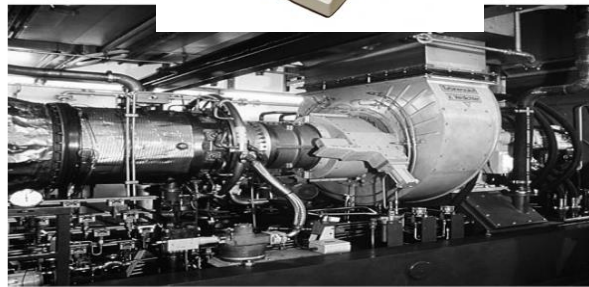


# Development Journal of Science and Technology Research (DJOSTER)

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## Development Journal of Science and Technology Research (DJOSTER)

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**NNPC Chair Professor and Coordinating Director,  
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nobaje@yahoo.com; nobaje@ibbu.edu.ng

08035925210, 08151800365

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## A PAPER REVIEW ON REVIEW AND RATING APPLICATIONS

Adamu Abubakar Isah\*<sup>1</sup> Adamu Abubakar<sup>1</sup> and Amina Muhammad Tako<sup>2</sup>

<sup>1</sup>Department of Computer Science Ibrahim Badamasi Babangida University Lapai, Nigeria.

<sup>2</sup>Department of Mathematics Ibrahim Badamasi Babangida University Lapai, Nigeria.

Corresponding Author email: adamuaisah@ibbu.edu.ng

### Abstract

Over the last decade, reviewing and rating applications have been a critical section of application development (mobile, web, desktop, and hybrid). It has evolved exponentially to help assess, improve, and support the usability of our apps nowadays. This paper reviews the methods and tools used in reviewing and rating applications. It was focused on the Google Play store, Apple Store and Samsung Review systems among many others. This study was used to determine the importance of application ratings and reviews for determining user feedback, tips, suggestions, and room for improvement of our applications for proper and continuous usability. Based on the literature, three variables were identified that influence the review and rating of applications, these factors are user interface, functionality, security, and privacy. The findings indicate that review and rating applications are core to the development and improvement of our application and are essential for future integration and upgrades to be provided by those applications used.

**Keywords:** Hybrid, Application, Web, Desktop, Feedback, Usability.

### 1. Introduction

The digital world is expanding rapidly which is causing the present increase in the development of applications globally, leading to the rise of unwanted applications to be used or for their purpose. To cope with this issue, reviewing and rating applications technologies are there to help curtail the unsolicited application to help manage the global storage space (Mendiola & Kalnicki, 2018). However, there is a clear imbalance in the applications we use and their purposes globally, specifically in our region here Africa. In recent years, the massive deployment of the information and communication technology (ICT) review and rating application have aimed to confront these issues. These review and rating applications have facilitated the removal of unnecessary application in the storage space (Kaiser, 2017). The introduction of different review and rating applications such as the Google Playstore in 2012, Apple Store in 2008, and Samsung Store in 2012 respectively. Google Playstore, Apple Store, and Samsung Store are digital distribution services, they serve as the official store for getting or downloading certified applications from these platforms for the smooth running of the devices they are being operated on. They are digital media stores offering games, music, books, and television programs applications (Farhin & Kaider, 2021). Applications utilizing the hardware capabilities of a device can be targeted at users of devices with specific hardware components, such as motion sensors, camera, and fingerprint. These digital stores are embedded with rating and review mechanism, to provide users of the application to give feedback, ranging from user experience, user interface, security and privacy, response time, usability, and many other factors.

Delivering a great overall experience is the best way to encourage positive ratings and reviews, but it's also crucial to choose the right time to ask people for feedback. Although every application is different, some possible ways to do this involve looking at how many times or how frequently people launch your app, the number of features someone explores, or the number of tasks they complete. People can always rate your application within these digital stores. Avoid interrupting people while they're performing a task or playing a game. Asking for feedback can disrupt the user experience and feel like a burden. Look for natural breaks or stopping points in your app or game where a rating request is less likely to be bothersome. Avoid pestering people. Repeated rating requests can be irritating and may even negatively influence people's opinion of your app. Consider allowing at least a week or two between requests, prompting again after people demonstrate additional engagement with your experience.

The technological advancement in these applications such as user reviews and rating, users can rate your application on a scale of one to five stars. Individual ratings inform your application summary rating, which is displayed on your product page and in search results. Written reviews allow users to share more detail about their experience with a particular application. These review and rating applications are embedded on the deployed application to give feedback to the developer or the owner of the application to help get errors, unwanted and ideal responses to help improve the application that has been deployed. These review and rating applications makes easier for both the user and the developer to get appropriate feedback on the platform, because there is full duplex communication between the two and serves as a document of reference for the review and rating application to know the type of applications the platform is hosting.

The aim of this paper is to review a review and rating application using some the digital stores. Objectives are: Is review and rating mechanism important for applications? Does review and rating mechanism help in the improvement and development of our application?

The scope of this study is limited to digital store application with review and rating mechanism using the platform to achieve this task. The Google Playstore, Apple store, and Samsung Store were selected among many other digital stores.

## **2. Literature Review**

### **Overview of Rating and Review Applications**

Over the last few years, we have observed an excessive evolution of mobile health applications than any other innovation in health care (Levine & Hass, 2020). The term 'app' is an abbreviation of the word 'application' that refers to a program that has been developed for a specific purpose and is generally configured to run on handheld devices like cell phones, tablets, computers, and certain wearable devices such as smartwatches (Kao & Liebovitz, 2017). In recent times, we have observed a proliferation of mobile apps that are mostly created for only two of the most important tech giants of smartphone operating systems- Apple IOS and Google Android. The World Health Organization (WHO) defines these applications as, 'medical and public health practice supported by mobile devices such as mobile phones, patient monitoring devices, personal digital assistants (PDAs) and other wireless devices. Similarly, according to Hamel et al. mHealth 'is the use of portable devices such as



smartphones and tablets to improve health'. mHealth apps in practice run on mobile devices with remote network connectivity and dynamic execution of contexts (Hamel & Cortez, 2014). Context is any information that can be used to characterize the situation of an entity, being either a person, place or object. The context awareness system collects real-time data from patients in a comprehensive manner and presents them to health care professionals to manage their tasks to increase the quality of patient care.

Extant literature on mHealth applications exhibits how mHealth apps are commonly used for health education, disease self-management, remote monitoring of patients, and collection of dietary data (Carol- & MoorHead, 2017). The information collected through mHealth apps can provide useful support for encouraging health behavior change, chronic disease self-care and effective management of many conditions while keeping healthcare providers informed of the patient's condition (Klasnja & Pratt, 2012). This also strengthens the relationship between the patient and the provider (Dicianno & Pramana, 2015). According to Scoping review findings, mHealth apps provide the potential for general practitioners to take medical history and make diagnoses, perform some physical examinations, aid in clinical decision making, and manage long term disease-specific care and promote general health well-being (Teoh & Woo NJ, 2020). Whilst traditionally, health care is delivered to individuals through face-to-face interaction with health care professionals, technology advancement has facilitated communication between patients and health care professionals (Zhao & Freeman, 2016). Moreover, mobile phone apps are commonly incorporated into the design of health promotion programs both face-to-face and online. Based on these, mHealth apps are mainly categorized into two categories—lifestyle management (such as fitness, lifestyle modification, diet and nutrition) and chronic disease management apps (such as mental health, diabetes, and cardiovascular diseases). The other categories include- self-diagnosis, meditational re-minders, and patient portal apps (Kao & Liebovitz, 2017). Studies document how mHealth apps provide information and health behavior interventions at a meagre cost, that is, easy to access and personalized for user-specific needs (Dahlke & Hong, 2015). A systematic review of mHealth apps for chronic diseases showed that there are improvements in patient lifestyle related to, healthier eating, weight loss, controlled blood pressure and glycemic levels, including treatment awareness options among patients (Debon & De Marchi, 2019).

### **Determinants of Mobile Health App Ratings**

At present, there is little known about which mHealth apps are most used and whether they align with app quality (Carlo & Ghomi, 2019). Majority of the mHealth apps found in the app stores are available in trial versions to attract potential users or as a promotional strategy to increase the adoption rate (Bautista, 2017). Fiordelli et al. in their systematic review brought to our attention that there are millions of mHealth apps (free and paid) publicly available on app stores, and to-date they have not been evaluated them. Byambasuren et al. highlighted that low quality and lack of effectiveness hinders the usability of mHealth apps, as the majority are developed by non-health care organisations which raises questions about the accuracy and trustworthiness of these apps (Biviji & Vest, 2020). While evaluating behavioral mHealth apps, studies report that app ratings are broadly inconsistent and often contradictory while most popular behavioral health apps rating are not favorable (Carlo & Ghomi, 2019). Furthermore, other frequently downloaded behavioral mHealth apps have questionable support in the literature and offer no evidence-based behavioral support. For example, research on the usage of mHealth apps by cancer survivor patients revealed that some apps used theoretical models of behavior

change, but most of the apps in the market did not apply any of those theoretical elements in their apps (Dahlke & Hong, 2015).

Some scholars suggest that independent and reliable sources should evaluate mHealth apps and should recommend a collection of trustworthy apps to health care professionals to, be referred to patients (Byambasuren & Sanders 2018). According to Levine et al. an app rating tool can be developed to identify mHealth apps that may cause potential harm and breach the privacy policy. When an appropriate mHealth app is prescribed by health care professionals, they must be confident about the functionality of the app, maintenance of data privacy and its usability (Byambasuren & Sanders, 2018). A survey conducted among mHealth app users in the USA found that 82 percent users would change providers if they were aware of alternative apps which were more secure. There is also no clear evidence available to suggest that an app developed by a health care organization will have more usability. Bivji et al. identified that price, user ratings, in-app purchase options and in-app advertisements were the greatest predictors of app downloads from the app store.

Other studies present that the actual usability and quality rating scales are primarily developed only for professionals, and not for end-users who are patients or care providers. It is widely recognized that rating scales that are usable by all end users would make mHealth apps more accessible and meaningful to consumers (Azad-Khaneghah & Neubauer, 2020). Janatkah et al. found that a mHealth app's usability is associated with the education level, employment, and place of user's residence.

While there is evidence of a weak relationship between user app ratings and usability and clinical utility of the app (Singh & Lee J, 2016) in the literature, generally we note that users make decisions related to app use, based on the title, price, star ratings, reviews, and number of downloads (Huang & Bashir, 2017). Furthermore, mHealth users disproportionately favors apps that take advantage of unique features of smartphones with higher ratings and present the real benefits to users to keep track of their health records (Liu & Holroyd, 2022).

Generally, we observe that mHealth app users' opinions or satisfaction levels, star rating system, app description of checklists are some common features used to measure the quality of the apps. However, scholars argue that none of these methods are scientifically adequate to measure the quality of the apps (Salazar & Failde, 2018). Singh et al. identified that store rating alone is not enough to determine whether an app is of high quality, but inclusion of clinicians and users' reviews will ensure that the recommended apps are usable and clinically useful. Further, we note that in the literature users' reviews of mHealth apps in relation to app rating is generally scarce. There is research on the effect of online assessment. This operationalization of review effectiveness warrants helpfulness and facilitates user's decision-making whilst inspiring trust and confidence among other potential users. Nevertheless, the existence of a contradictory total rating reduces the credibility of the analysis due to its negative impact on consumer product attributes (Qiu & Pang 2012). Some scholars are skeptical about the review 'helpfulness' level related to user votes, and suggest other diverse features, such as basic, stylistic, and semantic characteristics by applying data mining techniques from online user reviews. Although this multi-process conceptualization of multiple determinants for review effectiveness is emerging in the literature, some scholars are of the view that participation in reviews and polarity of reviews may be driven by different consumer behaviors (Zhang & Cheung, 2014) and emotions (Xu. X, 2020) so should

be studied separately. Although it is observed that positive review sentiments increase readership (Salehan & Kim, 2016).

The basis for digital health research is often primarily based on cataloging the number and types of apps dealing with a specific health issue that assess the theoretical effect of such features on user experience or identifies the behavioral concepts in a subset of mHealth apps. Studies can also explore a variety of multi-dimensional app features that contribute to a better user experience and eventually alter long-term behaviors (Mendiola & Lindenauer, 2015). Based on these gaps from the mHealth app rating, our study aims to extend current knowledge on how users' perceptions and app reviews can generate new app rating that may be different than the original/existing app rating. This paper also presents a new methodology, an AI-enabled mHealth app rating scale, which takes multidimensional measures to generate app rating. By adopting text mining as a novel methodology to extract various semantic characteristics from reviewers' texts, this paper evaluates user review determinants on mHealth app ratings.

### **mHealth app quality rating scale**

#### **mHealth applications**

The mHealth applications are an important part of the forthcoming next-generation Internet of Healthcare Things (IoHT) (Powell & Chans, 2016). This paper categorizes the mHealth apps into the following six types.

#### **Wellness management app.**

The Wellness management app tracks health aspects such as walking, sleeping, weight, body mass index, temperature, blood pressure, oxygen saturation (oxygen), pulse, consumption of food and water, etc. These apps allow users to monitor aspects of their health and lifestyle.

#### **Disease management app.**

Aging, demographics, lifestyles, and chronic diseases have been adding an increasing amount of pressure on health care systems around the globe. To reduce such pressure, disease management software is employed to assist the healthcare system, aiding in monitoring signs/symptoms, tracking medications' intake, and other side effects.

#### **Educational app.**

Educational applications offer disease-focused education and self-management training.

#### **Self-diagnosis and decision-making app.**

An emergency patient assessment with a symptom management questionnaire is performed via the self-diagnosis and decision-making app.

#### **Digital therapeutics and rehabilitation.**

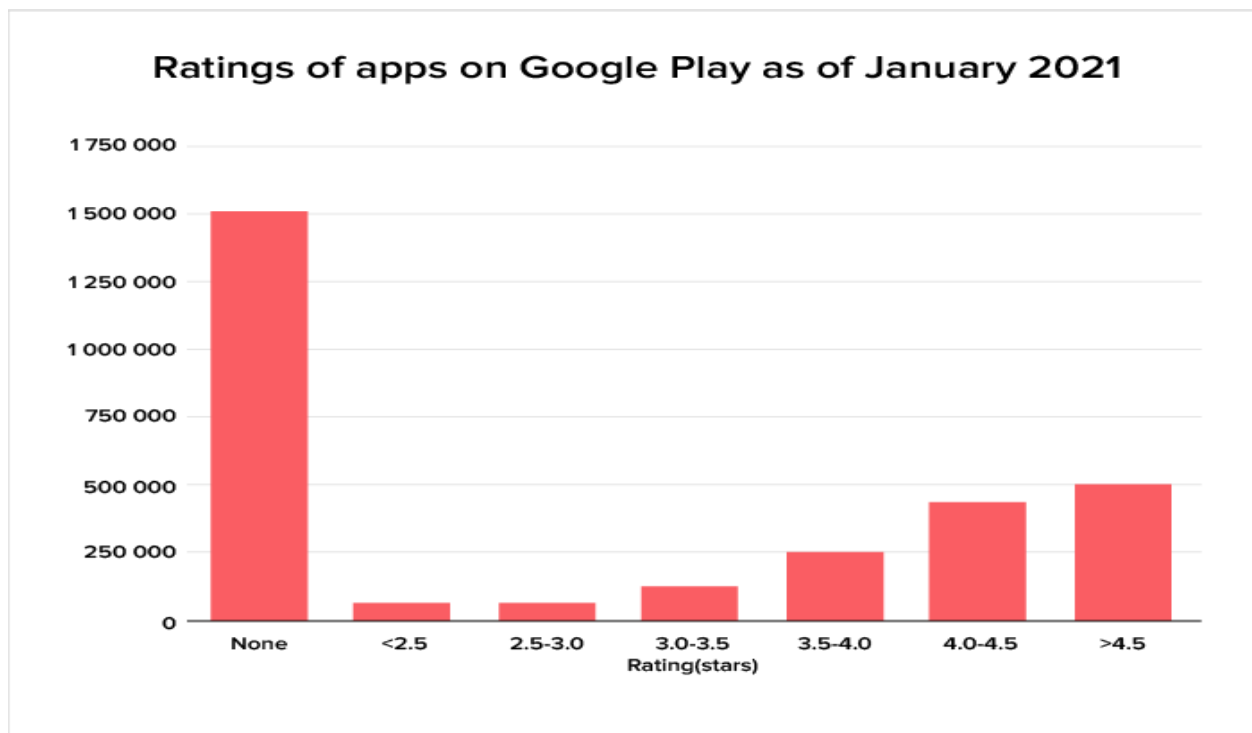
Digital therapeutics and rehabilitation may be used to prevent, control, or treat disease.

### 3. Benefits of Rating and Review Applications

If we talk from the perspective of a developer, application reviews and ratings are everything. Whenever you publish an app, surely, you get curious about the feedback of the user. User reviews and ratings are one of the primary criteria that decide if an app will survive and thrive in the market, or not. Now, to make that happen, go through the mobile app marketing guide, make an optimized and well-designed user interface, and integrate unique but useful features among others. ReviewTrackers, in a report published in 2018 says, 94% of customers avoided a business after reading negative reviews online. Moreover, 80% of customers do not interact with a business having a rating lower than 4.0 stars. That can be related to the app market as well.

In this article, we are discussing the importance of reviews. As a developer, you must have an idea of how important online reviews are. Therefore, I advise you to keep reading the rest of the blog to understand its depth.

To understand in-depth why ratings and reviews are important, let's have a look at a few important statistics.



**Figure 1: Chart of Ratings Google Playstore as of January, 2021**

(Image source: <https://www.mobileappdaily.com/importance-of-mobile-app-reviews> )

- a. As Statista's report for January 2021 says, Google Play Store had approximately 511,000 apps with an average rating of 4.5 or higher.
- b. Reviewtrackers stated that 80% of customers avoided business with a rating of 4.0 or lesser.
- c. As per AppBrain, Google Play has 48.9% which is 1,476,104 apps with an average rating of 4.1,
- d. Among most downloaded apps, FAU-G had 5 million-plus downloads with an average rating of 3.1.

- e. Among best free android apps in the United States, Lumbercraft is on the top with a 3.9 rating and 500K+ downloads.

Further facts might make it more clear for you to understand. Data published by TUNE says that 47% of iPhone Operating System (iOS) and 53% of Android users found the mobile app via search engines. Search engines display apps with good app reviews. So, a good strategy to improve app reviews might create an impact. As per a report published by Apptentive, app reviews can influence 70% of people in installing the app on Apple devices. On the other hand, 75% read app reviews and downloaded them. In 2014, the Apple App Store had 128,000 best business apps onboarded. With this competition, you can understand why reviews are important. The number of installations is directly dependent upon reviews. According to data by the Sensor Tower, overall, 71.5 billion mobile apps were downloaded. To make any app successful, user retention is important. The retention rate can boost with the help of a few tricks such as great user experience, easy navigation, and cool user-interface among others. In short, if users are happy with the app, they will stay, and provide good app reviews as well. Data by Upland Software states that the app retention rate can be multiplied by 3 with features such as In-App messaging. Moreover, integrating apps on multiple platforms or making them Omni-channel friendly will help in boosting the app retention rate and app reviews parallelly.

As a developer, your primary goal must be the app revenue, right? Well, app reviews affect app revenue directly. However, with good app reviews, opportunities arise. Your overall app rating will influence users to download your app. Moreover, it will also attract more promotional opportunities from clients. According to Statista, top-rated apps are expected to grow global revenue up to \$935.2 billion by 2023. As mentioned earlier, good ratings can have a direct impact on app searches. If you go through a few app download statistics, you will find that apps in the top 50 have a good number of reviews and ratings. In short, good ratings can make it easier for users to find your mobile app. One of the top importance of ratings and reviews is that good reviews push your app on the top in search engines. Currently, users are cautious about what they are installing on their smartphones. And for their assurances, app reviews come into the picture. A report by Apptentive shows that 90% of users go through reviews and ratings before installing any app. App ratings and reviews matter a lot when it comes to user acquisition. They play a massive role in a person's decision to download an app. Apptentive research shows that mobile users won't even consider downloading an app that's rated lower than 3-stars. Moreover, 79% of people will read at least one review before they install an app.



**79%**  
of consumers check ratings and reviews before downloading an app



**53%**  
Check ratings and reviews before updating an app



**55%**  
Check ratings and reviews before making an in-app transaction

**Figure 2: showing the app rating percentage before a user downloads an application**

(Image source: <https://appradar.com/academy/app-reviews-and-ratings>)

Another reason that app ratings and reviews are so important is they contribute significantly to your overall app branding. When your app has positive user feedback, new users will be able to trust your brand more quickly and with less friction. Your current users are providing social proof that reflects well on your app.

#### 4. Conclusions

While some might think it's difficult to quantify the importance of ratings and review applications, the above statistics prove their power. There are variety of ways that they are useful, both for businesses and their customers, education, medicine, technology and more. And not only ratings and reviews are necessary to today's consumers during the purchasing process, but companies are also missing out on sales, profits, and priceless information without them. Ratings and reviews are an invaluable source of feedback. Consumer reviews can help surface issues with products, shed light on new use cases, and inform product innovations. Shoppers want to see businesses use their reviews, both positive and negative to make product improvements. There are stories from users about ways they have improved their products and processes based on the feedback they've received from ratings and reviews.

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## ADSORBENTS FROM PERIWINKLE SHELL AND SODOM APPLE FOR REMOVAL IRON IN POLLUTED WATER

A.A. Ibrahim<sup>1</sup>, A. F. Usman<sup>1</sup> and S. Adamu<sup>2</sup>

<sup>1</sup>Department of Chemistry, Ibrahim Badamasi Babangida University, Lapai, Nigeria

<sup>2</sup>Nigerian Institute for Oceanography and Marine Research, Victoria Island, Lagos, Nigeria

Corresponding author Email: [alituraki@gmail.com](mailto:alituraki@gmail.com) [iaahmed@ibbu.edu.ng](mailto:iaahmed@ibbu.edu.ng),

### Abstract

Water is major natural resources, that provide wide ranges of benefits to human such transportation, energy, recreational areas, domestic usage etc. The activities of man gradually degrading the quality of water making it unfit for use. A number of methods have been used for purifying water contamination such as water purification using natural adsorbent. In this study periwinkle shell and Sodom apple were carbonized (at 900 and 550 °C) and activated with nitric acid (HNO<sub>3</sub>) and phosphoric acid (H<sub>3</sub>PO<sub>4</sub>) at 550 °C and used to remove iron (Fe) from water samples collected from Contonou, Katcha and Patigi. Periwinkle shell were obtained from Kure ultra-modern market Minna, Niger state. Sodom apple was collected from Minna area, Niger state. Periwinkle shell and Sodom were washed, dried, crushed, pulverized and carbonized. Comparison of untreated water with carbonized sodom apple activated using HNO<sub>3</sub> and with Periwinkle shell carbonized with HNO<sub>3</sub> and H<sub>3</sub>PO<sub>4</sub> were studied. Result indicated that the carbonaceous samples were effective in removal Fe from the polluted water. It was observed that periwinkle shell activated using HNO<sub>3</sub> was found to absorb more than activation using H<sub>3</sub>PO<sub>4</sub>.

### 1. Introduction

In Nigeria today, there is a high risk of various outbreaks of diseases like cholera, food poisoning, typhoid fever, malaria and other health hazards due to environmental pollution caused by indiscriminate refuse dumping within the residential areas (Madaki, 2010). Lack of environmental sanitation has been a feature common to all Nigeria settlements. Heavy metals deposition in water bodies destroy the self-purification process of natural water and thus affect aquatic life. Pollution of water bodies by heavy metals has been an environmental challenge for a long time. Heavy metals lead to rapid toxicity to people and to other organisms when their presence gets far-off permissible limits affecting the aquatic environment. Majority of the metals bio-accumulate and hence endanger human life. The direct deposition of heavy metal invested waste in water bodies needs to be checked to minimize environmental breakdown (Khan *et al.*, 2008).

Removal of toxic heavy metals from the environment is an important question. Over the years, various processes to remediate these water threats have been developed, such as photocatalytic degradation, ultrafiltration, oxidation, aerobic degradation, adsorption, filtration, ozonation, coagulation, flocculation, distillation, extraction, precipitation and membrane processes (Ahn *et al.*, 2009; Xiong *et al.*, 2009). However, most removal processes have disadvantages, such as continuous input of chemicals, high costs and even incomplete metal removal (Minceva *et al.*, 2007). However, Adsorption is a surface process in which multi-component fluids are attached to the surface(s) of a solid



adsorbent(s), forming chemical or physical bonds. It is being recognized as one of the widely applied and most efficient fundamental approaches in contaminated water treatment methods which mainly revolves on its technical feasibility, economic viability, socially acceptable and simple design and ease of operation and has always evolved as front line remediation for water purification (Foo and Hameed, 2010). Limiting adsorption, using activated carbons, biological materials, mineral oxides, or polymer resins have been documented as a possible method for removal of pollutants from water lately. Activated carbon has been used widely for remediation of various organic pollutants from wastewater among all the adsorbents. A wide variety of activated carbon has been synthesized from different bio-waste materials such as olive stones, vermiculate plant, bamboo dust, coconut shell, groundnut shell, rice husk and straw, banana peel and pomegranate peel, Apricot Stone, rice husk, corn cob, etc. Approximately 70% of the earth surface is covered with water. However, safe drinking water is becoming in short supply. Discharge of heavy metals in water bodies without recommended treatment is a potential threat to human health since they bio-accumulate and persist along the food chain. Consequently, there has been an urgent need to find modern technologies or bio-materials to rid heavy metal ions from contaminated water and bio-sorption is a promising option (Gupta and Rastogi, 2008). Approximately 70% of the world's entire surface is water with approximately 97% of it being seawater which is unacceptable for drinking as it contains excessive levels of salt concentration. Approximately 3% of the earth's water is fresh with 1.6% of it being held up in polar glaciers and ice caps. Additional 0.36% is present in underground wells and aquifers. Thus, about 0.036% of the entire planet's supply of water is accessible in rivers and lakes (Kumar and Lee, 2012).

Water quality degradation is becoming a serious problem across the globe, more so in poor countries with increased industrial and agricultural production, combined with inadequate wastewater treatment systems. Nearly all of the third world countries' waterways, traditionally used for safe water and for other community needs have been heavily polluted (Morrison *et al.*, 2009). An increasing number of contaminants enter waterways from human activities and industries like dyes, pharmaceuticals, heavy metals, pesticides, phenols, detergents, insecticides and fluoride. This has led to unforeseen health hazards surfacing that were not in existence. Additionally, waterborne pathogenic microorganisms are ubiquitous globally as they enter waterways as storm drains, untreated sewage, industries, septic tanks and surface runoff (Kumar and Lee, 2012). Water treatment entails the processing of removing water pollutants from a polluted water so as to fit for desired purpose or intended purpose through the prescribed standards of color, odor and taste. Chemical water treatment aims at removing solids, adjusting pH, to reduce dissolved elements, oxidize and disinfect water (Shiong, 2007). Most of the surface water in the world is not fit for consumption purposes, and hence water treatment processes should be used to attain the required water quality. The general water treatment technique for drinking water consists of several stages to remove or reduce the suspended particles, dissolved solids and microbial pollutants (Doosti *et al.*, 2012). According to the WHO Rules for Drinking Water Quality, 2008 report; water is necessary to maintain life and a suitable supply should be reachable to all. Increasing the safe water accessibility for drinking can result in concrete benefits to human health. The report further advises measures should be taken for attaining safe drinking water quality (Kithiia, 2011). The general significance of water pollution problems includes lesser health of the aquatic ecosystems, decreasing quality of drinking water, impaired recreation and sedimentation (Dosskey, 2001). Unlike natural factors like evaporation, geology, precipitation, soils influence on water quality, human activities for example, agricultural and domestic practices impact adversely on quality of river water.

Thus, it is significant to conduct regular water quality tests for sustainable management of water bodies and watersheds (Mwangi, 2012).

The most profuse heavy metal or element in the earth's crust is Iron. It is present in the environment mostly as  $\text{Fe}^{2+}$  or  $\text{Fe}^{3+}$ . Iron is generally present in surface waters as salts containing Fe(III) when the pH is above 7. It can give rise to a rusty red or brown stain on fixtures or laundry and/or cause your water to develop a metallic taste. Ingesting dietary iron supplements may extremely poison young children because Iron is a heavy metal to deal with. Iron is absorbed quickly in the gastrointestinal tract because ingestion accounts for most of the toxic effects of iron. The corroding nature of iron appears to further increase the absorption. Iron is an essential element in human nutrition, is a basic ingredient of cytochromes, metallic-enzymes and porphyrins. The ingestion of vast quantities of iron results in hemochromatosis. Hemochromatosis is a condition where normal regulatory mechanisms do not operate effectively leading to tissue damage as a result of the iron accumulation. In some instances of alcoholism, tissue damage has occurred through excessive intake of iron from alcoholic beverages (Central Water Commission (CWC) 2014; Mesías *et al.* 2013). Target organs are the liver, cardiovascular system, and kidneys.

The main aim of this study is to utilize natural adsorbent for purification of polluted water using Nitric Acid and Phosphoric Acid as an activating agent. Objectives of the study include utilization of periwinkle shell and Sodom Apple for the production of an adsorbent for water treatment; compare adsorbent activated using nitric acid ( $\text{HNO}_3$ ) and phosphoric acid ( $\text{H}_3\text{PO}_4$ ) in water treatment and compare adsorption tendency of Sodom Apple and Periwinkle Shell. is considered to be source of life and the most crucial of all natural resources.

### Sodom Apple

*Calotropis procera* is commonly known as Apple of Sodom. It is a species of flowering plant in the milkweed family (Asclepiadaceae) that is native to North Africa, Tropical Africa, Western Asia, South-Asia, and Indochina. It can also be found in roadsides, beachfront dunes, and watercourses. The plant grows well on sandy calcareous soils of coastal areas (Smith, 2002).



Figure 1: Plant of Sodom apple  
(source [en.m.wikipedia.org](https://en.m.wikipedia.org))



Figure 2: Flower of Apple of Sodom  
(source [www.healthbenefitstimes.com](http://www.healthbenefitstimes.com))

Sodom Apple is an upright flowering shrub or small tree which grows about 2.5 m (max 6) in height. It is relatively large greyish-green leaves (5-20 cm long and 4-10 cm wide) in pairs. Its flowers (20-30 mm across) have five petals that are white with purplish-colored tips and a purplish crown-like center, its fruit is a large (8-12 cm long) bladdery 'pod' which is greyish-green in color. This fruit splits open at maturity to release numerous seeds, each topped with a tuft of long, white, silky hairs (Weber, 2003). The stems are used as firewood and charcoal in impoverished areas. The coal is also used for polishing bull's horns. The smoky fire made from a stem is suitable for drying fish. The stem pith makes good tinder. The very light wood can also be used as fishing net floats. The stems are termite proof and used for roofing and building huts. Sodom apple (*Calotropis procera*) leaves can be used for mulching and green manure. It is planted to prevent soil erosion and is at times grown as an ornamental in dry or coastal areas. In Australia, *Calotropis procera* is considered an invasive plant. Leaf juice serves as a poison antidote, rubbed on scorpion stings and wounds infected by poisoned arrows; leaf pulp is taken to treat snakebites. They are occasionally taken by women to induce abortion. A leaf infusion or decoction is taken to treat colds, whooping cough, intestinal worms, psychosis and absence of menstruation. Dried leaf powder is sprinkled on wounds to improve healing and burnt ground leaves effectively reduce pain and swellings in rheumatic joints.

### Periwinkle

*Littorina littorea* is known as the common periwinkle, the edible periwinkle, and the wrinkle wrinkle. It is any marine small snail belonging to the family Littorinidae (class Gastropoda, phylum Mollusca). Periwinkle are found in many parts of the world widely distributed shore (littoral) snails, chiefly herbivorous, usually found on rocks, stones, or pilings between high- and low-tide marks; a few are found on mud flats, and some tropical forms are found on the prop roots or mangrove trees (Brenchley and Carlton, 1983).



Figure 3: Periwinkle on a mud  
(www.google.com)



Figure 4: Shell of a periwinkle  
(www.google.com)

Common periwinkle, *Littorina littorea*, is the largest, most common and widespread of the northern species. It may reach a length of 4 centimeters (1½ inches), is usually dark gray, and has a solid spiral (turbinate) shell that readily withstands the buffeting of waves. The average wrinkle lives three years and grows to a shell height of 16=38 mm, but the largest recorded wrinkle grew to 52 mm (Jackson, 2005). The width of the shell ranges from 10=12 mm at maturity. Periwinkles are also used as bait for catching small fish. The shell is usually crushed and the soft parts extracted and put on a hook. Periwinkles contain a huge amount of Omega-3 fatty acids. Omega-3 is an essential fatty acid and to

some extent polyunsaturated fat not produced by our body. The benefits of consuming omega-3 fatty acids are that it prevents heart diseases by reducing the risk of high blood pressure, improves our brain health by encouraging the development of cell membranes in the nervous system, and also helps in improving our memory (Chua B, *et al.*, 2006). Periwinkles equally contain high levels of magnesium. Our bodies need magnesium to strengthen bones, to maintain normal blood pressure, and also keep our heart in good condition. Periwinkle snails are also a great source of iron. Iron is essential for the formation of red blood cells and transporting energy around the body. Deficiency of iron can lead to enormous fatigue and anemia. It is also high in phosphorus. The function of phosphorus is to act as a passage of energy used for the metabolism of fats and starches. Phosphorus also helps the growth of healthy teeth and gums.

## 2. Materials and Methods

### Sample collection

Raw water was collected from three (3) different sources of water within and outside Nigeria (Cotonou, Katcha, Pategi) and polluted. Sodom apple (flower) was obtained from Tunga area in Minna, Niger State. The fleshy part of this flower had been removed, washed and then sun-dried for five (5) after collection. The well-dried flower was crushed and grinded with an electric blender and sieved to obtain the particle of uniform sizes.

Periwinkle shells were bought from Kure Ultra-modern market, Minna, Niger State. The periwinkle shells were crushed then washed with water more than once to remove the remnant of fleshy part and other surface impurities and then sun-dried for three (3) days. The crushed dried shell was pounded with a mortar and pestle until fine powder was obtained and then sieved with a sieve. Only the particles that passed through the mesh were used in my study.

### Carbonization

10 g of periwinkle shells were heated in a muffle furnace and carbonized at 900 °C (at 550 °C for one hour didn't carbonize) for three hours in the absence of air while the Sodom Apple was carbonized at 550 °C at one hour. The char material was cooled in a desiccator at room temperature before transferring into nylon.



Figure 5: Carbonized Sodom apple flower

Figure 6: Carbonized periwinkle shell

### Preparation of Activating agents

Preparation 4 M of  $\text{HNO}_3$  and 3 M  $\text{H}_3\text{PO}_4$ , 20% of both  $\text{HNO}_3$  and  $\text{H}_3\text{PO}_4$  was measured and transferred into a 500 ml volumetric flask containing distilled water. Water was added to fill up to the mark.

### Activation

5 g of carbonized periwinkle shells were weighed and soaked with 4 M of nitric acid, and 3 g of Sodom Apple were weighed and soaked with 3 M of phosphoric acid in a conical flask. The soaked charred samples were left for 6 hours at room temperature. The paste was washed with distilled water and then heated in a furnace for 1 hour at  $550\text{ }^\circ\text{C}$  in the absence of air to increase surface area of the charred samples, the activated samples were cooled at room temperature and stored in tight nylons.

### Adsorption Experiment

50 ml of raw water sample containing metal was added to a measured amount of activated carbonaceous material of periwinkle shell and Sodom Apple. The adsorbents were agitated using a stirrer for 20 minutes. The solution was filtered using Whatman no.1 filter paper and analyzed for the residue of concentrations of metals in the filtrate.



Figure 7: Filtrate of both activated periwinkle shell and Sodom apple



Figure 8: Filtrate stored in a plastic bottle

### Analysis of Samples

The filtered water samples were analyzed to determine the concentration of iron (Fe) using Atomic Absorption Spectrophotometer (AAS)-Flame. Characterisation of synthesized carbonaceous was carried out using Fourier Transform Infrared Spectroscopy (FTIR).

### 3. Results and Discussion

This chapter shows Atomic absorption spectroscopy (Flame) results of Fe concentration from contaminated water treated with natural adsorbent and Fourier Transform-Infrared Spectroscopy (FTIR) spectra of the absorption band of natural adsorbent (periwinkle shell and Sodom Apple).

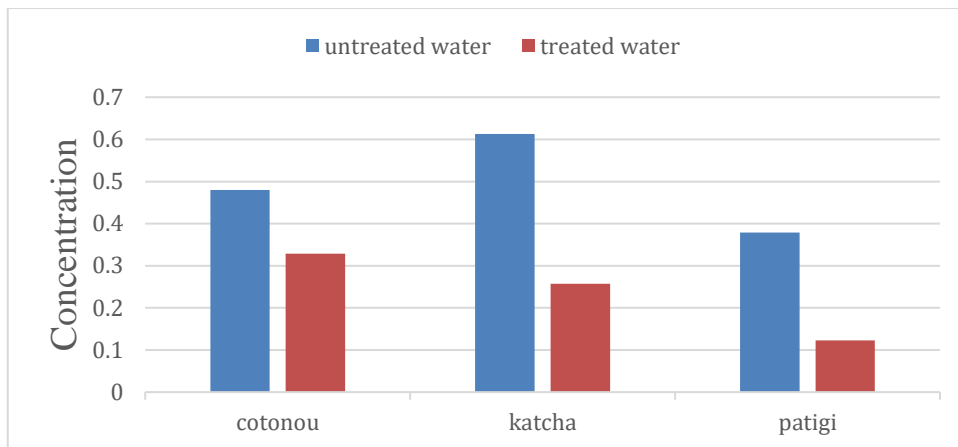


Figure 9 : Comparison of untreated water and treated water of periwinkle shell ( $\text{HNO}_3$ )

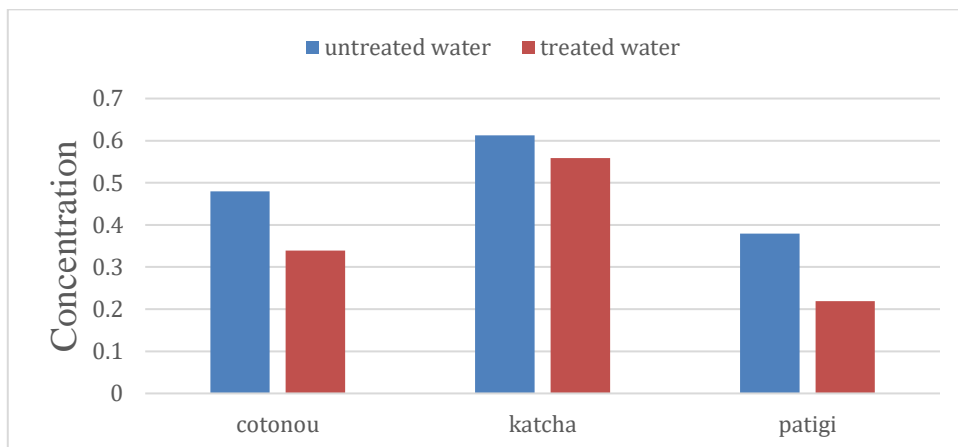


Figure 10: Comparison of untreated water and treated water of periwinkle shell ( $\text{H}_3\text{PO}_4$ )

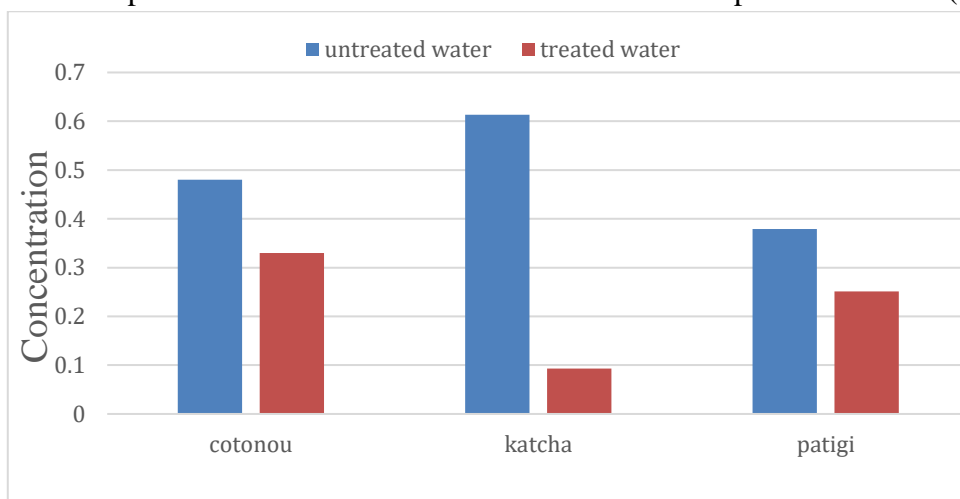


Figure 11: Comparison of untreated water and treated water of Sodom apple ( $\text{HNO}_3$ )

The comparison of iron concentration of untreated water and treated water using periwinkle shell and Sodom apple (with activating agent  $\text{HNO}_3$  or  $\text{H}_3\text{PO}_4$ ) on Atomic absorption spectroscopy (AAS)-Flame of polluted water collected from three (3) different sources of water within and outside Nigeria (Cotonou, Katcha, Patigi) were examined. The result of iron concentration of untreated water and treated water samples using periwinkle shell ( $\text{HNO}_3$ ) is illustrated in Figure 9. Fe concentrations were 0.480 ppm (Cotonou), 0.613 ppm (Katcha) and 0.379 ppm (Patigi) for the untreated water. The results of Fe concentration in water treated with adsorbent (periwinkle shell) activated using  $\text{HNO}_3$  were 0.329 ppm (Cotonou), 0.257 ppm (Katcha), and 0.219 ppm (Patigi). Katcha water sample gave a 58 % reduction in Fe concentration after treatment with periwinkle shell. The value was higher than 31 and 42 % obtained for Cotonou and Patigi respectively. This finding suggests that periwinkle shells activated with  $\text{HNO}_3$  can be used to remove Fe from water samples.

From Figure 10, treatment using periwinkle shell activated using ( $\text{H}_3\text{PO}_4$ ) gave Fe concentrations of 0.339 (Cotonou), 0.559 (Katcha) and 0.219 (Patigi). The water treated with periwinkle shells activated with  $\text{H}_3\text{PO}_4$  showed lower Fe ppm (Patigi). This shows that the periwinkle shell on activation serves as a remediation of polluted water. Although the concentration of untreated and treated are not too far as shown from the Figures 9 - 11. Comparing the two activating agents ( $\text{HNO}_3$  and  $\text{H}_3\text{PO}_4$ ) of the periwinkle shell from the two graph (Figures 9 and 10), it shows that periwinkle shell with activating agent ( $\text{HNO}_3$ ) remediate the water samples much more than that of periwinkle shell with activating agent ( $\text{H}_3\text{PO}_4$ ). From Figure 11, treatment using Sodom apple gave Fe concentration ranging from 0.330 ppm (Cotonou), 0.093 ppm (Katcha) and 0.251 ppm (Patigi). Katcha water sample with 0.613 ppm Fe concentration for raw water gave a value of 0.093 ppm after treatment with the Sodom apple flower. The value obtained was lower than values obtained when water samples from Cotonou and Patigi locations were treated. These results thus suggest that Sodom apple flower activated with  $\text{HNO}_3$  can be used for the removal of Fe in raw or untreated water samples.

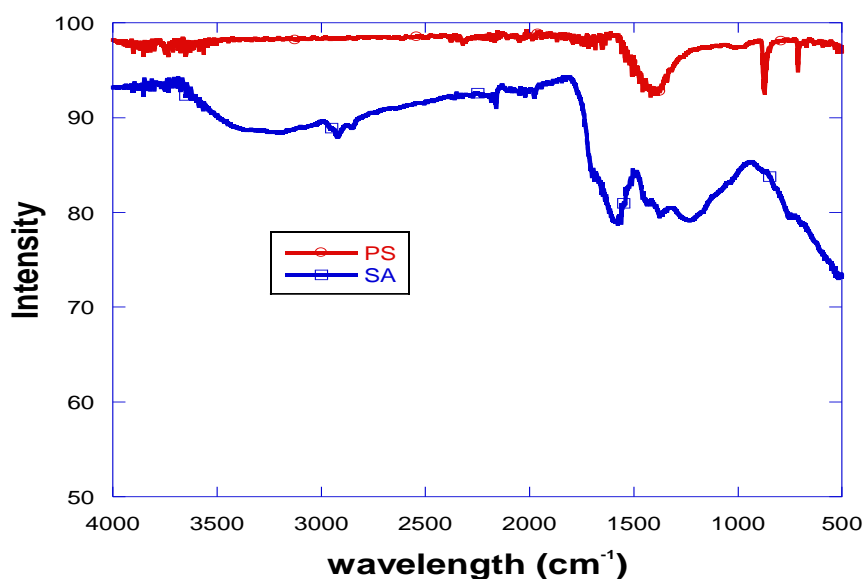


Figure 12: FTIR results for samples periwinkle shell and Sodom apple

From the FTIR analysis above, it can be seen that periwinkle shell (P.S) was completely carbonized with no functional group except the C-C bond with adsorption peak of less than  $1500\text{ cm}^{-1}$  while the sample Sodom apple flower which was carbonized and activated with nitric acid ( $\text{HNO}_3$ ) showed an adsorption peak of  $3300\text{ cm}^{-1}$  which is an indication of N-H bond though there are other bond at  $1600\text{ cm}^{-1}$  indicating a C=O bond likely from the interaction between the Carbon and activating agent. From the result of AAS, Sodom apple flower shows a better abstraction of heavy metals, this is likely to be as a result of functional absence from the FTIR result that is N-U and C=O.

#### 4. Conclusions

This study has shown that carbonized Sodom apples activated with  $\text{HNO}_3$  and carbonized periwinkle shells activated with  $\text{HNO}_3$  or  $\text{H}_3\text{PO}_4$  can be used to remove heavy metal from the polluted water samples. The untreated water iron concentration ranges from 0.480 ppm (Cotonou), 0.613 ppm (Katcha) and 0.379 ppm (Patigi). This shows that from the table of results the Fe concentration of adsorbent (periwinkle shell and Sodom apple) activated with either  $\text{HNO}_3$  or  $\text{H}_3\text{PO}_4$  ranges was lesser than that of the untreated water. This shows that these adsorbents exhibit a good method of polluted water remediation.

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## EVALUATION OF THE CURATIVE POTENTIALS OF METHANOL EXTRACT OF *Citrus aurantifolia* LEAVES IN *Plasmodium berghei* - INFECTED MICE

Sadiyat Oyiza Ibrahim<sup>1</sup>, Zainab Adamu<sup>1</sup>, Rabiya Unekwu Hamzah<sup>1</sup>,  
Asmau Niwoye Abubakar<sup>1</sup>, Garba Rahinat<sup>1</sup> and Umar Maimuna Bello<sup>1\*</sup>

<sup>1</sup>Department of Biochemistry, School of Life Sciences, P.M.B 65, Bosso Campus, Federal University of Technology, Minna, Nigeria.

Corresponding author: e-mail: [maimuna.umar@futminna.edu.ng](mailto:maimuna.umar@futminna.edu.ng)

[Phone no.: +2348035924168](tel:+2348035924168)

### Abstract

Malaria remains a public health problem, with most front line drugs not able to clear parasite infection completely due to parasite resistance. With the increased tempo in the search for new chemotherapeutic agents against malaria, the use of medicinal plants by extracting active principles still remains the most appealing option. Phytochemical screening and *in vivo* antiplasmodial potential of methanol extract of *Citrus aurantifolia* leaves in *Plasmodium berghei* infected mice were carried out using standard methods. Infected mice were grouped into five groups of five mice each. Treatment commenced 72 hours post infection and lasted for five consecutive days, with daily parasitaemia levels monitored. The packed cell volume (PCV) of the experimental animals was also monitored before infection, before the commencement of treatment and after treatment. Three groups A, B and C were administered 200, 400 and 600 mg/kg body weight (b.w) of methanol extract of *Citrus aurantifolia* leaves respectively. Group D was administered 5 mg/kg b.w Chloroquine (standard drug). Group E was left untreated, while a sixth group of five mice was not infected and not treated. The animals were also monitored for any mortality for a period of 28 days and the mean survival time calculated in days. The methanol extract of *Citrus aurantifolia* leaves was found to contain tannins, steroids, terpenoids, glycosides, anthraquinones and flavonoids. The percentage parasite inhibition as well as the mean survival time were calculated to be (50.51 %, 12.67±1.45 days), (57.78 %, 17.33±0.88 days), (63.59 %, 22.67±0.67 days) and (70.67 %, 28.33±0.88) for groups treated with 200, 400, 600 mg/kg b.w of the extract and 5 mg/kg b.w of chloroquine respectively. There was no significant difference in percentage packed cell volume after treatment. The results obtained from this study indicate that *Citrus aurantifolia* leaves have appreciable antiplasmodial activity against *Plasmodium berghei* infected mice in a dose dependent manner. However, bioactive-guided purification of the crude extract could bring about specific bioactive compound(s) for antiplasmodial activity which could result in a much higher percentage parasite inhibition.

**Keywords:** Antiplasmodial, *Citrus aurantifolia*, *Plasmodium berghei*, chloroquine, percentage inhibition

## 1. Introduction

Malaria is a disease caused by protozoan micro parasite of the genus *Plasmodium*. It is a leading cause of mortality especially in children below the age of five across many tropical and subtropical countries (Monroe *et al.*, 2022). The discovery of ACT could be considered as the most noteworthy achievement of ethnopharmacological research in the 20<sup>th</sup> century. However, clinically relevant Artemisinin resistance is likely to occur since it has been obtained in laboratory models (WHO, 2016). Although global priority is to reduce the high malaria burden while retaining the long-term vision of eradication, the world malaria report 2022 estimates 247 million cases of malaria and 619,000 deaths in 2021 (WHO, 2022). This might be attributed to resistance to frontline antimalarial drugs which result to treatment failure in significant number of cases and the emergence of COVID-19 infections, owing to limited access to malaria health care services in WHO African region. Moreover, the recently licensed malaria vaccine exhibits limited efficacy (Atanu *et al.*, 2021). Hence, the need for cost effective and more efficacious alternative. Folklore use of medicinal plants is a common global practice due to accessibility, cultural acceptability, and relative affordability (Qayum *et al.*, 2016). In fact, many reviews of plant-derived drugs and their contribution to the global disease pandemic agree that the future of drug discovery lies in isolation, identification and characterization of secondary metabolites from medicinal plants (Calixto, 2005). *Citrus aurantifolia* commonly known as “Lime”, is widely used traditional medicine in West Africa, particularly in Nigeria (Odediran *et al.*, 2020) for a plethora of diseases including fever, headache, jaundice, sore throat, oral thrush, arthritis, colds, coughs, as an antiseptic, antiviral, antifungal, anthelmintic, mosquito repellent, etc. (Enejoh *et al.*, 2015). This research was carried out to investigate the curative potentials of methanol extract of *Citrus aurantifolia* leaf in *Plasmodium berghei* infected mice.

## 2. Materials and Methods

### Parasites

The chloroquine sensitive *Plasmodium berghei berghei* (NK-65) was obtained from National Institute for Pharmaceutical Research and Development (NIPRD) Idu, Abuja, Nigeria. The parasites were kept alive by continuous re-infestation (I.P) in mice (Carvalho *et al.*, 1991) every 10 days.

### Animals

Thirty Albino mice of both genders, weighing between 20 g to 31 g were obtained from Nigerian Institute of Veterinary Research (NIVR), Jos, Nigeria. The animals were fed *ad libitum* with standard feed and had free access to water. They were also maintained under standard conditions of humidity, temperature and 12 hrs light/darkness cycle. The animals were acclimatized for two weeks before the commencement of the study. A standard protocol was drawn up in accordance with the Good Laboratory Practice (GLP) regulations (ENV/MC/CHEM (98) 17, 1998). The principle of laboratory animal care (NIH Publication No. 85-23, 1985) was also followed in this study.

### Sample Collection

Leaves of *Citrus aurantifolia* (key lime) were collected with permission from a garden in Maikunkele, Bosso Local Government Area of Minna, Niger State and identified in the Department

of Plant Biology, Federal University of Technology, Minna. They were washed in clean tap water, shade dried at room temperature and pulverized.

### Sample Extraction

The pulverized *C. aurantifolia* leaves (90 g) was extracted with 100 % methanol using a reflux method as described Cho *et al.* (2003). The filtrate obtained was concentrated by subjecting it to solvent recovery using a rotary evaporator set at 60 °C. The extract was placed in a water bath set at 60 °C to remove all traces of methanol and to yield the extract concentrate.

### Screening of the presence of Secondary Metabolites in the Plant Extract

Qualitative phytochemical screening of the plant extract was carried out according to methods described by Trease and Evans (1989), Siddiqui and Ali (1997) and Sofowora (2006).

### Inoculums

Parasitized erythrocytes were obtained from a donor- infected mouse by cardiac puncture in heparin and made up to 20 mL with normal saline. Animals were inoculated intraperitoneally with infected blood suspension (0.2 mL) containing about  $1 \times 10^7$  parasitized erythrocytes.

### Induction of Malaria and Monitoring of Parasitaemia

A total of twenty mice were used for this study. On the first day ( $D_0$ ), standard inoculums of  $1 \times 10^7$  *P. berghei berghei* infected red blood cells were injected into the mice intraperitoneally. Seventy-two hours later (after confirmation of infection), the mice were divided into five groups of four mice each. Different doses of the extract (200, 400 and 600 mg/kg/day) were administered orally to three groups. Chloroquine phosphate (5 mg/kg/day) was administered to the positive control group and 0.2 mL/day of distilled water was administered to the negative control group (infected not treated). The treatment lasted for five days at a single dose per day and daily blood smears were collected and examined microscopically to monitor the parasitemia level. The percentage parasite inhibition was calculated using the formula:

$$\frac{\text{Mean parasitemia in negative control group} - \text{Mean parasitemia in treated group}}{\text{Mean parasitemia in negative control group}} \times 100$$

The mean survival time for each group was determined arithmetically by finding the average survival time (days) of the mice (post-inoculation) in each group over a period of 28 days ( $D_0$ - $D_{27}$ ) (Ryley and Peters (1970); Chandel and Bagai (2010)).

### Determination of Packed Cell Volume

Packed cell volume (PCV) was determined using the capillary method for each mouse after inoculation and after treatment. Tail blood was collected into a heparinized hematocrit tubes, filled to  $2/3^{\text{rd}}$  of their volume and sealed at one end with plasticing, arranged on the micro hematocrit centrifuge and thereafter centrifuged for about 10,000 rpm for 5 minutes. The volume of cells was calculated as shown below:

$$\text{PCV} = \frac{\text{Erythrocyte Volume}}{\text{Total Blood Volume}} \times 100$$

### Data Analysis

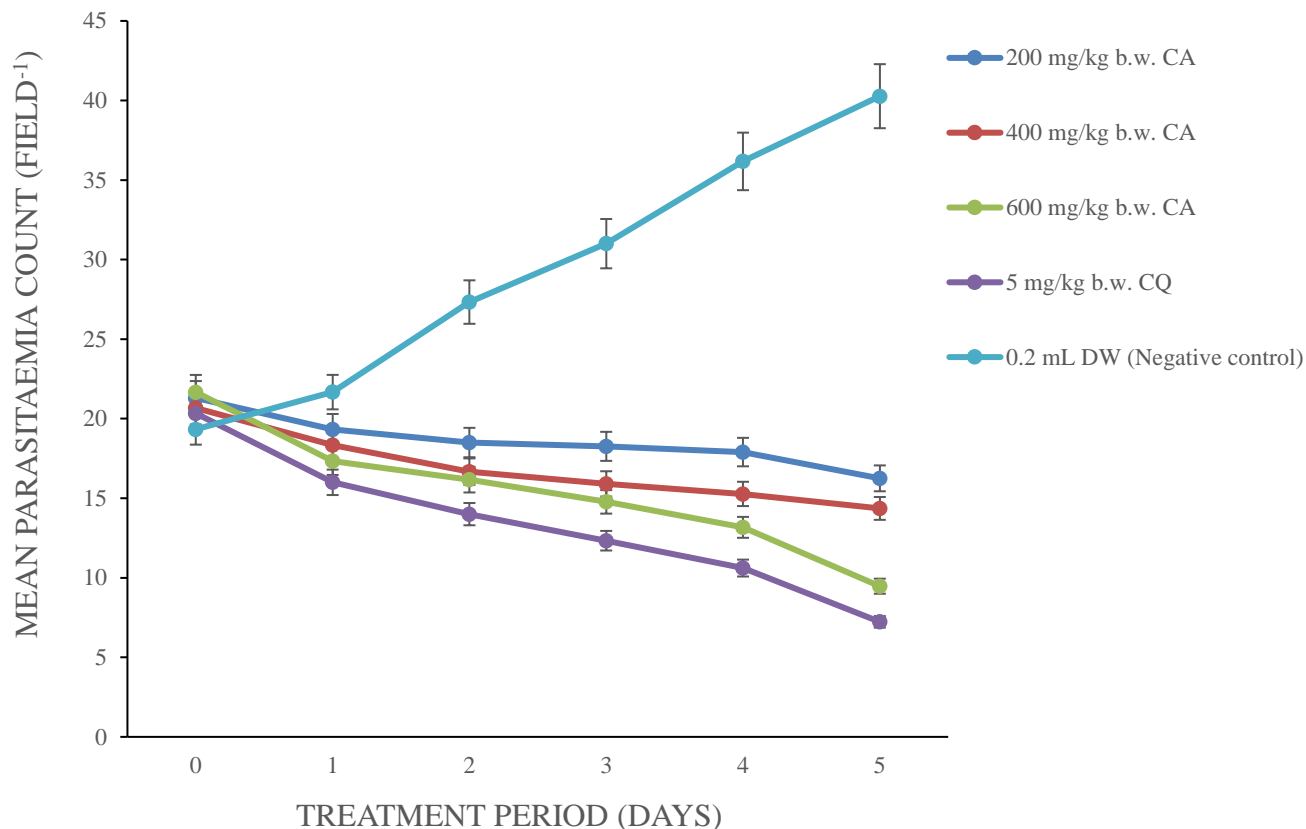
Data were calculated as mean  $\pm$  SEM and were analysed statistically using One-way ANOVA followed by Duncan multiple comparison test and values of  $p < 0.05$  were considered significant. Statistical Package for Social Sciences (SPSS), 20<sup>th</sup> version was used.

### 3. Results

**Table 1: Composition of Secondary Metabolites in Methanol Extract of *Citrus aurantifolia* Leaves**

<b>SECONDARY METABOLITES</b>	<b>INFERENCE</b>
<b>Alkaloids</b>	-
<b>Glycosides</b>	+
<b>Steroids and Terpenoids</b>	+
<b>Tannins</b>	+
<b>Reducing Sugars</b>	+
<b>Anthraquinones</b>	+
<b>Phlobatannins</b>	-
<b>Saponins</b>	-
<b>Flavonoids</b>	+
<b>Phenols</b>	-

Key: + = Present, - = Not detected.



**Figure 1: Antiplasmodial Effect of Methanol Extract of *Citrus aurantifolia* Leaves in *Plasmodium berghei*-infected Mice**

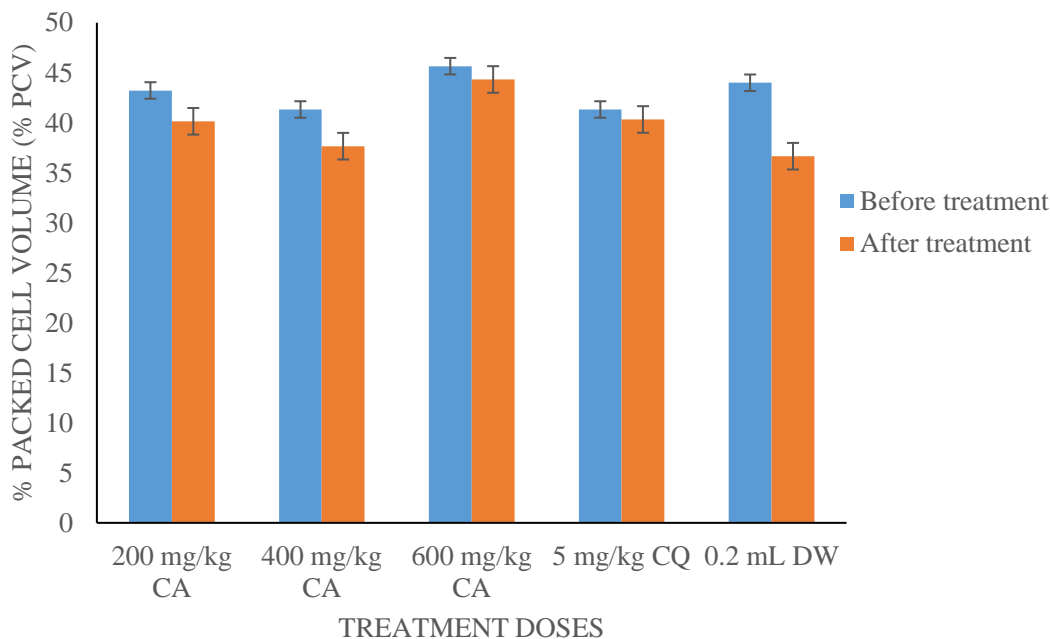
Keys:

CA: Methanol extract of *Citrus aurantifolia*

CQ: Chloroquine phosphate

DW: Distilled water

mg/kg b.w.: milligram per kilogram body weight



**Figure 2: Percentage Packed Cell Volume (PCV) of Plasmodium berghei-infected Mice treated with Methanol Extract of *Citrus aurantifolia* Leaves**

**Table 2: Mean Survival Time (Days) of Plasmodium berghei-infected Mice treated with Methanol Extract of *Citrus aurantifolia* Leaves**

Group	Dose (mg/kg b.w.)	Percentage parasite inhibition (%)	Mean survival time (Days)
Methanol extract of <i>Citrus aurantifolia</i>	200	50.51	12.67±1.45
Methanol extract of <i>Citrus aurantifolia</i>	400	57.78	17.33±0.88
Methanol extract of <i>Citrus aurantifolia</i>	600	63.59	22.67±0.67
Chloroquine phosphate	5	70.67	28.33±0.88
Distilled water	0.2 mL	-	3.33±0.33



#### 4. Discussion

The secondary metabolites present in the methanol extract of *Citrus aurantifolia* leaves such as alkaloids, flavonoids, tannin and anthraquinones, have been implicated in antimalarial activity of many medicinal plants (Christenzen and Kharazmi, 2001). When a standard antimalarial drug is used in mice infected with *P. berghei*, it suppresses parasitaemia to non-detectable level (Kamei *et al.*, 2000), which is in agreement with the effect of chloroquine and *Citrus aurantifolia* (at a dose of 600 mg/kg) in this study. The observed antimalarial activity in this study was dose dependent, with the group treated with 600 mg/ kg body weight having the highest percentage reduction in parasitaemia amongst the extract treated groups and the effect of the extract compared favourably with chloroquine. This is similar to the work of Ettebong *et al.* (2019) who reported the antimalarial activity of methanol extract of *Citrus aurantifolia* leaves at dose of 960 mg/kg body weight. A similar work by Laksemi *et al.* (2023) reported the percentage parasite suppression of Plasmodium berghei when *Citrus aurantifolia* was combined with stingless bee honey to be 78.8 % (Laksemi *et al.*, 2023). There was no significant ( $p \geq 0.05$ ) difference in the packed cell volume (PCV) of the chloroquine and methanol extract of *Citrus aurantifolia* leaves (600 mg/kg b.w.) treated groups before and after treatment. However, there was significant drop in the PCV of the infected and not treated group. The drop in the PCV that is responsible for malarial anaemia occurs both through an increase in the rate at which old Red blood cells are broken and a decrease in the rate at which new ones are produced. Plasmodium not only causes the rupture of parasitized red blood cells, but stimulates the activity of macrophages in the spleen, which then destroys both parasitized and unparasitized red blood cells. The observed high survival time of the group treated with 600 mg/kg body weight compared to the other extract treated groups might not be unconnected with the dose dependent parasite inhibition.

#### Conclusions

The present study revealed that oral administration of methanol extract of *Citrus aurantifolia* leaves exhibited antimalarial activity against *P. berghei*-infected mice. This suggests the beneficial effects of the plant. The findings in this study have also lent scientific support to the folkloric use of *Citrus aurantifolia* in the treatment of several ailments including fever and malaria.

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## PETROGRAPHIC INTERPRETATION OF CHARNOCKITIC ROCKS FROM OSUNTEDO AND WASIMI, SOUTHWESTERN NIGERIA

Ehitua Julius Oziegbe<sup>1</sup> and Olubukola Oziegbe<sup>2</sup>

<sup>1</sup>Department of Geosciences, Faculty of Science, University of Lagos, Nigeria

<sup>2</sup>Department of Biological Sciences, Covenant University, Nigeria

Corresponding author Email: ([eoziegbe@unilag.edu.ng](mailto:eoziegbe@unilag.edu.ng))

### Abstract

Samples of charnockitic rocks from Osuntedo and Wasimi were subjected to petrographical analysis to determine the mineral present and the textural relationship of the mineral assemblage. It was observed that the charnockitic rocks contain pyroxene, biotite, amphibole, plagioclase feldspar, orthoclase and quartz with apatite and titanite present as accessory mineral. The textural relationship shows pyroxene included in biotite, and biotite mantling pyroxene. Also, amphibole reaction rims were noted around pyroxene, biotite, plagioclase and quartz. In addition, there were inclusions of euhedral apatite in biotite, antiperthite is surrounded by orthoclase feldspars. Plagioclase feldspar show zoning and bent twin lamellae. The sequence of crystallization of minerals follows the order; pyroxene, biotite and plagioclase, with amphibole showing a late appearance. The textural relationship of the minerals in the charnockitic rocks of Wasimi and Osuntedo demonstrate that the rocks are of igneous origin. Charnockitic rock of Wasimi contain more quartz compared to that of Osuntedo.

**Key words:** Hypersthene, antiperthite, reaction rim, zoning, apatite

### 1. Introduction

Charnockites are orthopyroxene (hypersthene) bearing rocks. Charnockite are used to describe orthopyroxene-bearing igneous rocks as well as orthopyroxene-bearing granitic orthogneisses associated with granulite terranes (Frost and Frost, 2008). Charnockite can be of igneous or metamorphic origin (Bohlender et al., 1992; Touret and Huizenga, 2012). Orthopyroxene formed from prograde form of metamorphism occur in very low water activity environment ((Newton et al., 1980; Waters, 1988; Ballèvre et al., 1997). Charnockitic rocks has been recognized as one of the major group of the rocks of the Basement complex of southwestern Nigeria (Hubbard, 1975; Rahaman, 1976). Charnockite remnants have been recognized in the north and center of the large elongate Ikire-Iwo complex (Figure 1). Field observation complemented with geochemical evidence show that the charnockite-granite association in Ado-Ekiti of southwestern Nigeria forms a cogenetic sequence similar to rapakivi granite-anorthosite-charnockite (Olawajaju, 1987). Charnockite occurring as individual bodies has been described by Rahaman (1976) as the third type (in terms of occurrence), which is found in Lagun, Awo and Osuntedo areas of Southwestern Nigeria. The charnockite of Osuntedo occur as isolated hills, dark-grey to greenish in colour (Figure 2). Charnockite at Wasimi is porphyritic in texture, and dark grey in colour which often occur as isolated low-lying outcrops (Figure 3). Charnockite has been reported to find various uses most

especially in the construction industries. Soils derived from charnockite has found suitable use pavement layer material (Kayode and Akinwunmi, 2017). In General, charnockite is an important rock in the list of heritage stones (Sreejith et al., 2001). This study is aimed at using microstructural features to interpret the crystallization sequence of minerals in charnockite.

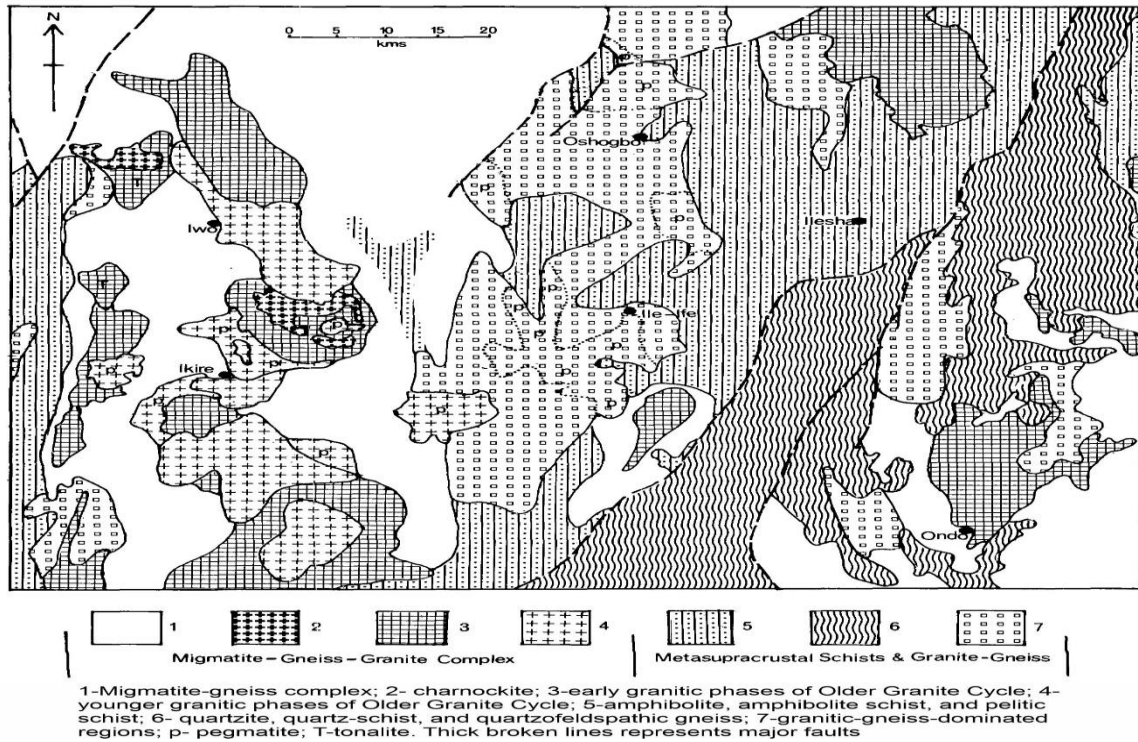


Figure 1: Geologic map of Iwo region showing Ikire-Wasinmi complex (Hubbard, 1975).



Figure 2: a) Field photograph of charnockitic rock from Osuntedo. b) Hand specimen of rock sample from osuntedo



Figure 3: Field photograph showing charnockite from Wasimi

## 2. Methodology

Four fresh rock samples (two each) were taken from both Osuntedo ( $07^{\circ} 41.863'N$ ,  $04^{\circ} 19.903'E$  &  $N07^{\circ} 41.424'N$ ,  $04^{\circ} 20.268'E$ ) and Wasimi ( $07^{\circ} 26.123'N$ ,  $04^{\circ} 15.893'E$  &  $07^{\circ} 25.960'N$ ,  $04^{\circ} 15.775'E$ ) areas of southwestern Nigeria. Eight thin sections (two from each rock) were prepared at the laboratory of Department of Geology, Obafemi Awolowo University, Ile-Ife, Nigeria. Petrographic studies of prepared thin sections were carried out at the Department of Geosciences, University of Lagos using a polarizing microscopes and photomicrographs of areas of interest were taken using a digital camera.

## 3. Results

### Petrography

#### Osuntedo charnockite

The rock texture can be described as hypidiomorphic granular. Most pyroxene crystals are euhedral to subhedral (Figures 4a-4d). Pyroxene occur as inclusion in biotite (Figure 5a). Amphibole forms reaction rim around both pyroxene and biotite (Figure 5b). Biotite are randomly oriented and in some cases mantles pyroxene (Figure 5b). Euhedral crystals of apatite are included in biotite (Figure 5b) while pyroxene occur as inclusions in plagioclase feldspar (Figure 5c). Some biotite grains have deformed cleavages (Figure 5d). Carlsbad twinning is common in K-feldspar (Figure 5c), while

plagioclase have a combination of both Carlsbad and albite twinning (Figure 4b). Anterperthitic plagioclase mantled by orthoclase feldspar was observed (Figure 5c).

### Wasimi charnockite

The pyroxene grains are euhedral to subhedral in shape. Large phenocrysts of clinopyroxene contains inclusions of orthopyroxene (Figures 6a & 6b). Amphibole forms reaction rim around pyroxene and biotite (Figures 6a-6d, 7a-7d). Plagioclase is included in amphibole (Figure 6b). Pyroxene which have reaction rims are included in biotite (Figures 7c).

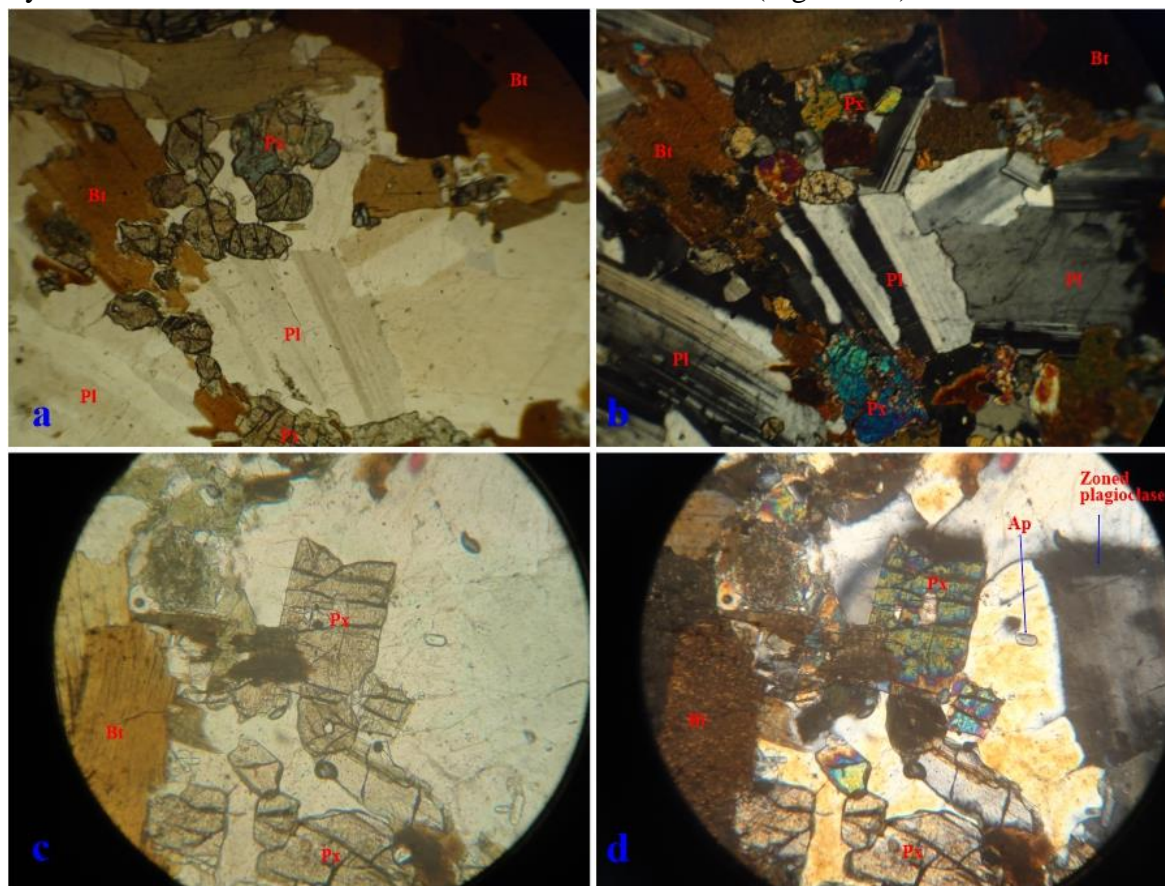


Figure 4: Photomicrographs of charnockite from Osuntedo showing a) euhedral to subhedral pyroxene b) euhedral to subhedral plagioclase feldspar exhibiting a combination of both polysynthetic and Carlsbad. XPL c) euhedral to subhedral pyroxene d) euhedral to subhedral plagioclase feldspar exhibiting a combination of both polysynthetic and Carlsbad, euhedral apatite included in plagioclase. XPL



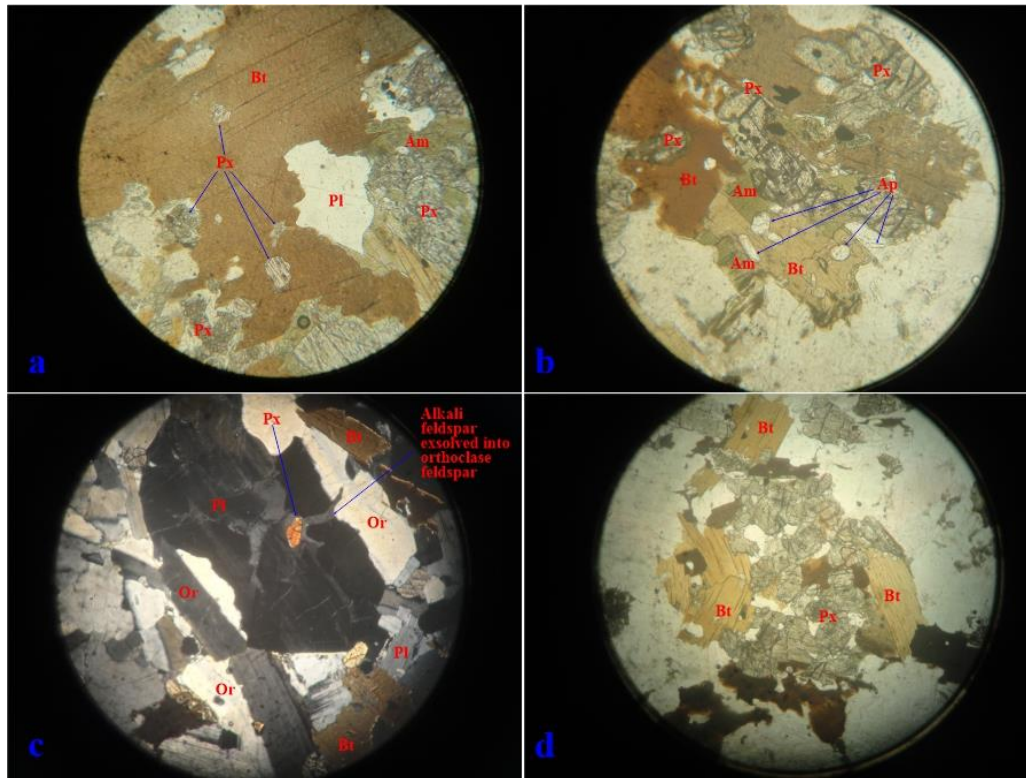


Figure 5: Photomicrographs of charnockite from Osuntedo showing a) pyroxene as inclusions in biotite. PPL b) amphibole (Am) forming a rim round pyroxene (Bt) and biotite (Bt)apatite (Ap) as inclusions in biotite (Bt). PPL c) inclusion of pyroxene in antiperthitic plagioclase. Take note of the irregular shape of the enclosed alkali feldspar. XPL d) deformation of biotite, take note of the bent cleavages. Orthoclase (Or) mantles the antiperthitic plagioclase. PPL

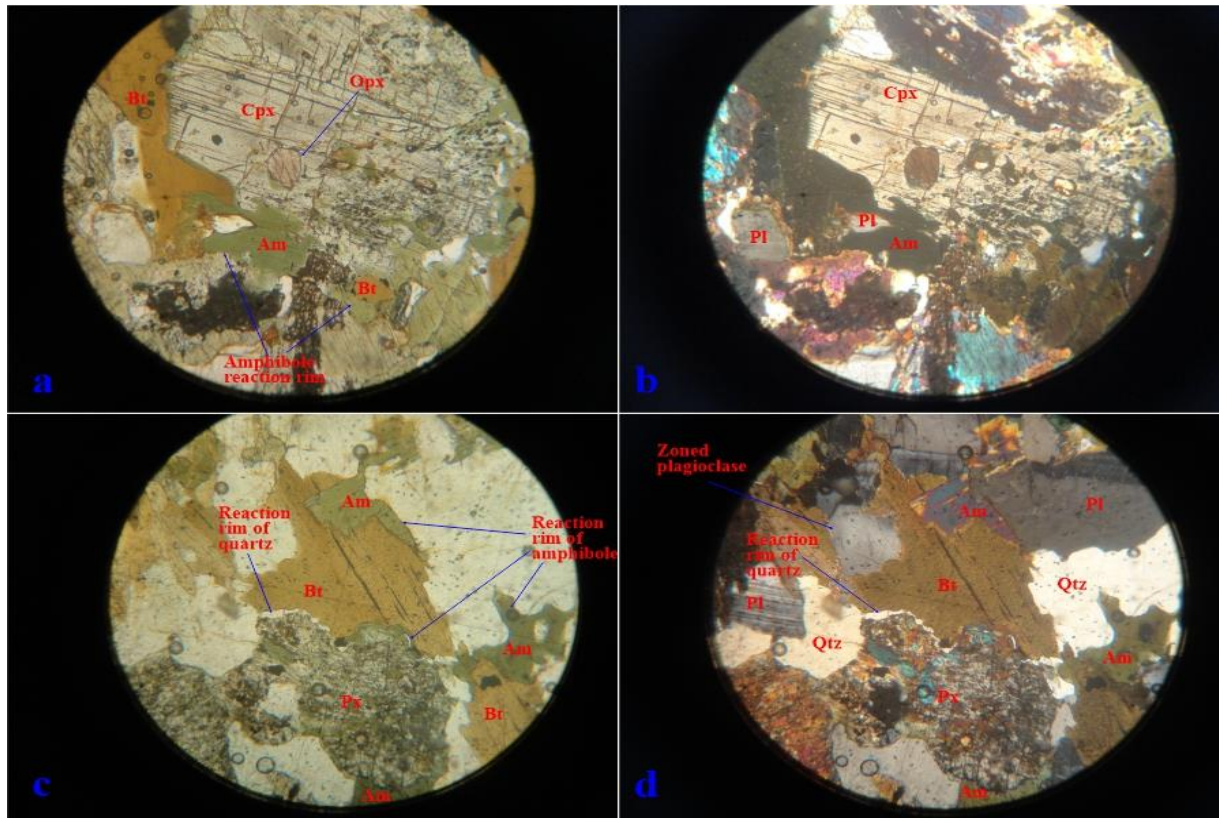


Figure 6: Photomicrograph of charnockite from Wasimi showing a) orthopyroxene (Opx) included in clinopyroxene, amphibole forming reaction rim on clinopyroxene (Cpx) and biotite (Bt). PPL b) plagioclase (Pl) occurring as inclusions in amphiboles (Am). c) reaction rim of amphibole on both pyroxene (Px) and biotite (Bt), amphibole cuts through cleavages of biotite (Bt). PPL d) zoned plagioclase and altered pyroxene, amphibole (Am) forming reaction rim around plagioclase (Pl). XPL

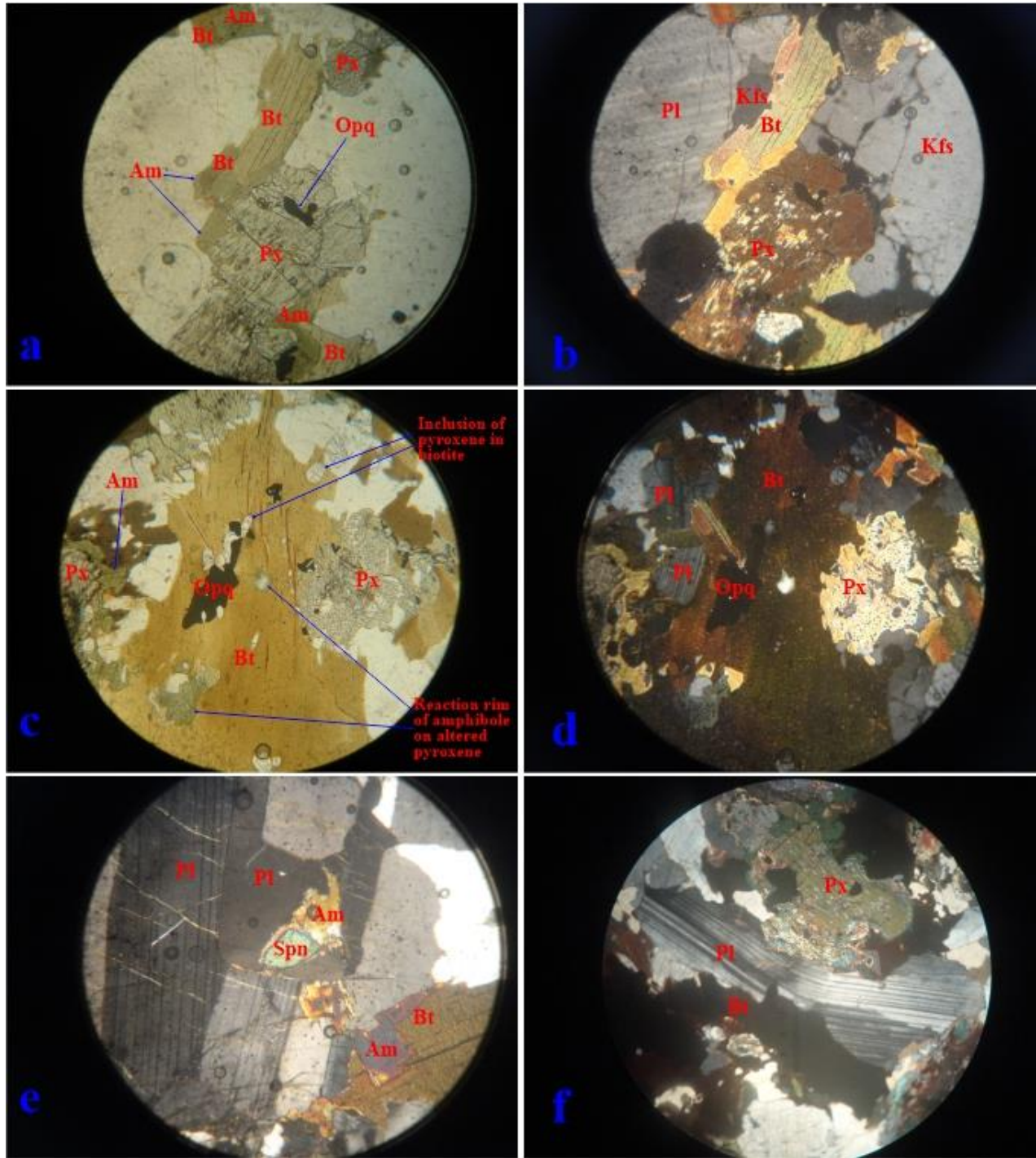


Figure 7: Photomicrographs of charnockite from Wasimi showing a) amphibole form a reaction rim around pyroxene (Px) and biotite (Bt), opaque minerals occurring as inclusions in pyroxene (Px). PPL b) K-feldspar in contact with biotite c) amphibole form a reaction rim around pyroxene which is included in biotite, opaque minerals occurring as inclusions in biotite (Bt). PPL d) plagioclase (Pl) in close association with biotite (Bt) and pyroxene (Px) e) spinel with a reaction rim of amphibole occurring as inclusion in plagioclase. XPL f) bent twin lamellae of plagioclase of charnockite from Wasimi. XPL

Reaction rim forms around sphene which is included in plagioclase (Figure 7e). Plagioclase feldspars showing zoning (Figure 6d). Also, plagioclase crystals have bent cleavages which is an evidence of deformation (Figure 7f). Quartz is anhedral and associated with the other minerals, most especially euhedral plagioclase (Figure 6d).

#### 4. Discussion

Charnockite from Osuntedo and Wasimi both contain pleochroic pyroxene which is hypersthene, and there is no preferred fabric for minerals. Both charnockites have porphyritic textures with euhedral to subhedral crystals (Figures 4a, 4b, 5b & 6a). Charnockite of igneous origin have been reported to have euhedral to subhedral crystals of both pyroxene and feldspar (Frost et al., 2000). Porphyritic texture in charnockite is characteristic of igneous origin (Ramaswamy and Murty, 1973). Euhedral apatite (Figure 5b) in charnockite is believed to indicate magmatic origin. Also, euhedral sphene (Figure 7c) suggests magmatic origin. The fact that amphibole forms reaction rim around pyroxene and biotite (Figures 5b, 6a, 6c & 7a), is an indication that amphibole was formed later. Amphiboles usually form in the late stage of crystallization in charnockite (Liu et al., 2006; Zhang et al., 2010). Also, plagioclase occur as inclusion in amphibole (Figure 6b), suggesting that plagioclase was formed before amphibole. A similar crystallization sequence with late amphibole has been reported in igneous pyroxene-bearing granitoid of Northeastern Superior province, Canada (Percival and Mortensen, 2002). Moreover, late crystallization of amphibole has been reported in the granodiorite of Wasimi (Oziegbe et al. 2023). Experimental studies have suggested that dry magmas do crystallize pyroxenes in the early stages while biotite and amphiboles are produced at lower temperature in the later stages of magmatic differentiation (Green and Lambert 1965, Naney, 1983). Amphibole could have formed by late-magmatic or submagmatic conditions (Zhang et al., 2010). The opaque minerals form close to pyroxene which are associated with biotite (Figures 5b & 7a). Plagioclase feldspars show zoning (Figures 4d & 6d) which is typical of feldspars of magmatic origin (Wiebe, 1968; Shcherbakov et al., 2011). The bent cleavage of plagioclase is an indication that the rock has been subjected to plastic deformation (Olsen and Kohlstedt, 1985). Deformation and recrystallization during emplacement are characteristic feature of intrusive charnockites (Kilpatrick and Ellis, 1992). Such deformation has been reported in the granodiorite of this region (Oziegbe et al., 2020). Charnockitic rocks from southwestern Nigeria have been previously reported to show traits of deformation (Ademeso and Olaleye, 2014). Antiperthitic plagioclase (Figure 5c), is a common phenomenon in charnockitic rocks (Heinrich, 1956; Hubbard, 1965). Antiperthitic plagioclase occurs in close association with orthoclase feldspar, with the latter mantling the former (Hubbard, 1965). A texture where alkali feldspar in the antiperthite, exsolved into the surrounding orthoclase (Figure 5c), suggests that both minerals formed depending on each other (Hubbard, 1965). Synneusis has been suggested for such texture (Stull, 1979). Quartz grains which occur in contact with pyroxene and amphibole, and in some other cases forms thin reaction rim on pyroxene (Figure 6d), can be described as interstitial (Bédard, 2003; Bédard et al., 2003). Charnockites containing quartz are described as enderbite. Enderbite has been described as igneous

rock which is a member of the Charnockite rock series (Frost and Frost, 2008). Although, Hubbard (1965) had earlier described the charnockites of Wasimi as enderbitic.

## 5. Conclusions

Both charnockites from Osuntedo and Wasimi show great similarity in terms of microstructures, but charnockite from Wasimi show more alteration of pyroxene and the presence of quartz. Our detailed microstructural studies give the sequential order of crystallization as, orthopyroxene, clinopyroxene, biotite, plagioclase, K-feldspar, quartz and amphibole, and thus suggests the these charnockites to be of igneous origin.

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## AN ENVIRONMENTALLY-FRIENDLY TRANSFORMER OIL FROM CASHEW KERNEL OIL AND ZNO-NANOPARTICLES

S. Umar<sup>1\*</sup>, A.S. Gene<sup>1</sup>, I. Musa<sup>2</sup>, H.A. Mohammed<sup>1</sup>

<sup>1</sup>Department of Physics, Ibrahim Badamasi Babangida University, Lapai

<sup>2</sup>Department of Mathematics, Ibrahim Badamasi Babangida University, Lapai

\*Correspondence: [sadiqmx@gmail.com](mailto:sadiqmx@gmail.com)/[sumar@ibbu.edu.ng](mailto:sumar@ibbu.edu.ng) Tel. 07030976078

### Abstract

The increasing concern over the environmental impact of petroleum-based transformer oil has prompted research into alternative insulation and cooling liquids. In this study, a composite thermal liquid was developed from cashew kernel oil using a two-step approach without the use of surfactants. The liquid was filled with 0.2 wt% to 1.5 wt% of functionalized zinc-oxide nanoparticles (ZnO-NPs) as a filler material. The stability of the nanofluid was evaluated using UV-Vis spectrometry and showed good stability after 168 hours of observation. The addition of 1.5wt% of filler material enhanced the thermal capacity of the base liquid by about 19%, and the sample had a viscosity of 0.031Pa.s and activation energy of 0.148 eV/mol, similar to that of commercial natural ester, FR3 oil. The developed composite thermal liquid shows great potential as a green alternative transformer oil candidate.

**Keywords:** Arrhenius plot, Activation energy, cashew kernel oil, UV-vis., liquid nanodielectric

### 1. Introduction

Nanofluid (NF) is a liquid for which nano-size solid materials have been suspended to develop novel functional properties. And nanofiller materials form a glossary of solid materials with at least one of their dimensions in the range of 1 to 100 nm (Goyal, 2018). NF has been applied essentially for the improvement of heat transferability and insulation properties of cooling and insulation systems in several industrial processes and applications; such as cooling in nuclear reactors, electric car batteries, microchips, High-Voltage (HV) Transformers, etc. (Wong and Leon, 2010; Yu and Xie, 2012). Power grids worldwide have seen a significant expansion and upgrade due to increasing urbanization and industrialization, especially in developing countries. The high-voltage (HV) transformer is a key component of the transmission system of which insulation liquid is at its center. In addition, the modern industrial design requirement of miniaturization and improved performance at reduced cost has placed greater demand on heat dissipation management in HV facilities. The conventional heat transfer immersion liquids (i.e. transformer oil) used cannot effectively dissipate this heat. This has necessitated research in the development of superior insulation systems with better loading capabilities for which Nanodielectric fluid (NDF) offers greater utility advantages over the conventional base fluid (Sima *et al.*, 2014). Heat dissipation in a transformer is essential as when left, it could result in weakening of the dielectric voltage tolerance and induce local electric



arc in the transformer oil, and then degradation of insulation which will eventually lead to system failure with costly financial implications. Hence heat dissipation is necessary for the safety and reliability of the insulation system. Petroleum-based transformer oil has been used successfully as insulation and cooling liquid. An environmental concern associated with petroleum-based liquid has stirred attention to natural ester based oil as an alternative liquid. Natural ester oil has some utility advantages over mineral oil based oil. They are biodegradable, have high fire and flash points, moisture absorption, etc (Rao *et al.*, 2019; Jacob *et al.*, 2020). However, they also have inherent properties that are undesired such as oxidation in the presence of air and elevated temperatures which restrict their usage to hermetically sealed systems.

One of the main challenges faced in developing NDF is its lack of colloidal stability. There has been significant research interest in enhancing the stability of NDF, as evidenced by several studies (Ilyas *et al.*, 2017; Rafiq *et al.*, 2020; Shukla & Aiyer, 2015). Strategies aimed at improving colloidal stability primarily involve the use of surfactants such as oleic acid and span 80 as stabilizers (Ahmad *et al.*, 2019), mechanical or ultrasonic agitation during preparation to improve dispersion (Farade *et al.*, 2021), and the surface modification of nanoparticles through surfactant-free functionalization (Peppas *et al.*, 2016). These techniques are often combined to achieve the desired result. In the present study, insulation liquid was developed from Cashew Kernel Oil (CKO) as the base liquid and functionalized Zinc-Oxide Nanoparticles (ZnO-NPs) as filler materials. The thermal and rheological properties have been considered for its suitability as an alternative insulation liquid for application in High-Voltage transformers.

## 2. Experiments

### 2.1 Materials

Three (3) liters laboratory purified sample of cashew kernel oil was obtained, Zinc Oxide-Nanoparticles (ZO-NPs) laboratory prepared samples from (Gene *et al.*, 2020), Malvern Zetasizer available at the federal University of technology (FUT) Minna, UV-vis Spectrophotometer available at chemistry department, Ibrahim Badamasi Babangida University, Lapai, Lagged copper calorimeter, liquid in-glass thermometer, U-shaped (Ubbelohde) glass capillary viscometer available, Stop watch, Acetone (99.5%) was purchased from BDH Chemicals (England).

### 2.3 Synthesis of the Nanodielectric Liquid

Laboratory refined samples of crude kernel oil (CKO) were obtained and placed in a vacuum oven at 80°C for two hours to remove moisture from the oil. A two-step approach was employed for the development of the nanofluid. ZnO nanoparticles (ZnO-NPs) were synthesized separately and then mixed and dispersed in the host liquid.

To prepare the nanofluid, 5 g of purified CKO was placed in a 250 mL flask. The desired weight percentages (0.2 wt%, 0.5 wt%, 1 wt%, and 1.5 wt%) of ZnO-NPs were added to the flask, and the

mixture was mechanically stirred using a magnetic stirrer equipped with a magnetic stir bar. The stirring was carried out for 1 hour at a rotation speed of 300 rpm and a temperature of 60°C to ensure proper dispersion of the filler particles.

An aliquot of the nanofluid was taken for stability testing and other characterization.

#### 2.4 Measurement of Dynamic Viscosity

The viscosity was measured using an u-shaped glass capillary viscometer in the temperature range of 20°C to 90°C. 10 ml of the sample oil sample was heated up to 20°C and was gently poured into the viscometer to avoid air bubbles. The time taken for the fluid to flow through the timing marks of the Ubbelohde U-shaped glass viscometer from point A (start mark) to B (stop mark) was recorded using a digital stopwatch. The measurement was repeated and average readings recorded for accuracy. The viscometer was washed and cleaned with distilled water and acetone and dried in an oven. The same procedure was repeated for all the remaining samples. The dynamic viscosity of the samples was evaluated using Equation 3;

$$v = \frac{\eta}{\rho} = Kt \quad 1.$$

where  $v$  is kinematic viscosity in unit centi-Stokes (cSt),  $\eta$  is dynamic viscosity and  $\rho$  is density.  $K$  is viscosity constant and is characteristic of the viscometer used. And, for water and the liquid samples, we can write

$$\frac{\eta_w}{\rho_w} = Kt_w; \frac{\eta_l}{\rho_l} = Kt_l \quad 2.$$

Therefore, the dynamic viscosity is obtained from the following

$$\eta_l = \frac{\rho_l t_l}{\rho_w t_w} \eta_w \quad 3.$$

where  $\eta_l$  and  $\eta_w$  are the dynamic viscosities of the oil samples and water respectively, (in Pa.s);  $\rho_l$  and  $\rho_w$  are the densities of the oil and water samples respectively, (in g/cm<sup>3</sup>); while  $t_l$  and  $t_w$  are the time taken for the oil and water to fall in the viscometer respectively (Wilke et al, 2015).

#### 2.5 Measurement of Thermal Capacity

The specific heat capacity was determined by applying the mixture method. The oil samples were placed in a copper calorimeter so that it is about two-third of the calorimeter. The mass of the calorimeter and the oil samples were measured using a weighing balance. A piece of copper metal was placed in boiling water contained in a boiling kettle and placed on a gas cooker was removed and quickly placed in the oil-filled calorimeter, it was covered and stirred for about 10 minutes for the mixture to attain thermal equilibrium. Then the temperature of the final mixture was taken using

a thermometer. The specific capacity of the liquid,  $C_L$  in joules per kilogram per kelvin ( $\text{Jkg}^{-1}\text{K}^{-1}$ ) was then evaluated using equation 2, generated from the law of conservation of energy;

$$C_L = \frac{m_{cu}C_{cu}(100 - \theta_f) - m_{cl}C_{cu}(\theta_f - \theta_i)}{m_l(\theta_f - \theta_i)} \quad 2.$$

where  $m_{cu}$ ,  $m_{cl}$ ,  $m_l$  are the masses of the copper metal piece, the calorimeter, and the liquid/oil sample respectively,  $C_{cu}$  is the specific heat capacity of copper in  $\text{Jkg}^{-1}\text{K}^{-1}$ , where  $\theta_i$  and  $\theta_f$  are the initial temperature and final/equilibrium temperature of the oil and calorimeter in kelvin or degree celsius (K or  $^{\circ}\text{C}$ ).

### 3. Result and Discussion

The results and findings of the research are presented and discussed in this section.

#### 3.1 Nanoparticle Size Distribution

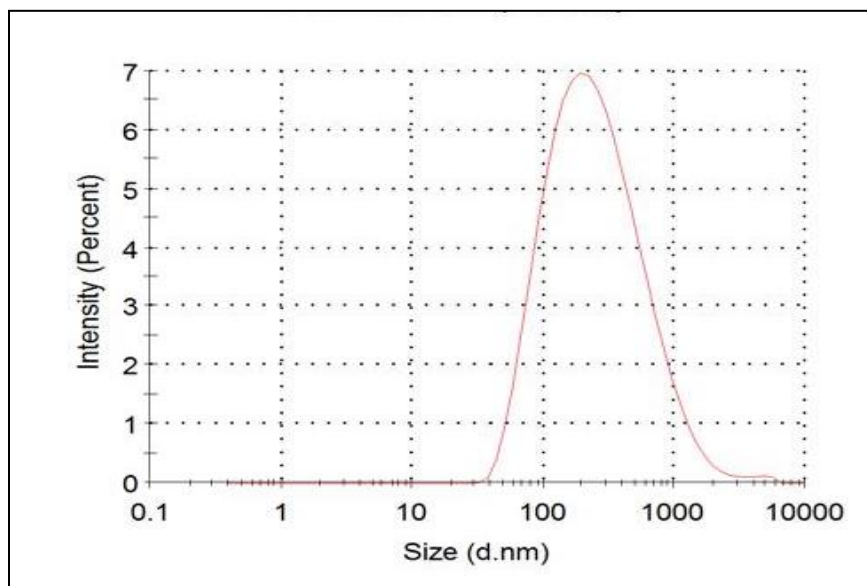


Figure 1. Filler size distribution

The particle size distribution of the ZnO-NPs used is shown in Figure 1. Malvern Zetasizer was used for the analysis. Particle size determination is of great importance because the particle size is crucial to the dispersion of the nanopowder in the oil. The size distribution of particles in the sample of the nanopowder is not the same. A fraction of the particles fall within the nano-range (1 to 100 nm), and the average particle size is 335.3 nm in dimension with a Z-average of 181.0 nm, which is out of the standard nano-range of 1 to 100 nm.

#### 3.2 Colloidal Stability Study using UV-vis Spectrometry

The stability of the nanofluid developed in this study was assessed using UV-vis absorbance. The methodology of using UV-vis spectroscopy to evaluate the stability of the nanofluid is based on the Beer-Lambert law, which states that the absorbance of light passing through a transparent solution in a container is directly proportional to the path length and the concentration of the solution. As a result of suspended particles in a nanofluid, there is a direct correlation between the amounts of light absorbed and the concentration of the nanofluid. Therefore, unstable nanofluids experience the settling of their suspended particles over time, and the concentration of the supernatant provides information about the stability of the nanofluid. The light absorbance of each sample at a wavelength of 316 nm was recorded and presented in Table 2. Figure 2 shows that the Beer-Lambert law is satisfied since the absorbance is directly proportional to the sample concentration. The UV-vis test was repeated after 24, 72, and 168 hours, and no significant variation in absorbance was observed for the samples. This suggests good stability, but further evaluation of the nanofluid's long-term stability is necessary for its application as an insulation liquid.

Table 1: Absorbance of the samples at a selected peak wavelength of 316.0 nm for all the samples

Sample	Description	Absorbance
<b>CKO+0.0</b>	CKO	0.610
<b>CKO+0.2</b>	CKO & 0.2wt% ZnO	0.947
<b>CKO+0.5</b>	CKO & 0.5wt% ZnO	0.967
<b>CKO+1.0</b>	CKO & 1.0wt% ZnO	1.067
<b>CKO+1.5</b>	CKO & 1.5wt% ZnO	1.237

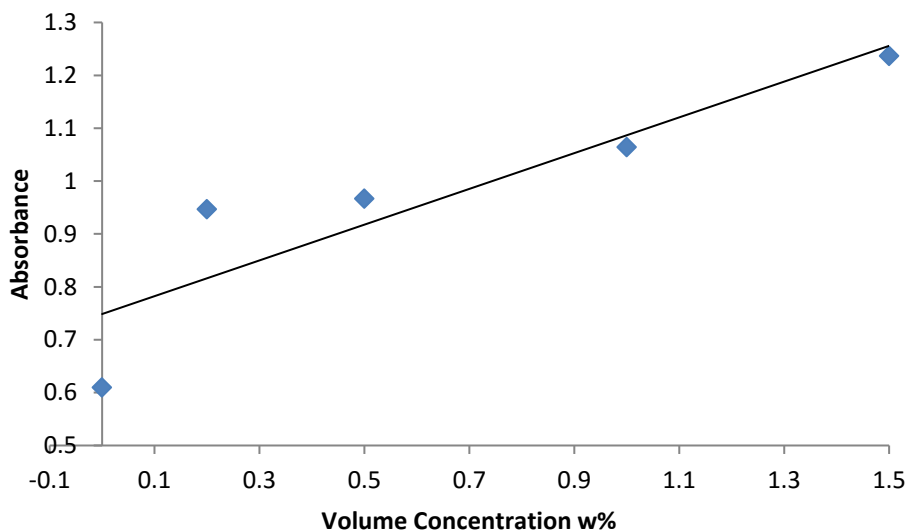


Figure 2: A plot of Absorbance against filler volume concentration

### 3.3 Viscosity

Rheology is a field of study that deals with the flow and deformation of both Newtonian and non-Newtonian liquids when subjected to an external deformation force. It is a fundamental aspect of liquid behavior and aids in understanding the underlying nature of liquids and the impact of various parameters on their behavior. One of the key rheological properties of a liquid is its dynamic viscosity.

To investigate the effect of temperature on the viscosity of oil samples, a study was conducted and the results are presented in Figure 3. The data show a consistent reduction in viscosity across all samples as temperature increases, as seen in Figure 3. However, there is a notable exception at 50°C, where the viscosities of all samples sharply increase.

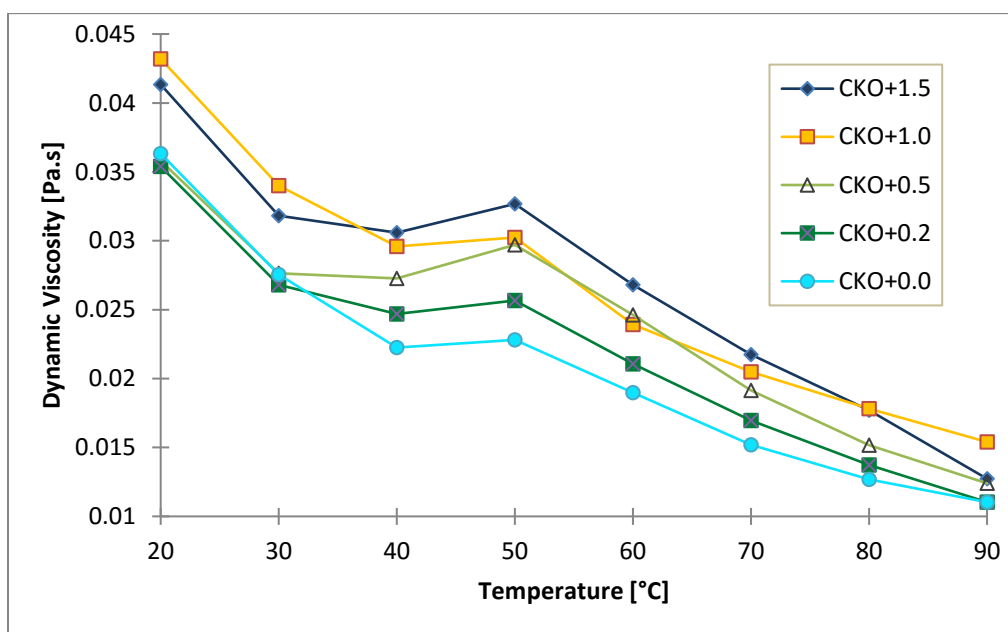


Figure 3. Temperature dependence of viscosity of the samples

Compared with the FR3 vegetable oil, The CKO+1.5 could make a good alternative insulation and cooling liquid for high-voltage applications. It has the relatively highest activation energy making it more susceptible to temperature changes due to an increase in the heat it has a viscosity similar to that of FR3.

The dynamic viscosity of the developed oil samples at 40°C was measured following the American Society for Testing and Materials (ASTM) standard, and the values obtained are presented in Table 2.

Table 2. Rheological properties of the developed liquid samples and others at 40°C

<b>Samples</b>	<b>Dynamic Viscosity [Pa.s]</b>	<b>Activation Energy [eV/mol]</b>	<b>Source(s)</b>
CKO+0.0	0.022	0.133	Present study
CKO+0.2	0.025	0.128	Present study
CKO+0.5	0.027	0.125	Present study
CKO+1.0	0.030	0.139	Present study
CKO+1.5	0.031	0.148	Present study
FR3	0.029 - 0.031	-	Cargill, 2021

The dynamic viscosity of FR3 was evaluated with the density at 20 °C and the kinematic viscosity at 40 °C

In comparison with a commercial natural ester brand, Cooper Power Systems' FR3 oil, the viscosity values of the developed oil samples show good rheology.

### 3.3.1 Arrhenius Behavior of the Liquid

The activation energy for the liquids was determined from the Arrhenius plot (see Figure 4) using the Arrhenius type equation;

$$\eta = A \exp(Ea/KT) \quad 4.$$

where  $\eta$  is the dynamic viscosity in pascal second (Pa.s),  $K$  is the Boltzmann constant in electron-volt per kelvin ( $eVK^{-1}$ ),  $T$  is the temperature in kelvin (K),  $A$  is the pre-exponential term in pascal second (Pa.s) and  $Ea$  is the activation energy (eV/mol) which can be determined from the slope of a plot of  $\ln(\eta)$  against  $1/T$  (Umar et al, 2018). Molecular mobility in the oils is a temperature-activated process and activation energies for the viscosity of the oil samples are presented in Table 2.

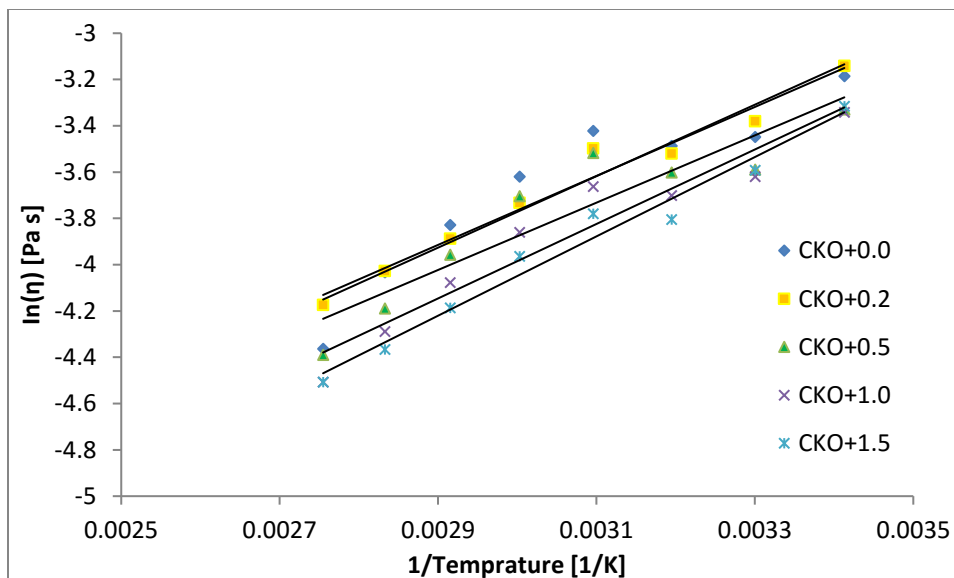


Figure 4. Arrhenius plot for viscosity for the liquid samples

An insulation liquid in high-voltage equipment absorbs, transfers, and dissipates heat during operating hours. The heat transfer coefficient of the liquid is directly related to its dynamic viscosity which as well depends on temperature changes in the oil. An increase in temperature results in to increase in the kinetic energy of the molecules of the samples. The increase in their kinetic energy consequently leads to a reduction in resistive forces acting between layers of the oil samples. The straight lines in the Arrhenius plot (see Figure. 4) fit on the points with  $R^2$  values of 0.8665, 0.9713, 0.8547, 0.9256, and 0.9717 for the CKO+0.0, CKO+0.2, CKO+0.5, CKO+1.0, and CKO+1.5 samples respectively

### 3.4 Thermal capacity of the developed fluid

The specific heat capacities of the samples are shown in Table 3.

Table 3. Thermal capacities of the developed oil samples

<b>Samples</b>	<b>Thermal Capacity [Jkg<sup>-1</sup>K<sup>-1</sup>]</b>	<b>Standard Error [Jkg<sup>-1</sup>K<sup>-1</sup>]</b>
CKO+0.0	2629.04	±26.27
CKO+0.2	2610.13	±26.09
CKO+0.5	2237.88	±22.36
CKO+1.0	2270.05	±22.36
CKO+1.5	3126.10	±31.24

As can be seen, the addition of 0.2 wt%, 0.5 wt%, and 1.0 wt% respectively to the base oil cause a drop in the thermal capacity of the base oil with improvement recorded only when the filler concentration was increased to 1.5 wt%. There is an increase of  $497.06 \text{ Jkg}^{-1}\text{K}^{-1}$  in thermal capacity with the addition of 1.5 wt% Zn-NPs. This represents an 18.9% enhancement over the thermal capacity of the base CKO. The addition of a certain percentage ZnO-NPs in a base fluid is observed to increase the thermal capacity of the base fluid (Bhagat et al., 2015). For cooling applications such as in the power transformer, high specific heat capacity is desired hence the CKO+1.5 sample represents the best for such an application since it has less temperature rise due to increasing heat transfer.

#### 4. Conclusions

A nanofluid has been developed from cashew kernel oil and zinc-oxide nanoparticles for its potential application as a cooling and insulation liquid. The following highlights the findings of the research. The viscosity of the base CKO shows a slight increase with the increase in filler concentrations, The thermal capacity of the base liquid is diminished by the addition of ZnO-filler of concentrations in the range of 0.2wt% to 1wt%. However, about 19% enhancement is observed with the addition of a filler of 1.5wt%. And, the nanofluid show good stability in the observed short duration of 168 hrs. The developed nanofluid with the addition of 1.5wt% filler material is an excellent candidate for a prospect as a green alternative insulation liquid. The findings are preliminary work on the prospect of CKO as an insulation liquid. However, a lot of issues still need to be investigated. Issues such as the oxidation stability of the liquid, its long-time colloidal stability, dielectric strength, compatibility with paper insulation, partial discharge initiation voltage, etc.

#### Acknowledgment

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## DESIGN OF A CROWD-SOURCED ALMAJIRI FUNDRAISING AND SPONSORSHIP APPLICATION

Zainab Tassala Muhammad, Abdullahi Abubakar Kawu, Jamilu Yahaya Maipanuku and Adamu Isah Abubakar

Department of Computer Science, Ibrahim Badamasi Babangida University, Nigeria.

Corresponding Author: Zainab Tassala Muhammad

Email: [zainabtassalam@gmail.com](mailto:zainabtassalam@gmail.com)

### Abstract

For a long time now, Almajiri children have suffered a lot of negligence which deprive them of their child rights, including right to education and good healthcare service. The main cause of this negligence is the lack of parental care and lack of government involvement in their daily activities. It is common to see Almajiris begging on the streets just to survive in society, a situation attributed to a lack of resources and funds by their custodians. However, there are little or no formal platforms to financially contribute to supporting the Almajiri children. Hence, this study aims to describe the design and development of a web platform for supporting and sponsoring the Almajiri using the crowdsourcing approach. The web application intends to create an interactive interface for the prospective donors to fund or support the livelihood of the Almajiris. The web application is developed using WordPress technology.

### 1. Introduction

Originally, the Hausa word Almajiri referred to a pupil under the tutelage of an Islamic teacher receiving Qur'anic education. In Nigeria, Almajiri is one of the poorest children. Around 7.5 million street-begging, maladjusted, forceful, and out-of-school children make up this group (Okadigwe and Akas, 2019). The poor conditions of Almajiri children in Northern Nigeria, particularly those from poor families, are alarming, heartbreaking, and dehumanizing (Okadigwe and Akas, 2019). The Almajiris are supposed to be like any other Nigerian child, with all of the rights that entails, but they are completely different humans. Due to denial of education, good parental care, good feeding, health, and moral upbringing, they lack the basic amenities that every growing child should have, resulting in debased lifestyles of street begging, terrorism, thievery, rape, and wandering. According to Islamic teachings, Almajiri children are supposed to be tomorrow's Islamic leaders or Imams, but this possible and achievable given Almajiri children's current situation, in which they are denied basic child rights and are turning to deadly terrorists. Okadigwe and Akas (2019) concluded that the average Almajiri child is going through a terrifying ordeal that requires the attention of both the Nigerian government and well-intentioned citizens.

Goodluck and Juliana (2013) looks into Nigeria's long-term street child support. Despite the continuous increase in the number of street children in Nigeria, the study highlights the limitations of all stakeholders in providing support for them in order to identify policy options in light of the stakeholders' inability to adequately support the children. According to the study's findings, stakeholders are unable to address the problems of street children due to a lack of necessary skills, a lack of necessary facilities, and stakeholders working hand in hand, among other things. Some Government agencies, such as the Social Welfare Department, lack the necessary resources to effectively combat street children. Similarly, while Education is central to all and especially to Almajiri in the fight against poverty and discrimination, Almajiri does not have easy access to formal education largely due to a lack of financial support to do so (Magashi, 2015).

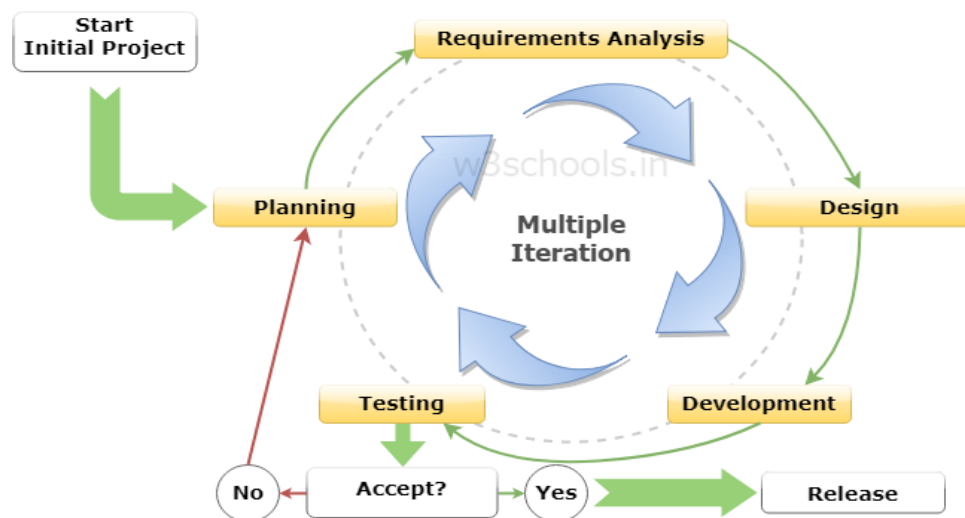
This study thus aims to develop a web application where the Almajiri receive financial support from individuals and non-profit organisations (NGOs) towards their education, the web application will create opportunities for Almajiri to get funded and change the lifestyle of the Almajiri through education and skills acquired.

## **2. Literature Review**

Alabi and Ijaiya (2018) investigated Nigeria's current Early Childhood Education (ECE) funding strategies in order to make recommendations for ways to improve funding and sustainability. Adequate funds are required in Early Childhood Education to provide a variety of resources. The study concluded that the Nigerian Federal Government has unquestionably increased its efforts and commitment to Early Childhood Education and Development (ECCD). However, the paper claims that much more needs to be done in terms of adequate funding for quality teachers/caregivers, the provision of appropriate facilities and stimulating learning materials, and ECCD program supervision. We also observed that until recently, funding for the ECCD does not explicitly consider the needs of the Almajiris. Kasri and Putri (2018) looks into how corporate and government zakah agencies use traditional fundraising strategies, including a partnership approach to collecting zakah and a community-oriented approach to communicating zakah. To gain insight into the zakah collection models used in Indonesia, important aspects of the fundraising function, such as donor types, fundraising programs, and payment approaches/methods, were investigated. The study's main finding, according to Kasri and Putri (2018), is that different types of zakat institutions use different fundraising (collection and communication) strategies. Taken together, the findings show that zakat institutions' resource streams have a significant impact on fundraising for initiatives like Almajiri, which is consistent with a resource dependence theory of fundraising, according to the study. Despite the foregoing efforts at fundraising through Zakat and charity (sadaqa), not many other platforms for fundraising exist. Hence, this study is an attempt to develop the platform to enable individuals and organisations to support these disadvantaged individuals.

### 3. Methodology

This chapter describes the method of the research work, analysis and design. The software was developed using the Software Development Life Cycle (SDLC). In the software industry, the Software Development Life Cycle (SDLC) is a method for designing, developing, and testing high-quality software. The Software Development Life Cycle (SDLC) refers to the entire software development process (Intellectsoft,2019) . Software development life cycle models include the waterfall model, prototype model, Agile model, V-shape model, incremental model, and spiral model (Tutorialspoint n.d.). For this project, the Agile model was chosen to be the SDLC model for the development.



**Figure 1: Stages involved in agile model**

The Agile SDLC model combines iterative and incremental process models with a focus on process adaptability and customer satisfaction by rapidly delivering a working software product (Tutorialspoint n.d.). The web application carefully followed the Agile model from the planning phase where the Almajiris were interviewed to understand their basic needs to the requirement phase (putting all the data from the interview together to know what is required to do) down to development phase (creating the web app with the help of Wordpress) and the test phase (to identify an errors and functionality of the web app).

#### 3.1 Software requirements

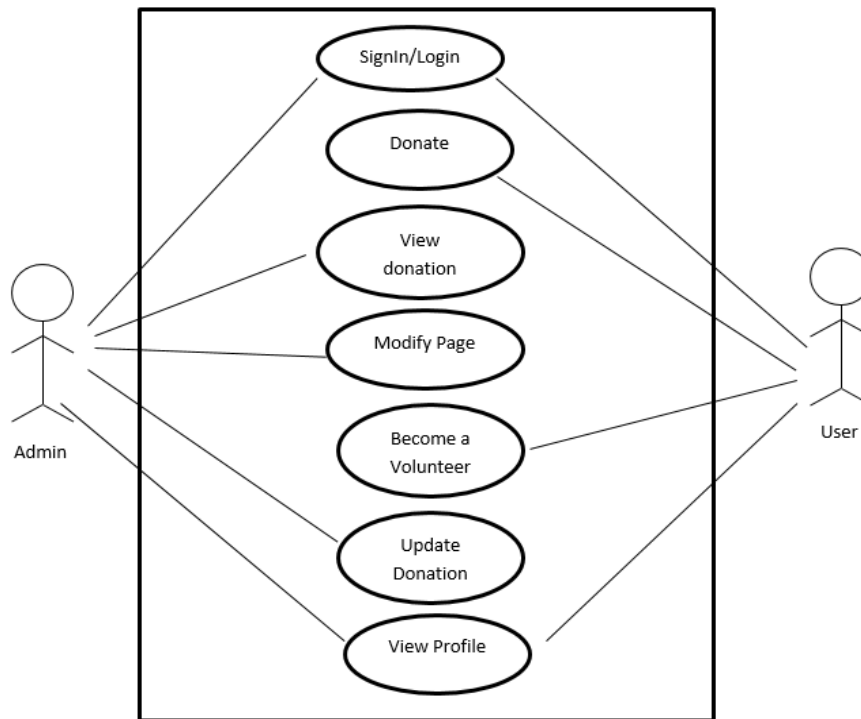
Software requirements are descriptions of the target system's features and functionalities (Stephen J, 2020). Software requirements, when properly documented, serve as a road map for a development team to build the right product quickly and with minimal rework. For brevity, functional requirements were addressed in this project.

### 3.2 Functional requirements

Functional requirements is how the system works at its most basic level. It specifies what a software system must or must not be able to do (Stephen J, 2020). Use case is one of the functional requirements. Use cases and Activity diagrams are some of the most effective methods for obtaining functional requirements.

#### 3.2.1 Use Case

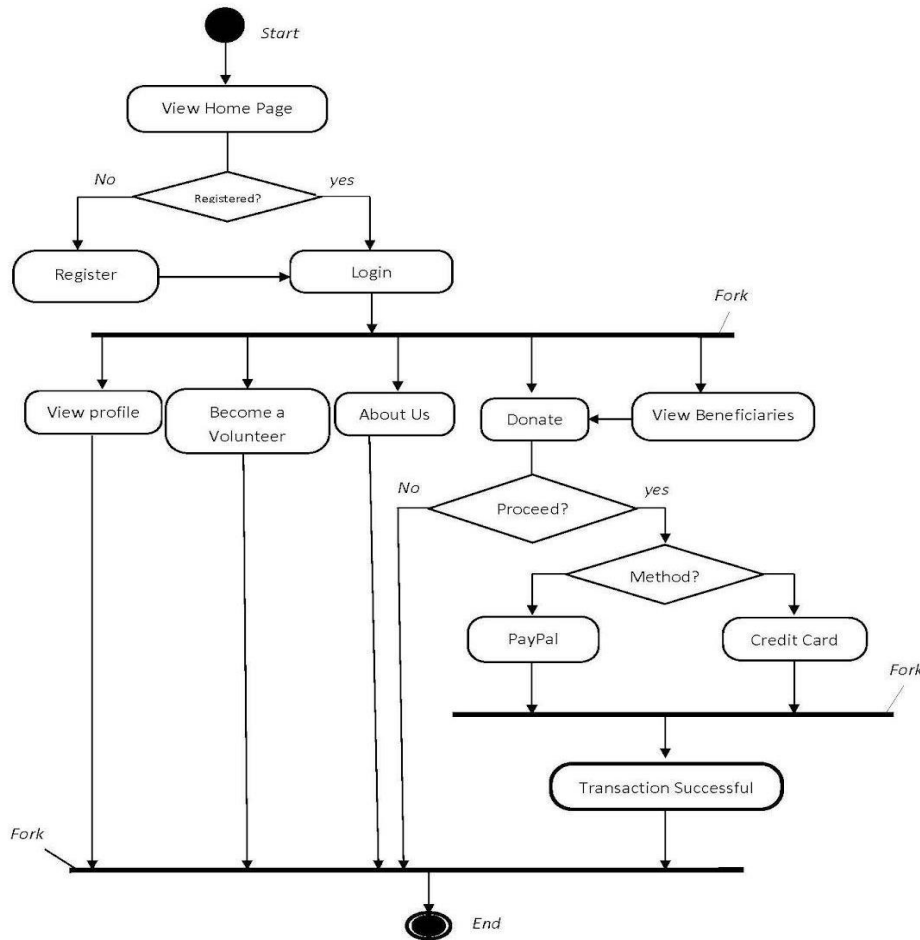
Use Case is a graphical illustration used to describe how a user uses a system to accomplish a particular goal. For this project, the following use case was specified.



**Figure 2: Use case**

#### 3.2.2 Activity diagram

An activity diagram is typically created for a single use case and may depict various scenarios. Below is the activity diagram for the login and donation process of this software:



**Figure 3 Activity diagram**

#### 4. Result - Application Design

Following the requirement gathering process, the web application was designed and developed by converting all specifications into user interfaces of a web application with the aid of a CMS application. We used WordPress CMS application to achieve a Minimum Viable Product (MVP) design. WordPress is an open-source website-building platform that is free to use. It's a PHP-based content management system with a MySQL database. It's versatile because it can run any kind of website (Chyckarov Y., et al., 2019).

Below are the screenshots from the designed and developed web app:

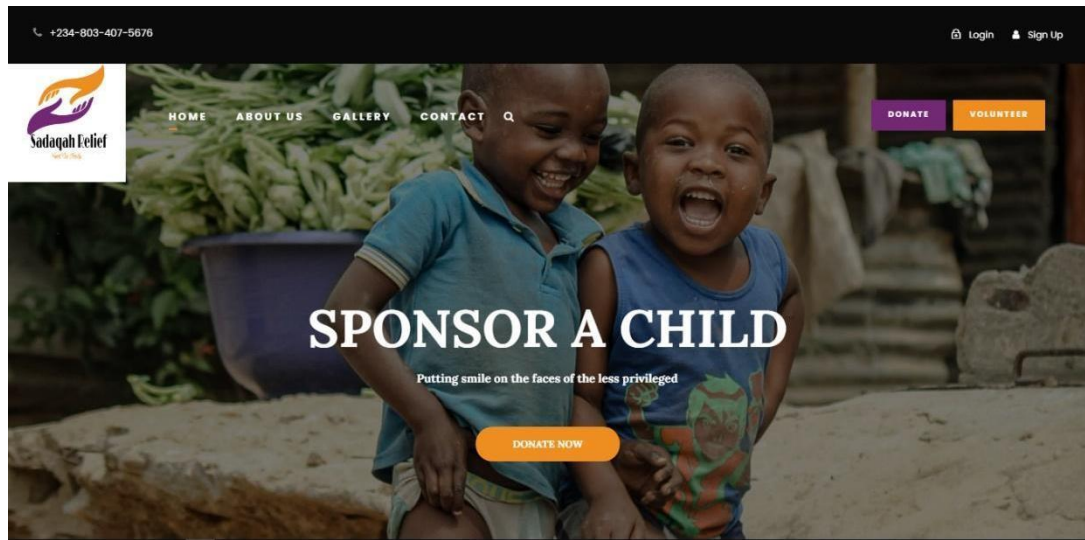


Figure 4. The Home page Design

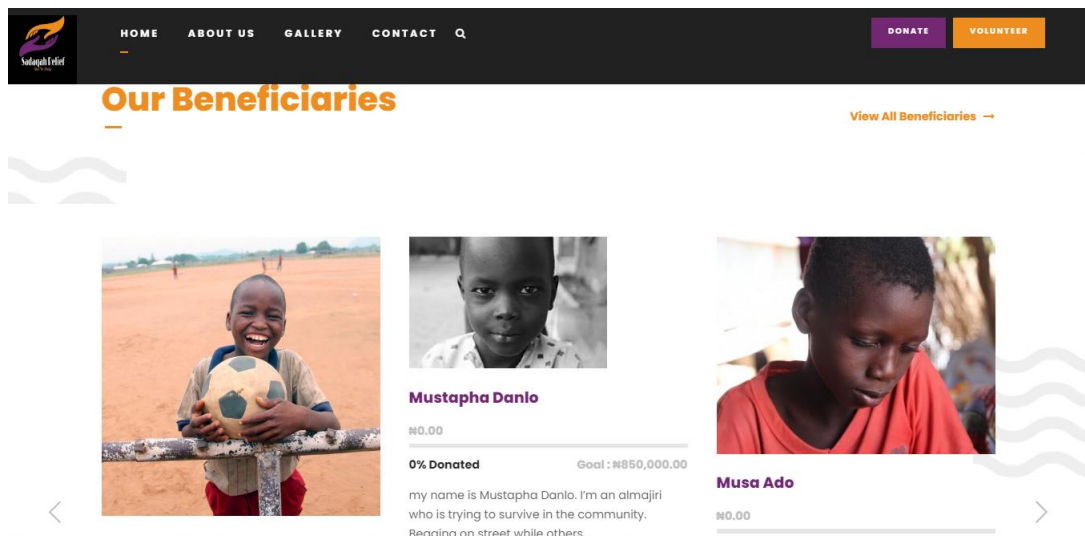


Figure 5: Home Page Beneficiaries Page Design

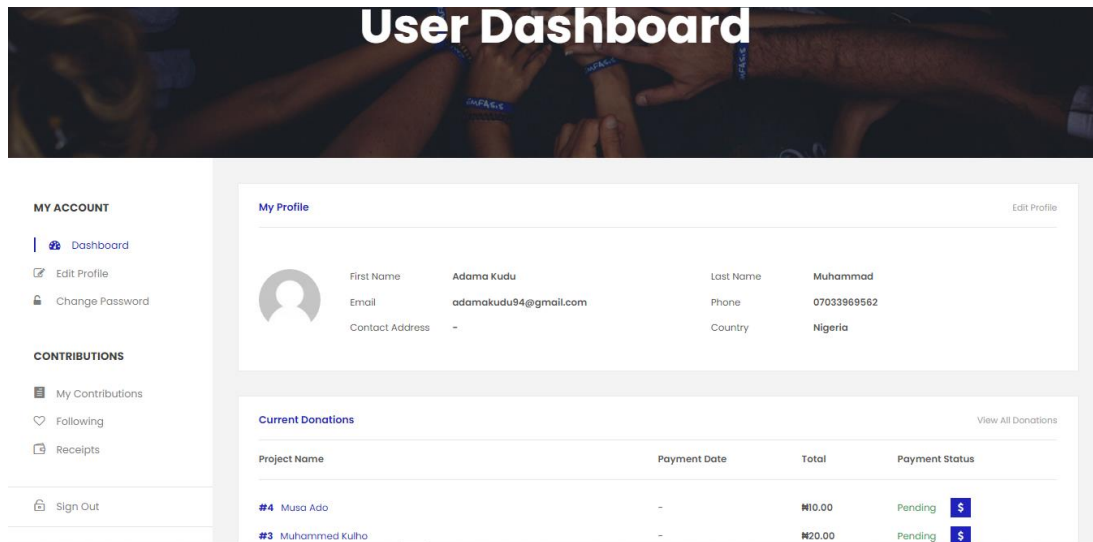


Figure 6: The Dashboard page Design

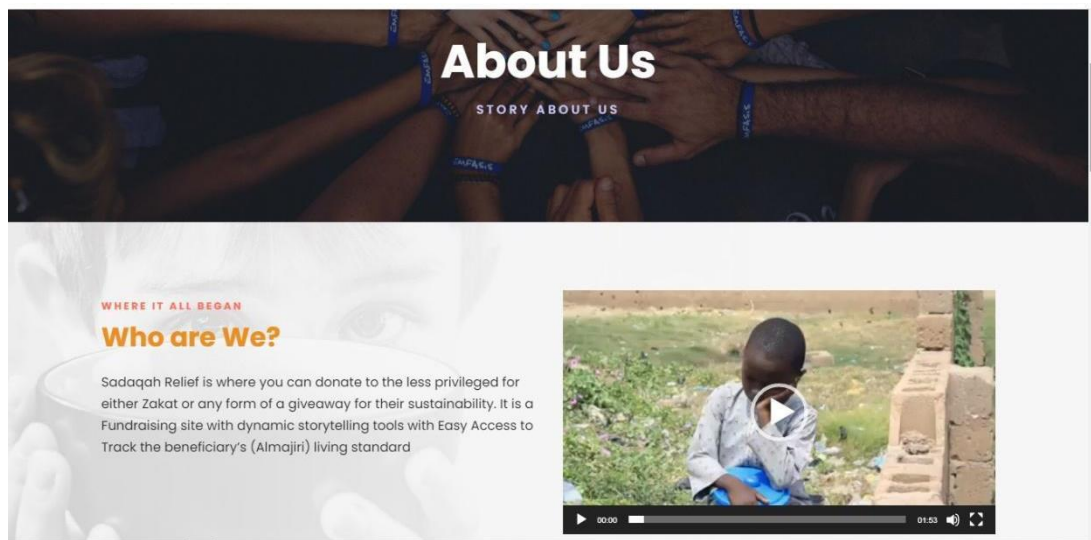


Figure 7: About us Page Design



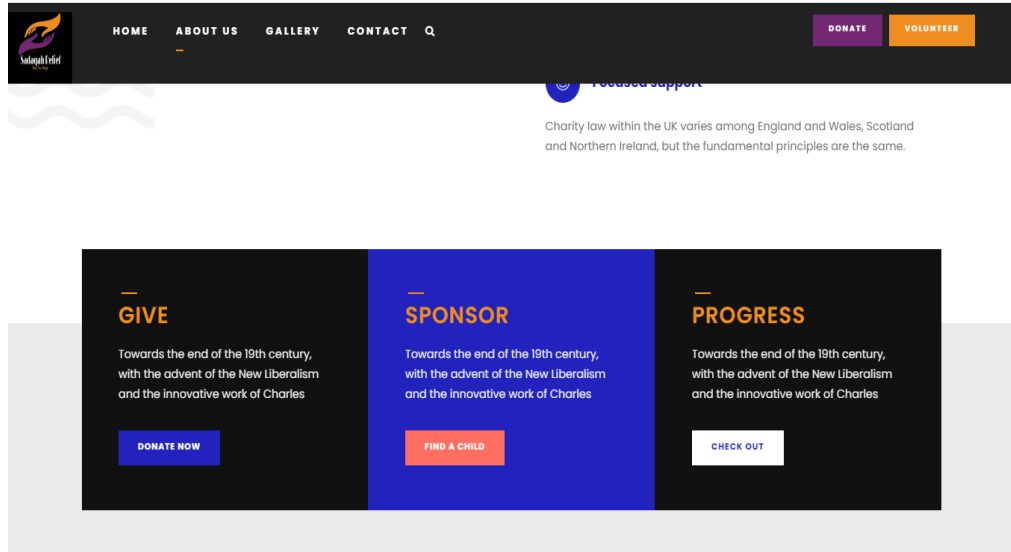


Figure 8: About us Page Design

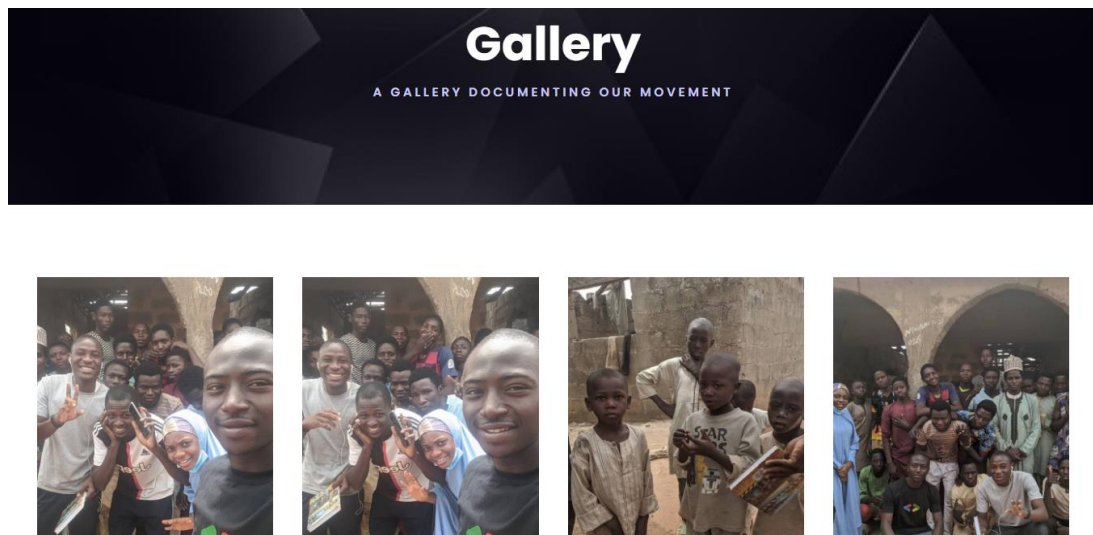


Figure 9. Gallery page Design

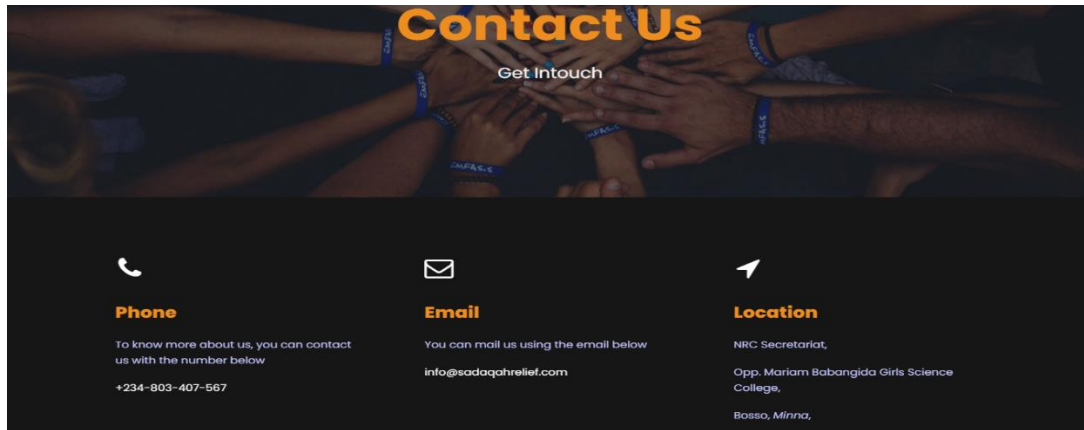


Figure 10. Contact us Page Design

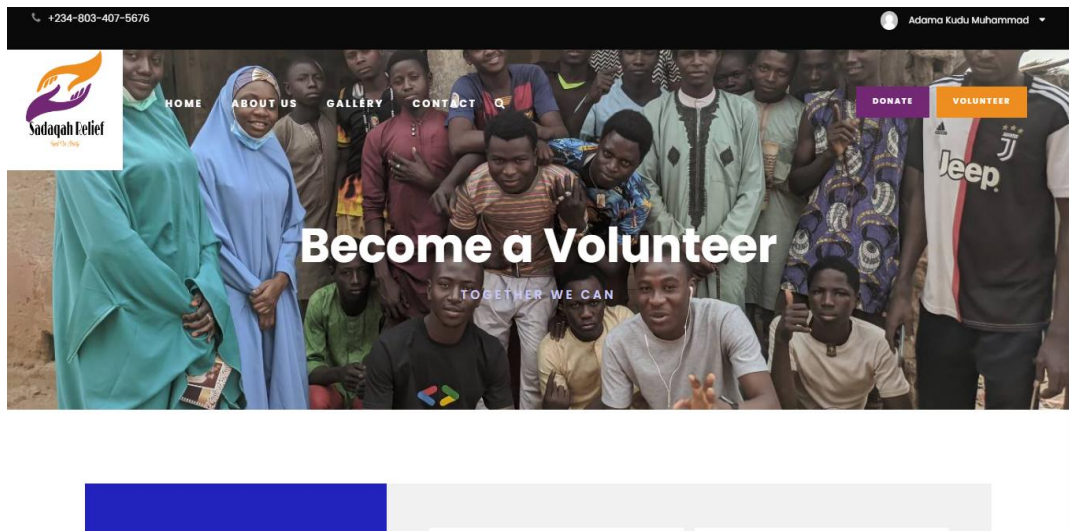
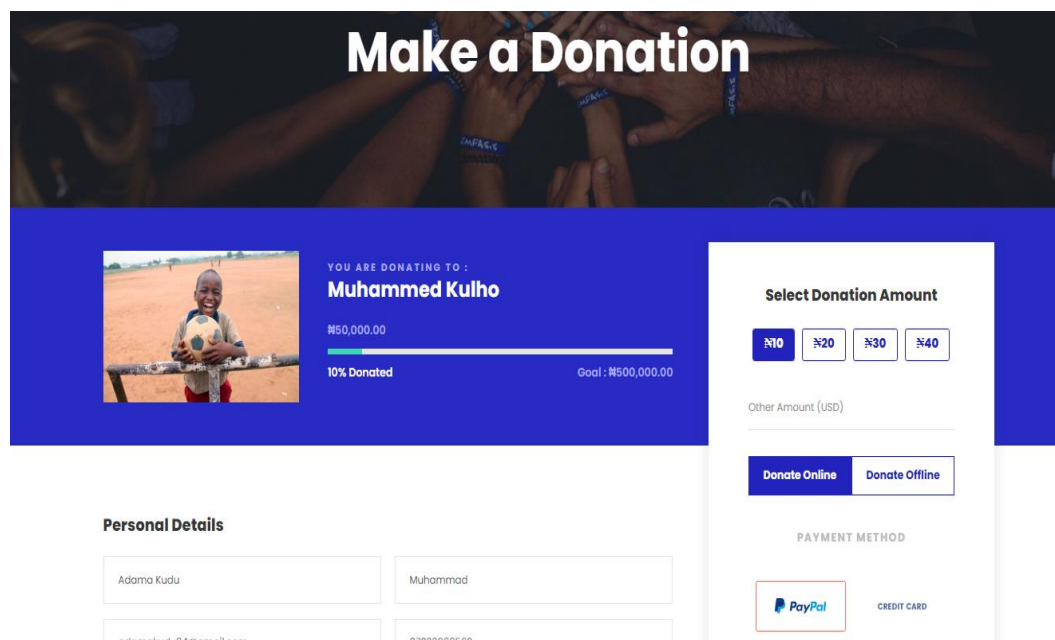


Figure 11. Volunteer page Design



**Figure 12. Donate page Design**

## 5. Conclusions

This study aims to provide a web application platform where individuals and non-governmental organizations (NGOs) can donate to the education and overall well-being of the Almajiris. It provides a funding platform towards supporting the education and welfare of the Almajiri. Using a Content Management System (CMS) platform, we successfully design a minimum viable product (MVP) of an alternative fundraising platform for Almajiri. If implemented, the proposed sponsorship web application will provide an alternative funding source, away from government towards the provision of education and healthcare for the Almajiris. It will indirectly also address the insecurity currently experienced in the country.

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## ASSESSMENT OF THE FACTORS AFFECTING WATER DISTRIBUTION IN MINNA METROPOLITAN AREA

Muhammed Etudaiye Ohida<sup>1</sup>, Isa Imam<sup>2</sup>, Yusuf Ndagi Baba<sup>3</sup>, Ibrahim Damana Abubakar<sup>3</sup>

Corresponding author

[ohidamuhammedetudaiye@gmail.com/](mailto:ohidamuhammedetudaiye@gmail.com/)

+2347034480533

<sup>1</sup>Department of Transport and Logistics, Federal University of Technology, Minna, Niger State;

<sup>2</sup>Centre for Human Settle and Urban Development, Federal University of Technology, Minna,

Niger State; <sup>3</sup>Department of Transport Management, Ibrahim Badamasi Babangida University, Lapai, Niger State

### Abstract

It is impossible to overestimate the significance of water because it is necessary for both plant and human living on a daily basis. Actually, the value of water is established in both culture and religion. For instance, religious worshippers utilise water to purify themselves. Water scarcity is a challenging issue that is being discussed both locally and globally. Numerous factors lead to physical water scarcity or inadequate water distribution in urban areas. This study aims to identify the variables influencing water distribution in the Minna Metropolis. The study utilized descriptive research design and random sampling to distribute 120 questionnaires to employees of the Niger State Water and Sewage Corporation (NISWASEC). Three significant factors (that is; availability of water at the sources, inadequate distribution pipe infrastructure, and inadequate transport vehicle) were extracted from the eleven factors impacting water distribution using component factor analysis. The gathered data was analysed using percentages, frequency, mean index score, and the hypothesis was tested using T-test. The study results showed that availability of water at the sources (P-value= .000), limited distribution pipes infrastructure (P-value= .000) and inadequate transport vehicle to distribute water (P-value= .000) are statistically significant at 0.05. The study concluded that these three factors identified are very significant in water distributions in Minna metropolis. The study suggests, among other things, that adequate transport vehicles, such as water tankers, be made available to supply water in areas that are not linked to the distribution pipes at least twice a week. The state government should also purchase modern water abstraction infrastructures to aid in the water abstraction.

**Keywords:** Water distribution, inadequate transport, inadequate funds, population, Minna metropolis

### 1. Introduction

In order for humans to survive on a daily basis, they need access to water as a vital resource. Water is necessary for a variety of tasks, such as drinking, household chores, building projects, and industrial processes. Water scarcity is caused by insufficient water access or distribution, which has

caused up to 6% of the GDP of several regions to be lost, prompted migration, and sparked conflict (World Bank, 2016). Due to poor sanitation, 2.4 billion people worldwide are at risk of contracting diseases including cholera and typhoid fever as well as other water-borne ailments (Wildlife Fund, 2023). Water scarcity is a significant issue that affects many regions of the world and is a result of factors such as drought, water pollution, climate change, urbanization, and business activity expansion (Shan *et al.*, 2015). Water shortages in metropolitan areas are also a result of inadequate distribution systems. A water distribution system is a component of the water supply network that transports potable water from a centralised treatment facility or wells to users to meet their needs for residential, commercial, industrial, and firefighting purposes (National Academic Press, 2006). According to Bhave & Gupta (2006), the term "water distribution network" describes the portion of a water distribution system that extends up to the service points of bulk water users or demand nodes where several consumers are clustered together. According to Musa and Fumen (2013), pipes are an essential part of the water distribution system because they enable the transportation of water in various amounts from headworks through treatment facilities to the service reservoir and, finally, to users. Lansey *et al.* (1989) concluded that distribution mains from the distribution network and service pipe connections built on distribution mains convey water from the source to the plant and the service reservoir, as opposed to the main trunk, which transports water from the source to the plant and the service reservoir.

The lack of "state-of-the-art technologies, inadequate knowledge about industry best practices, and insufficient training" (LaBrecque, 2015) is the cause of inadequate water distribution systems in many regions of the world. A lack of respect for government property, which could lead to pipeline damage, is one of the issues contributing to the water distribution issue in Africa, particularly in Nigerian cities (Obessisan & Famous, 2016). A similar issue with the water distribution system exists in the metropolitan areas of Minna, the capital of Niger state.

Water scarcity is still a major issue in Minna metropolis despite all efforts by the Niger state government to provide adequate water distribution through Niger state Water Board and Sewage Corporation (i.e., Gidan Ruwa), as the problem of water lost due to old pipes, leaking pipes, insufficient funding to improve distribution pipelines, poor operations, maintenance, and inadequate water abstraction infrastructures are still a common problems (American Water Works Association, 2018; Ali, 2012; Enefiok & Ekong, 2014; Adeosun, 2014). However, the available literatures showed that there still exists a gap in the area of availability of water at the sources, limited distribution pipes infrastructures, inadequate transport vehicle to distribute water, and increased population which the current research is here to fill. In light of this, the foregoing research aims to evaluate the factors affecting water distribution in Minna Metropolitan area. The study developed one null hypothesis, which state that there are no statistically significant to the 3 key factors affecting the distribution of water in Minna metropolis.

## 2. Literature Review

### 2.1 Theoretical Review

The present study is influenced by a number of management ideas that have been theorised by researchers. Resource Base View (RBV) is the most popular theory used in describing water distribution. It was Barney (1991) who created the RBV. According to RBV, firms can adopt different strategies because they have different resource mixes (Levie, 2008). This is because heterogeneous resources allow for the creation of heterogeneous enterprises. The RBV focuses managerial emphasis on the company's internal resources in an effort to pinpoint those resources, skills, and abilities that have the potential to produce superior competitive advantages. According to the RBV, Niger State Water Board and Sewage Cooperation (i.e., Gidan Ruwa) will distribute water among the households of Minna metropolis taken into consideration their available resources such as available water abstraction technology, water availability at the sources and available electric power supply to pump water. Distributional theory is a different theory that supports the research presented above. According to distribution theory, the marginal productivity of a factor of production determines its price (Kaldor, 1955). When it comes to the distribution of water, the distribution theory makes the claim that water distribution is similar to production in that it enables the generation of water by combining the production factors that are dispersed fairly among the homes in metropolitan areas. The water supply reliability theory is a different theory that has been employed over time to describe water distribution. Failures of a system's physical components can be characterised as a lack of water supply reliability. Shamir and Charles (1981) were the first to present the theory. According to Shamir and Charles (1981), a dependability factor can be described in terms of demand rate or demand volume for a single failure or for a chosen time period. The factors to be taken into account when evaluating the reliability of a water supply were described by Damelin *et al.* (1972). They created a computer simulation model to assess the dependability of particular water supply systems, and they established a reliability factor in terms of shortfalls in annual delivery amounts. The impact of a supply failure on the dependability of a system depends on the demand of the system at the time the failure takes place. Another theory used to describe the distribution of water is the concept of constraints. Eliyahu (1984) defined a constraint as anything that prevents the system from achieving its goal. The Theory of Constraints (TOC) asserts that there shouldn't be tens or hundreds of constraints, despite the fact that limitations might take many different forms. In any given system, there is at least one, but rarely more than a few. In the context of water distribution implies that there may be at least one constraint which prevent Gidan Ruwa from distributing water among the residents of Minna. However, these factors may be internal relating to the water board or external such as inadequate power supply to pump water.

### 2.2. Assessing the factors affecting water distribution

In order to distribute water, a system of pumps, pipes, and tanker vehicles is typically used by public utilities, businesses, nonprofits, and even individuals. Systems for distributing public water are essential to society' proper functioning. These systems provide drinking water to people all around

the world. The distribution of water is influenced by a wide range of factors. Abdullahi and Abdulrahman (2015) asserted that the lack of sufficient information about water resources, combined with a lack of technology and its applications, impede the distribution of water in the majority of the world's developing nations. In an effort to identify the causes of inadequate access to portable water in rural areas of developing nations, Awoke (2012) identified a number of factors that can affect water supply, including design, performance, and maintenance issues, social issues, institutional failures, and financial constraints. In lieu of this, Ali (2012) points to inadequate water supply infrastructure, inadequate technical capacity of the host communities, and a lack of a sufficient framework that incorporates portable water supply as the factors that account for low access to water supply. Lack of upkeep, a lack of community involvement, a lack of coordination and cooperation among stakeholders, politics, ineffective monitoring, and a bad attitude towards government property are some of the causes of insufficient water supplies in rural areas (Enefiok, and Ekong, 2014).

### 2.3 Empirical review

In research of the sources of potable water supply in the Ilorin Metropolis, Kwara state, Nigeria by Musa and Fumen (2013). The goal of the investigation was to identify Ilorin's portable water delivery systems. The authors came to the conclusion that the majority of residential areas in Ilorin depend on boreholes and dug wells rather than the city's tap water supply. In a separate study, Chia *et al.* (2014) conducted research on the issues of domestic water supply in Makurdi Metropolis of Benue state. The goal of the study was to examine the numerous water sources, their distribution among the several wards, and their availability in Makurdi metropolitan areas. The investigation indicates that the area's water supply issue is related to the rise in water demand as opposed to the insufficient water supply caused by a lack of power and a problem with inadequate pumping infrastructure. Akoteyon (2019) examined the factors influencing household access to water supply in residential regions of the Lagos metropolitan area of Nigeria. The goal of the study was to look at the factors influencing water supply availability in the city of Lagos. According to the study's findings, the Lagos metropolis's primary water source, income, and cost are the main factors influencing access to water supply. The study suggests that, in order to increase socioeconomic sustainability and promote healthier lifestyles, water infrastructure investments should be prioritised with a higher emphasis on low-income residential areas. A study by Kurian and McCarney (2010) examined the factors affecting the provision of adequate water and sanitary facilities in Peri-urban areas. With a cross-sectional survey as the study's methodology, the study is strongly tied to the European setting. The results showed that a number of factors may be thought to affect the sufficiency of water and sanitation service delivery patterns, leading to future infrastructure and facility improvement as population growth occurs. In another study, Amina *et al.* (2021) investigated the water supply and sanitary conditions in the northern Nigerian city of Kaduna. The aim of the study was to determine which households have access to better water sanitation facilities. According to their survey, 90% of homes in urban areas and urban slums have access to better sanitation facilities, while the majority of households in Kaduna have access to



improved water facilities. The study's findings indicate that many households lack access to Kaduna State Water Board-treated water. According to the report, the private sector should be involved in water supply in terms of raising money for the development, upkeep, repair, and extension of water supply and sanitation facilities in the Kaduna city. The sustainability of the water supply system in Zanzibar's West Region Unguja was studied by Nassir (2019). The goal was to ascertain how Zanzibar's poor water infrastructure, inexpensive water rates, and water utility failures affect reliable water supply. The study's findings indicated that low rates, a lack of water infrastructure, and water utility failure have an impact on the sustainability of the water supply. Rahman et al. (2021) looked into the factors that could affect water distribution network rehabilitation. The purpose of the study was to identify elements that would affect the rehabilitation of the Water Distribution Network (WDN), with a particular emphasis on a series of one-on-one interviews with professionals in the industry who manage the WDN. The study's findings indicated that two important elements influencing the rehabilitation of the water distribution network are internal and external influences. Cost, location, and design are internal factors, whereas local governments and the neighbourhoods around the project are external. Hassan and Abbas (2015) investigated the key factors that contribute to water supply system and urban water distribution network leaks. The purpose of the study was to identify the significant reason generating leaks in the water supply system and urban water distribution network. The findings demonstrated that other parameters might be disregarded in favour of pressure, age, material, and pipe diameter as the key determining factors. In the Ethiopian city of Meleke, Desalegn (2014) investigated the causes and difficulties of urban water supply. The findings showed that during periods of piped water service availability and water supply interruption, the mean daily per capita water usage was 11.9 litres and 20.46 litres, respectively. Additionally, the disparity between supply and demand as well as the unmet demand of city dwellers were growing yearly. Spatial Inequality in Access to Public Water Supply in Minna was explored in research by Yahaya et al. in 2022. The survey found that only 38% of the houses had access to the public water supply in their community, despite the fact that 25 of the 32 neighbourhoods were connected to the public water mains. All of the neighbourhoods have between 25% and 90% access to public water. The study also found that the amount of access to the public water supply in Minna neighbourhoods varies statistically significantly from one neighbourhood to the next. To support the city's sustainable growth, the authors advise enhancing access in all neighbourhoods, regardless of the socioeconomic status of the locals. In Owah-Abbi, Delta State, Obisesan and Famous (2016) investigated the variables influencing the water supply. The goal of the study was to identify the elements that contribute to insufficient water supply. The results showed that corruption (37.33%), unfriendly government policies (25.33%), theft and vandalism of water supply facilities were the main causes of the water deficit in the Community. Other factors were the facilities' poor management culture, the community's unstable power supply, faulty hydraulic equipment, and carelessness. The study suggested that the government urgently provide water for the residents of Owah-Abbi, that the existing water infrastructures be protected, that the residents of Owah-Abbi be informed about the necessity of water filtration, and that awareness-raising campaigns be organised in the region.

### 3 Research Methodology

#### 3.1 Research design and study population

The descriptive research design was used for this investigation. According to Shields *et al.* (2013), a descriptive survey is used to report the characteristics of the population under study. It provides an answer to queries about characteristics of the size of the population under study. The study's participants are the NISWASEC (Niger State Water and Sewage Corporation) employees. To obtain their opinions on the variables impacting water distribution in the Minna metropolitan area, NISWASEC staff members were randomly given 120 questionnaires.

#### 3.2 Research instruments and Method of data analysis

The questionnaires utilised for the study are divided into two sections: the first section asks about the socioeconomic characteristics of the NISWASEC employees, and the second section contains eleven variables that indicate the factors influencing water distribution in Minna city. The second section was created so that staff replies could be scored on a Likert scale of 1 to 5, with 1 denoting strongly disagree and 5 denoting strongly agree. The mean, frequencies, and percentages were used to evaluate the collected data. Three primary factors—availability of water at the sources, limited distribution pipe infrastructure, and inadequate transport vehicles to carry water—were extracted from the eleven factors impacting water distributions in Minna metropolis using component factor analysis. After that, a T-test was employed to determine the degree of significance of the three main components.

#### 3.3 The study area

Minna is situated at 9° 36' 50" North latitude and 6° 33' 24" East longitude. One of Nigeria's 36 federal states, Niger state, has it as its capital. It comprises of the Nupe and Gwari, two significant ethnic groups (Free Encyclopaedia, 2019). Cotton, Guinea maize and local ginger are the primary agricultural goods that support Minna's economy. Yam is another crop that is widely grown across the city. Minna Airport provides service to the city. With a population of 293,000 and a growth rate of 2.81% in 2006, Minna may be proud of its size (NPC, 2006). The thriving Minna economy is responsible for the city's rising population, which has led to an imbalance between the city's water supply and demand. Minna has a typical Middle Belt tropical savanna climate with two seasons: an oppressively hot, muggy wet season from May to October that is dominated by monsoonal air masses, and an arid, dusty, harmattan-dominated dry season from November to April. Water scarcity in Minna is at its worst right now. Because Minna has a tropical savanna climate, there is a water scarcity. The route map for the study region is depicted in Figure 1.



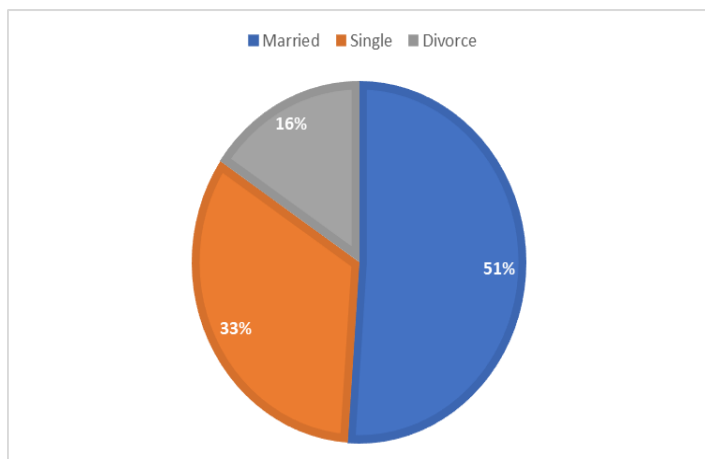


Figure 3: Marital status of the water board staff

Sources: Author’s survey (2023)

The analysis in Figure 3 reveals that more than half (i.e., 51%) of the water board staff in Minna metropolis were married, 33% of the staff were still single and only 16% of the staff were divorced. The outcome is a revelation that there are more married people working with NISWASEC. Being married, indicate that they are responsible and may know how married people will have high demand for water in Minna metropolitan area.

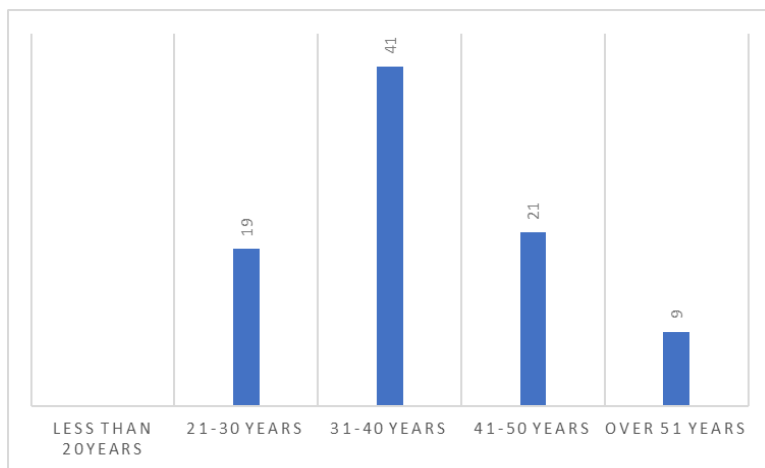


Figure 4: Age of the water board staff

Sources: Author’s survey (2023)

Figure 4 reveals that forty-one (i.e., 41) water board staff whom took part in the study were between the age of 31 and 40 years, twenty-five (i.e., 25) staff were between the age of 41-50 years, nineteen (i.e., 19) staff were between the age of 21-30 years and only nine (i.e., 9) of them were over 51 years of age.

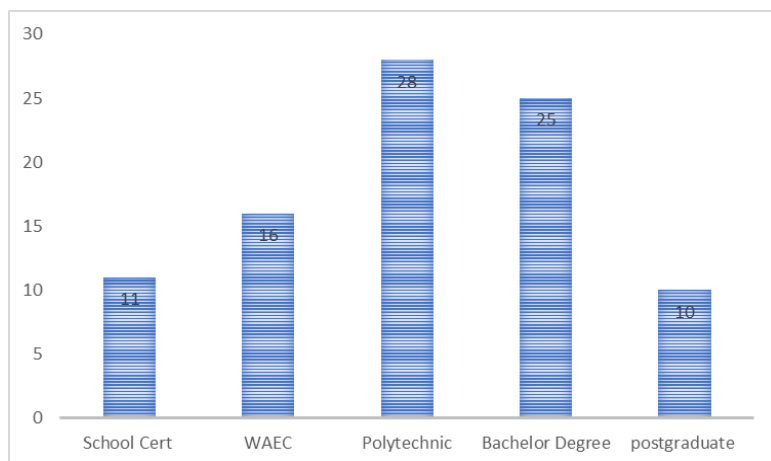


Figure 5: Educational level of the water board staff in Minna  
Sources: Author’s survey (2023)

In addition, Figure 5 shows the educational background of the water board staff in Minna metropolis. From the analysis it was observed that twenty-eight staff had polytechnic certificate, twenty-five (i.e., 25) staff has bachelor degree certificate, and sixteen (i.e., 16) staff had West Africa Examination Council certificate. Moreover, eleven (i.e., 11) staff possess primary school certificate and only ten (i.e., 10) staff had postgraduate school certificate.

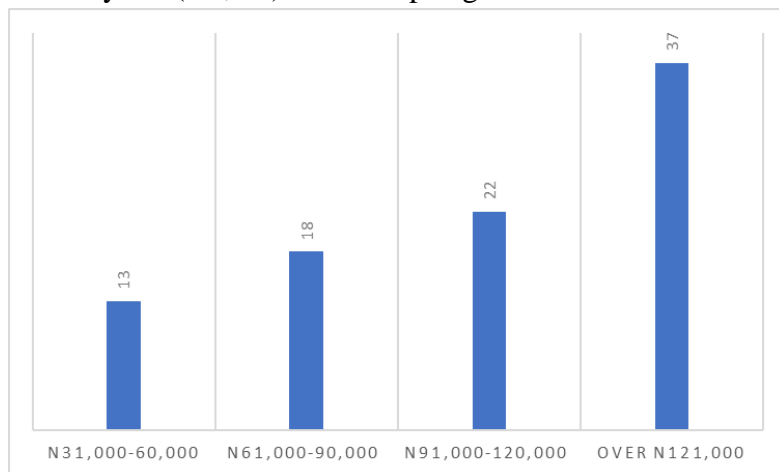


Figure 6: Monthly income earned by the water board staff  
Sources: Author’s survey (2023)

Figure 6 reveals that thirty-seven water board staff earned over ₦121,000 monthly, twenty-two of them earned between ₦91,000 and ₦120,000 monthly, and eighteen of them earned between ₦61,000 and ₦90,000 monthly. Similarly, Figure 5 point that thirteen water board staff earned between ₦31,000 and ₦60,000 per month.

Table 1: Distribution of Water board staff years of working experience

Years of working experience	Frequency	Percentages
1-5years	15	16.7
6-11 years	33	36.7
12-17 years	26	28.9
Over 18 years	16	17.7
Total	90	100.0

Sources: Author survey (2023)

Table 1 recorded that about 36.7% of the water board staff had between 6-11 years of working experiences, 28.9% of them had between 12 and 17 years of working experience, 17.7% of them had over 18 years of working experience and only 16.7% of the staff had between 1-5 years of working experiences. This analysis is a revelation that water board staff as qualified staff as they great majority of them possess over 6 years of working experience in distributing water to Minna Metropolis.

## 2.2 Analysis of Factor Affecting Water Distribution in Minna Metropolis

Table 2 Mean distribution of the factor affecting water distribution in Minna

Factors affecting water distribution in Minna (M)	Mean
Availability of water at the sources	4.2903
limited distribution pipes infrastructure	3.4421
Inadequate transport vehicle to distribute water	3.9978
Increasing poverty rates	3.6538
Inadequate resources to purchase water abstraction	4.5159
high cost of acquiring water purification facilities	3.9120
Water pollution/contaminations	3.2935
Absent of rain due to climate change	4.1333
Rocky surroundings preventing individual water sources	2.7030
High level of concretization due to urban Growth/increasing population	2.1672
Inadequate electric power supply	2.0114

Sources: Authors Survey (2023)

The analysis in Table 2 above shows the factors affecting water distribution in Minna metropolis. From the analysis it was observed that availability of water at the sources (M= 4.2903) affect water supply or distribution. Asgedom (2014) proposed that a lack of water at the source is one of the factors causing water delivery interruptions. Water shortages in metropolitan areas can occur when water is physically unavailable at the sources of supply, making distribution challenging. Another factor influencing water distribution in Minna metropolitan area is inadequate resources to purchase

water abstraction infrastructure (M= 4.5159) which may result to inadequate water abstraction from the ground water in this way, the distribution will be affected thereby causing water scarcity. The major problem of pipe-borne water distribution in the Minna metropolis is inadequate funding. According to Ishiaku et al. (2014) posited that inadequate funding culminated into obsolete equipment's, insufficient pumps, insufficient funds for new water works and inadequate electric power supply (M= 2.0114) to power the existing water pumps. Which is also contributing factor to inadequate water distribution in Minna. Also, absent of rain due to climate change (M= 4.1333) influence water availability at the sources. Unsurprisingly, climate change is one of the main reasons behind the global water crisis (McConville, 2022). However, a 1°C rise in global temperatures would result in a reduction of runoff, excess rainwater that flows across the land's surface by up to 10% (Lai, 2022). This global rise in temperature result to shortage of water distributed from the source. Similarly, high cost of acquiring water purification Facilities (M= 3.9120), and increasing poverty rates (M= 3.6538) are also determinant for water distribution in Minna Metropolis. Inadequate transport vehicle to distribute water (M= 3.9978) is a factor influencing water distribution in the Minna metropolis. An adequate transport vehicle is required for distributing water in areas which are not connected to distribution pipes.

Furthermore, limited distribution pipes infrastructures (M= 3.4421) affect water distribution. Many people worldwide, especially in poor developing countries, are still not connected to the public water infrastructure (Imam, 2023). In this manner, they result in purchasing water from private vendors or owning a private source of water. Pollution/contaminations (M= 3.2935) were also seen as factor affecting water distribution. Unsafe sewage management practises, oil spills, agricultural runoff, landfill leaks, and extensive marine dumping are the main causes of this contamination (Howell, 2020). Moreover, Rocky surroundings preventing individual water sources (M= 2.7030), and high level of concretization due to urban growth/increasing population (M= 2.1672) are perceived as other important factor affecting water distribution in Minna metropolitan areas.

### 2.3 Test of Hypothesis

H02 there is no statistically significant to the 3-key factors affecting water distribution in Minna metropolitan areas.

In other to achieve the stated hypothesis in section 2.3, component factor analysis was used to reduce the ten factors believed by the staff of NISWASEC in Minna as affecting the distribution of water in Minna. the component factor results are displayed in Table 3 & 4. however, Table 3 showed the communalities of the eleven (11) factors which were factorized using factor analysis.

Table 3 Communalities

s/n	Factors affecting water distribution	Initial	
Extraction			
1	Availability of water at the sources	1.000	.705
1	limited distribution pipes infrastructures	1.000	.776
3	Inadequate transport vehicles to distribute water	1.000	.723

4	Adequate resources to purchase water abstraction	1.000	.730
5	High cost of acquiring water purification facilities	1.000	.543
6	water pollution/contaminations	1.000	.506
7	Absent of rain due to climate change	1.000	.543
8	Rocky surroundings preventing individual water sources	1.000	.630
9	High level of concretization due to urban growth/increasing population	1.000	.700
10	Inadequate electric power supply	1.000	.669
11	High poverty rates	1.000	.372

Extraction Method: Principal Component Analysis.

Sources: Author's survey (2023)

Table 3 shows the communalities result for the factor analysis. From the analysis, it was observed that availability of water at the sources ( $R^2 = .705$ ), limited distribution pipes infrastructure ( $R^2 = .776$ ), inadequate transport vehicle to distribute water ( $R^2 = .723$ ), adequate resources for water abstraction ( $R^2 = .730$ ), high cost of acquiring water purification facilities ( $R^2 = .543$ ), water pollution/contaminations ( $R^2 = .506$ ), absent of rain due to climate changes ( $R^2 = .543$ ), rocky surroundings preventing individual water sources ( $R^2 = .630$ ), high level of concretization due to urban growth/increasing population ( $R^2 = .700$ ), and inadequate electric power supply ( $R^2 = .669$ ) contribute much to the factors affecting water distribution in Minna metropolis. However, high poverty rate contributes less to the factor affecting the distribution of water in Minna since the  $R^2 = .372$  is lower.

Table 4 Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared		
	Loadings					
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	4.616	46.156	46.156	4.616	46.156	46.156
2	2.959	15.767	61.923	2.959	15.767	61.923
3	1.559	12.593	71.516	1.577	12.593	71.516
4	.768	7.685	79.201			
5	.541	5.405	84.606			
6	.415	4.155	88.761			
7	.363	3.628	92.389			
8	.312	3.119	95.508			
9	.202	2.201	97.016			
10	.273	2.730	98.238			
11	.176	1.762	100.000			



Sources: Authors' survey (2023)

Table 4 shows the total explained variables. From the analysis it can be observed that there were total of eleven variable which were evaluated as the factors affecting water distribution in Minna. However, the factor analysis showed that availability of water at the sources (4.616), limited abstraction infrastructure (2.959), and inadequate transport vehicle to distribute water (1.559) exceed the Eugene value of 1. Therefore, these three factors were perceived by the staff of NISWASEC as the most important factors affecting water distribution in Minna metropolitan area. However, these three factors were further used in testing the hypothesis which is displayed in Table 5.

Table 5: T-Test result

	Test Value = 0					
	T	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the distance	
					Lower	Upper
Availability of water at the sources	29.850	89	.000	3.588	3.350	3.827
Limited distribution pipes infrastructure	33.665	89	.000	3.889	3.659	4.118
Inadequate transport vehicle to distribute	22.176	89	.000	3.613	3.420	4.782

Sources: Authors' Survey (2023)

Table 5 shows the T-test result. However, the analysis reveals that Availability of water at the sources (P-value= .000), limited distribution pipes infrastructure (P-value= .000) and inadequate transport vehicle to distribute (P-value= .000) are statistically significant at 0.05. which indicate that there are statistically significant to the available of water at the sources, limited distribution pipes infrastructure and inadequate transport vehicle to distribute water on water distribution in Minna metropolis. This study is therefore in line with the work of Asgedom (2014).

## 5. Conclusions

This study on assessment of the factors affecting water distribution in Minna metropolitan area focus on determining the factors influencing inadequate water distribution in Minna metropolis. Component factor analysis were use to determine three major factors affecting water distribution in Minna metropolis. While T-test statistics were use to test the significance of these factors. The study result enables the author to conclude that availability of water at the sources, limited distribution pipes infrastructure and inadequate transport vehicle to distribute water are the three major factors affecting water distribution in Minna. The study also concluded that there are statistically

significant to these three key factors affecting water distribution in Minna Metropolis. The study concluded by recommending that;

1. Adequate transport vehicles such as water tankers should be made available to distribute water in places which are not connected to the distribution pipes for at least twice a week.
2. Modern water abstraction infrastructures should be acquired by the state government to assist in the water abstraction.
3. Adequate resources should be made available by the government to invest in sewerage technology and water purification facilities
4. NISWASEC should work in collaboration with the Power holding company (i.e., Abuja Electricity distribution company) to provide adequate electric power supply to pump water to distribute among the Minna metropolitan area.

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## AN ASSESSMENT OF TEA PROCESSING AND CONSUMPTION AMONG TEA FARMERS' IN MAMBILLA, TARABA STATE, NIGERIA

I.-Ndagi

Department of Agricultural Economics and Extension Services, Faculty of Agriculture  
Ibrahim Badamasi Babangida University, Lapai, Niger State, Nigeria  
[idrisndagi515@gmail.com](mailto:idrisndagi515@gmail.com); 08034009756

### Abstract

This study assessed tea processing and consumption among tea farmers' in Mambilla, Taraba State, Nigeria. Simple random sampling was used to select 384 tea farmers in the study area. Data were collected from the respondents with the aid of a structured questionnaire. Simple descriptive statistics, Chi-square and Pearson Product Moment Correlation (PPMC) were the major analytical tools employed in analysing the data. The study revealed that majority of the respondents were male, married and within the age bracket of 31-50 years. The study also revealed that majority of the respondents (55.9%) consumed about 1.44 litres of tea per day and that majority of the respondents (91.4%) consumed the tea in the morning. Majority of the respondents (94.3%) consume home prepared tea and black tea was the most consumed tea by the respondents. Alcoholic drinks, cocoa, and coffee are alternative drinks to tea consumed in the study area. The study further revealed that sex and education influenced the quantity of tea consumed in the study area. It was therefore recommended that there should be intensive enlightenment on the health benefits associated with tea consumption.

**Keywords:** Tea consumption, Black tea, Consumers, Tea farmers, Beverages, Mambilla

### 1. Introduction

In Nigeria, the consumption of tea as a beverage is common among different categories of people and households. Consumption of tea in Nigeria is not restricted to consumer households, it is purchased, taken to motor parks, bus stops and is hawked by different classes of people who earn their living through this means (Sowunmi et al., 2009). According to Sowunmi et al. (2009), tea consumption is high among the age bracket of 65 years and above and majority of tea consumers preferred Lipton yellow label tea. According to Sowunmi et al. (2009) consumers of tea in Nigeria preferred either eateries or "mai tea". Tea is widely consumed all over the world according to Deng, Tan & Li (1998). Tea is second most consumed beverage in the world after water (Nutraingredients, 2004). The general objective of this study was to carry out an assessment of tea processing and consumption among tea farmers in Mambilla, Taraba State, Nigeria. Specifically, the study describes the socio-economic characteristics of the respondents in the study area; and determine the quantity of tea consumed, time, place and type in the study area.

### 2. Methodology

The study was conducted in North eastern part of Nigeria. Taraba State was purposively selected for the study. Taraba state lies between latitudes 6°25'N and 9°30'N and between longitudes 9°30'E and 11°45'E and covers a total land area of about 54,428 square kilometre (Wikipedia, 2019). The state is located within the tropical zone and has is surrounded by a vegetation of low forest in the southern part and grassland in the northern part. It has a population of about 2.294 million (NPC, 2006). The major occupation of the

people of Taraba State is agriculture. Cash crops produced in the state include coffee, tea, ground nuts and cotton while the major food crops produced include maize, rice, sorghum, millet, cassava and yam.

Mambila in Sardauna Local Government Area of Taraba State was purposively selected. Random sampling technique was used to select 384 tea farmers from the study area. The data was collected from the respondents with the aid of structured questionnaire.

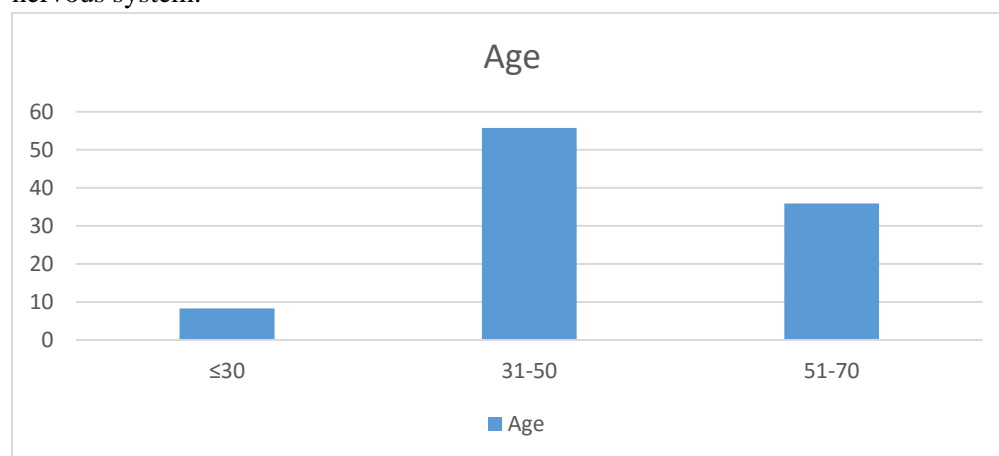
The data collected for this study were analysed using simple descriptive statistics, chi-square and Pearson Product Moment Correlation (PPMC).

### 3. Results and Discussion

Socio-economic characteristics of the respondents

#### Age

Figure 1 below shows that 35.9% of the tea consumers were between 51 and 70 years old, while only 8.3% were less or equal to 30 years old. This in agreement with previous study by Sowunmi *et al.*, (2009) that tea consumption is high among the age bracket of 65 years and above. This shows that most of the tea consumers in Nigeria were aged. This may be, because of the caffeine that serves as a mild stimulant of the central nervous system.

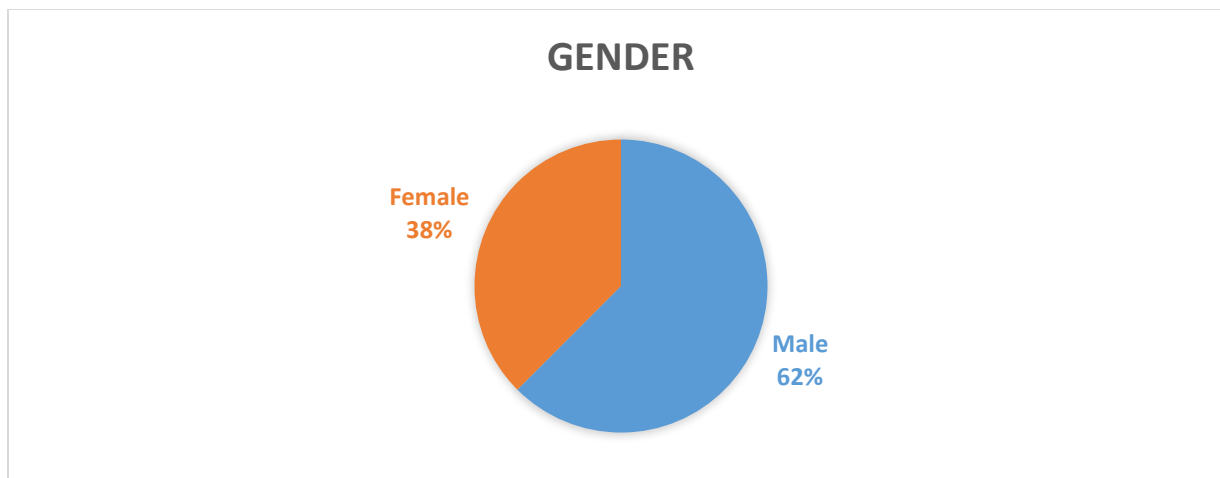


Source: field survey, 2014

**Figure 1: Distribution of respondents based on age**

#### Gender

Figure 2 shows that about 62.5% of the respondents were male while 37.5% were female. This shows that there were more male tea consumers than female in the study area. Involvement of more male in tea consumption may not be far from the fact that, tea consumption is associated with energy booster.

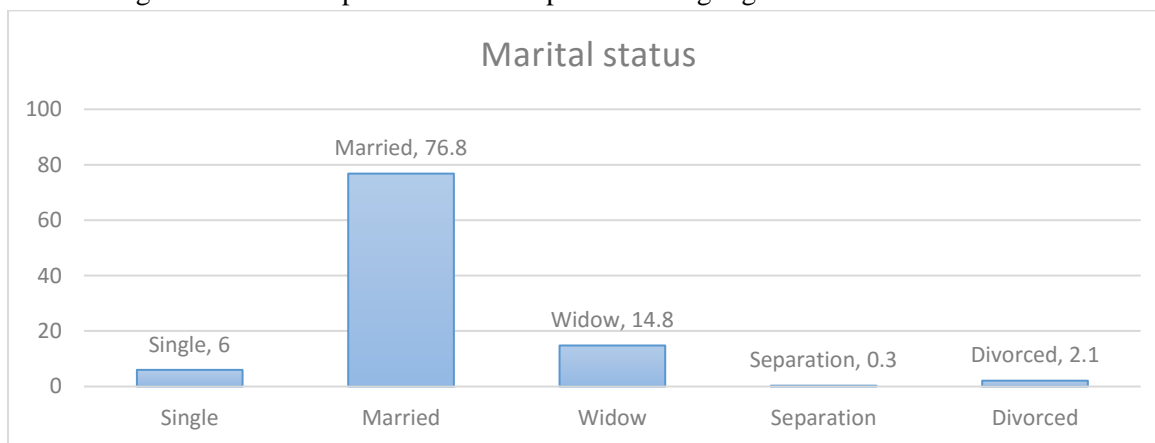


Source: field survey, 2014

**Figure 2: Distribution of respondents based on gender**

### Marital status

Majority (76.8%) of the tea consumers are married and (14.8%) were widows while only 6.0% were single. This implies that almost all the tea consumers place high premium on marriage. This may be because; a married tea consumer can easily ask a family member to prepare him a cup of tea. Goldsmith (2005) reported that marriage is a relationship of two or more persons living together to make ends meet.

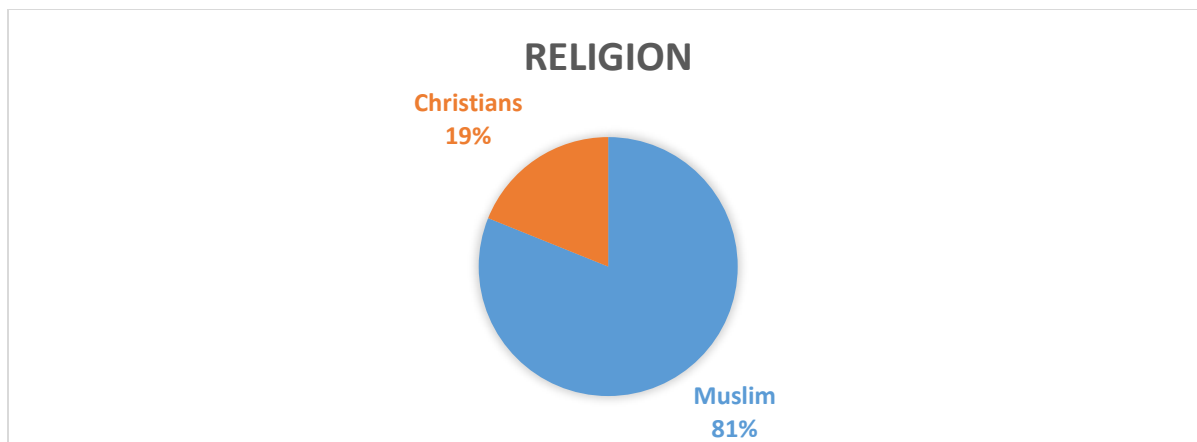


Source: field survey, 2014

**Figure 3: Distribution of respondents based on marital status**

### Religion

It was also revealed that majority (81.1%) of the tea consumers were Muslims, while 18.9% were Christians and none of the respondents interviewed practiced traditional religion. This may not be far from the fact that, the study area is located in the northern part of Nigeria where Islam is the most popular religion among the people. Also, the domination of Muslims among the tea consumers in the study area is as a result of its acceptance as an alternative to alcoholic drink.

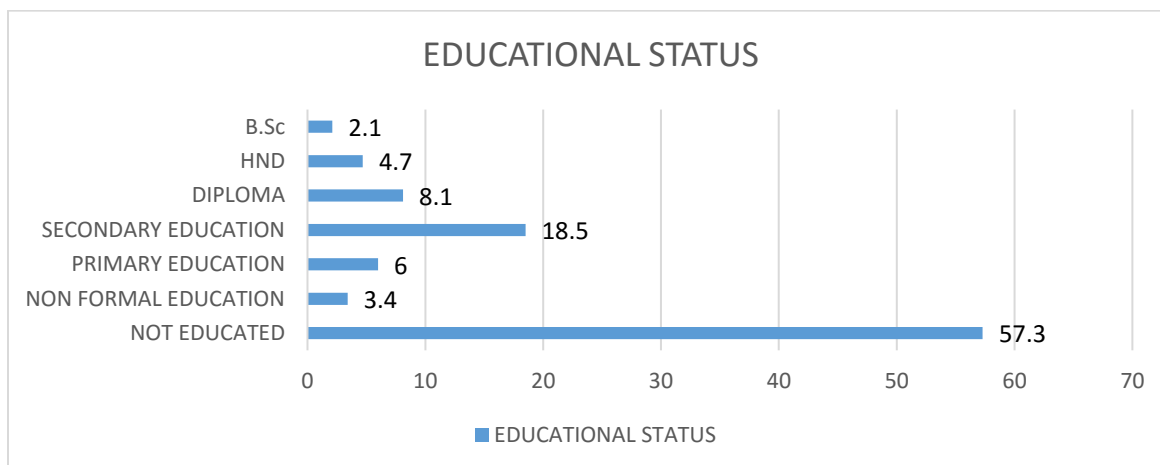


Source: field survey, 2014

**Figure 4: Distribution of respondents based on religion**

**Educational status**

The educational status of respondents revealed that most (57.3%) of the respondents were not educated, while 39.4% of the respondents acquired one or more form of formal education and 3.4% of the respondents have no formal education.



Source: field survey, 2014

**Figure 5: Distribution of respondents based on educational status**

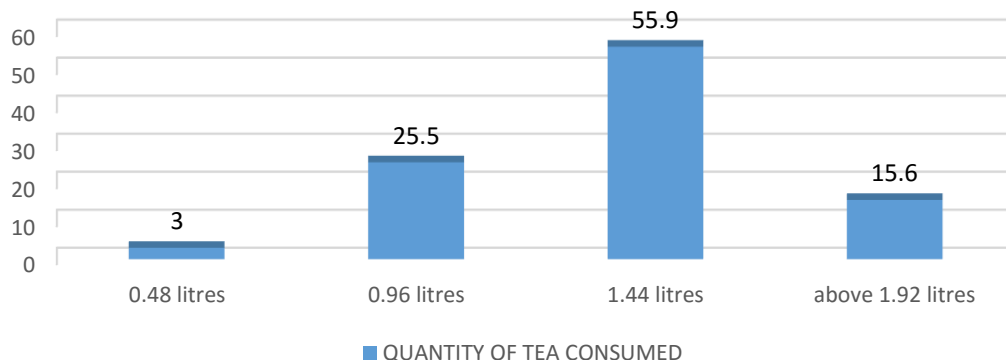
**Respondents' quantity of tea consumed per day**

Figure 6 below shows that consumers of 1.44 litres of tea per day formed the highest proportion (55.9%) while 25.5% consumed 0.96 litres of tea per day, 15.6% consumed above 1.92 litres of tea per day and 2.1% consumed 0.48 litres of tea per day. Sowunmi *et al.*, (2009) stated that tea is consumed hot as a hot beverage during the cold season and taking as ice tea during the hot season. Also, Stephanou (2004) reported that consumers of tea for at least one year or 4 cups of tea per day will not develop high blood pressure. While Costa, Gouveia & Nobrega (2002) and Rietveld & Wiseman (2003) believe that consumption above require cups of tea for this categories of heart condition patients or major cardiovascular patients and pregnant and breast feeding mothers can cause an increase in heart rhythm. This implies that required quantity of tea



consumption is put at 4 cups per day for normal healthy person and 1 or 2 cups of tea per day for categories of patients mentioned above.

### QUANTITY OF TEA CONSUMED



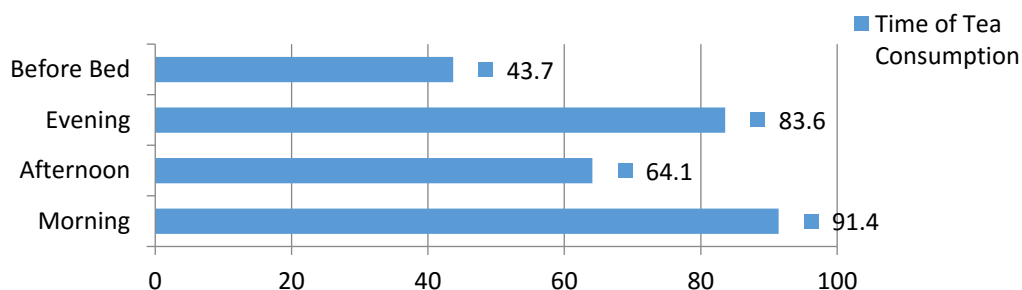
Source: field survey, 2014

**Figure 6: Distribution of respondents based on quantity of tea consumed**

### Respondents' time of tea consumed per day

Figure 7 revealed that morning tea consumers formed the highest proportion (91.4%) in the study area. About 84% consumed tea in the evening, while 64.1% consumed tea in the afternoon. Only 43.7% of the respondents consumed tea before going to bed. The implication is that tea is generally consumed by many during breakfast and also used to warm the body temperature in the morning and evening during harmattan. Therefore, those consuming tea as breakfast sees it as a normal meal not knowing that they also stand to gain the health benefits associated with tea consumption. Also, consumers of tea in the evening may consume it for the evening harmattan which is common among security guards so as to remain alert throughout the night.

### Time of Tea Consumption



Source: field survey, 2014

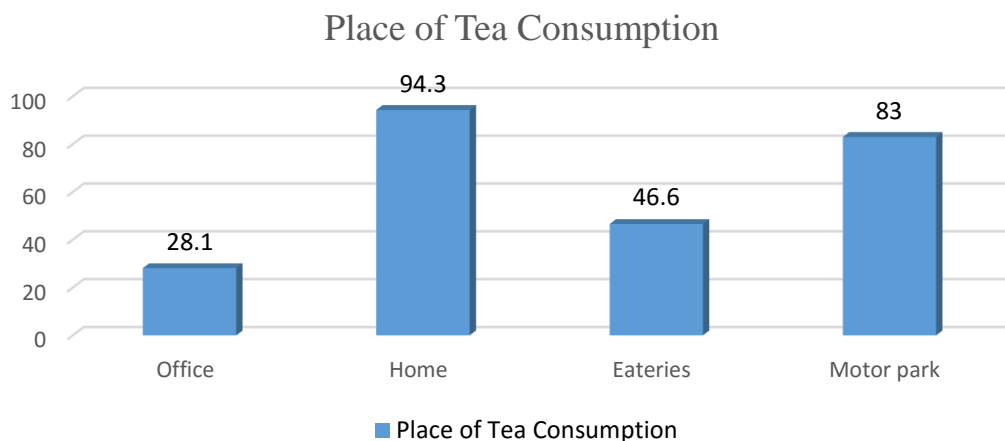
\*multiple responses

**Figure 7: Time of tea consumed per day**

### Respondents' place of tea consumption

Figure 8 below revealed that the high proportion (94.3%) tea consumers take home prepared tea, 46.6% consumed tea at eateries while 28.1% and 21.6% respectively consumed tea in the office and at Motor Park. The domination of tea consumers at home may not be unconnected with the fact that most of the respondents'

consumers were married and will easily have access to hot tea at home. Also eateries offer free tea service to their customers instead of water. Some of the tea consumers claimed to take tea in the office so as to be mentally alert and that tea consumption make them active throughout the day in office. This finding is consistent with previous study by Sowunmi *et al.*, (2009), who reported that tea is consumed at motor park, bus top, office and home and is hawked by different classes of people. This implies that tea can be consumed anywhere convenient and of interest to consumers.

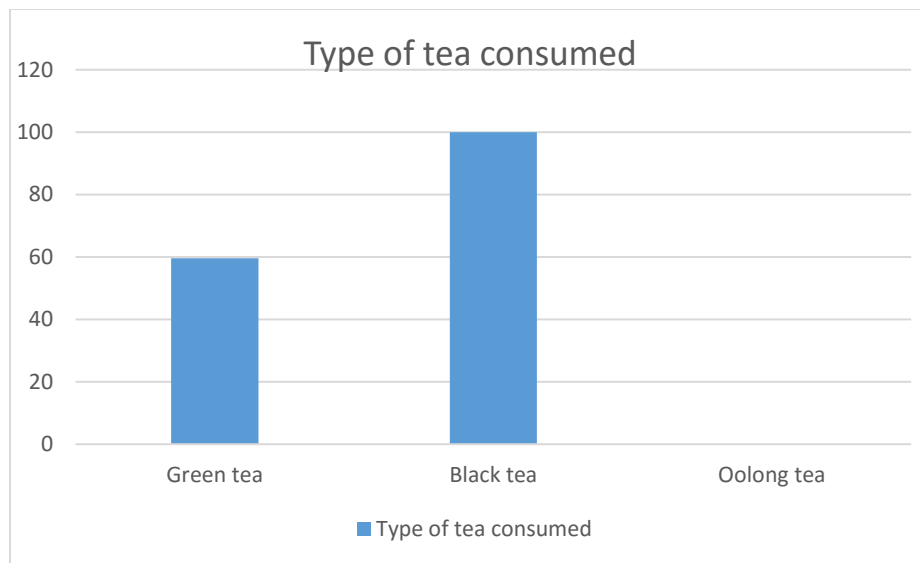


Source: field survey, 2014 \*multiple responses

**Figure 8: Place of tea consumption**

#### **Respondents' type of tea consumed**

Figure 9 shows that all (100%) of the respondents consumed green tea but have never drank oolong tea. About 59.06% of the respondents consumed green tea. The high proportion of the black tea consumers may not be unconnected with the fact that black tea is one of the commonest and cheapest tea available in Nigerian market. However, green tea is not very common and is very expensive, but of higher health benefits compared to black tea. According to Siddiqui, Afaq, Adhami, Ahmed & Mukhtar (2004), green tea is the best good source of group called catechins. Catechins are more powerful than vitamin C and E in halting oxidative damage to cells and appear to have other disease fighting properties. Furthermore, according to the author, regular consumers of green tea stand the benefit of reduced risk of heart disease and the antioxidants in tea help block the oxidant of LDL (bad) cholesterol, increase HDL, (good) cholesterol and improve artery function. In other words, green tea is richer in terms of health given properties than black tea. This implies that close to half of the respondents were not consuming high quality (green) tea in Nigeria.

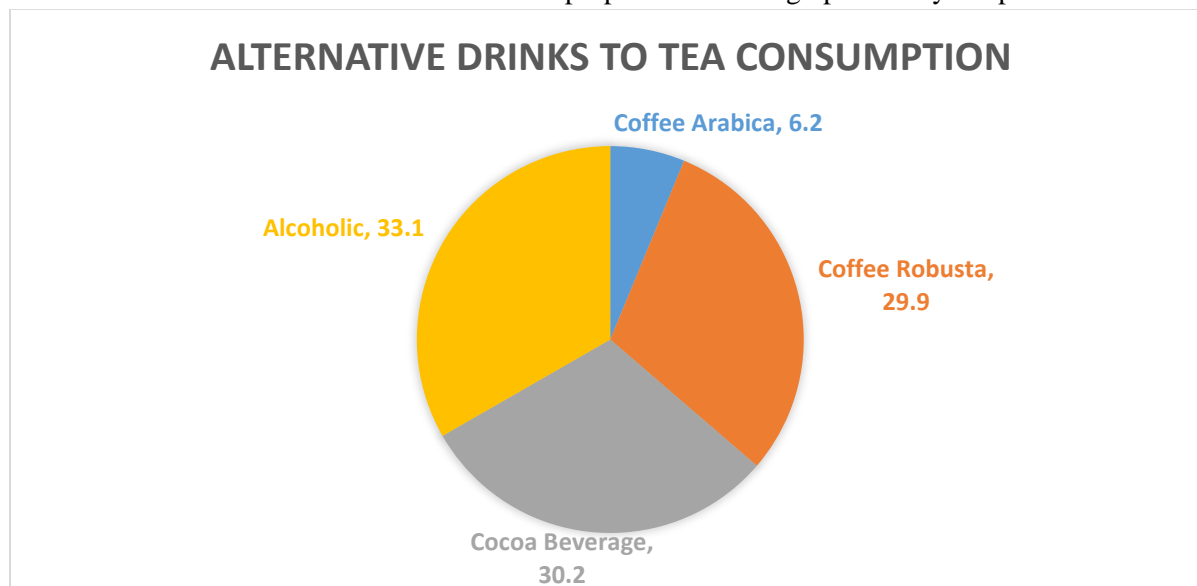


Source: field survey, 2014 \*multiple responses

**Figure 9: Type of tea consumed**

**Respondents’ alternative drink to tea**

Figure 10 below shows that many (33.1%) of the respondents consumed alcoholic drink, (30.2%) cocoa, (29.9%) coffee robusta (6.2%), coffee arabica as alternative drink to tea. The high consumption of alcoholic drinks and coffee robusta as an alternative to tea among the respondents may not be far from the fact that alcoholic drink is locally brewed and processed locally in the study area. On the other hand, cocoa beverage (Bournvita, Milo, and Ovaltine) is one of the commonest beverages that are found in Nigeria market. All these alternative drinks were consumed for the purpose of warming up the body temperature.



Source: field survey, 2014 \*multiple responses

**Figure 10: Alternative drinks to tea**

### Relationship between socio-economic characteristics and quantity of tea consumed

Table 1 revealed that only marital status and religion of the respondents were not significant factors in tea consumption, while sex and education of the respondents were significant factors in tea consumption ( $p < 0.01$ ). Data in Table 1 showed that sex of the respondents ( $X^2 = 19.47$ ,  $p \geq 0.05$ ) influenced the quantity of tea consumed in the study area. This is probably because tea consumption is associated with health benefits. This is in line with Siddiqui *et al.*, (2004) assertion that regular consumers of tea stand the benefit of reduced risk of heart disease and block bad cholesterol and increase good cholesterol and improve the entry function. Also, there was an indication that education of the respondents ( $X^2 = 54.15$ ,  $p \geq 0.05$ ) had positive influence on quantity of tea consumed. As the consumers level of education increases, the quantity of tea consumed increases. This implies that a consumer that is highly educated will be widely informed on the health benefits of tea consumption and consequently consume a good quality of tea. This is supported by Ola (2009) that education is generally believed to be the bed rock of development.

Marital status of respondents ( $X^2 = 7.21$ ,  $p \geq 0.05$ ) was not significant factor of the quantity of tea consumed in the study area. This indicates that, irrespective of whether an individual is single or married, the quantity of tea consumed in the study area was not affected. This might be because tea is offered free like water in almost all the eateries in the study area due to weather condition. Also, Table 1 revealed that religion of the respondents ( $X^2 = 3.53$ ,  $p \geq 0.05$ ) was not a significant factor of the quantity of tea consumed in the study area. This implies that, the religion of an individual either Islam or Christianity does not influence the quantity of tea consumed in the study area. This may not be unconnected with the fact that tea is offered free in almost all the eateries, is non-alcoholic and also associated with health benefits.

**Table 1: Relationship between socio-economic characteristics and quantity of tea consumed**

Socio-economic variables	$x^2$ value	Df	P value	Decision
Sex	19.47	1	0.00	Sig
Education	54.15	6	0.00	Sig
Marital status	7.21	3	0.65	Not sig.
Religion	3.53	1	0.60	Not sig.

Source: field survey, 2014

### 4. Conclusions

In the foregoing, the study examined from a historical perspective the fundamental role of some socio-economic characteristics of the tea consumers in Nigeria. The result available also revealed that the quantity of tea consumed by tea consumers, place, time and type of tea consumed in the study area. The consumers of tea in the morning with home tea consumers were high. The statistical result revealed that only marital status and religion of the respondents were not significant factors in tea consumption, while sex and education of the respondents were significant factors in tea consumption ( $p \geq 0.01$ ). Based on the findings, the study recommended that there should be intensive enlightenment campaign on the health benefits associated with tea consumption by both printing and electronic media so as to promote tea consumption in the study area. The need to step down the tea cultivation to low land areas and promote local processing of

both black and green tea in the study. It is hoped that, the recommendation given in this study, if given careful consideration, will help to increase tea consumption and improve health status of the tea farmers.

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## IMPACT OF ELECTRONIC INFORMATION RESOURCES, DEMOGRAPHIC VARIABLES AND WORK ENVIRONMENT ON LIBRARIANS' JOB PERFORMANCE IN ELECTRONIC LIBRARIES IN FEDERAL UNIVERSITIES IN NORTHERN NIGERIA

Mohammed Shantali Musa CLN

Abubakar Gimba Library  
Ibrahim Badamasi Babangida University, Lapai, Niger State  
[shantalimusa@gmail.com](mailto:shantalimusa@gmail.com)  
08030946208

### Abstract

This study investigated how electronic information resources, demographic variables and work environment influence librarians job performance in federal universities in Northern Nigeria. Three research questions and three hypotheses were tested at 0.05 level of significance. Abraham Maslow's theory of hierarchy of needs and diffusion of innovation theory by Rogers in 1995 was the theoretical framework underpinning the study. The study population consisted of 732 academic librarians in Northern Nigeria university libraries. Out of this total, 400 copies were duly completed and returned for quantitative analysis, giving a response rate of 79%. Sampling was purposive and enumerative as all members of the population were used for the study. Data collected were analysed using SPSS. The result for influence of electronic resources on the job performance of librarians in the university electronic libraries reveals that it is true for the following: electronic journals have positive influence on job output, electronic books help improve Librarians electronic skills, electronic theses have improved my work and electronic magazines play vital role in my work output. And the result based on factors militating against the full utilization of electronic information resources in the electronic libraries, shows that it is true that the following factor militate against the full utilization of electronic information resources: information literacy, access to the internet, self-concept, peer influence, unavailable mobile phones and computers to accessing information; and no access to current information surfing the web easily. Also, the result based on influence of demographic variables on job performance of librarians reveals that it is true that: age, marital status, gender, educational background, job position and work experience are major influence on job performance of librarians in the electronic libraries. The research further shows that there is a significant relationship between electronic information resources and job performance of librarians. And there is also a significant influence of work environment on job performance of librarians. And there is a significant relationship between demographic variables and job performance of librarians. With their respective P-values = 0.000, 0.027 and 0.000 from Chi-square statistic is less than 0.05

**Keyword:** Electronic library, Job performance, Demographic variables, Electronic resources, Librarians job performance.

## 1. Introduction

Job performance put succinctly refers to the extent to which librarians or workers are performing the job they are employed for. It is an obligation for librarians to perform their duties effectively, efficiently and satisfactorily so as to serve as a propelling factor for library patrons to be willing to use library resources repeatedly, irrespective of whether the library operations are fully digitised or semi-digitised. If the services of librarians are poor, patrons will not utilize the library as they should even if the information materials they are looking for are available. This is one of the reasons why patrons do not utilize some libraries. Armstrong and Baron (2010) argued that librarians' job performance is the key determinant of the success of any library. All the librarians especially in academic library work as a team in order to harness their potential contributions towards the achievement of the library objectives and goals.

Performance could also refer to the different work activities that are carried out in the university libraries including the electronic ones so that the users can utilize the electronic information resources that are available in the electronic library and also the conventional one so that the goal of establishing the libraries will be met. It is expected that with the provision and availability of information resources in place by the institutions, the extent to research and development will be undertaken will improve greatly. Performance is important for institutions as employees' performance leads to the success of the institutions. Performance is also important for librarians, as achieving tasks can be a source of satisfaction to the universities and users (Muchhal, 2014). The librarians can only be satisfied when the universities and users that come to use the resources print, non-print or electronic resources are satisfied with their services. Job performance can be defined as behaviours or activities that are performed towards accomplishing the organization's objectives. Librarians Job performance is the execution of different tasks in a situation that allows optimal outcome it is the librarians or employees ability to achieve the organisation's objectives. Librarians or employees are considered to achieve good performance when they meet up with the set goals and objectives of an organisation and the libraries meet up with the parent institutions objective of teaching, learning and research. Individual job performance or contribution to the institution could have a great influence on an organisation's overall performance. Yaya, Achona and Osisanwo (2014) argued that job performance refers to the work activities that are carried out by the librarians or library workers towards the achievement of organisational objectives. It is also the fulfilment of librarians' primary responsibility to the organisation.

Employee performance is the outcome or contribution of employees to make them attain goals, while performance may be used to explain what an organisation has accomplished in respect to the process, results, relevance and success. Every employee owes the employer the responsibility of performing their duties for which they are employed for so that the institution or organisation can achieve their aims and objectives for which they were established. Job performance is the ability to carry out statutory duties which could be based on the field of specialisation or areas of training and development as well as organisations objectives. Afshan, Sobia, Kamar and Nasir (2012) viewed

that performance is the achievement of specific tasks measured against predetermined or identified standards of accuracy, completeness, cost and speed. Employee performance can be manifested in improvement in production or services easiness in using the new technology, highly motivated workers. The degree to which academic library institutions meet up with the parent institutions objectives of teaching, learning and research depends largely on the commitment, dedication and job performance of librarians. The librarians know the library information materials whether (print or electronics) to acquire, process and make them available to users. Institutions of higher learning cannot operate without established libraries and librarians.

Information and Communication Technology has penetrated into every areas of human endeavour today and its use in the 21<sup>st</sup> century. This has accordingly modernized and changed the university libraries' environments. Today libraries are using ICT for better, improved and speedy services and equally satisfying numerous users' needs more than ever before. Academic libraries now have electronic information resources. Electronic information resources are resources that one can only utilize through the use of computer, hand set any or any electronic devices to access; they can be accessed on the Internet or CD-ROM respectively. Electronic information resources are available only in electronic format (Pwanra, Asapo and Plockey, 2017). These resources can be accessed anywhere but if it is on Internet there must be network. Electronic information resources include: electronic journals, electronic books, electronic theses, electronic mail etc. It is observed that electronic information services are provided in the electronic section of the libraries in federal universities in northern Nigeria or around the library where there is strong network for users that come with either their laptop hand set for browsing. Owolabi, Idowu, Okocha and Ogundare (2016) noted that the use of electronic information resources is low. The university made this resources available to assist in research teaching and learning, however there is low utilization of the resources. The aim of libraries is to provide effective combination of print, non-print and electronic information resources in support of teaching, learning and research in parent institutions. Electronic information resources provide efficient access to electronic information beyond institutional boundaries. Gwazah (2011) regretted that electronic information resources are not fully utilised by users in higher institutions in Nigeria, despite the huge amount of money libraries invest in it. Some of the institutions encounter problems of strategic planning: adequate or reliable funding, some institutions do not fully fund it, the bandwidth of the internet is slow and cannot provide electronic information services to users and there is no consistent training for users in new ICT services and some university libraries do not even adequately train patrons all. Unfortunately, this is the situation with most of the universities in northern Nigeria.

Academic libraries subscribe to electronic information resources for their patrons use, however the utilization of the resources by the users is low, the ICT (Information and Communication Technology) facilities in some of the universities are poorly managed by the universities, if there is a problem in the electronic libraries, and it takes long time to resolve. Lefuna (2014) regretted that in spite of the increasing use of electronic information resources, academic libraries are not managing the resources effectively, for libraries to ensure access and full utilisation of the



resources. For example, observation revealed that some of the universities in northern Nigeria that are using inverter as alternative source of energy to the electronic libraries normally have problem of timely replacement of battery when they are weak. Most often when you go to the electronic library that is supposed to be in use for 24 hours daily you will observe that it is either they are locked up, few users or there is always one problem or the other that hinder full utilisation of the resources. This study aims at investigating how electronic information resources, demographic variables and work environment influence librarians job performance in federal universities in Northern Nigeria.

## **2. Literature Review**

### **Theoretical Framework**

The study is based on two (2) theories, they are namely: Abraham Maslow's theory of Hierarchy of Needs and Diffusion of innovation theory by Rogers in 1995. These two theories are related to employees' motivation, satisfaction, job performance and Information and Communication Technology (ICT).

### **Maslow's Hierarchy of Needs Theory**

The theory of Maslow's Hierarchy of Needs is relevant to this study in the sense that if an individual is physiologically unstable, feels unsafe or insecure; or feels that nobody loves or cares for him or her that his/her esteem is being threatened, it is certain and concluded that such employee could not have self-actualisation in his or her chosen career. If an individual is not self-actualized the job performance can never be at the optimum or maximum. If an employee works in an unclean and unhealthy environment, he or she could develop physiological problems that would adversely affect his job performance. Moreover, if his physical environment is endangered or unsafe, the job performance of an employee could suffer a setback. If he or she feels that the co-workers are unfriendly, he/she would not be able to put his best in his job. The above factors could have cumulative effect on self-esteem and his self-actualisation which could negatively influence his job performance.

### **Diffusion of Innovation Theory**

Innovation diffusion theory was established by Rogers in 1962. The theory seeks to explain how, why, and at what rate new ideas and technology spread. Rogers argued that diffusion is the process by which an innovation is communicated over time among the participants in a social system. For Rogers (2003), adoption is a decision of full use of an innovation as the best course of action available and rejection is a decision "not to adopt an innovation". Rogers defines diffusion as "the process in which an innovation is communicated thorough certain channels over time among the members of a social system. The four key components of diffusion of innovation are innovation, communication channels, time, and social system.

### **The individual Innovativeness**

The individual innovativeness is based on who adopts the innovation and when. A bell shaped curve is often used to illustrate the percentage of individual that adopt an innovation. The first category of adopters is innovators. These are the risk-takers and pioneers who lead the way. They climb on board the train early and help spread the word about the innovation to others. The third and fourth groups are the early majority and the late majority. The innovators and early adopters convince the early majority. The late majority wait to make sure that adoption is in their interests. The final group is the laggards. These are the individuals who are highly skeptical and resist adopting until absolutely necessary. In many cases, they never adopt innovation (Rogers, 1995). This is applicable in university libraries. ICT adoption in libraries go through stages depending on individual universities.

### **Relevance of diffusion innovation theory to ICT research**

According to Sury (1977) diffusion in its simplest form investigate how the major element of diffusion and a multitude of factors interact to facilitate or impede the adoption of specific product or practice among members of a particular adopter group' Clark (1999) observed that diffusion theory has potential application to information technology ideas, artefacts and techniques, skills have been used as the theoretical basis for a number of research in information technology.

Hayati and Jowkar (2008) studied the process of adoption of electronic reference materials in academic libraries of Iran. The results show that the most effective factors in adopting electronic reference materials are the ability of electronic reference materials to facilitate information retrieval, shortening the time of searching and fair cost of resources.

The use information and communication technology (ICT) in academic libraries, is an indicator of diffusion. The use of electronic information resources shows the relative advantage of compatibility, complexity, friability and observability, are positively correlated with the use of information and communication technology (ICT) by the library users (Usluel, Askar and Bas 2008). The use of information and communication technology (ICT) is getting more widespread in higher education. The faculty members make use of ICT mostly as a means of communication, for doing research about the courses they teach through the Internet and for publications. Thanuskodi (2012) opined that electronic resources are the electronic representation of information. There are available in various formats like electronic books, digital libraries, online journal magazine, electronic learning tutors and on line test. Because of the effectiveness of its presentation with multimedia tools, these e-resources have become the source of information. Electronic resources deliver the collection of information as full text databases, e-journals, image collections, multimedia in the form of CD, tape, internet, web technology etc. E-resources also include e-journals, e-discussions, e-news, e-data archives, etc can be called as an electronic resource. In addition, electronic information source is a wide range of products going from electronic periodicals to CD-ROMs, from mailing list to databases, all of them having a common feature of being used and sometime modified by a computer.

Ugwu and Onyegiri (2013) are of the opinion that electronic resources include, but are not limited to web sites, online databases, e-journals, e-books, electronic integrating resources, and physical carriers in all formats, whether free or fee-based, required to support research in the subject covered, and may be audio, visual, and/or text files. Electronic information resources are considered as an indispensable tool for scholarly work. These provide high quality information services in support of teaching and research for academic staff members as well as acquisition of knowledge of the students. The term e-resource is frequently used to refer to information that is retrieved electronically and which may or may not have a print copy. The International Federation of Library Associations and Institutions (IFLA, 2012) specifies types of electronic resources as: e-books, e-journals, full text (aggregated) databases, indexing and abstracting databases, reference databases (biographies, dictionaries, directories, encyclopaedias, etc), numeric and statistical databases, e-images, e-audio/visual resources. The journals, books, databases and abstracting tools provided on the Internet are referred to as Web Resources or e-resources (electronic resources). Just a handful of these resources continue to be published on CD-ROMs. Also, a few resources are free; most scholarly resources are very expensive. Irrespective of the cost, electronic resources are preferred to printed resources because current editions get to users as soon as they are posted on the website. It could be on the same day, provided there is network. To this end, electronic resources represent an increasingly fundamental component of the collection-building activities of libraries (IFLA, 2012).

An electronic resource is defined as a resource which requires computer access or any electronic product that delivers a collection of data, be it referring to full text bases, electronic journals, image collections, other multimedia products and numerical, graphical or time based, as a commercially available title that has been published with an aim to being marketed. These may be delivered on CD ROM, on tape, via Internet and so on. Libraries are not only acquiring printed materials such as books and journals but also making provision for users' access to various learning electronic resources. The different types of electronic resources are, E-books, E-journals, Databases, CDs/DVDs, E-conference proceedings, E-Reports, E-Maps, E-Pictures/Photographs, E-Manuscripts, E-Theses, E-Newspaper, Internet/Websites - Listservs, Newsgroups, Subject Gateways, USENET, FAQs (Kenchakkanavar, 2014). The electronic books are helpful because of their easy portability and its feature of including more than one resource material in a single hand held device. The published materials could also be available on open access platform. This helps a lot of people also to get the information required free of cost and bridge the digital divide. Demographic variable according to Oyewole and Popoola (2015), are personal characteristics that include age, gender, educational level, tenure or working experience, job level and monthly salary. Some frequently used demographic variables include age, sex (gender), race / ethnicity, education, location of residence, socio-economic status (SES), income, employment status, religion, marital status, ownership (home, car, pet, etc), language, mobility, population size and family size.

According to George (2010) demographic characteristics are personal staff characteristics and include information such as ethnicity, race and family size. Bell (2008) defined demographic characteristics as personal statistics on information such as gender, age, sex, education level, income level, marital status, occupation, religion, birth rate, death rate, average size of family, average age at marriage. For example, considering age, one is expected to be energetic and enthusiastic at an early age of their employment. Demographic variables are varying characteristics, that is, an important or social statistic that defines an individual, sample group, or population. Lee and Schuele (2010) define demographic variables as independent variables because they cannot be manipulated. Demographic variables are used in this study as independent variables, they are age, gender, marital status, years of experience, academic status and educational qualifications. Attempts were made to find out if they have any effect on research productivity, which is the dependent variable.

### **3. Research Methodology**

#### **Research Design**

The research design adopted for this study is survey research. Survey research will be appropriate because it allows planned collection of information from sample of respondents through their responses to questions for the purpose of description as a guide to action or for the purpose of analysing the relationship between certain variables (Check and Schutt 2012).

#### **Population of the Study**

The target population of the study will consist of seven hundred and thirty-two (732) librarians working in federal universities in Northern Nigeria.

#### **Sample and Sampling Technique**

The main objective of sampling strategies in survey research is to obtain a sufficient sample that is representative of the population of interest. A large random sample increases the likelihood that the responses from the sample will accurately reflect the entire population. In order to accurately draw conclusions about the population, and generalise result, the sample must include individuals with characteristics similar to the population. However, the researcher sampled three hundred and eighty-four (384) librarians from five universities that are having functional electronic libraries in federal universities in Northern Nigeria. The target sampled population of the study will consist of three hundred and eighty-four (384) librarians working in electronic libraries of five (5) sampled federal universities in Northern Nigeria.

#### **Method of Data Analysis**

The data that will be generated from this study will be subjected to descriptive statistical analysis using frequency, percentage and counts mean for the analysis of respondents' bio-data and to answer the research questions. Pearson Chi-square and Correlation analysis will be used to test the

stated null hypotheses at 0.05 level of significance. The statistical Package for Social Sciences (SPSS) version 23 will be used to analyse all statistical data.

#### 4. Results

**Table 1: Return Rate by Institutions for the job performance of librarians in the university electronic libraries under study**

<b>Institution</b>	<b>Copy of Questionnaire Administered</b>	<b>Number of returned Questionnaire</b>	<b>Percentage Returned</b>
Ahmadu Bello University (ABU)	100	90	18
FUT Minna	100	75	15
University of Abuja	100	75	15
University of Agriculture Makurdi	100	80	16
University of Ilorin	100	75	15
<b>Total</b>	<b>500</b>	<b>395</b>	<b>79</b>

The result from this table shows the return rate of the sampled institutions in Nigeria. From the table we observed that Ahmadu Bello University (ABU) have the highest return rate of 18.00% this could be attributed to presence of the researcher at the institution during collection of data. We observed that there are more than average return rates from four other Universities from which sample is drawn based on number of questionnaires administered to each Librarians in each institution.

**Table 2: What is the influence of electronic resources on the job performance of librarians in the university electronic libraries under study?**

<b>Statement</b>	<b>Strongly Agree</b>	<b>Agree</b>	<b>Disagree</b>	<b>Strongly Disagree</b>	<b>FX</b>	<b>Mean</b>	<b>Decision</b>
Electronic journals have positive influence on job output	359(89.8)	41(10.3)	0(0.00)	0(0.00)	1559	3.90	True
Electronic books helps improve Librarians electronic skills	181(45.3)	219(54.8)	0(0.00)	0(0.00)	1381	3.45	True
Electronic theses have improved my work	161(40.3)	239(59.8)	0(0.00)	0(0.00)	1361	3.40	True
Electronic magazines play vital role in my work output	185(46.3)	215(53.8)	0(0.00)	0(0.00)	1385	3.46	True

Electronic reference is of great importance job performance of librarians	58(14.5)	17(4.3)	196(49.0)	129(32.3)	804	2.01	Not True
<b>Overall Mean</b>							<b>3.25</b>

From the table, values in the parenthesis are percentages of the frequency counts. Decision for each statement is made comparing the overall mean with the individual means. If the specific mean is greater than or equal to the overall mean, then it is true otherwise it is false.

The result from table 2 shows the influence of electronic resources on the job performance of librarians in the university electronic libraries under study. From the table, we observed that, in each case larger percentage of the sampled respondents strongly agreed to the responses on influence of electronic resources on the job performance of librarians in the university electronic libraries. It is observed from the decision made in the table that it is “true” that; (a) *Electronic journals have positive influence on job output* (b) *Electronic books helps improve Liberiarians electronic skills* (c) *Electronic theses have improved my work* (d) *Electronic magazines play vital role in my work output*. And it not true for the statement *Electronic reference is of great importance job performance of librarians*.

**Table 3: What are the factors militating against the full utilization of electronic information resources in the electronic libraries of the university libraries under study?**

Statement	SA	A	D	SD	FX	Mean	Decision
	(4)	(3)	(2)_	(1)			
Information literacy	120(30.0)	98(24.5)	90(22.5)	92(23.0)	1046	2.615	True
Access to the internet	120(30.0)	100(25.0)	82(20.5)	98(24.5)	1042	2.645	True
Self-concept	109(27.3)	123(30.8)	88(22.0)	80(20.0)	1061	2.653	True
Peer influence	123(30,8)	96(24.0)	90(22.5)	91(22.8)	1051	2.627	True
Poor Circulation Services Unavailable mobile phones and Computers to accessing Information	114(28.5)	101(25.3)	97(24.3)	88(22.0)	1041	2.603	True
No access to current information Surfing the web easily	137(34.3)	102(25.5)	84(21.0)	77(19.3)	1099	2.748	True
	147(36.8)	76(19.0)	79(19.8)	98(24.5)	1072	2.68	True
<b>Overall Mean</b>							<b>2.647</b>

From the table, values in the parenthesis are percentages of the frequency counts. Decision for each statement is made comparing the overall mean with the individual means. If the specific mean is greater than or equal to the overall mean, then it is true otherwise it is false.

The result from table 3 shows the factors militating against the full utilization of electronic information resources in the electronic libraries of the university libraries under study. From the table, we observed that, in each case larger percentage of the sampled respondents strongly agreed to the responses on factors militating against the full utilization of electronic information resources in the electronic libraries. It is observed from the decision made in the table that it is “true” that; (a) *Information literacy* (b) *Access to the internet* (c) *Self-concept* (d) *Peer influence* (e) *Unavailable mobile phones and Computers to accessing information* (f) *No access to current information Surfing the web easily*. And it not true for the statement *Poor Circulation Services*.

**Table 4: What is the influence of demographic variables on the job performance of librarians in the electronic libraries of the universities in Nigeria?**

Demographic Variables	SA	A	D	SD	FX	Mean	Decision
Age	113(28.3)	115(28.8)	92(23.0)	80(20.0)	1061	2.653	True
Marital status	115(28.8)	115(28.8)	88(22.0)	82(20.5)	1063	2.658	True Not
Self-concept	113(28.3)	105(26.3)	84(21.0)	98(24.5)	1033	2.583	True
Gender	121(30.1)	118(29.5)	81(20.3)	80(20.0)	1080	2.700	True
Educational background	121(30.1)	104(26.0)	88(22.0)	87(21.8)	1059	2.648	True
Job position	107(26.8)	132(33.0)	77(19.3)	84(21.0)	1062	2.655	True
Work experience	96(24.0)	147(36.8)	78(19.5)	79(19.8)	1060	2.650	True
<b>Overall Mean</b>						<b>2.649</b>	

From the table, values in the parenthesis are percentages of the frequency counts. Decision for each statement is made comparing the overall mean with the individual means. If the specific mean is greater than or equal to the overall mean, then it is true otherwise it is false.

The result from table 4 shows the influence of demographic variables on the job performance of librarians in the electronic libraries of the universities in Nigeria. From the table, we observed that, in each case larger percentage of the sampled respondents strongly agreed to the responses on influence of demographic variables on the job performance of librarians in the electronic libraries of the universities. It is observed from the decision made in the table that it is “true” that; (a) *Age* (b) *Marital status* (c) *Gender* (d) *Educational background* (e) *Job position* (f) *Work experience*. And it not true for the statement *Self-concept*.

### Hypotheses Testing

In this section, a Chi-square analysis was performed to establish the relationship between the variable. The results are shown in Tables 5 and 6 below:

**H<sub>0:1</sub>** There is no significant relationship between the influence of electronic information resources and job performance of librarians

**Table 5: Chi-Square Test showing significant relationship between the influence of electronic information resources and job performance of librarians**

	Chi-Sq	DF	Asymp. Sig (P-Value)
Pearson Chi-square	299.451 <sup>a</sup>	45	0.0000
Continuity Correlation <sup>b</sup>	299.231	45	0.0000
Linear by Linear Association	302.167	45	0.0000

The result from table 5 shows the output of chi-square analysis to establish the relationship between the influence of electronic information resources and job performance of librarians using the sampled information from the five selected federal universities in Nigeria. From the table the result shows that the P-value = 0.000 for Pearson Chi-square is less than 0.05 significance level. This infers, there is a significant relationship between electronic information resources and job performance of librarians. Thus, the researcher rejects the null hypothesis. Also, the result for Continuity Correlation in the table shows that the P-value = 0.000 less than 0.05 significance level signifies that there a positive correlation between the influence of electronic information resources and job performance of librarians.

### Hypothesis Two

**H<sub>0:2</sub>**. There is no significant relationship between the influence of work environment and job performance of librarians.

**Table 6: Chi-Square Test showing relationship between the influence of work environment and job performance of librarians**

	Chi-Sq	DF	Asymp. Sig (P-Value)
Pearson Chi-square	46.698 <sup>a</sup>	30	0.027
Continuity Correlation <sup>b</sup>	46.699	30	0.025
Linear by Linear Association	50.560	30	0.000

The result from table 6 shows the relationship between the influence of work environment and job performance of librarians using the sampled information from the five selected federal universities in Nigeria. From the table the result shows that the P-value = 0.027 for Pearson Chi-square is less than 0.05 significance level. This infers, there is a relationship between the influence of work



environment and job performance of librarians. Thus, the researcher rejects the null hypothesis. Also, the result for Continuity Correlation in the table shows that the P-value = 0.025 less than 0.05 significance level signifies that there is a positive association between work environment and job performance of librarians.

**H<sub>0:3</sub>**. There is no significant relationship between demographic variables and job performance of librarians

**Table 7: Chi-Square Test showing significant relationship between demographic variables and job performance of librarians**

	Chi-Sq	DF	Asymp. Sig (P-Value)
Pearson Chi-square	73.719 <sup>a</sup>	27	0.000
Continuity Correlation <sup>b</sup>	73.815	27	0.000
Linear by Linear Association	67.726	27	0.000

The result from table 7 shows the significant relationship between demographic variables and job performance of librarians using the sampled information from the five selected federal universities in Nigeria. From the table the result shows that the P-value = 0.000 for Pearson Chi-square is less than 0.05 significance level. This infers, there is a significant relationship between demographic variables and job performance of librarians. Thus, the researcher rejects the null hypothesis. Also, the result for Continuity Correlation in the table shows that the P-value = 0.000 less than 0.05 significance level signifies that there a positive association between demographic variables and job performance of librarians

## 5.0 Conclusions

The study demonstrated that the electronic information resources, demographic variables and work environment remain critical factors for enhancing the job performance of academic librarians in some selected academic libraries in North-Central region of Nigeria. It is noticeable from the hypothesis of this study that:

- a. There is a significant relationship between electronic information resources and job performance of librarians.
- b. There is a relationship between the influence of work environment and job performance of librarians. And
- c. There is a significant relationship between demographic variables and job performance of librarians.

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## A CONCEPTUAL REVIEW ON THE DEVELOPMENT OF NIGERIAN INDIGENOUS SOUP AS INSTANT FOOD

**S. I. Kolo**

Department of Food Science and Technology  
Ibrahim Badamasi Babangida University, Lapai, Niger State.  
E-mail: [salamatuk@ibbu.edu.ng](mailto:salamatuk@ibbu.edu.ng)

### **Abstract**

Nigeria, known for its diverse culture and rich culinary traditions, offers a wide variety of indigenous soups that are not only delicious but also possess significant nutritional value. As the world embraces convenience and fast-paced lifestyles, the demand for instant food products has risen exponentially. This conceptual review aims to explore the development of Nigerian indigenous soup as instant food, examining the potential benefits, challenges, and opportunities associated with this emerging trend. Through an analysis of existing literature, this article highlights the cultural significance, nutritional composition, processing techniques, and packaging considerations for transforming traditional Nigerian soups into instant food products. Additionally, the review identifies the potential market opportunities and socio-economic implications of introducing Nigerian indigenous soup as instant food on a global scale. The findings of this review contribute to the understanding of the feasibility and potential impact of incorporating traditional Nigerian cuisine into the fast-paced food industry.

**Keywords:** Indigenous soup, instant food, food products, cultural significance, dehydration, freeze-drying

### **1. Introduction**

Nigeria, with its diverse ethnic groups, is a country with a diverse culinary heritage. Nigerian indigenous soups represents both cultural identity and traditional values. (see Table 1). Nigerian foods are recognized by rural communities' customs and traditions and are derived from indigenous plants grown by residents (Raji et al., 2017). The traditional Nigerian foods are divided into two main groups: the ones consumed as traditional dietary staples in the areas where they are grown, such as cassava, potatoes, plantains, cocoyam, yam, and maize, and those consumed as accompanying relishes and sauces, such as oilseeds, fruits, and vegetables. The items in the second category are typically used in the preparation of traditional soups (Okeke et al., 2009). These soups are served alongside staple foods such as cassava, yam, cocoyam, sweet potatoes, plantain, and maize. According to Raji and Akinoso (2020), Nigerian soups are naturally rich in micronutrients, and regular consumption may aid in the prevention or reduction of some micronutrient deficiencies. Despite their numerous benefits, indigenous vegetables are on the verge of extinction, as consumers

increasingly prefer continental dishes/soups. (Olugbuyi et al., 2023). Nevertheless, one of the major ways of consumption of this indigenous vegetable is making of indigenous soup.

**Table 1. Some Indigenous soup across the geopolitical zones of Nigeria**

South-south	South-east	South-west	North
Afang	Oha	Ewedu	Miyan kuka
Edika ikong	Ogbono	Gbegiri	Miyan gyada
Nsala	Onugbu	Soko	Miyan kubewa
Banga	Egusi	Tete	Miyan taushe

Source: (Kayode et al., 2010)

However, the modern lifestyle demands convenient and time-efficient food options, leading to the emergence of instant food products (Liew et al., 2021; Swamy et al., 2012). The idea of quality instant food products fits the needs of the modern lifestyle. As reported by Mubarak and Syed (2018), most people like to consume food that calls for little preparation time before eating it (Ali and Ibrahim, 2018; Liew et al., 2021). Furthermore, people are in agreement that they are under time pressure to prepare food conventionally, yet they still demand tasty meals. Hence, this results consumers attitude and interest in high-quality instant food products (Ismail and Yusop, 2014; Jebaraj, 2014).

Instant food is a convenient food that saves time and cooking energy. It is produced forms of ready-to-cook (RTC) and ready-to-eat (RTE) food products (the canned product, frozen food, baked products etc.) (Tamlurkar, 2006). The trend is on instant food is gaining attention increasingly around the world (Ismail and Yusop, 2014; Liew et al., 2021; Nnam and Nwofor, 2001; Otong and Musa, 2019; Raji et al., 2017; Sudarsan et al., 2017; Swamy et al., 2012). It is unsurprised to notice that assorted new and superior quality instant food products occupy shelf space in retail markets. With instant food, people get more free time to engage in other daily's undertakings. This conceptual review explores the potentials of developing Nigerian indigenous soup as instant food, investigating the potential to preserve cultural heritage while meeting the demands of contemporary consumers.

## 2. Nigerian Indigenous Soups

Soups are primarily liquid food generally served warm or cold. It can be taken alone or as an accompaniment with other dishes. Soups are generally classified into two main groups: clear and thickened soup (Bakare et al., 2016). Examples of these commonly consumed Nigeria indigenous vegetables includes - *Vernonia amygdalina* "Ewuro/bitter leave", *Ocimum gratissimum* "Efirin", *Corchorus olitorius* "Ewedu", *Clerodendun volubile* "Marugbo", *Gossypium arboretum* "Koro

owu” *Brodelia ferrugineae* “Ira”, *Solanecio biafrae* “Worowo”, *Cucurbita pepo* “Elegede”, *Solanum americanum* “Odu”, *Talinum fruticosum* “water leaf”, *Xanthosoma Schott* “dry cocoyam leaf” etc (Olugbuyi et al., 2023). Soups are consumed either fresh or dry in Nigeria. Fresh soup is typically prepared after purchasing the previously mentioned vegetables, which are chopped and cooked with the addition of water, meat or fish, and seasonings. This type of soup is more common and appreciated in rural areas. In this case, the dried vegetables are reconstituted with water, and the soup is ready after the addition of oil, seasonings, meat or beef, and a shorter cooking time.

## 2.1 Some Common Nigerian Indigenous Soups

### *Bitter Leaf Soup*

*Vernonia amygdalina* is a perennial shrub popularly called bitter leaf in English, *Ewuro* in Yoruba (Southwest Nigeria) and *Chusar-doki* in Hausa (Northern part of Nigeria) (Constance et al., 2020). The leaves are green with a characteristic smell and bitter taste. The leaves can be squeezed, blended, and consumed or used as soup condiments after thorough washing to get rid of the astringent taste (Olugbuyi et al., 2023). Bitter leaf is known for their medicinal and culinary purpose due to bioactive compounds such as coumarins, flavonoids, saponins etc. which makes it suitable in regulating blood glucose, boost immune system and controlling gastrointestinal disorder (Gasaliyu et al., 2022).

### *Ewedu*

*Ewedu* (*Corchorus olitorius*) commonly consumed by the Yorubas in Nigeria. It contains phytochemicals and antioxidants which plays medical role in human health (Oluwole et al., 2021). The succulent leaves of *C. olitorius* leaves soften rapidly with little cooking and thicken into a viscous mucilaginous soup which can be eaten with starch foods developed from processing of the common staple root and tuber crops (Sanni and Adesina, 2012).

### **Okra**

Okra (*Abelmoschus esculentus L*) commonly known as “*Ila*” in south west Nigeria and *kubewa* in northern Nigeria. According to Lawal et al., (2018), it is an important tropical vegetable with total world trade estimated to over \$5 billion. The fresh immature pods are consumed as vegetables, soups and salads; offering a mucilaginous consistency when cooked. The mature ones known to be rich sources of riboflavin , folic acid , dietary fibre, zinc, calcium, vitamins B6, A and C (Gemedede et al., 2016, Lawal et al., 2018).

### **Scent leaf soup**

*Ocimum gratissimum* leaf known as Scent leaves in English, *Effirin* (yoruba) *neh-anwu* (Ibo), *ntion* (Efik) and *dai-doya ta gida* (Hausa) is used as spices for cooking delicacies due to its aromatic taste. It is reported to be rich in calcium, phosphorus, iron, and vitamin K. Extracts from it helps in

lowering blood pressure, aids digestion, and helps in treating respiratory disorders when consumed (Olugbuyi et al., 2023, Salemcity et al., 2021).

### ***Egusi soup***

The melon seed (*egusi*) is a wild member of gourd family native to West Africa. It is native to the Igbos in the southern parts of Nigeria, and Yorubas in the west. Hausas call it *miyan Gushi*. The seed is milled for soup with the addition of other spices, seasonings, oils and vegetables. Egusi soup is very rich in Omega-3 Fatty acids, vitamins, protein, zinc, potassium, iron and calcium (BABAYEJU et al., 2014, Datsugwai et al., 2019).

### ***Miyan yakuwa (Roselle/Sorrel Calyx Soup)***

This is a sour Nigerian soup made from roselle hibiscus leaves. It is consumed in northern Nigeria and served with tuwo or rice (Salau et al., 2020).

### ***Banga Soup (Ofe Akwu)***

Banga soup is sweet and spicy with an earthy, nutty flavor. Banga soup is prepared from palm fruits (*Elaeis guineensis* extract) together with spices. These includes; dried beletete leaves (*Heinsia crinita*), ataiko seeds (*Aframomum sceptrum*), fresh obenetietien leaves (*Ocimum basilicum*). The soup is consume by the people of the Niger Delta parts of Nigeria, particularly the Urhobo, Ukwuani, Izon and Itsekiri ethnic group of Delta State (Otuaga et al., 2020).

### **Dehydrated Nigerian Indigenous Soups**

Some of the Nigerian Indigenous soup can be consumed in the dry or dehydrated form. This mostly applies to those vegetables with the thickening effect commonly called “draw soup” in Nigeria. However, the practice of drying these vegetables evolved as a method of preserving them for a longer period of time. Traditionally in Nigeria, we have Okro in the dry form as *busheshen kubewa* (Shaibu et al., 2023), dry baobab leaf as *miyan kuka* (Oton and Musa, 2019), the dry melon seed or *egusi* soup (Datsugwai et al., 2019), *ogbono* soup or dry dika seed (Bamidele et al., 2015). Several of these soups in dry form were assessed by Uthman et al., (2023); the Assessment of micronutrient contents of standardized commonly consumed native soups among Nupe people of Niger state was carried. The ingredients for the recipes of six (6) “*eni kuka* or *kuka* soup”, “*eni kpanmi* or Okro soup”, “*eni tsuku* or dry okro soup”, “*eni nungbere* or Custard Apple Calyx Soup”, “*eni ezowa* or beans soup” and “*eni emagi* or dry hibiscus carlyx soup” commonly consumed soups were standardized, prepared and evaluated for some mineral and vitamin contents. The result shows the soups contain appreciable amount of minerals and vitamins B1 and B2, which could contribute in meeting the recommended dietary intake of the people. A lot of techniques and evaluations keep going on how to preserve these vegetables better in order to retain most of its nutritional qualities. Fruits and vegetables have been dehydrated by different methods. Each method`s implication on the final product quality includes degradation of the texture, colour and physiologically active

compounds. As reported by Raji et al., (2017), Freeze drying (FD) is one of the dehydration methods that is a gentle technique, which retains the biological features of raw materials, flavor, aroma, and color. Their final products can be reconstituted easily by adding water. It involves using a low-temperature process to minimize chemical alteration or food degradation that occurs during dehydration of food products. This method of drying has proven overtime to be better than air or drum drying (Hsu et al., 2003). The FD method has been tested out on several of Nigerian soups; Raji et al., (2017), assessed the reconstitution potentials and moisture sorption isotherms of selected freeze dried Nigerian soups (*Ogbono, Ewedu, Ila, Kuka*) and the result showed that the moisture contents of the soups, which ranged from 7.87 to 9.82% (dry basis), were all within the acceptable limit of 10% dry basis for good storage stability. Furthermore, the Influence of ambient storage condition on the nutritional quality of selected freeze dried instant Nigerian soups (*Ogbono, Ewedu, Ila, Kuka*) was also analyzed. Resultantly, Freeze-drying reduced soups moisture contents by 90.0-90.8 %, thus increased the concentrations of other constituents. The nutrients quality of the freeze dried soups was well maintained for a storage period of two months (Raji and Akinoso, 2020).

### 3. Potentials of Nigerian Indigenous Soup as Instant Soup

The process of making Instant dried foods is done in a way that hastens preparation or reconstitution of the final product. They are usually homemade but are also mass produced on an industrial scale and treated in various ways to preserve them (Miller, 1995). A wide variety of instant soups exist commercially and are usually dried or dehydrated, canned, or treated by freezing. One of the major advantages of instant foods is that they can be preserved for long periods of time as long as the water content does not exceed 12 % (Ihekoronye and Ngoddy, 1985). Nigerian indigenous soups, such as Egusi soup, Ogbono soup, and dry okro, dry baobab leaf etc. have the potential to be transformed into instant soup products. The following presents characteristics that make some Nigerian Indigenous soups successful as instant soups:

1. **Flavorful and Authentic Taste:** Nigerian indigenous soups are known for their rich and distinct flavors. These flavors can be captured and preserved in instant soup form, providing consumers with a convenient way to enjoy the traditional taste of Nigerian cuisine. The nutritional and sensory evaluation of Instant ogbono mix powder revealed that it had higher nutritional value, was easy to cook and had the highest overall acceptability in all attributes in terms of color, flavor and taste (Bamidele et al., 2015).
2. **Cultural Diversity:** Instant Nigerian indigenous soups can showcase this cultural diversity and offer a range of options for consumers to explore different flavors and culinary traditions (Bakare et al., 2016). In this case a lot of soups are common to the south-west, north and eastern Nigeria (Okeke et al., 2009, Shaibu et al., 2023, Uthman et al., 2023). This plays a vital role in the country's culture and are often associated with communal dining experiences and social gatherings. These soups are prepared using locally sourced ingredients, traditional recipes, and cooking techniques passed down through generations.



The preservation of cultural heritage through the development of instant soup products can help promote Nigerian cuisine globally while maintaining a connection to its roots.

3. **Processing Techniques, Convenience and Time-Saving:** Preparing Nigerian soups from scratch can be time-consuming and require several ingredients. Instant soup versions can save time and effort by providing a quick and convenient meal option that only requires hot water or minimal cooking. The transformation of Nigerian indigenous soups into instant food products requires appropriate processing techniques. Several methods, such as freeze-drying, spray drying, and vacuum drying, can be utilized to remove moisture from the soups without compromising their flavor and nutritional content (Raji and Akinoso, 2020, Raji et al., 2017, Shaibu et al., 2023).
4. **Shelf Stability:** Properly processed instant soups can have a long shelf life, making them suitable for storage and distribution, both domestically and internationally. This allows people outside Nigeria to experience Nigerian cuisine easily and conveniently. Based on the findings by (Datsugwai et al., 2019), instant *egusi* soup with addition of vegetable and other spices was recommended as a preference over the one without vegetable because of the better microbial quality, longer shelf-life and overall acceptability. Additionally, the selection of suitable additives and preservatives can ensure product stability and shelf-life.
5. **Health and Nutrition:** Nigerian indigenous soups are typically rich in vitamins, minerals, and dietary fibers due to the variety of vegetables, herbs, and spices used in their preparation. Incorporating traditional ingredients into instant soup products can provide consumers with a convenient and nutritious meal option. (Gemedede et al., 2016; Kayode et al., 2010; Lawal et al., 2018; Okeke et al., 2009; Olugbuyi et al., 2023; Otong and Musa, 2019; Uthman et al., 2023). However, careful consideration must be given to processing techniques to minimize nutrient losses during production.
6. **Global Market Potential:** Nigerian cuisine is gaining popularity worldwide, and there is a growing demand for diverse and authentic food experiences. Instant Nigerian indigenous soups have the potential to tap into this market, catering to both Nigerians living abroad and individuals interested in exploring new flavors. The global market for instant food products is expanding rapidly, offering significant opportunities for the introduction of Nigerian indigenous soup (Ismail and Yusop, 2014; Swamy et al., 2012; Tamlurkar, 2006). By capitalizing on the country's culinary diversity, Nigerian entrepreneurs can contribute to economic growth, create employment opportunities, and enhance the global perception of Nigerian cuisine.
7. **Packaging suitability**

Most Instant Soup are in powder form, therefore, they exhibit light weight for transportation and storage at all time of the year (Rekha, 2010). Packaging plays a crucial role in the development of instant soup products. It must maintain product quality, prevent contamination, and provide convenient portioning options. That way, they can also be

quickly reconstituted for use by working families, motels, hospitals, eateries, and other institutions.

#### 4. Conclusions

The development of Nigerian indigenous soup as instant food presents a promising opportunity to merge tradition and convenience. This conceptual review has provided an overview of the potential benefits, challenges, and opportunities associated with this emerging trend. By leveraging the cultural significance, nutritional composition, processing techniques, and packaging considerations, Nigerian cuisine can find its place in the global instant food industry, fostering economic development and promoting cultural appreciation.

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