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Formulation Of Stoneware Glazes Using Selected Natural Raw Materials From Benue State Nigeria

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ABSTRACT
The industrial development of a nation could be achieved through the effective and efficient utilization of the available raw materials and ceramic industries are some of the enterprises that rely heavily on such raw materials. Benue State been endowed with natural resources including ceramic raw materials, the exploitation and utilization of the mineral resources in the area will improve the living standard of some people in the state and Nigeria. This study investigated the formulation of stoneware glazes using selected natural raw materials from Benue State, Nigeria. Data from geological document and information received from local potter aided the identification of location and subsequent collection of the raw materials. These are ball clay, feldspar and silica. Chemical analyses and physical property tests were conducted. The sample tests pieces were produced and bisque fired. The triaxial blend method was used to formulate glaze batches. Glazes were applied using dipping and spraying method, bases cleaned and wares loaded in-to electric, gas kilns and gloss fired to temperature of 1,200^{o}C. Based on the chemical analysis and physical tests performed, the study found that Ohirigwe Ball clay, Oboru Feldspar and Abofutu Silica are suitable raw materials for the production of stoneware glazes. Based on the analyses and findings from the practical experiments conducted in the study, the following recommendations have been made, that students and other potters should try using the local raw materials for formulation of stoneware glazes in ceramic productions. Government and private individuals can go into mining of this important and abundant raw material for studio pottery and for industrial use in companies.
Keywords: Stoneware Glazes, Natural Materials, X-ray and Fluoresces

INTRODUCTION
Ever before man started farming and hunting for food, he saw the need for cooking and preserving his food. This global need for cooking, perhaps, added to the evolution of pottery, not only in other parts of the world but also in the geographical location now known as Nigeria. Pot as a container for cooking and preservation of food, has a long history. According to Cooper, (1972) the Udam people of Cross River

State started producing pots right from the prehistoric era. Though the origin of pottery cannot be traced with precision, however, it is argued that man started the art of pottery right from the pre-historic era. In agreement with this view, Leach, (1972) states that man, both super-civilized and under-civilized has been fascinated by pottery for seven thousand years using pot not only as one of the great practical uses in daily life, but as a means for direct visual expression. Charles, (1971) Also observes that right from creation man saw the need for making pottery, not serving only as container but also depicts the culture of a people. In Nigeria generally pottery is of two types traditional and contemporary. In many areas however, the traditional pottery is by far the largest and somehow more significantly stylish. The abundance of pottery raw materials had offered a wide range of production techniques and thus, provides evidence of the intelligence and mastery with which the people have used the materials and likewise understanding their potentialities. These materials go through manufacturing processes such as sizing, shaping or a combination of two or man's proof to serve some critical, physical and chemical purposes.

Ceramics is a class of inorganic, nonmetallic solids that are subjected to high temperature in manufacture. The most common ceramics are composed of oxides, carbides, and nitrides. silicides, borides, phosphides, tellurides, and selenides are also used to produce ceramics (Brosnan, 1992). Ceramics are also defined as inorganic, nonmetallic materials that exhibit such useful properties as high strength and hardness, high melting temperatures, chemical inertness, and low thermal and electrical conductivity but that also display brittleness and sensitivity to flaws (Encyclopaedia Britannical (2023). Glazes are responsible for the appearance, (colour and brilliancy) of the ceramic but they equally have other functions. They make the ceramics waterproof enabling them to contain liquids and food (Kitchen and table ware). Glazes add value to the ceramic objects through the choice of colours and designs, make them fashionable and in some cases, making them luxury products and therefore an object to trade.

Ceramic bodies are classified into the following: stoneware, earthenware, porcelain, white ware, and ironstone, etc. (Conrad, 1980). All these mature at various temperatures depending on the composition of various materials. Stoneware body according to Mckee (2015) in Matin (2018) is the hard and durable clay that is fired to temperatures between 1200^{o}C-1260^{o}C with little or no absorption. Shearer (2005) defines a glass former as the major ingredients of a glaze and the one that requires additional melting from the fluxes and stiffening from the stabilizers. Additives such as Phosphates, Carbonates and Aluminun Oxide are to be used as flux (Santos, & Rodríguez, (2024)). Cobalt, Cromuon Oxide, is used as colourant for this study.

Ball clays are characterized by moderate kaolinite content, some organic material such as Lignite, Silica (SiO_2) in the form of Quartz (sand) in varying degrees of fineness, illite, montmorillonite (Al,Mg) $OSi_4O_{10}(OH_2)$) and other minerals such as mica (Opoku, 2015). Clay body refers to specific composition of clay types, and preparation to meet required needs for the production and uses of ceramic objects. Kalilu, (2006) observe that the two major types of clay are the foundation of three basic types of clay bodies: earthenware, stoneware, and porcelain, whose maturing temperatures range between 750°C to 1150°C, 1150°C to 1350°C as well as 1400°C to 1700°C respectively.

Statement of the Problem

A survey conducted in two ceramic studios in the College of Education, Oju and College of Education, Katsina-Ala in Benue State Nigeria, revealed that none of these studios used locally formulated glazes. These ceramic studios seek for glazes from potters outside the state at exorbitant rate, a factor that contributed to the development of this study. The scarcity of locally formulated glazes and limited documentation background data on the glaze formulation and development using locally available materials therefore, invoked a need to research into, formulation and development of stoneware glazes. Also, ceramic local materials such as ball clay, silica and feldspar are abundantly available at Oju and Obi Local Government Areas in Benue Sate, but available records indicate that no study or research has been carried out to know the chemical constituent and their suitability for formulation and production of

stoneware glazes. Despite the abundance of these raw materials, they are almost non existing industry or ceramic studio that uses these raw materials. A study of these raw materials will spur students and other investors to utilize the raw materials for production of ceramics. This study therefore aspires to formulate stoneware glazes using these local raw materils for students and other potters because of difficulties faced in sourcing for glazes.

Aims and Objectives

The aim of this study is to critically examine the ceramic raw materials (ball clay, feldspar and silica) selected from Oju and Obi Local Government Areas in Benue State and to evaluate their suitability for the production of stoneware glazes. The objectives of the study are to:

i. Obtain and beneficiate of the raw materials
ii. Characterization of the chemical composition of the raw materials by the means of X-ray fluorescence.

Research Questions

In order to undertake a successful study, the following research questions were drawn for the purpose of the study;

i. Could the raw materials founded from different locations in Benue State be source and beneficiated?
ii. What are the physical and chemical properties of the ceramic raw materials?

METHODOLOGY

The study adopts experimental research as stated by Asika (2001) in Ogoh (2019) that "experimentation is a type of research that explores whether relationship exist among some variables and what the nature of these relationships are" This research work is quantitative and purely studio experiments to determine the suitability of clay, silica and feldspar from Oju and Obi for development of stoneware glazes.

Materials

The constituent raw materials ball clay and feldspar were collected from Ohirigwe and Oboru in Oju local government area while silica was collected from Abofutu in Obi local government area in Benue State. Equipment such as Camera, X-Ray Fluorescence (XRF) Spectrometer, Lead Digital Scale, Balance weighting scale, ball mill, electric kiln, gas kiln, gas cylinder with their accessories, tools such as cutlass, digger, micrometer mesh (80), plastic containers, plaster moulds, polythene paper, knife, throwing tools, metric ruler and water are used for this study.

Field trips were carried out to the locations in order to procure the selected raw materials. Raw materials procured were ball clay, silica and feldspar, were collected from two Local Government Areas of Benue State (Oju and Obi).

Plate I: Traditional Potter (Christina Ereima Iji) and the researcher sourcing the investigated material at Ohirigwe
Source: Researcher's work (2026).

Preliminary Physical Property Test for Materials

The materials procured were exposed to a number of physical tests to determine if they were the right materials. For example, ball clay was picked based on its brownish, grayish and buff appearance as well as its plastic quality. Silica was obtained because of its glassy and milky white appearance. Feldspar was attracted by its pinkish appearance and cleavage hardness, and when silica was scratched on it a mark was noticed.

Table 1: Physical Property of Raw Material Samples

Type Test	**OBC**	**OF**	**AS**
Colour Raw Clay	Brown	Pink	Milky white
Texture Visual	Fine	Fine	Fine
Tactile	Smooth	Fairly Smooth	Fairly Smooth

Source: Researcher's work 2026

Chemical Analysis

Chemical analysis using XRF was carried out at the Cross Road Scientific Laboratory Kaduna to ascertain the Chemical Composition of the raw materials and for the purpose of selecting the most suitable constituent for glaze production.

Table 2: Chemical Result of Ohirigwe Ball Clay

Elements	**Si O_2**	**AL_2 O_3**	**T_1 O_2**	**Fe_2 O_3**	**Ca O**	**Mg_0**	**Na_2O**	**K_2O**
Percentage	43.038	18.334	3.518	27.399	2.188	1.936	0.000	1.240

Source: Cross Roads Scientific Laboratory Kaduna, 2025.

Table 3: ***Chemical Result of Oboru Feldspar.***

Elements	**Si O_2**	**AL_2 O_3**	**T_1 O_2**	**Fe_2 O_3**	**Ca O**	**Mg_0**	**Na_2O**	**K_2O**
Percentage	70.180	12.689	0.142	1.378	3.969	0.000	0.000	10.173

Source: Cross Roads Scientific Laboratory, Kaduna 2025.

Table 4: ***Chemical Result of Abofutu Silica***

Elements	**Si O_2**	**AL_2 O_3**	**T_1 O_2**	**Fe_2 O_3**	**Ca O**	**Mg_0**	**Na_2O**	**K_2O**
Percentage	77.689	16.731	1.871	0.553	0.286	0.000	0.000	0.000

Source: Cross Roads Scientific Laboratory, Kaduna 2025.

Sample Processing

The materials procured require some treatment to remove impurities such as lumps soil attached, silica, feldspar and stone were picked out from clay. The treatment would also improve the quality of the materials for maximum use. The scheme of processing ceramic raw materials was followed accordingly. The processing involved washing, soaking, calcination, crushing, ball milling, sieving and drying.

RESULTS AND DISCUSSION

The analysis of results of tests conducted for the study was as follows: chemical analysis and physical property tests, triaxial blend, glaze formulation, application as well as firing tests**.** Feldspar was collected from Oboru and Ball Clay from Ohirigwe in Oju LGA, while Silica was collected from rocky area of Abofutu in Obi LGA, Benue State.

Objective One

Table 5: The Result of Physical Property of Raw Material Samples

Type Test	**OBC**	**OF**	**AS**
Colour Raw Clay	Brown	Pink	Milky white
Texture Visual	Fine	Fine	Fine
Tactile	Smooth	Fairly Smooth	Fairly Smooth

Chemical Analysis

In an attempt to find out if the procured raw material samples were suitable ingredients for glaze composition, the Chemical Analysis of Ohirigwe ball clay, Oboru feldspar and Abofutu Silica were carried out at Cross Roads Scientific Laboratory, Kaduna.

Objective Two

Table 6: Result Chemical Analysis of Ohirigwe Ball Clay.

Elements	**Si O_2**	**AL_2 O_3**	**T_1 O_2**	**Fe_2 O_3**	**Ca O**	**Mg_0**	**Na_2O**	**K_2O**
Percentage	43.038	18.334	3.518	27.399	2.188	1.936	0.000	1.240

Source: Cross Roads Scientific Laboratory Kaduna, 2025.

Table 7: Result of Chemical Analysis of Oboru Feldspar

Elements	**Si O_2**	**AL_2 O_3**	**T_1 O_2**	**Fe_2 O_3**	**Ca O**	**Mg_0**	**Na_2O**	**K_2O**
Percentage	**70.180**	**12.689**	**0.142**	**1.378**	**3.969**	**0.000**	**0.000**	**10.173**

Source: Cross Roads Scientific Laboratory, Kaduna 2025.

Table 8: Result of Chemical Analysis of Abofutu Silica

Elements	**Si O_2**	**AL_2 O_3**	**T_1 O_2**	**Fe_2 O_3**	**Ca O**	**Mg_0**	**Na_2O**	**K_2O**
Percentage	**77.689**	**16.731**	**1.871**	**0.553**	**0.286**	**0.000**	**0.000**	**0.000**

Source: Cross Roads Scientific Laboratory, Kaduna 2025.

The chemical results showed the dominance of silica in all the three materials, alumina in ball clay and feldspar are the major elements as expressed in percentages in form of their oxides as: SiO_2, AI_2O_3, Ca O and K_2O and other traced minerals. SiO_2 is a glass former and filler, AI_2O_3, acts as a stabilizer, and is used to improve corrosion resistance and K_2O is a flux, used to lower the melting point and improve the overall

flow of the glaze materials. These materials when combined and fired to high temperature it produced hard, chip and corrosion resistant ceramics.

Characterization and chemical composition of the raw materials

According to Nelson (1964) in Alkali (2014) there are three components in glaze. One of these is Silica (SiO_2) which gives the glaze its glassy, transparent quality. The second is Alumina (Al_2O_3) a refractory element, which contributes toughness and abrasion resistance to glaze, while the third CaO and K_2O as flux that controls the melting temperature. Since all these characteristics are found in the selected three raw materials, it could and has been considered for use in the composition of glaze in this study.

Finding

Based on the test and experiments carried out in respect of this study, the following findings were made:

1. Oboru feldspar was chemically established to have high concentrations of potash; as such it was considered to be potash feldspar. Feldspar serves as a fluxing agent in glaze. Grema (2004) confirmed that potash feldspar is the purest type of feldspar and therefore good for glaze formulation. Ohirigwe ball clay was found chemically suitable in terms of a high concentration of silica and alumina required in stoneware glazes. Ahuwan (1997) emphasized that the percentage contents of silica and alumina are significant in the chemical properties of clay. Abofutu silica was chemically found to be higher in silica concentration. The silica content is fundamental in stoneware glazes. Principally, silica is a source of flux in glaze formulation.
2. The beneficiation of raw materials involving soaking, washing, calcination, crushing, ball milling, sieving and drying were confirmed to be suitable in view of the result obtained. Ball mill and pulverizing machine were used to grind feldspar, silica into fine powders. It was also used to blend the materials for glaze batches; therefore, ball milling was found to be an effective way for the grinding and mixing of glaze ingredients for the study. Ball milling has been employed to process ceramic raw materials in various studies. Grema (2004).

CONCLUSION

In conclusion, the glaze compositions formulated for this study were found to be suitable for stoneware glazes, when fired to about 1200°C, the glaze adhered and fired nicely on the bodies. Glaze compositions, batches A, AB and AC, developed for this study was found to be suitable stoneware glazes for the production of stoneware ceramics.

RECOMMENDATION

Based on the analyses and findings from the practical experiments conducted in the study, the following recommendations have been made;

1. Students and other potters should try using the local raw materials for formulation of stoneware glazes in ceramic productions. Government and private individuals can go into mining of this important and abundant raw material for studio pottery and for industrial use in companies.
2. Scholars should be encouraged to conduct further research on the local pottery materials in their domain so as to help cut down on ever-increasing dependency on imported/foreign materials which are more expensive. The general lack of interest in pottery can also be traced to the above reason.

REFERENCES

Ahuwan, A.M. (1979) *Determination of Physical Property of Clay Samples in Bauchi State Suspected to be Kaolin. Environ-Journal of Environmental Studies* Vol.1 No Pp. 29.

Asika N. (2001) *Research Methodology in the Behavioral Sciences, Longman Nigeria Plc*

Charles, C., Charles, W. H. (1971) *Welcome to the World of Potter. Atlanta, Georgia, Anderson, Droke House*.

Conrad, J.W. (1973) *Ceramic Formulas: The Complete Compendium. Macmillan Publishing Co. Inc. New York*: https://mon.uvic.cat/mecamat/eaa-barcelona2018-glaze-production-technology-in-the-medieval-and-post-medieval-mediterranean/ Retrieved 15/10/20.

Grema, B. (2004) *Studies on the Potential of Selected Bomo Raw Materials for the Production of Porcelain and Porcelain Glazes*. Unpublished M.A. Tech. Dissertation, ATBU Bauchi. Pp. 28-40

Ogoh, U.J. (2019) *Chemical Analysis of Ukpulewu Clay and the Determination of its Suitability for Earthenware Production*. Unpublished M.A. Dissertation submitted to Industrial Design Department, Ahmadu Bello University, Zaria. Pp. 25-26.

Opoku, E.V. (2015) *Substitution of Rice Husk Ash for Quart in Ceramic wall tiles.* Unpublished PhD Theses submitted to Post Graduate School Ahmadu Bello University Zaria. Pp. 11-

Matin, M. (2018). by Matin, Tite and Watson, Journal of Archaeological Science 97:42–66; journal details in thesis incorrect: https://doi.org/10.1016/j.jas.2018.06.01156.

Shearer, D (2005). *Glaze Chemistry*. Reinhold publishing corporation, New York. Pp. 43-50.