borers have gathered together in that area attacking the bamboo will be easy and fast since they would be attracted to new bamboos to feed on.

Plate 3.10: Sample of Treated and Untreated *Bambusa vulgaris* Placed in a Borer Prone Area

(Source: Researcher's Field Work)

CHAPTER FOUR

RESULTS AND DISCUSSION OF FINDINGS

4.1 Overview

In the study, several observations were made, and these were documented and discussed in this chapter. These are invariably answers or observations to the objectives set for the study. From the results of the several test conducted using neem extract, it could be deduced that preservation of bamboo is mainly poisoning of the bamboo to make it toxic to any pest that will like to feed on it. From the results of the preservative treatment using neem extract and the information given by renowned writers like Jayanetti and Follet, it can be said that the principle by which liquid preservatives enter into bamboo for preservation is by diffusion irrespective of the methods adopted, and again preservation could be done either by boiling, painting, diffusion by submersion or otherwise using a kind of pest killer or repellants.

Preservatives have been employed since ancient times. Smoked red meat and other smoke preserved organic matter for instance have phenols and additional chemicals that impede spoilage. Preservation of foods and other materials has developed greatly over the centuries and has been influential in increasing food safety.

Usage of preservatives varies greatly depending on particular nation. Many developing nations that do not encompass rigid rules and regulations to regulate the use of preservatives face much dangerous level of preservatives in foods or a total avoidance of foods that are considered not natural somewhat unfamiliar. Within urban settlements and highly populated countries, the awareness of contents of food tends to be extremely low, despite use of other foreign foods.

Preservatives derived from plants have in the past been used without any source of reference. Today many if not all are authenticated at the laboratory before accepted for use.

4.2 According to Objective 1

To identify and study the traditional methods of bamboo preservation.

It was observed that, traditional methods of preserving bamboo were part of the culture of the people. These were seen among the Japanese, Indonesians, Indians and the Chinese. The traditional methods used, differ from place to place, but all aim at giving preservative treatment to the bamboo. Gnanaharan and Mosteiro (1997) contend that in Japan, one of the traditional methods used involves extraction of gummy or sticky substances and the decrease in the starch content of the bamboo. They argued that the purpose of taking away the gummy substances is to achieve even colour, while the removal of the starch decreases later attacks by fungi and insects. This to some extent gives preservative treatment to the bamboo making it unattractive to pests. According to INBAR (2006) and as cited by Baah in notes on bamboo, the following traditional methods were identified;

1. The harvesting season or period
2. Soaking bamboo culm in water and mud
3. Placing the fresh cut bamboo culm in running water
4. Boiling the culm in water and with salty water
5. Smocking in open fire
6. Drying in open air or sunlight
7. Stacking and leaning the culm against walls or trees.

In an interview with Steiner (2016), it became clear that traditional methods are ways that indigenous people have developed over the years in giving preservative treatment to their local bamboo for use in housing, fencing and other forms of construction.

According to Addai (2003) in Ghana, bamboo for housing is cut fresh and buried in swamps of water for at least three days, they are then carried home and kept in the traditional kitchen over ceiling for smoking and drying. This makes the bamboo unattractive to pest. Concoctions are used to paint the ends of the bamboo that will be buried in the earth or make contact with the earth. He further opined that the earth surrounding the bamboo is mixed with a residue of the concoctions for protection in the soil.

Steiner (2016) reports that in Indonesia, cow dung is mixed with water and used to paint structures made with bamboo for their protection. Some of the structures include fencing and on farm props. It could be concluded that traditional bamboo preservative methods is part of the overall achievements of a society and this forms an integral part of their culture.

4.3 According to Objective 2

To identify the active ingredient in neem plant as potential material for bamboo preservation

Azadirachtin was discovered to be the active ingredient in the neem plant although water extracts are effective as pesticides. It is one of the first active ingredients isolated from neem and has proven to be the plants main agent for battling insects. It appears to cause about 90% effectiveness in dealing with most pests. (Cloyd, 2015)

From the study conducted it was found out that Azadirachtin being the main active ingredient in the neem plant constitutes about 95%. According to Cloyd (2015), the seed kernel contains the highest concentration of Azadirachtin but it can be found elsewhere in the tree. Azadirachtin is inhibited in the leaves, bark and root. The azadirachtin being the main component responsible for antifeedant and toxic effects in insects, other limonoid and sulphur-containing compound with repellant, antiseptic, contraceptive, antipyretic and anti-parasitic properties are also found in the leaves and barks of the neem plant.

The extract from the neem leave has a pungent smell (strong odor) and bitter taste. Due to the sweet nature of the ligning constituents in the bamboo that attract pest and insect to feed on, when the neem extract is applied on the bamboo culm, because of the bitter taste and the smell of the neem extract, it makes the bamboo culm unattractive to pest and other degrading organisms

According to Mochiah (2017), the Azidarachtin in the neem extract does not kill insect immediately instead it repel and disrupt their growth and reproduction. Research for the past 20 years has shown that it is one of the most potent organic growth regulator and feeding deterrents ever gotten.

Frimpong (2017), also asserted in an interview that, the azidirachtin has not gotten what we call the knockdown effect but rather it repel and prevent insects from feeding (molting). It deforms the insects' wings, legs and the parts that help them move or reproduce.

Frimpong (2017) opines that, the active ingredients in the neem can be extracted through crude means, thus, soaking in water and alcohol, boiling in water and grinding the dry

leave, bark and root into powder. Again, other chemical and laboratory extraction processes can be carried out to obtain the active ingredient in the neem plant which is azadirachtin.

Steiner (2016) asserted that, soaking in water and alcohol for about a week or more help leach the active ingredients from the neem plant into the water or alcohol. He believes that the colour change in the water or alcohol physically can be attributed to extraction of some the main ingredients in the neem plant of which azadirachtin is part.

Mochiah (2017) affirm that, since most organic insecticides are in powdery and cake form, they are used when they are mixed with water to become solution. They are then sprayed, sprinkled, painted or applied on the post or farm produce to battle insects and other crop borers which mostly resides in the woody material used for the post or support. He trusts that same application can be employed in the treatment processes of bamboo against insects, borers and other degrading organisms.

According to Mordue and Nisbet (200), the azadirachtin from the neem tree affects insects in over 200 species of insects and it possesses considerable toxicity towards insects. It acts as an antifeedant, insect growth regulator and sterilant. Due to the results of the active ingredient and its medicinal properties in the neem plant, the plant is described as the "Tree of the 21st Century" by United Nation, and in India as "Divine Tree", "Life giving tree", "Natures Drugstore", "Village Pharmacy" and, "Panacea for all diseases".

4.4 According to Objective 3

To apply and test the efficacy of neem leave extract as preservative on *Bambusa valgaris.*

To process the neem leaves for preservation is basically preparing the neem leaves to extract the active ingredient necessary for giving preservative treatment to bamboo.

It was established during the interview sessions that most plant extracts are taken from the leaves, back of the tree, roots and the stem which endorses Steiner (2006) who sort to identify which parts extracts are obtained from. He explained that soaking the leaves in water can in most cases create opportunity for the leaves to leach out active ingredients for preservation into the water. He further explained that boiling of the leaves is another effective way of extracting the active ingredients in the leaves, and this applies to the other parts of the plant. Steiner also explained that breaking down the material is an effective way of processing the material for extraction. This observation made in Steiner's work was similar to what was established in this research.

The outcome of the various interviews granted by professionals in preservation of bamboo was the background from which all the activities were designed. In all the activities, the extracts changed the colour of the water supporting the assertions raised by some of the interviewees. Where the material was beaten through pounding, the colour of the water was darker. Boiling of the leaves also produced darker solution.

Samples from the six experiments conducted with the neem extracts in treating bamboos were exposed to termites and borers for almost four weeks. The third and fourth days of the observation period, they were met with rain showers, they were steadily covered with mud. The treated *Bambusa vulgaris* were not wholly covered; it was an undeniable fact

that the formation of moulds around the sample pieces was confirmation of termites on the pieces. The uninterrupted termite moulds built up on the pieces were critically observed within the third week.

From the observation it was noticed that, parts of the bamboo were having some white powdery substance, giving an indication that the unpreserved bamboo had been attacked. It became obvious that the unpreserved samples were highly infected by the termite or pests.

Plate 4.1: Sample of Unpreserved and Preserved *Bambusa vulgaris* with Neem Leave Extract Exposed to Borer Attack (Source: Researcher's Field Work)

This confirms the declaration that was made by K. A. Baah during consultation that, the sugar content of vulgaris, which is the primary food for degrading agents, is very high and which even makes the material's natural resistance to pest and fungi very low.

When bamboo product surfaces are coated, most areas will be covered by the solution as means of casing the surface. After the coating the surface of the bamboo species as means of preserving them were done, it was exposed to termite attack for 21 days. After the 21days of exposure, the bamboos were picked, cleaned and critical observation done on it to verify any act of termite attack.

During the observation by the researcher, it was evidently clear that no outer part of the sample bamboo species had been attacked by any biodegradable organism. Upon careful observation of the sample bamboo pieces, it was recognized that greater portion of the inner lining of bamboo (lumen) of the sample pieces has been consumed and only the outer part of the bamboo where the painting was done were intact.

The sample pieces that had been split and preserved were also taken out and cleared of the mud for close observation. It was evidently clear that sample of bamboo pieces were not affected. The other sample pieces were also removed, cleared of the mud and examined for termite's infestation by the researcher. Even though it was observed in the early stages of the test that the termites had built mounds around the test samples, there had not been any evidence of any part of the samples being affected, infested or eaten up by pest.

It was observed that, the split treated bamboo species with the neem leave extract had not been attacked or any part eaten up by the termites but they were left intact.

Plate 4.2: Preserved Split *Bambusa vulgaris* with Neem Leave Extract after Termite Attack

(Source: Researcher's Field Work)

Considering the tests conducted and the major ingredients in the preservative, it became known that neem, as a biological preservative is more suitable for the preservation by diffusion, boiling and pounding. According to Steiner (2001) this is most suitable for the production of domestic products like chopsticks, other kitchen wares, fruit plate, chopping board and anything that may serve as a container or carrier for edibles and most importantly preservatives that contain chemicals as the major constituent such as chlorpyrifos should be used in preserving or treating non domestic products like chair and table, beds, wardrobes, garden light stands, cupboard, window frames and other bamboo products for construction. This claim by Steiner falls in line with the treatment techniques established in this research and it also endorses the earlier claim that when *Bambusa vulgaris* is treated with neem extract it is the most suitable option amongst the bamboo for domestic products

It was also confirmed by Steiner (2001) *Bambusa bambos* are more suitable for constructional purpose which will last longer when preserved well in addition he said that vulgaris is suitable for domestic products while *vulgaris var vitata* for products that will always be subjected to heat like chopsticks, ladles etc. The whole culm products must be made complete, preserved and finished, this will avoid cutting after preservation, which can expose unpreserved parts of the material in use to attack.

Plate 4.3

Plate 4.3

Plate 4.5

Plates 4.3, 4.4 and 4.5: Samples of *Bambusa vulgaris* Products Preserved with Neem Leave Extract after Subjecting them to Borer Attack.

(Source: Researcher's Field Work)

4.5. Findings

From the experiments and research conducted on this project, the researcher found the following;

1. Treating bamboo culm with neem leave extracts are possible and has the efficacy to protect the bamboo from insect, borers and other degrading organisms but it is advisable to administer the neem leave extract on smaller bamboo crafts example, flower vas, center pieces, wall hanging, fruit bowl, desktop organizers and other domestic kitchen items.
2. The traditional method of bamboo preservation coupled with organic means of preservation example using neem leave extracts add value to the environment by protecting the environment from toxic waste being thrown into the environment and does not pose any harmful treat to the bamboo user and the environment as a whole.
3. The neem leave is readily available and accessible in the community, which makes it cheap to assess, and worked with, therefore boosting production in the local bamboo industry.
4. The procedure and steps employed in administering the neem leave extract for the preservation of bamboo culms are easy, basic and require simple knowledge and does not call for any sophisticated tools and materials in the process of treating the bamboo culms.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 SUMMARY

Protection of bamboo and other woody products from destruction date back to the prehistoric era. Several methods of protecting the woody plant was done in fast, convenient and affordable means which included soaking in the mud or water, smocking, good harvesting times and others, all with the aim of making it durable, last longer and also protecting the environment. Unfortunately, most bamboo industries in the country use poisonous chemicals to control pest and insect attacks on bamboo, which at the long run causes environmental pollution. The experiments conducted indicates the possibilities of preserving *Bambusa vulgaris* using neem leave extracts which is readily available in the locality in a more simple way and also goes a long way to protect the environment from hazardous chemicals.

To realize this, the following objectives were outlined for the project

1. To identify and study the traditional methods of bamboo preservation.
2. To identify the active ingredient in neem plant as potential material for bamboo preservation.
3. To apply and test the efficacy of neem leave extract as preservative on *Bambusa valgaris.*

To achieve these objectives, the researcher visited some bamboo preservation centers to see at first hand the structures for preservation and the methods adopted at the various points for preservation.

There was insufficient information on the topic, however the researcher reviewed accessible literature and conducted interview on 29 out the 41 targetted respondents working in preservation centers, bamboo industries, teachers of bamboo and rattan and plant research centers. The experimental and descriptive methods of research were espoused for this research work.

The results of the experiment indicate that all the objectives that were outlined for this study were achieved, thus proving the possibility of the use of neem leave extracts for the preservation of *Bambusa vulgaris*.

5.2 CONCLUSION

From the research conducted it can be concluded that:

Treatments given to bamboo culms using neem leave against termites and other insects are effective. The treatment of the bamboo culms using neem leaves performed comparably well as the already existing traditional methods.

Despite the fact that the traditional methods of bamboo preservation in general are simple, cost effective, low or no special tools and equipment and little technical knowledge are used. These methods are not enough and appropriate to preserve bamboo for long-term projects and are not good techniques of preservation for industrial and large scale users.

Considering the research conducted so far and thes active ingredients in the preservative, it was discovered that neem leaves extracts, as a preservative, is more suitable for the preservation of domestic products example chopsticks, ladles, chopping boards, fruit trays and anything that will serve as a carrier or container for edibles and other small items such as vases, wall hangings and other decorative pieces.

The cost of preserving bamboo using neem leave is as cheap as most of the traditional methods being used on the market.

5.3 RECOMMENDATIONS

The researcher recommends for future researchers to undertake additional research into other environmental friendly and organic means of preserving bamboo, to educate, sensitize and encourage craftsmen on the negative impact of toxic chemical preservatives which will go a long way to help bamboo users and also solve many environmental problems attributed to the use of poisonous substances.

The researcher again recommends that, coating of the surface of bamboo is not a proper means of preserving whole bamboo culm since most degrading organisms attack the bamboo from inside but split bamboo surfaces can be coated as means of preservation.

The researcher recommends that, further research should be carried out to experiment the use of other parts of the neem plant apart from the neem leave that has the potentials of preserving bamboo.

It is recommended that, further research should be conducted to find out other organic means together with traditional methods of preserving bamboo for industrial and large scale users example furniture making, constructional works and other bigger works.

This project description should be made available and easily accessible to all and copies be made available in libraries, educational centres throughout the country and to serve as an educational resource material for industries that are into bamboo craft and production firms. Again copies left at the department of integrated rural art and industry as a reference material.

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