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Selected Clays of the Bida and Anambra Basins of Nigeria: Their Characteristics, Fired Properties and Ceramic-Suitability

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ABSTRACT

Clay samples selected from four different locations within the Anambra and Bida Basins of Nigeria were characterized in accordance with American Society of Testing and Material (ASTM). Some ceramic properties of the clays were also determined. The chemical composition of the clay samples shows that Silica range from 52.66% to 79.17%, Alumina-9.76% to 24.35%, Iron Oxide-1.27% to 7.78%, Calcium Oxide-0.01% to 0.24%, Magnessium Oxide-0.11% to 0.14%, Alkali (K_2O+Na_2O) is 1.42% to 1.75% and trace elements like Titanium, Phosphorus and Sulphur Oxides. The range of the mean drying linear shrinkages for selected clays is 6.5-11.6%, while the range of the mean fired linear shrinkages for the selected clays (about 150° C) is 7.7-12.3%. The drying Modulus of Rupture of the clays range from 2.7-11.7MPa. The fired Modulus of Rupture of the clays range from 6.3-16.3MPa. The Loss-on-Ignition (LOI) varied from 5.3-12.8%. The characteristics of the firing behaviour revealed a dry-to-firing colour variation of white-to-white, grey-to-light brown, milky white-to-brilliant brown and light brown-to-brilliant red. This confirms the suitability for wide range of ceramicwares application ranging from vitrified whitewares to brickwares, coloured vaze and tiles.

Keywords: *Clay, Ceramicwares, Linear Shrinkage, Modulus of Rupture*

1. INTRODUCTION

Clay as a product of disintegration from chemical weathering of feldspathic rock is a viable mineral that exhibit high economic significance and usefulness that affects every spheres of life [1]. It consists of fine particles of hydrous aluminium silicate which has a wide variety of physical characteristic such as plasticity, shrinkage under firing and under air-drying, fineness of grain, colour after firing, Hardness cohesion and capacity of the surface to take decoration [2]. Clay is a common name for a number of fine-grained, earthy materials that become plastic and tenacious when moist, and that becomes permanently hard when baked or fired. Thus, clay can be shaped while wet and soft, and then fired to obtain ceramic product [3]. Clay varies in plasticity, all being more or less malleable and capable of being molded into any form when moistened with water [4]. Thus, white-ware ceramic manufacturing industries use clay as the prime raw material [5].

Ceramic is the science of manufacturing prepared from pliable, earthy materials that are rigid by exposure to heat [6]. As early as about 24,000 BC, animal and human figurines were made in settlements around Egypt, China, India and Mesopotamia, from clay and other materials dug from the ground and fired in kilns [7]. They are typically crystalline, having ordered structure. These materials are used in application areas ranging from household items (porcelain, sanitaryware, etc) to high-performance tools for industrial use (e.g ball bearings, cutting tools, isolators, catalysts, etc) [6].

The study area in the Anambra and Bida Basins lies within Kogi State, which is located in the North-Central Part of Nigeria, just below the Federal Capital Territory. The focus of this work is to characterize selected clay samples as well as determine their ceramic properties.

2. MATERIALS AND METHODS

The clay samples studied were obtained by channeling on the face of pits excavated for the specific purpose of clay sampling. The samples contained only clay, clean and free of lateritic soil and other contaminations. The samples were taken from both surface and sub-surface (from a depth of about 5mtrs), so as to ensure that the influence of weathering on the chemical composition is obviated, or at least taken into consideration. All samples were carefully selected and thoroughly blended to obtain an averagely true representation of the each deposit under investigation.

The study area covered four selected villages and lies within Kogi State of Nigeria. They are Enjji, Ahoko, Ajelele and Itobe villages as shown in Table 1.

Clay samples from the Anambra Basin were taken from Eniji, Ajelele and Itobe villages while those from Bida Basin were taken at Ahoko village.

Table 1: Location of the Study Area

Sample Code	Basin	LGA	Co-ordinates of Locations	
			Latitude	Longitudes
Eniji A	Anambra	Dekina	$07^0$33’N	$006^0$56’E
Eniji B	Anambra	Dekina	$07^0$33’N	$006^0$56’E
Ahoko A	Bida	Kogi	$07^0$18’N	$006^0$51’E
Ahoko B	Bida	Kogi	$07^0$18’N	$006^0$51’E
Ajelele A	Anambra	Dekina	$07^0$35’N	$006^0$55’E
Ajelele B	Anambra	Dekina	$07^0$35’N	$006^0$55’E
Itobe A	Anambra	Ofu	$07^0$25’N	$006^0$43’E
Itobe B	Anambra	Ofu	$07^0$25’N	$006^0$43’E

2.1 Determination of Linear Shrinkages (Drying and Fired) of Clay Samples

In accordance with ASTM 15.02: C 326, about 2kg of the clays were dried, pounded in a pan mill and sieved through a 20 or 30-mesh screen. The slip of the undersize was passed through 425µm. The undersize was mixed with water to the ‘wedge point’ (a state whereby moistened clay body remained in a ball-in-hand state until intentional vibration causes the mixture to flow). Sodium Silicate (about 4-5g) was also added and thoroughly mixed with the mixture. About 8 bars were casted from the wedged sample using brass shrinkage moulds lubricated with talc powder or thin film of machine oils. The bars were left in the mould for about 4-6hrs. The sample bars were marked at initial 10cm intervals, green lenght, *Lg*, using vernier calipers. The bars were air-dried naturally for about 24-36 hrs, on a lightly oiled pallet. The length of the bars after drying, *Ld* was measured and the linear drying shrinkage was determined as *Sd*. Afterward, the bars were checked for warping before being sent to the pre-heating zone of the laboratory oven for further drying for 48hrs at a temperature of about 100° C. Some of the dried bars were fired in the firing zone of the laboratory oven for about 24hrs at a temperature of about 250° C and the lenght of the marked interval after firing, *Lf*, was measured and the linear firing shrinkage determined as *Sf*. The total linear shrinkage, *St*, was determined while the shrinkage factor, *Fs*, was calculated from equation 1.

$$Fs = \left[\left[\frac{Lg}{Lf}\right]\right] \quad (1)$$

Where:

Lg = green or plastic length of test bar, cm
Lf = fired length of test bar, cm
Fs = shrinkage factor

2.2 Determination of Modulus of Rupture (Drying and Fired) of Clay Samples

The clay samples were mixed thoroughly, pulverised in a 3-foot pan mill and screened through a 20 or 30-mesh sieve. The “slip” of the sample made for the MOR is sieved through 125µm. The test bars were moulded. The procedure is in accordance with America Standards on Tests and Material [8]. The knife-edge above the specimen bar delivered uniform load at the centre of the bar which was supported on two knife-edges. For the drying MOR bars, the Gabbrielli CRC SRL was used to deliver maximum load of 25kg. For the fired MOR bars, the Gabbrielli Crometro was used, with the distance between the two knife-edges adjusted to 100mm and the maximum deliverable load was 400kg. An accurate value of the applied force at the point when failure occured was recorded, and the area of the broken test bar was measured.

The Gabbrielli CRC SRL machine was used to deliver uniform load at the centre of the bar which was supported on two knife-edges through the knife-edge above the dried specimen bars. The digital screen of the machine displayed the load (force) applied at the point of failure, *f*. The test was carried out in accordance with ASTM 10.04: F 417. The machine was internally calibrated to accommodate the dimension of the bar, and a constant factor (K = 9.8) of the machine was taken into consideration to determine the drying Modulus of Rupture, *Md*, using equation 2.

$$Md = F \times k \qquad (2)$$

Where:

Md = Modulus of Rupture of dry bar, kg/cm^2
P = Pressure applied at failure of dry bar, kg/cm^2
k = Constant factor of machine calibration, relative to the dimension of the specimen bar

The Gabbrielli Crometro was used to deliver uniform, perpendicular load on the fired bars, with the distance between the two knife-edges adjusted to 100mm. The test was carried out in accordance with ASTM 04.05: C 67. The applied bending load which broke the specimen bars at the centre was recorded as *w*. The lenght *l*, breadth *b* and height *h* of the bars were noted to determine the area of the broken test bar. The Modulus of Rupture of the fired bar, *Mf*, was determined using equation 3.

$$M_f = \frac{3wl}{2bh^2} \qquad (3)$$

Where:

Mf = Modulus of Rupture of fired bar, kg/cm^2
W = weight required to break the bar, kgf
L = distance between supports, cm
B = breadth of specimen bar, cm
H = height of specimen bar, cm

2.3 Determination of Firing Behaviour and Colour Variation

The variations in colour of samples before and after firing were noted. Moisture-free samples from the pre-heating zone were weighed. The samples were then heated in the furnace and re-weighed. The weight loss was also recorded as ignition loss [9].

2.4 Determination of Chemical Composition of Selected Clay samples from Kogi State

The OXFORD LAB-X LZ35OO Spectrometer was used to carry out x-ray fluorescence analysis for the determination of percentage composition of the oxides in the solid samples. The samples were ground in a vibratory disc mill to attain desired fineness. Few grams of the samples were fused with lithium tetra borate salt. The mixtures were then heated in a platinum crucible to above 1000° C by a fusion machine. The resulting pelletized samples were exposed to beam of x-rays. The procedure is in accordance with ASTM, Designation: C 118.

3. RESULT AND DISCUSSION

3.1 Shrinkage Characteristics of Selected Clays

The Linear Drying and Fired Shrinkages of selected clays from Kogi State were tested and characterized as index of plasticity [10] and [11]. The results of the clay sample bars tested for their drying and fired linear shrinkages are in Tables 2. The Average Values of Linear Drying and Fired Shrinkages of Selected Clays are as shown in Table 3. An average linear shrinkage value of 10% or more, qualifies a clay as suitable for the manufacture of earthenware, sanitaryware, vitrifiedware, white and coloured tile, and electrical insulator [12]. From Table 3, the average linear drying shrinkage of clay samples from Eniji is 9.9%, while the average linear fired shrinkage is 10.9%. It implies that the Eniji clays are suitable for the above ceramic products and other high-grade porcelains, as the values fall within acceptable limits for ceramic production.

Table 2: Results of Shrinkage Tests and Firing-behaviour of Clay Samples from Eniji, Ahoko, Ajelele and Itobe

Location	Green Length (cm)	Dry Length (cm)	Fired Length (cm)	Colour Variation		LOI
				Dry	Fired	
Eniji A	10	9.05	8.10	Grey	Light Brown	7.4
Eniji B	10	8.97	7.95	Grey	Light Brown	7.2
Ahoko A	10	9.28	8.55	White	White	10.7
Ahoko B	10	9.15	8.29	White	White	11.2
Ajelele A	10	8.93	7.89	Milky White	Brilliant Brown/Red	12.5
Ajelele B	10	8.75	7.62	Milky White	Cream Brown	13.1
Itobe A	10	9.42	8.74	Light brown	Brilliant Brown/Red	5.7

Itobe B	10	9.27	8.51	Creamy white	Brown	6.1

Table 3: Average Values of Linear Shrinkages and Modulus of Rupture of Selected Clays in Kogi State

Location	Average Linear Dry Shrinkage (%)	Average Linear Fired Shrinkage (%)	Shrinkage Classification	Average Dry Modulus of Rupture (MPa)	Average Fired Modulus of Rupture (MPa)	Strength Classification
Eniji Clays	9.9	10.9	Good Plasticity *(Range: 7-10%)*	10.1	15.3	High Strength
Ahoko Clays	7.85	8.65	Good Plasticity *(Range: 7-10%)*	3.6	8.8	Medium Strength
Ajelele Clays	11.6	12.3	Very High Plasticity *(Range: above 10%)*	11.7	16.3	High Strength
Itobe Clays	6.55	7.65	Low Plasticity *(Range: below 7%)*	2.6	6.4	Medium Strength

Ahoko clays have an average linear drying shrinkage value of about 7.9% and average linear fired shrinkage of 8.7%. This shrinkage value suggest that the clay from Ahoko village may not very suitable for very-high grade vitrified whiteware and earthenware. However, the clays could best be used for other lower-grade earthen ware. Shrinkage value ranging between 7-10% is best for the production of medium-to-high tension porcelain and medium-grade earthenware [13].

Ajelele clays have the highest average drying and firing shrinkage values of 11.6% and 12.3% respectively. The shrinkage value (above 10.5%) satisfied the allowable standard values recommended by American Society of Testing and Material (ASTM) [11]. Figure 1 shows that Ajelele clays have the highest value of shrinkage factor (i.e about 1.31), among all tested clay samples from the selected locations. This supports the indication that Ajelele clays are suitable for vitrified ware, sanitary ware, white and coloured tiles (floor, paving, wall and roofing), and almost all other vitrification processes. The factors of shrinkage for selected clay samples are shown in Figure 1.

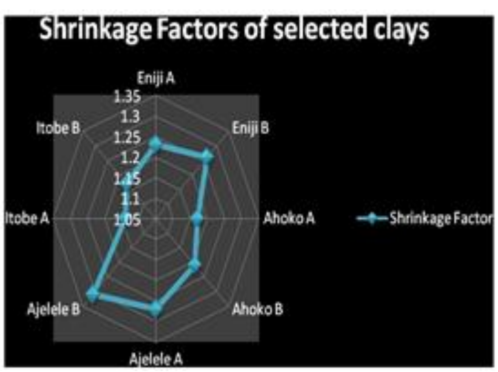

Figure 1: Factors of Shrinkage of Selected Clays

Table 4 shows the classification of Shrinkage and Modulus of Rupture of the selected clays. Itobe clays have the average linear drying shrinkage of 6.5% and average linear fired shrinkage is 7.7%. These values fall within the lower acceptable limit. In practice, shrinkage values lower than 7.0% may be suitable for production of low-tension porcelain and lower-grade earthenware [13].

3.2 Strength Characteristics of Selected Clays

The Modulus of Rupture (i.e traverse/flexural strength) of selected clays from Kogi State were tested and characterized as index of strength of ceramic bodies, in accordance with ASTM 10.04: F 417, and classified based on Kevas et al (2007) and Singer (1979). Figure 2 shows the fired modulus of rupture of selected clays sample.

From Table 3 and Figure 2, Ajelele clays have the highest mean dry and fired Modulus of Rupture values of about 11.7MPa and 16.3MPa respectively. This indicates that Ajelele clays are very suitable for both traditional and industrial ceramic applications. Also, the MOR values of Ajelele clays are closely followed by the mean drying and fired MOR of Eniji clays at about 10.1Mpa and 15.3MPa respectively. These values are also good strength indices for ceramic wares. Mean drying and fired MOR of Ahoko and Itobe clays are about 3.5MPa and 8.8MPa, 2.6MPa and 6.4MPa respectively.

Table 4 shows the strength classification of selected clays in Kogi State of Nigeria. Although both Ahoko and Itobe strength index also fall within the acceptable limit, clay from both locations could be considered for low-grade ceramic, tiles and Sanitaryware production.

Table 4: Classification of Shrinkage and Modulus of Rupture of Selected Clays in Kogi State

Location	Linear Dry Shrinkage (%)	Linear Fired Shrinkage (%)	Total Linear Shrinkage	Shrinkage Factor	Application based on Shrinkage	Dry Modulus of Rupture (MPa)	Fired Modulus of Rupture (MPa)	Application based on Strength Classification
Eniji A	9.5	10.4	19	1.23	Suitable for medium-to-high tension porcelain, earthenware, coloured tiles, electrical insulators, etc	9.5	14.6	High Strength
Eniji B	10.3	11.4	20.5	1.26		10.7	15.9	
Ahoko A	7.2	7.9	14.5	1.17	Suitable for medium-grade earthenware, lower-grade porcelain, medium porousity tile, etc	3.4	8.4	Medium Strength
Ahoko B	8.5	9.4	17.1	1.21		3.7	9.2	
Ajelele A	10.7	11.6	21.1	1.27	Suitable for vitrifiedware, sanitaryware, white and coloured low-porousity tiles (floor, paving, wall and roofing) etc	11.4	15.6	High Strength
Ajelele B	12.5	12.9	23.8	1.31		11.9	16.9	
Itobe A	5.8	7.2	12.6	1.14	Suitable for manufacture of low-tension porcelain and lower-grade earthenware	2.3	5.6	Medium Strength
Itobe B	7.3	8.1	14.9	1.17		3.0	7.3	

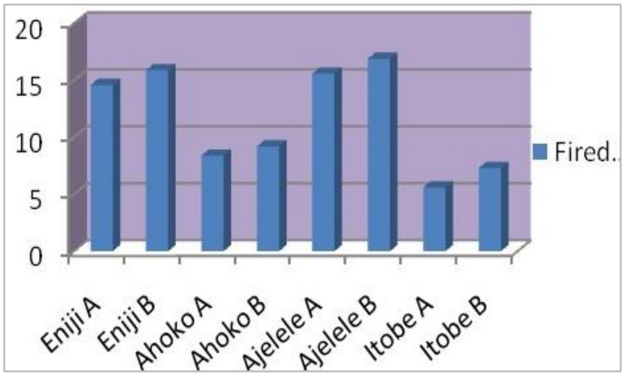

Figure 2: Fired Modulus of Rupture of Selected Clays

Owing however to their proximities to the lower limit, they may not be recommended for industrial application (where excellent hardness, durability and strength are desired), except with skilful combination with other carefully selected raw materials. The Modulus of Rupture (or transverse/flexural strength) of clay raw material is proportional to plasticity, a highly desirable characteristics in ceramicware clays [11]. Both strength and plasticity are due to colloidal clay mineral particle [13]. ASTM acceptable range of dry MOR ranges in the region between 1.4 to 10.3MPa [11]. Higher values, though rare, are also desirable. It is observed in the results that the strength behaviour was found to increase with temperature, and this could be attributed to bond formation in the glassy phase [11].

3.3 Firing Behaviour and Colour Characteristics of Selected Clays

The firing behaviour, ignition loss and colour variation of selected clays from Kogi State were tested and characterized, in accordance with ASTM 15.02: C 323, and classified based on Kevas et al (2007) and Singer (1979). The results of the clay sample bars tested for their Firing Behaviour (Colour Variations) are shown in Tables 5. The result of firing behaviour of Eniji clay in Table 5 shows a colour variation from grey (drying) to light brown (fired) colour. The light brown colouration may be due to the presence of 2.7% iron-oxide (Fe_2O_3), as shown in the chemical analysis result. This colour variation is considered useful for the manufacture of flowerpot [11].

Table 5: Variation in Firing Behaviour (Colour) of Selected Clays in Kogi State

Location	Colour Variation		Classification
	Dry	Fired	
Eniji A	Grey	Light brown	Suitable for flowerpot, coloured vaze, etc
Eniji B	Grey	Light brown	
Ahoko A	White	White	Suitable for vitrified whiteware refractories, etc
Ahoko B	White	White	
Ajelele A	Milky white	Brilliant brown/red	Suitable for stoneware, flowerpot, etc
Ajelele B	Milky white	Creamy brown	
Itobe A	Light brown	Brilliant brown/red	Suitable for stoneware, flowerpot etc
Itobe B	Creamy white	Brown	

Dried clay samples from Ahoko are white. The whiteness of Ahoko clays is retained even after firing. It is notable that the iron-oxide is 1.3%. This indicates that the clay is suitable for manufacture of whitewares (earthenware, Porcelain, etc); white-burning sedimentary plastic refractory clays are known as Ball Clays [13]. The variation in firing behaviour of selected clay is shown in Table 5. Dry Ajelele clays have milky white colour. After firing, Ajelele clays changed from its milky-white colour to reddish brown. The brilliant brown/red colour variation could be attributed to the very high content of Iron oxide (7.8%). The ferrous Iron impacted a red colour on the fired sample due to conversion from ferrous to ferric compound [11], as the clay was being fired to 1,150° C. The good plasticity of Ajelele clay (as indicated above by its shrinkage) makes it very suitable for wide range of ceramic applications and industrial products, but the high iron oxide may limit its use to stoneware.

The colour of dry Itobe clays samples range from creamy white to light brown. The colour of the fired samples varied from brilliant brown to red. The brilliant brown and reddish colouration of fired Itobe clays may be due to the presence of iron-oxide [11]. Itobe clays contain Iron Oxide (Fe_2O_3) of about 4.1%. This reddish-brown fired colour variation could be considered useful for the manufacture of stoneware, flowerpot, etc.

3.4 Loss on Ignition Characteristics of Selected Clays

Table 6 shows the classification of ignition loss of selected clays in Kogi State of Nigeria. The classification is after Singer(1979). Ajelele clays have mean L.O.I. of 12.8%, Silica-52.66% and Alumina-21.40%. These values fall within the range of Kaolinitic or China Clays. Also, in Table 4.6, Ahoko clays have mean L.O.I. of 10.9%, Silica-60.47% and Alumina-24.35%. This is an index of Ball Clays. Eniji clays have mean L.O.I. of 7.3%, Silica-77.29% and Alumina-10.52%. Itobe clays have mean L.O.I. of 5.3%, Silica-79.17% and Alumina-9.76%. The values of Eniji and Itobe clays match the range of Siliceous Clays [13].

Table 6: Variation in Firing Behaviour (Loss-on-Ignition) of Selected Clays in Kogi State

Location	LOI (Mean, %)	Classification
Eniji	7.3	Siliceous clays (Silica-77.29%, Alumina-10.52%)
Ahoko	10.9	Ball clays (Silica-60.47%, Alumina-24.35%)
Ajelele	12.8	Kaolinitic clays (Silica-52.66%, Alumina-21.40%)
Itobe	5.3	Siliceous clays (Silica-79.17%, Alumina-9.76%)

3.5 Chemical Composition of Selected Clay

The percentages of oxides of selected clay from Kogi State were characterized using X-Ray Fluorescence Spectrometer, in accordance with ASTM: C 118. Table 7 shows the chemical composition of the selected clay samples. The clay samples from Ahoko and Itobe have the highest (1.75%) and lowest (1.42%) Alkali percentages respectively. High alkali contents in clays lower the melting point during firing of ceramic bodies, and as such are desirable for the manufacture of ceramicwares. Also, Ajelele and Ahoko clays have the highest (7.78%) and lowest (1.27%) Iron Oxide percentages respectively. The presence of iron oxide could be responsible for the reddish-brown colouration after firing, as shown in Table 7, making it unsuitable for whitewares products. However, the iron content in fire clays could be desirable, acting as fluxes in highly refractory and infusible products [14].

Table 7: Chemical Composition of Selected Clay Samples

Oxides	Eniji	Ahoko	Ajelele	Itobe
SiO_2	77.29%	60.47%	52.66%	79.17%
Al_2O_3	10.52%	24.35%	21.40%	9.76%
Fe_2O_3	2.67%	1.27%	7.78%	4.13%
CaO	0.24%	0.22%	0.01%	0.04%
MgO	0.12%	0.14%	0.14%	0.11%
K_2O+Na_2O	1.59%	1.75%	1.70%	1.42%
TiO_3, P_2O_5 SO_3, etc	Trace	Trace	Trace	Trace
H_2O (LOI)	7.3%	10.9%	12.8%	5.3%

Figure 3 shows alkali oxides, iron oxide and water percentages, while figure 4 shows silica and alumina percentages in selected clays respectively.

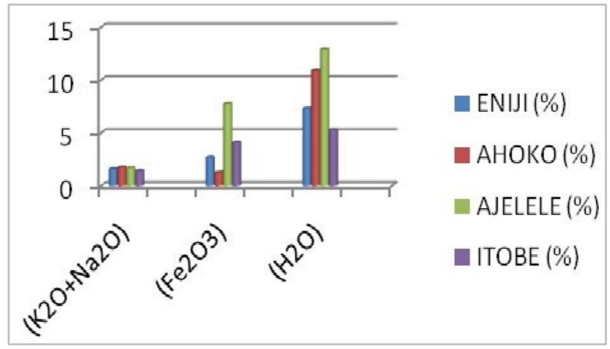

Figure 3: Alkali oxides, Iron oxide and Water Percentages in Selected Clays

The percentages of silica and alumina in Eniji, Ahoko, Ajelele and Itobe clays are shown in Figure 4. The clay samples from Itobe and Ajelele have the highest (79.17%) and lowest (52.66%) silica percentages respectively. Also, Ahoko and Itobe clays have the highest (24.35%) and lowest (9.76%) alumina percentages respectively. Clays with high alumina and less silica contents are usually plastic. Traditionally, high silica content in ceramic raw material accounts for low plasticity. The highly siliceous clays (Itobe and Eniji clays) also contains appreciable amount of alkali and iron bearing minerals which could spoil the ceramic properties of the products until and unless it is mixed with good Kaolinitic clays.

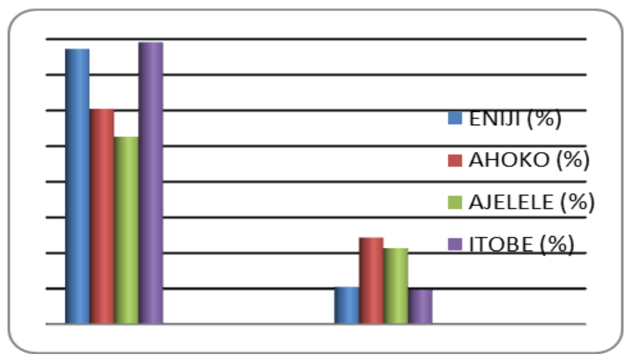

Figure 4: Silica and Alumina Percentages in Selected Clays

4. CONCLUSION

Two samples each were taken from four selected locations in Kogi State of Nigeria. The tests on physical properties and chemical composition were carried out on all eight samples of clay in accordance with American Society of Testing and Material (ASTM). The result of the Linear Drying Shrinkage (mean values) of the selected clay samples vary from 6.5% to 11.6%. The values of the Linear Fired Shrinkage (mean values) of the selected clay samples vary from 7.7% to 12.3%. This is an index of good plasticity as the shrinkages of these samples fall within acceptable international range of 7% to 10%.

The strength characterisation of the selected samples shows that the dry Modulus of Rupture ranges from 2.7MPa to 11.7MPa. The strength characterisation of the selected samples shows that the fired Modulus of Rupture ranges from 6.3MPa to 16.3MPa. The result indicates a strength classification of medium to high strength.

The characteristics of the firing behaviour reveals a dry-to-firing colour variation of white-to-white, grey-to-light brown, milky white-to-brilliant brown and light brown-to-brilliant red. This confirms the suitability for wide range of ceramicwares application ranging from vitrified whitewares to brickwares, coloured vaze and tiles. Further characterization on firing behaviour of the revealed test result on ignition loss of the samples ranging from siliceous clays, ball (china) clays to kaolinitic clays. The mean values of Loss on Ignition (LOI) of the samples ranges from 5.3% to 12.8%.
The chemical composition of the clay samples also determined in accordance with ASTM, using X-Ray Fluorescence Spectrometer. This shows Silica range of 52.66% to 79.17%, Alumina-9.76% to 24.35%, Iron Oxide-1.27% to 7.78%, Calcium Oxide-0.01% to 0.24%, Magnessium Oxide-0.11% to 0.14%, Alkali (K_2O+Na_2O) is 1.42% to 1.75% and elements like Titanium, Phosphorus and Sulphur Oxides are traceable.

The results of various analysis on Physical and Mechanical properties, and Chemical Composition of the selected clay and feldspar in Kogi State of Nigeria were found to satisfy the allowable standard values for manufacture of ceramicwares as recommended by American Society of Testing and Material (ASTM). The analyses showed that Ajelele clay is Kaolinitic or China clays, Ahoko is Ball Clay, Eniji and Itobe are Siliceous Clays. Also the selected raw materials are suitable for the manufacture of a wide range of ceramicwares, ranging from vitrified whitewares to brickwares, coloured vaze and tiles.

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