FORMULATION OF NEW CERAMIC GLAZES: TEST RESULTS OF ROCK MATERIAL FOUND IN EASTERN UGANDA

Received: 2th May, 2023, Reviewed: 8th May 2023, Accepted: 24th May 2023

• Philemon Ahami

Corresponding Author:
•Mr. Anthony Ngondo
ngondo08@gmail.com

FORMULATION OF NEW CERAMIC GLAZES: TEST RESULTS OF ROCK MATERIAL FOUND IN EASTERN UGANDA

ABSTRACT

Background: Glazes are very thin glass layers or coatings used to cover clay bodies to make them impermeable, mechanically tougher, scratch-resistant, chemically more inert, and more aesthetically beautiful. Glazes are moderately cheap in price as they are produced using naturally occurring local resources that tend to be plentiful in supply, easy, and dependable to mine. Scholars have reported that the best way to learn about the formulation of ceramic glazes is to have the ingredients used in their manufacture tested. The tests carried out involve varying different amounts of the ingredients that make the glaze formulated and then fired at different temperatures in a kiln. **Problem:** There, however, has not been much research done on glaze formulation using geology in Uganda. According to the survey done on the three studios located within Mukono district in Uganda, geared towards outlining glaze challenges faced by practicing ceramics artists showcased the difficulties they underwent in finding glazes. **Objective:** The main objective of this paper was to report the test results of glaze formulation experiments done on selected natural materials found in the Mukono and Jinja districts of Eastern Uganda. **Design**: This paper used a Quasi-experimental research design and furthered the Solomon four-group design. **Setting:** The rock samples were collected from Jinja and Mukono districts, Uganda, and transported to the Kenyatta University Ceramic Studio for testing. **Subject:** the subject of this paper are rock samples form Mukono and Jinja districts of eastern Uganda. **Results:** The paper presents the aesthetic and functional qualities of the fired glazed test bars that had been constituted with different rock samples and fired at different temperatures. The results indicate that most of the glaze samples matured better and had better aesthetic and functional qualities when fired at higher kiln temperatures of 1250°C than they did at low kiln fire temperatures of 1100°C. **Conclusion:** Glazes can be formulated using natural materials. Similarly, at the higher temperature, the glazes appeared to have a better shine and gloss finish as opposed to their aesthetic look when fired at the lower temperature. Documentation of the aesthetic and functional qualities of the new glaze is done.

Key Words: Glazes, Glaze formulation, Rock Material.

INTRODUCTION

Glazes are therefore thin glass layers bonded to the body's surface. They are used to cover bodies to make them impermeable, mechanically tougher and scratch-resistant, chemically more inert, and more aesthetically beautiful (Felix, 1963). Glazes are produced using naturally occurring local resources. There, however, has not been much research done on glaze formulation using geology in Uganda. According to the survey done on the three studios located within Mukono district in Uganda, geared towards outlining glaze challenges faced by practicing ceramics artists showcased the difficulties they underwent in finding glazes. These raw materials vary from place to place. During glaze formulation processes the type of raw materials, calcining, grinding of samples, test firing, and addition of additives are considered. The temperature of firing is also an important variable in glaze formulation. Once formulated the glazes are tested to determine their aesthetic and functional qualities.

This paper reports the test results of glaze formulation experiments done on selected natural materials found in the Mukono and Jinja districts of Eastern Uganda. It expects to give a guide on what raw materials from the study area would be suitable for producing suitable glazes that can be used to finish and decorate ceramic ware.

THEORY

Ceramics is one of the oldest known crafts that have a significant impact on human life (Gustami, Guntur & Irfan, 2019). Wibisono, (2000) writes that ceramics have commonly been used to make domestic appliances, building materials, food containers, home décor, body jewelry, money-saving instruments, metal-working tools, and lighting equipment. These shaped ceramics are usually enclosed in decorative, water-resistant, paint-like materials, thin, hard, shiny, and usually transparent layers known as glazes.

During the formulation and development of glazes, the locations, relevance, types of natural raw materials, and their characteristics should be considered because clay materials are available. But one must learn about these materials and how to use them. According to Mamza & Jidai (2014), a potter must have applied knowledge of the elements or metallic oxides, including their properties, how they interact with other elements, what heat conditions produce the best results, and what compounds are readily available. Then one will be able to brilliantly devise glaze recipes.

Natural local resources that are used to produce glazes are picked from treated and beneficiated minerals. Glaze has a moderately cheap cost since the local resources employed in it are plentiful, easy to get, dependable, and reasonably priced. (Thomas 2020). Barongo, L, (2017), agrees that there is a great wealth of the earth's resources though, differences occur in the type and availability of natural materials from region to region.

The process of glaze formulation starts with washing and drying the natural materials, before measuring them and packing them in a kiln for calcination. Calcination helps to remove moisture and drive out carbon dioxide from the ore. Two types of reaction occur during calcination - decomposition, and combination. Several different reactions may occur, depending on the nature of the raw materials and the desired end product. Crushing glaze materials in a ball or attrition mill then takes place before sieving through 40-80 meshes. The glazes are then applied to test bars for firing (Mamza & Jidai, 2014). Glazes are often applied by spraying or dipping, and, depending on their ingredients, mature at temperatures ranging from 600°C to 1500°F (1110°C to 2730°F).

Henrik & James (1993) write that glaze formulation is similar to cooking: the same formula may yield very unlike outcomes when prepared by two, unlike chefs. In glaze formulation, there may be differences due to changes in raw materials and firing procedures. Glaze testing is done after crushing the glazes in the ball mill. Henrik & James (1993) and Thomas (2020), say that whereas it is important to do test samples when formulating glazes, the choice of test sample is a matter of personal choice. There are many different ways of test sampling when formulating glazes such as line blending and tri-axial blending. In this study, line blending was used as the test sampling method. Glaze performance on its part has the following specifications: a horizontal or vertical surface, a textured region, a hole to bind it together (this helps to keep comparable tests together for future reference), and a labeling area that has the full formula of the test bar on each trial.

Ceramic glazes each have a temperature range that they should be fired. Most glazes will not mature if they are fired at too low a temperature. If the temperature rises too high, the glaze melts and runs off the surface of the pottery. A potter must understand the temperature ranges at which their glazes mature to be successful. A low temperature of 1100°C and a high temperature of 1280°C can be used in the testing to classify low and high-temperature glazes (Henrik & James 1993).

Burleson (2001) suggests conducting a test firing on small batches of clays to determine properties such as opacity, fluidity, and surface texture. Barongo L., (2017) agrees and underscores the primary reasons for conducting glaze tests on smaller pieces: it helps to examine the prospect of an individual material or, in the case of formulation, to examine the behavior of additives used when formulating the clay. The test firing of small raw materials also showcases the melting point behaviors of each clay sample. The results obtained help the potter to rethink or make adjustments to the recipe if mistakes are detected,

Taylor. J.R & Bull. A.C. (1986) argues that the best way to learn about ceramic glaze materials is to test them. By studying what happens when varying amounts of various ingredients are combined in a glaze and then fired to various temperatures, researchers start to understand how materials affect each other, and therefore how to troubleshoot when wrong results are achieved.

In addition to being decorative, scholars have written the following about the different characteristics of glazes:

a) Transparent, and translucent glossy glaze layers.

These occur when all raw material particles of the glaze mix are dissolved and melted out, and no crystalline precipitates have formed during cooling. Transparent glossy glazes are easy to obtain if they consist mainly of frits. Hairline cracks can disturb the transparency of these glazes so to avoid such disturbances, the glaze is either applied as thinly as possible or is composed in such a way that it becomes as thin as possible. If such glazes are needed, as many raw materials as possible should be used.

b) Opaque and glossy.

Most glazes contain disturbances in the glazed layer without being visible to the naked eye and without disturbing the surface. Such glazes are then very limitedly permeable to light. The smaller and more numerous the disturbances, the greater the cloud. Disturbances are in the form of unresolved particles in the backfill, newly formed crystals, bubbles, or even segregated droplets.

c) Crystallized silk matt

If raw materials contain relatively small amounts of SiO2 and B2O3 and the cooling in the glaze firing is slow enough, the melt of the glaze can solidify and crystallize if the composition is suitably made. Using many very small crystals produces a matt but smooth surface. This glaze may be colorless or colored.

RESEARCH METHODS

The study applied a Quasi-experimental research design. This is because Quasi-experimental research designs establish a cause-and-effect relationship between an independent and dependent variable, (Mugenda & Mugenda, 2003). It assists in understanding the relationship between objectives and variables. Further, the Solomon four-group design, a type of experimental research design that seeks to achieve three purposes: assessing the result of treatment, assessing the result of the pre-test, and accessing the interaction between a pre-test and treatment conditions was used in the study.

The study reported in this paper was studio based with the samples collected from Mukono and Jinja districts, Uganda. The samples were ground and then fire-tested as clay samples. Data analysis involved categorization where categorization was done according to the regions or areas that they were picked. The samples were then fired at a low temperature of (1100°C) and a high-temperature firing of 1250°C.

RESULTS

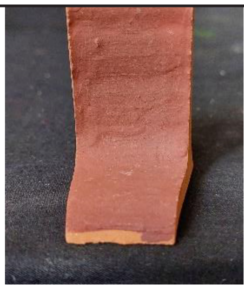
The followings are the results of low-temperature firing (1100°C) and high-temperature firing of 1250°C of selected rock samples from the identified sites:

Table 1: Results of low (1100°C) and high-temperature firing (1250°C) of selected rock samples

No	Code	SITE 1	ow t emperatures of 1100ºC	high t emperature of 1250ºC	RESULT SUMMARY
1	JC 1 J	inja central			The sample glaze was fused with the clay test bar in both. The glaze did not mature at the required temperature.
2	JC 2 J	inja central			The glaze did not melt in both high and low firing The sample showed similar characteristics to the test bar in sample JC 1 above.

3	JC 3 J	inja central			The glaze melted on the clay test bar with bubbled cracks and rough on top in the high firing but did not melt at low fire temperature.
4	JC 4 J	inja central			The glaze fused with the clay test bar at low firing and peeled off the test bar at high firing. The glaze did not mature in both high and low firings.

5	MK I	Mpumudde - Kimaka			The glaze matured at high temperatures of 1 250ºC. The color of the glaze after firing was dark brown s hiny and glossy. The glaze did not melt at low fire temperatures.
6	MK 2	Mpumudde - Kimaka			The glaze gave a glossy/shiny appearance with coffee brown colors at high firing. The glaze did not at l ow firing but fused o n the bar.

7	WM 1	Walukuba Masese				The glaze exhibited glassy/ shiny effects in a dark brown color at high firing. The glaze did not melt at low firing but fused on the test bar.
8	WM 2	Walukuba Masese				The sample did not mature after firing. The glaze fused with the clay tile but did not melt at high and low temperatures
9	WM 3	Walukuba Masese				The sample had the potential to melt when fired at high temperatures with a grey

					color. Additives can be used to low down the maturity temperature of the glaze.
10	MK 3	Mpumudde - Kimaka			A smooth, glossy which shows the maturity of gloss firing and glaze melting is exhibited in the sample. The glaze did not melt at low temperatures .
11	WM 4	Walukuba Masese			The glaze was fused with the clay test tile but it did not evidence of the melting behaviors of

					the glaze when fired at high and low temperatures
12	KAS 1	Kasawo			The sample melted at high temperatures with a small bubble, pin-like appearance. The sample also exhibited slightly crawling behaviors. The glaze did not melt at low.
13	KAS 2	Kasawo			The sample melted w ith small spotty effects pin-like on top of the glazed body in h igh firing and

					fused with the glaze and did not melt at low firing.
14	KAS 3	Kasawo			The glaze did not melt at both high and low temperatures , but the glaze was fused on the clay test bar. Although the color was white opaque.
15	KAT 1	Katosi			The matt-like crawling form was evidenced in the glaze after firing. The color of the glaze was

					coffee brown.
16	KAT 2	Katosi			The glaze had a shiny smooth surface body. The color of the glaze was dark brown when fired at high firing. But did not melt at low temperatures.
17	NAK 1	Nakifuma			The sample did not melt at both required temperatures. The glaze peeled off from the clay tile surface in high firing. The color of the glaze was

					white.
18	N A K 2	Nakifuma			The sample has similar characteristics to the glaze sample number 17 above when fired at both high and low. The glaze peeled off the test bar.

DISCUSSION OF FINDINGS

Generally, natural materials from Jinja and Mukono districts in Uganda formulated good glazes. Most of the glazes matured at high temperatures and melted with a shiny and glossy finish on the top surface of the glaze. This can be evidenced in samples specifically picked from Mpumudde-Kimaka (MK 1, MK 2, and MK 3) and Walukuba Masese (WM 1) from Jinja and Kasawo (KAS 1, and KAS 2) and Katosi (KAT 1, and KAT 2) from Mukono district. The glazes melted without any additives added in the glaze which shows that if additives like fluxes and refractories were added to the recipe can lead to the improvement of the glaze samples in terms of smoothness, effects, and good melting flow on the test bar.

The glaze samples that melted with small pins, cracks, and crawls which can be evidenced in sample number 12 and 3 can also be improved by additives like kaolin and feldspar which can stabilize the glaze melting effects in the kiln during firing. Most of the glazes did not melt or mature at low temperatures of 1100 degrees celsius but the sample glazes fused on the clay body. This shows that the stone samples contain lots of silica which is a high-firing element. Additives like ash and salt can be added to the composition during mixing to low down the melting point of the glaze. The glazes had ranges of brown colors in high firing and lots of reds in low temperatures.

It is noted that natural materials from Jinja and Mukono districts in Uganda can be used to formulate glazes. Concerning the glaze testing and firing, most of the glazes matured at high temperatures and melted with shiny and glossy finishing on the top surface of the glaze. Most glazes melted without any additives added in the glaze which shows that if additives like fluxes and refractories were added in the recipe can lead to the improvement of the glaze samples in terms of smoothness, effects, and good melting flow on the test bar.

RECOMMENDATIONS

From the foregoing results, it is clear that high temperatures of 1250^{o}C are recommended for melting stone glazes. This is seen from Samples number 5(MK 1), 6(MK 2), 7(WM 1), and 16 (KAT 2) all in Table 1, that matured well after the clay tests. These samples are immediately recommended for use in formulating glazes in the Mukono and Jinja districts of Eastern Uganda.

Similarly, ceramists elsewhere can also follow a similar procedure in their environments to formulate glazes for use. The ceramists can go on to widen the color ranges and textural effects of their formulated glazes by using glaze colorants.

REFERENCES

Barongo, L, (2017). Glaze Formulation Using Selected Geological Material from Nakuru and Kiambu counties, Kenya. Unpublished Thesis.
Burleson, M. (2009). The Ceramic Glaze Handbook, Materials, Techniques, and Formulas. Revised edition by Lark Books New York. P44.
Felix, S & Sonja S.S. (1963). Industrial Ceramics. London, Chapman, and Hall.
Gustami, S & Guntur, Guntur & Kadir, Irfan. (2019). Continuity of Traditional Ceramic Arts in The socio-cultural context of Crafters Society.
Henrik N, and James D. (1993). Self-Reliant Potter Glazes. Preparation of Glazes. https://vdocuments. Mx/reader/full/self-reliant-potter-glazes-you-can-make.
Mamza, & Jidai, A. (2014). The Formulation of Glazes using Raw Materials from selected states in Northeastern Nigeria.
Mugenda, O and A. Mugenda. (2003). Research Methods: Quantitative and Qualitative Approaches. (1st ed). Acts Press, Kenya.
Taylor. J.R. & Bull. A.C. (1986). Ceramics Glaze Technology, the Institute of Ceramics and Pergamon Press.
Thomas Kronberg, (2020). Properties of raw glazes- The impact of composition, firing and functional coatings, Abo Akademi University, Finland.
Wibisono. S, (2000). Terakota Masa Klasik. Dalam buku 3000 Tahun Terakota Indonesia: Jejak Tanah dan Api, Museum Nas. Indones. Jakarta, hal, pp. 13-18.