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Triangulation Clay Bodies Formulation for Lapohan Traditional Pottery

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Abstract

This study investigated traditional local clay in Kampung Selakan, Selakan Island. Traditional lapohan pottery uses the triangulation formula to define the body of the clay. The purpose of this research was to study the effect of gosong (local black sand) on the lapohan's properties as a solution to protect the market from decline as traditional Lapohan pottery is important for the preservation of heirloom heritage requires. In the experiment, 18 formulations used varied the composition of Selakan clay (SC) by introducing gosong (black local sand) from 2% to 18% of the weight percentages studied. The durability, water absorption and shrinkage of the clay body is tested for each sample. The higher gosong content has resulted in higher water absorption, low shrinkage, and stability. Experiment on the production of the firing temperature at 900°C. The effects of heat on the composition of clay were measured quantitatively and the interaction between the mechanical resistance and the components of the lapohan pottery clay body was tested. The result comparison shows that the best composition is obtained by adding gosong which generated pottery products with improved aesthetic workability of clay. A descriptive approach of qualitative analysis, including observation and in-depth interviews for written or visual data collection, will gather the necessary details for the report. The study's findings and significance indicate that traditional development of lapohan pottery in Selakan Island primarily involves awareness and technological usage of clay as a primary material, preparation of clay bodies, and adaptation for potters utilising local natural source.

Keyword: Traditional Pottery, Local Clay, Triangulation Formula

Introduction

The Bajau ethnic community on the island of Selakan, Semporna, or rather the sea Gypsies, are predominantly boat dwellers and coastal fishermen. This ethnic group is known for its traditional artistic heritage, especially the conventional hand-made clay stove or lapohan. It is a warmer meal at sea. Lapohan pottery also represent the symbolic significance of natural artifacts portraying the identity of Bajau community (Chia, 1994; Ibrahim, 2002; Suresh Narayanen, 2017). Selakan Island is a part of 49 scattered islands surrounding Semporna Peninsula in south-eastern Sabah, Malaysia. Four hundred forty-two square miles of land near Indonesia and the Philippines.

In Malay society, art history occurred in the discovery of functional objects. The study of pottery artifacts is also useful in creating concepts about society, economic conditions, and cultural evolution of society.(Said et al., 2011). Traditionally, pottery is generally a woman's job that she will do after her job is done. (Ham Rabeah Kamarun, 2005). The relationship between artists and culture has a long history. Moreover, according to Chia (2005) considers ceramics to be important for history. Prehistory and anthropologists will be able to understand and rearrange ancient history, culture and art as well as understand the historical stages of the progress of a country and its civilization. The development of ceramics is one of the oldest practices in the history of human life. Furthermore, pottery was one of the first crafts produced by human culture (Arifin, 2015; Mohamad, 2005).

Ceramic pottery is one of the hallmarks of Sabah's heirloom, closely linked with folk cultures but normally used as cooking or storage containers. The Lapohan is a traditional clay-made stove which is intertwined closely with the ethnic Bajau Laut culture. The Bajau Laut, literally meaning Sea Gypsies, use the Lapohan to prepare meals and to warm foods. The Lapohan is considered a treasured relic of their culture, for the Bajau Laut normally use this device while they are at sea. However, the Lapohan is not just a device for cooking unlike our modern kitchen utensils. These devices hold a particular artistic and cultural meaning towards the Bajau Laut. Even so, the Lapohan as a culture is dying, as there are fewer uses for it and there is a lack of skilled people who are able to create the Lapohan. Thus, the objective of this particular finding is to maintain the cultural and artistic value the Lapohan has by increasing its workability in terms of scientific value.

According to Chia (2005) Year 2006, a group of archaeologist researcher from Universiti Sains Malaysia had found that traditional pottery (Lapohan) already exist since 3000 years before in Tengkorak Cave in Semporna. Besides the similarity of lapohan can see it from the shape and process of making lapohan. Azmi Ariffin (2015) In Malaysia, the inventions of pottery was an indication of the beginning of civilization; it is irrefutable evidence of the origins of the primal communities referred to as the Malay. According to Norton (1956), Primitive pottery-making is almost universal in association with an early man over the whole surface of the earth. Because communication was practically non-existed, we are led to the conclusion that it evolved independently in many regions.

Study of the prehistoric clay commodity required to look at the technology and raw materials used at the time. Technology and raw materials used at the time, ancient clay product research was necessary. Malaysia pottery substance can be enhanced by its chemical clay formulation (N. A. Gani et al., 2015). There are several items of concern in pottery making, and one of them is chemical clay formulation. These key factors influence pottery products in terms of structural characteristics and pottery quality. The chemical composition of the clay comprises elements which affect the processing as well as the consistency of clay. The clay should be low in terms of Fe, Al and Si to generate productive pottery products. (N. Gani et al., 2017) Consequently, minor variations in the concentration of essential elements in clay can contribute to pottery processing and quality.

Our objective is to enhance the Lapohan's usability by combining the local clay of Pulau Selakan with different percentages of fluxes and fillers to create a novel clay body formula, making it more energy efficient and useful in cooking. Through practical reconcile and firing experiments cones 015, 04 and 4, our goal is to organize proportions of the raw materials using the acquired suitable formula process. Through these two methods, our hope is that the clay workability is increased, and it can produce quality clay. These compositions were determined using X-Ray Powder diffraction (XRD), X-Ray Fluorescence (XRF) and Scanning Electron Microscopy with Energy Dispersive X-Ray Spectroscopy (SEM/EDX). Through XRF, the presence of Silicate, Ferum Oxide and Aluminium Oxide in most of the Lapohan compositions was found to be not of minimum level. Observation of the physical and mechanical properties showed that local clay materials are suitable to use in ceramic industries. We are also looking at to apply the triangulation formula to not just make it more efficient, but to create different artistic designs of the Lapohan while integrating the Bajau Laut essence of motifs and patterns, creating a modern version of the Lapohan.

Nevertheless, this study aims to explore the technological usage and to understand the clay material, body preparation and modification for traditional ceramic pottery development on Selakan Island. Many consumers are more attracted to recognizable conventional Lapohan pottery with smooth and appealing forms that can be used for the purposes because of lower prices and a more distinctive clay stove. Whereas in this provincial region, most local potters need to manufacture their lapohan according to buyers' demand.

Traditional lapohan pottery producers are seeking to widen the market to manufacture traditional pottery according to the current requirement, but the limits of their production method have stayed the same since prehistoric times. In addition, the key thing that causes this typical lapohan pottery to have issues with cracking and splitting is the preparation of a clay body that is too hard to bend the different decorations due to the clay caused by the particle size of coarse foreign particles, such as sand. During the development of traditional lapohan pottery, especially the local unglazed low-fired terracotta, the preparation of Selakan clay body is a very important phase. Various gosong contents have been tested and gosong may even be properly used as an additive as a result.

The physical, mechanical and chemical characteristics of the finished product are often influenced not only by the clay properties, but also by the percentages of the elements in the clay. Increasing main aspects, such as silica, lead to the melting point, minimize elasticity and improve strength and hardness. In addition, the increased aluminium content lets the green body retain sintering temperature and also boost pottery strength (N. A. Gani et al., 2015)

Literature Review

Kampung Selakan is situated on Selakan Island at latitude 4.5749 and longitude 118.6945, 13 metres above sea level (Figure 1. 1). Hj Kapital Patal, 71 years old, the head of the village, claims there are 500 people on the island. As farmers and fishermen, the majority of the villagers work. A long time ago, pottery manufacturing was carried out in this village, but none of the population of this village are involved in pottery making today. There are a couple of ex-potters who still live in the community.

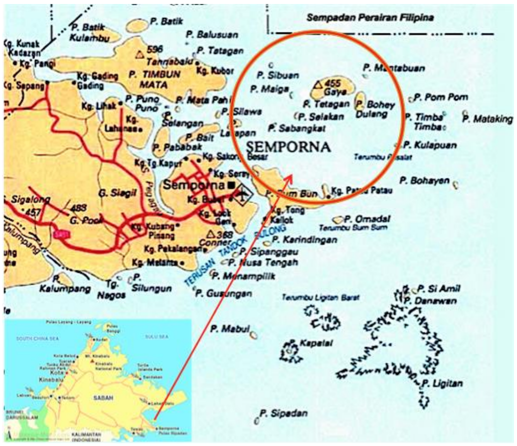

Figure 1. 1: Map of Selakan Island in Semporna, Sabah

Figure 1. 2 show the information from Mineral and Geo sciencee Malaysia (JMG), the raw clay deposit is on Selakan Island. It mainly consists of sedimentary clay, sand, clay and peat accumulated in freshwater. The Selakan Island sediment clay has no standardized composition and chemical structure.

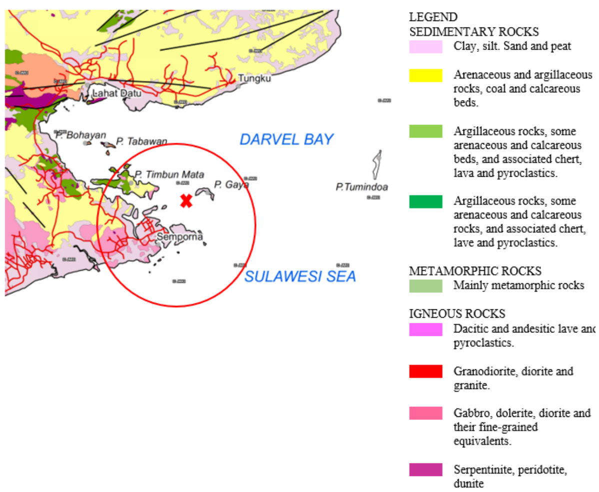

Figure 1. 2: Geological map of Selakan Island, Semporna Sabah. Adopted from JMG Malaysia

2.2 Clay

It is possible to describe the word clay as a plastic content substance, shaped by natural forces which can be found in nature. A continuing phase is the erosion and decomposition of the surface of the earth. In igneous rocks, there are two primary components, silica and alumina, which are an important ingredient in clay. The property of clay as a natural resource, in its raw state, may be shaped into a different shape, directly by hand. In nature, Clay is readily accessible; some processing needs to be prepared (Neupert, 2000; Robert, 1994).

Two forms of clay group, depending on geological composition, are primary and secondary. In colour and shape, primary clays are pure since they have fewer contact with other foreign substances contained in their place of origin. While secondary clay is highly plastic as it is combined with organic and inorganic matter until it enters the mud lake. In addition, underground compression and distance allow secondary clay to change in colour (Hommel, 2013).

The bulk of the secondary clay, which is earthenware, can be contained on Selakan island. The whole method of creating a lapohan is carried out along the coast of the island. The basic measures are similar to traditional pottery; at the beach near the island, firstly gathering clay and sand used for modest is generated. Second, the 50:50 mixture of clay and sand is blended and soaked with salt water (tahik). Using equipment such as wooden trough (boggo '), pestle (hallu), wooden plank (papan), wooden paddle (ta'pet), bamboo spatula (hindip) and shell (Kuba) for scrubbing, then trying to form and shaping, Ritano Ono (2006).

Methodology

The whole research is an experiment focused on local clay in the island of Selakan, Semporna Sabah, which aims to increase the strength and durability of the clay. Figure 3 presence the key indicator for Triangulation Formula, percentages of variations flux and filler to create high-quality clay that can produce innovative artwork. Local clay (Selakan Island clay) is a key raw material that is mixed with varying percentages of gosong. Mixtures chosen have been wet-processed. All of these experiments were carried out in compliance with the MS ISO 10545-4:2003 Malaysia standard. The outcome of the test was taken with each mixture as the sum of the 18 specimens influenced by the corresponding standard deviation. It may also be only a basic test analysis of the existing clay body of the Selakan formula.

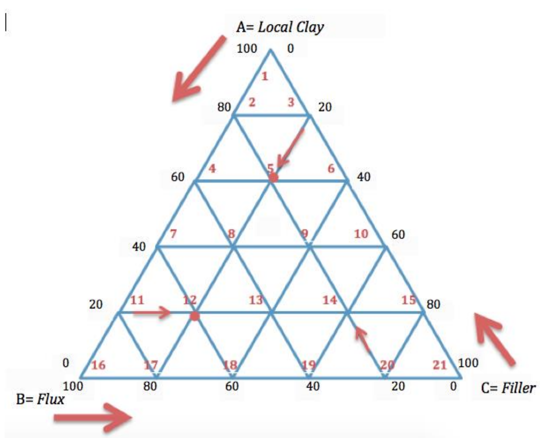

Figure 3. 1: Trigulation Formula

Preparation of Selakan Clay (SC)

The local clay was taken from a local potter in Kampung Selakan. The Selakan clay obtained was analysed using X-ray fluorescence spectrometry (Uniquant 2 software). Table 3.1 shows the chemical composition of the local clay. Figure 3.2 shows the distribution of the regional clay particle scale.

In the manufacturing of clay with unique sizes smaller than 125 µm, the Selakan clay was dissolved in water and then stirred at high speed in a blunger for almost six hours until it slipped. Before the clay has been drained from the mould, the slip was inserted into the plaster mould using a

120-mesh sieve to vacuum out the water. The gathered clay will be drying at 110 ° C for four hours in the oven and ready in all tests to be used as a clay raw resource.

Table 3. 1: *Chemical composition of the Selakan clay*

Composition	**SiO^2**	**TiO^2**	**Al^2O^3**	**Fe^2O^3(t)**	**MnO**	**MgO**	**CaO**	**Na^2O**	**K^2O**
wt%	24.16	8.40	12.95	38.77	0.32	2.10	1.10	0.68	0.11

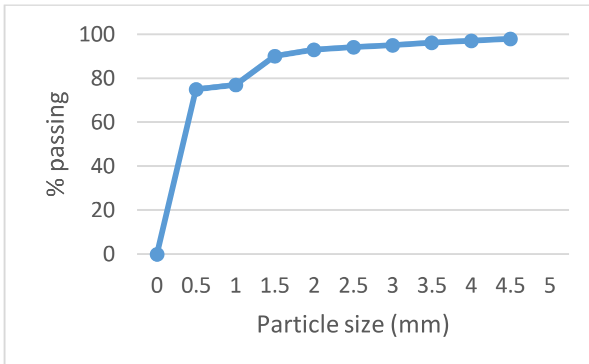

Figure 3. 2: Partical size of gosong

Preparation of Gosong (size < 178 μm)
The local black sand or gosong collected from Kampung Selakan was soaked with water and then dried for 4 hours in an oven at 110 ° C. By way of sieve analysis, the particle size distribution of the gosong was studied, as seen in Figure 1. The gosong going through an 80-mesh sieve was processed in a sealed bag to be used as an additive in the clay body in the preparation of sand having particle sizes of less than 178 μm.

Clay Bodies Study
For the preparation of clay body bodies which included the Selakan clay (size< 125 μm), gosong (size< 178 μm), which were previously prepared, have been used in this analysis. The prepared clay body was a combination of SC clay with just one additive, such as gosong. The experimental plan is stated in Table 2. Gosong in the SC clay of 0 to 18 wt percent was used in the sequence of tests at different weight percentages. The properties of clay with no additives were also checked (S0 100 in Table 2). The gosong was soaking in 55 percent water for each test, and then combined with SC clay in an agitating tank for 3 hours to scatter gosong over a clay body for 3 hours. It was poured into a plaster mould after a smooth paste was formed that would adsorb the moisture from the slip for approximately one day before the clay could be removed from the plaster mould. And it was hand-wedged to extract the air bubbles from the body of the SC clay. In a mould 10 cm long and 1.2 x 1.2 cm 2 in cross section region, the samples of SC clay body were shaped as clay bars, 20 test bars in each test. Also measured was the initial moisture content of the SC clay body used to shape the test bars. The samples were dried for 4hours at 110 °C in an oven and then fired for 8hours at 900 °C in an electric kiln. After drying, the drying shrinkage and drying module of the rupture test were carried out. Tests for firing shrinkage, water absorption, and fired rupture modulus were analysis.

Table 3. *2* show the experimental plan for the SC clay body tests, with the weight percent of each additive raw material gosong (G), in the Selakan clay body (SC).

Table 3. 2: *Weight percentages of Selakan clay (SC) and gosong (G) in the clay body formulation.*

SC	100	98	96	94	92	90	88	86	84	82
G	0	2	4	6	8	10	12	14	16	18

The Lapohan clay body, the classified materials by size mix of SC clay and gosong for making Lapohan at Kampung Selakan. Evaluated for original moisture quality, drying shrinkage, dried rupture module, firing shrinkage, water absorption, and fired rupture module as above. Both experimental findings were presented as mean values. Standard errors were presented between experimental results and mean values.

Clay Body Testing Measurement of Initial Moisture of Clay

The body was tested for the original moisture content of the clay body used to shape the test bars. Wet-based moisture content is the weight of water contained in the sample per unit of sample weight. Any of the three samples was weighted and then dried for 24 h at 110 °C in an oven. Per sample was then measured again. The moisture content was measured in conjunction with the following equation:

$$\%\text{Moisture content (w.b.)} = \frac{W^i - W^d}{W^d} \, x \, 100$$

To measure the average of moisture content, weight wet W^i and dried W^d of sample has been recorded.

Measurement of Water Absorption of Clay Body

At 900 ° C, ten samples were fired and then measured. They were boiling for 2hours in water, and then they were taken out. Each sample was measured. The percentage absorption of water has been determined as follows:

$$\%\text{Moisture of absorption} = \frac{W^{sat} - W^c}{W^c} \, x \, 100$$

$W^c$and W^{sat} are the weight of the sample after fire and after boiling in water.

Measurement of Shrinkage of Clay Body

The shrinkage calculations of the clay body, — for example drying shrinkage, firing shrinkage and complete shrinkage, were carried out by directly measuring the length change of the 10 body samples collected after drying at 110 °C for 4 hours and after firing at 900 °C for 8 hours, accordingly. The following calculations have been determined for the estimates of the drying and firing shrinkage of the clay body:

$$\%\text{Drying shrinkage} = \frac{L^w - L^d}{L^w} \, x \, 100$$

$$\%\text{Firing shrinkage} = \frac{L^d - L^{af}}{L^d} \, x \, 100$$

and the overall shrinkage was measured

$$\%\text{Total shrinkage} = \frac{L^w - L^{af}}{L^w} \, x \, 100$$

After the sample is formed, it will be labelled as L^w. Although the label has already been dried for sample as L^d.The sample will be tagged as L^{af} after firing.

Measurement of Modulus of Rupture of the Clay Body

Using a universal testing unit, the strengths of dried and fired samples were checked (Lloyd 500). In the bar shape, fifteen samples were evaluated and then the MOR value was determined using the following equation:

$$\text{MOR} = \frac{3pl}{2bd^2}\ x\ 100$$

If the MOR is a rupture-module, (kgf/cm2), P shall be the splitting load (kgf), L shall be the diameter of the knife edges to sustain the spectra (cm, b shall be the average sample width (cm) and d shall be the average sample width (cm) (cm).

Results and Discussion

The properties of Selakan clay (SC) (size < 125 μm) and lapohan clay body (LC) are shown in Table 3.

From observations, the surface of the lapohan pottery clay body is much coarse and hard to carve various patterns on the surface because of the large size of non-clay contaminants in local sand and local clay. Development of the appropriate clay body for this work was to use the small-sized gosong for mixing with small-sized clay in order to create a clay body having fine texture easy for sculpting the smooth figures on the green ware.

From the findings, the composition of the lapohan pottery clay body is very rugged and hard to design various patterns on the surface due to the mass scale of the non-clay chemicals in local sand and local clay. Thus, the research in the creation of a suitable clay body for this experiment was to use a small partical saiz for gosong and SC in order to build a clay body with a fine texture that was simple to design surface decoration on a green ware.

Effect of the Amount of Gosong

In order to test the characteristics of gosong-SC clay bodies improved by comparing clay with gosong, the series of tests was conducted out by expanding the weight percentage of gosong in the SC clay body from 0 to 18 wt percent (Table 1). The results of gosong on the characteristics of the SC clay body are seen in Table 3. 4. The findings as seen in Figure 3. 3, Figure 3. Figure 3. 4 and Number 3. 5.

Table 3. 4 show the analysis of the properties of the materials clay bodies (NPS) improved by comparing Selakan clay with various percentages of gosong. Figure 3. 3 indicates the result of the characteristics of Selakan clay (SC) and lapohan (LC).

Table 3. 3: *Properties of Selakan clay (SC) and lapohan clay body*

	Mechanical properties	(SC)	(LC)
1	Moisture content (%)	9.23	4.49
2	Water absorption (%)	7.86	14.37
3	Drying shrinkage (%)	6.00	3.81
	Total shrikage (800c) (%)	12.0	8.56
4	Dry MOR (kg/cm)	12.9	18.03
	Fired MOR (kg/cm)	55.74	59.37

Table 3. 4: Physical properties of SC -gosong

Percentages of *gosong* (%)	Initial moisture of green body (%)	Physical properties of SC- Gosong					
		Water absorption (%)	Drying shrinkage (%)	Total shrinkage (%)	Dry MOR (kg/cm)	Fired MOR (kg/cm)
0	9.23	7.86	6.00	12.0	12.9	55.74
2	10.66	9.33	6.29	13.2	16.27	93.74
4	11	9.64	6.97	14.7	21.56	89.83
6	12.35	10.28	7.42	15.2	19.45	83.44
8	12.93	11.36	8.12	15.9	17.39	78.55
10	13.58	11.96	8.72	16.4	16.12	77.72
12	13.9	12.61	8.81	16.5	15.5	72.23
14	14.44	13.65	8.93	16.6	14.88	70.96
16	15.31	14.59	9.15	17.1	14.27	66.64
18	15.56	15.26	9.21	17.1	13.34	62.09

Figure 3. 1 Represents the characteristics of drying shrinkage and overall shrinkage of SC-clay bodies at various sand contents. It is observed that the drying and overall shrinkage decreased with rising gosong content and that the drying shrinkage was slightly less than the total shrinkage in both studies. The shrinkage of the drying was much higher than the shrinkage of the fire (data not shown).

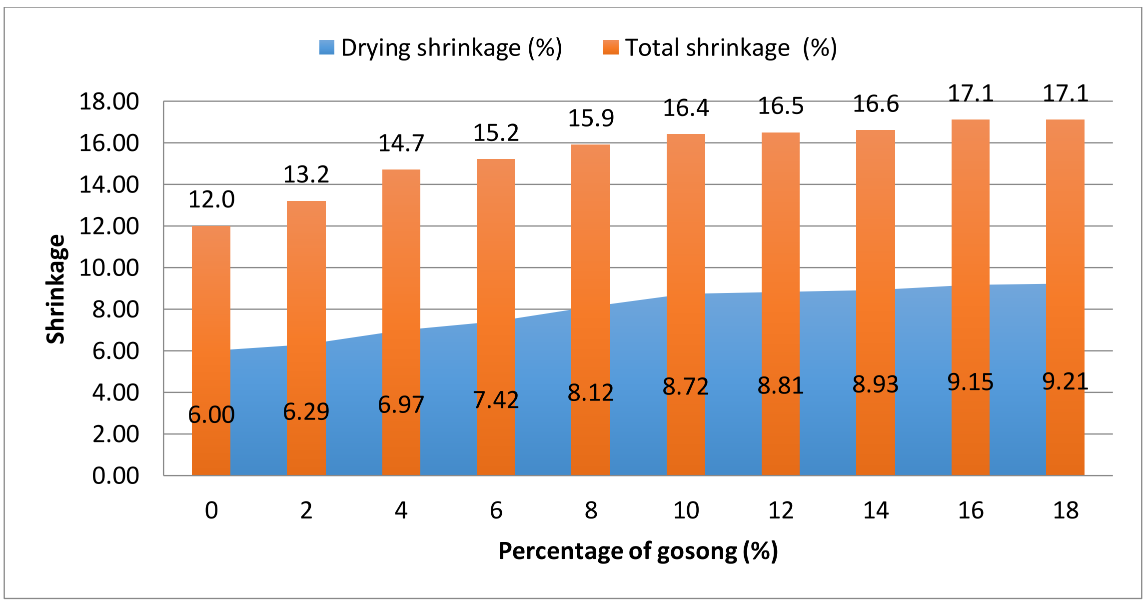

Figure 3. 3: Percentage of Gosong

Figure 3. 4 Shows the values of the water content of the fired gosong-SC clay body. For larger amounts of gosong, the water absorption increased, i.e., the absorption of water enhanced by 9.33 per cent to 2% gosong and by 15.26 per cent to 18 per cent gosong. From the findings, it can be assumed that a larger gosong content has resulted in higher water content and lower shrinkage of the gosong-SC clay body.

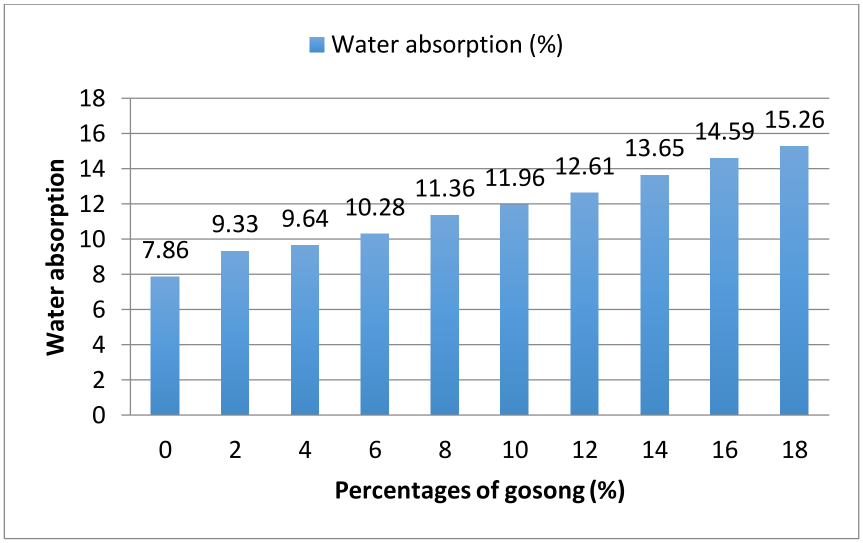

Figure 3. 4: Percentage of Gosong

The intensity of the dried and fired gosong-SC clay is shown in Figure 3. 5. It is clearly evident that the dried MOR values (13.34 – 21.56 kgf/cm2) were considerably lower for both studies than the MOR values (62.09 – 93.74 kgf/cm2). The overall MOR value of the fired gosong-SC clay was 93.74 kgf/cm2 at 2% sand. When analyzing the fired MOR values above 90 kgf/cm2, it was evident that the suitable amount of gosong combined with SC clay was in the range of 2-4% gosong with relation to the fired MOR optimization, as only a particular part in the impact of gosong amounts on the fired MOR values was identified (93.74 and 89.83 kgf/cm2 respectively). However, the fired MOR rates, at higher gosong levels (6-18%), decreased from 83.44 to 62.09 kgf/cm2. From an improvement in the volume of gosong from 2 to 14 per cent, the MOR values of gosong-SC clay bodies were higher than those of the lapohan clay body (59.37 kgf/cm2 in Table 3.3). This indicates that the adjustment of gosong in combination with SC clay are used in a large range of 2-14 per cent since the fired gosong-SC clay bodies had a higher fire intensity than the lapohan clay body. The first series of tests found that gosong with a particle size of or less 178 µm is being used as a filler to enhance the SC clay body ideal for producing decorative pottery, compared to the smooth surface and high intensity, therefore decreasing imperfections in the decoration of green ware but also the actual problem of cracking.

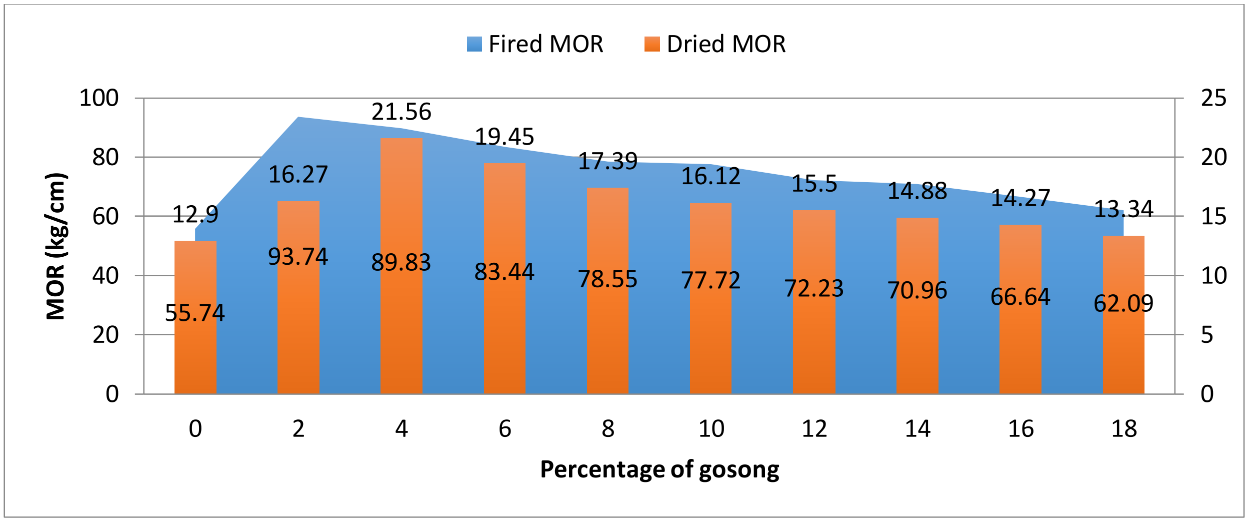

Figura 3. 5: Percentage influence of gosong on MOR of Selakan clay (SC)

Conclusion

Based on preliminary findings, the effects on the material characteristics of the clay bodies of the different contents of each filler, such as gosong, were being recorded. The weight ratio of each filler to the clay for each additive form impacted the properties of the dried and fired clay body, such as shrinkage, water content and intensity as well. The higher sand content has been shown to contribute to higher water content but reduced clay body shrinkage. The fired MOR values of clay bodies were elevated above those of the local pottery clay body (59.37 kgf/cm2) at the sand content between 2 and 14 percent. The sand-clay body's overall fired MOR value (93.74 kgf/cm2, at 2 percent sand) was strongly better than those of Lapohan clay. The studies produced in the present work indicate that it is possible to use gosong (size < 178 µm) as a filler to create a better quality, flexible clay body by mixing with clay (size < 125 µm), enhancing its capacity for pottery decoration. The need for more studies to enhance the properties of the local pottery clay body, contributing to an improvement in performance, was summarised in this research. In addition, Malaysia's pottery product may be enhanced by concern for their chemical composition of clay. Both art and science are incredibly intertwined through the Lapohan as it started off as piece of artistic culture which the Bajau Lauts made, but science has contributed to make the Lapohan more practical in terms of use. It was art the propelled the Bajau Lauts to pick the best type of clay used and use handmade techniques to create a Lapohan, but science proved its workability in terms of cooking. We aim to shed light onto delving into the science of ceramic art, understanding what are the chemical compositions of particular models, in this case the Lapohan, why are they used, what the scientific processes to create such a model and how can science improve not just its benefits to science, but to art as well. Since modern kitchen utensils are normally used even by the Bajau Lauts, the Lapohan now are only reduced to being art forms, a culture heritage that only is another Sabahan tourist attraction. However, by delving into its composition and the creation process, science is able to improve the features of the Lapohan, making it on par with other kitchen utensils, while making it able to retain its artistic features.

All in all, we believe that cultural art is an underappreciated form of expression in Malaysia, and we must put in all efforts to try and preserve it. Through enhancing the Lapohan's properties, this Sabahan treasure can be preserved by making it relevant to the modern society, by applying modern scientific principles towards it. In turn, this will revive and renew the locals' knowledge on pottery production, and with an optimised composition and creation process, it can encourage the development of traditional pottery by the establishing more relevant cottage industries, that marry art and science by selling traditional wares that can be used in this 21 st century. This is in line with the "Satu Daerah, Satu lndustri" policies set by the government, where we envision the generation of a Lapohan industry in Pulau Selakan.

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Interview:

Bunga Inuh, 58 years old. Traditional Bajau Potter, Kg Selakan, Pulau Selakan, Semporna. 18 April 2017

Hj Kapital Patal 71 years old. The village Headman, Kg Selakan, Pulau Selakan, Semporna. 18 April 2017