Humanities, Arts and Social Sciences Studies

Research Article

Humanities, Arts and Social Sciences Studies
https://so02.tci-thaijo.org/index.php/hasss
ISSN (Online): 2630-0079

ASH GLAZE FROM DURIAN WASTE FOR CERAMIC CREATIONS

Thatree Muangkaew

Faculty of Decorative Arts, Silpakorn University, Thailand

Corresponding author:
Thatree Muangkaew
muangkaew_t@su.ac.th

Received: *3 August 2021*
Revised: *9 November 2021*
Accepted: *10 November 2021*
Published: *23 December 2022*

Citation:
Muangkaew, T. (2022). Ash glaze from durian waste for ceramic creations. Humanities, Arts and Social Sciences Studies 22(3): 755-767.

ABSTRACT

The art of ceramic creation is one of the human cultural prosperity indicators. It has existed in human society for thousands of years. Archeological evidence shows that ceramics have been utilized in various aspects of daily life throughout that time, and glazing has been an important process for enhancing the durability and beauty of ceramics. Glazing improves strength and hardness, as well as the resistance of the surface to acidic and basic substances when ceramic wares are fired at over 1,200 Celsius. These properties have resulted in the persistence of ceramics for thousands of years. The ash glaze is one of the ancient glazes. Chinese potters have used it since the Han dynasty period (206 B.C. – 200 A.D.), more than 2,000 years. In Thailand, Sukhothai pottery is distinguished from Chinese Suzhou pottery by its shape and design, as well as the colors inscribed on it. In recent year, the researcher observed that the consumption of large amounts of durian fruit produces a lot of waste and a difficult waste disposal problem. This Thai durian rind waste causes pollution and affects society. In order to use these wastes, the researcher was interested in trialing them in experimental ash glazes. Raw materials were collected from various sources, then dried and burnt. After being burnt into ashes, glazes were made from it for ceramic creations in accordance with the research process. Since it can be used for several types of ceramics, this study provides a model for using durian rind ash for making an uncomplicated ceramic glaze. As a result, various forms of ceramic works with the durian rind ash glaze were created.

Keywords: Ash glaze; durian waste; ceramics; creation

1. INTRODUCTION

Thailand has a tropical climate, so there are various kinds of tropical plants and fruits here. Many tropical fruits are industrial crops that sell throughout the country and all year long. Since there is extensive consumption, extensive parts of fruits, such as rind and fallen ones, finally become wastes. There have been 60 to 70 percent of durian waste results from consumption; therefore, the researcher was interested in using waste from durian to experiment with ceramic ash glazing (Figure 1). The results of this study were recorded as new knowledge. People who are interested in ceramics can adapt this knowledge to create future works (Cheok et al., 2018: 335).

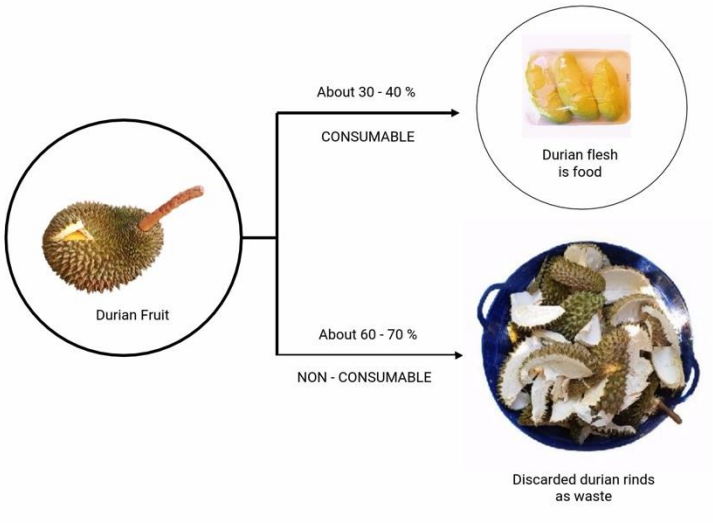

Figure 1: Parts of a Durian Fruit, about 60-70% Non-consumable

According to the literature review, a lot of durian waste is produced during the durian season, as evidenced by news reports in the newspaper (Figure 2). Thus, this research has the following objectives:

1. To study about waste from durian rinds for ceramic glaze making.
2. To develop new knowledge about glaze making from durian rind ash and record this research in the database. People who are interested in fruit ash glaze can adopt this method and develop new formula for ceramic glazing.
3. To create various forms of ceramic works as case studies of the durian rind ash glaze research.

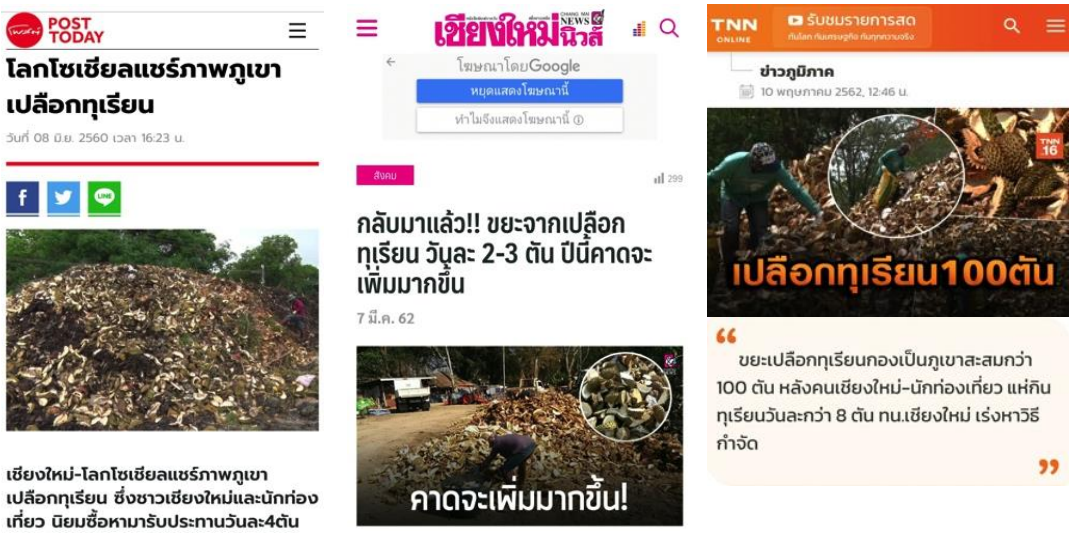

Figure 2: News about Durian Waste (Post Today, 2018; Chiang Mai News, 2019; TNN, 2019**)**

2. METHODOLOGY

This research aims to use durian rind waste and transform it into ash glaze. The methods and procedures are as follows:

1. Durian rind ash production
2. Durian rind ash chemical composition analysis and testing
3. Durian rind ash glaze formula calculation using triaxial blend diagram
4. Equipment for weighing and grind mix raw materials
5. Glaze firing

The methodology diagram presents the concept of creating the study's ash glaze from durian waste for ceramic works (Figure 3).

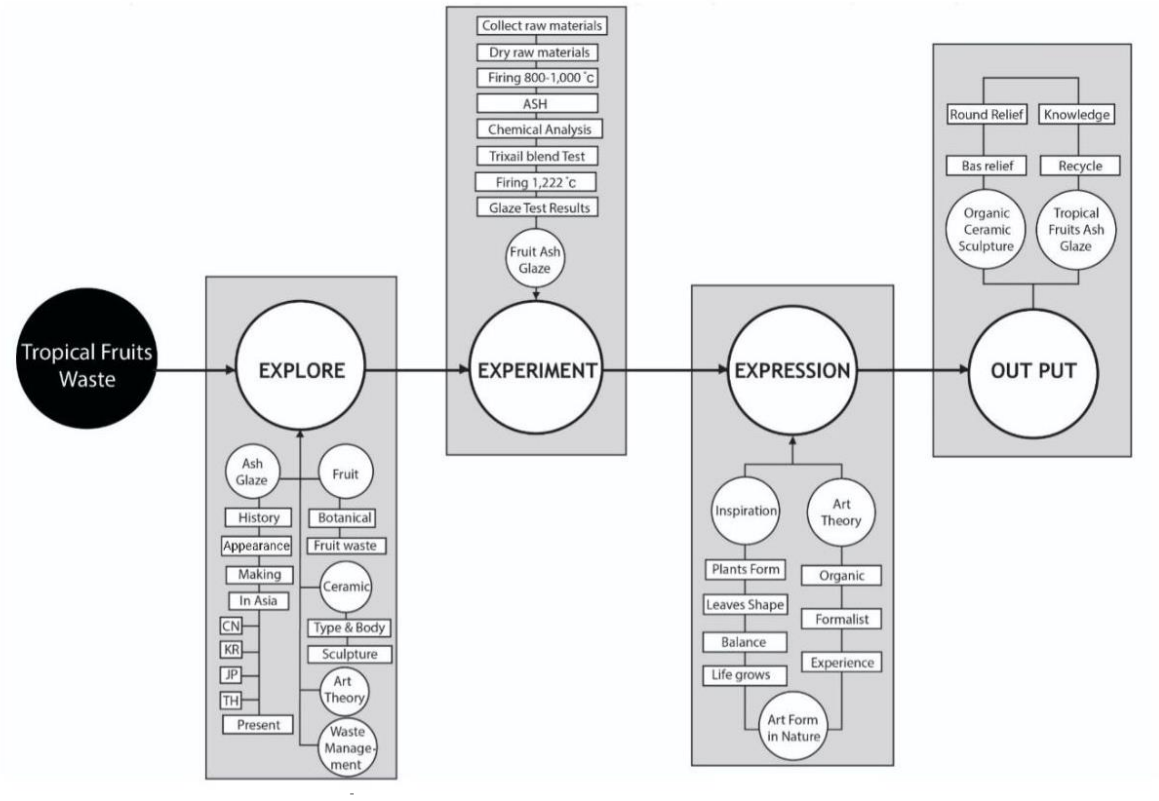

Figure 3: Methodology Diagram (Muangkaew, 2021)

2.1 Durian rind ash production

The durian ash production was made in 3 steps as follows:

1. Gathering raw materials: the researcher surveyed raw materials from markets and locations where the fresh cut durians (aril without rinds) were sold. According to inquiry, the merchants said that they did not use any durian rinds after they peeled durians. Due to the high consumption of durian, they had to dispose of a lot of durian rinds waste every day. Therefore, the researcher asked for those durian rind wastes for the research. The process of gathering raw materials is shown in Figure 4.

2. Drying raw materials: the researcher dried the raw materials on clean cement courtyard for 2 weeks. It is necessary to sweep the courtyard and avoid adulterated things before drying raw materials. Moreover, raw materials should be dried on the sunshiny area because the solar heat causes fast drying to the durian rinds. When the durian rinds are dry, they become hard and brown. The researcher collected raw materials and dried durian rinds to do the research (Figure 4).

Figure 4: Collecting Raw Materials and Dried Durian Rinds for the Research

3. Burning raw materials into ash: there are several techniques for burning raw materials, such as outdoor burning, burning in a steel box, burning in a brick kiln, and burning in a ceramic kiln. The raw materials must be burnt in the oxidation atmosphere. In this study, the researcher used an electric kiln to burn the dried durian rinds into ash at 800°C because the electric kiln has the temperature display. If there is no ceramic kiln, it could be burnt by using other techniques. The process for firing durian ash is shown in Figure 5.

Figure 5: Putting Dried Durian Rinds into a Pot for Firing in the Kiln at 800°C

2.2 Durian rind ash chemical composition analysis and testing

Durian rind ash chemical composition test have the percentage of various concentration of oxide. As shown in Table 1, calcium oxide is 2.862%. The ash produced by burning the rinds contains calcium oxide, which is crucial for melting and making the shiny glaze on works of art. The ash was melted into the glaze at 1,200°C. The distinctiveness of each ash glaze's color is determined by its chemical components, external conditions, and necessary elements for plant growth. (Nakbau, 1993: 12; Palprame, 2009: 6).

Table 1: Volume of Durian Rind Ash Chemical Composition (Suttiruengwong, 2019)

Dry Durian Rinds	**Durian Rind Ash**
	
Concentration	**(% w/w)**
Sodium Oxide	2.578
Magnesium Oxide	6.368
Aluminum Oxide	0.094
Silicon Oxide	2.417
Phosphorus Pen Oxide	5.34
Potassium Oxide	15.034
Calcium Oxide	2.862
Manganese Oxide	0.035
Iron Oxide	0.14
Carbohydrate	65.131

2.3 Durian rind ash glaze formula calculation using triaxial blend diagram

There are several ways to calculate the glaze formula such as the comparison of ratio of glaze compositions. In this study, the triaxial blend diagram was used as glaze formula calculation with the main compositions as follows:

1. Calcium carbonate, phosphates, potassium carbonate, and other metals are the main compositions in making durian rind ash glaze. However, the ratio of chemical compositions depends on soil and cultivated area of each plant (Nakbau, 1993: 12; Palprame, 2009: 6).

2. Soda feldspar is an important ingredient in clay body and feldspar glaze. It is a natural mineral which contains a large amount of alkali. It is a flux, an oxide that causes the glaze to melt at a low enough temperature (Nakbau, 1993: 12; Palprame, 2009: 6).

3. Clay could likely be an aid to reduce the melt fluidity of the glaze. The firing temperature depends on types of clay (Nakbau, 1993: 12; Palprame, 2009: 6).

2.4 Equipment for weighing and grinding mix raw materials

1. Weighing the raw materials according to the formula, see Figure 6.

2. Mixing the raw materials for glaze making (Soda Feldspar, Durian Ash, and Clay), see Figure 7. Percentages of the raw materials depend on 21-Point Triaxial Blend.

3. Painting the glaze on earthenware and stoneware clay body test plates, see Figure 8.

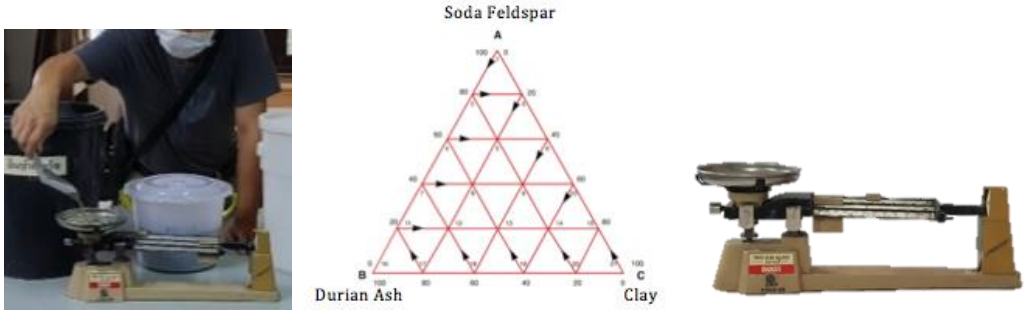

Figure 6: Weighting Raw Materials

Figure 7: Process of Mixing Raw Materials

Figure 8: How to Paint the Glaze on Earthenware and Stoneware Clay Body Test Plates

2.5 21-point Triaxial blend diagram

The triaxial blend theory was used to calculate the glaze formula (Figure 9). It is a method for determining the ratio of basic compositions of glaze which are three or more. This glaze formula is more fused than others that use only two kinds of compositions. Moreover, the glaze formula calculation from the triaxial blend theory will yield more various glaze properties including the diversity of texture and color. For instance, opaque- transparency, and gloss- matte surfaces. There are more optional glazes if more colors are available. Each 10% or 20% difference of composition ratio is determined by the triaxial blend. The ratio of compositions could be available at 21, 36, 66 points, or more than 66 points (Nakbau, 1993: 32).

To calculate the glazing formula, the Triaxial Blend Theory was Applied. There is a total of 21-points that determines each 20% difference of composition ratio. The Ratios of composition “A” is termed A-B, “B” Is Termed B-C, and “C” is termed C-A (A = Soda Feldspar/ B = Fruit Ash/ C = Clay). The precise percentages for the glazing Formula are provided in Table 2.

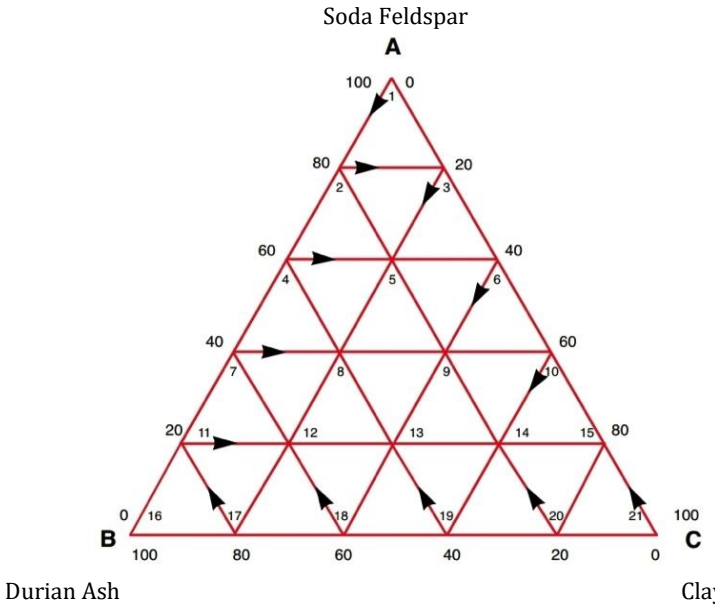

Figure 9: Calculation of the Glazing Formula Using the 21-Point Triaxial Blend Diagram

Table 2: Triaxial Blend Formula/Percentages of Durian Rind Ash Glaze in 21 Points

1	**2**	**3**	**4**	**5**	**6**	**7**
A: 100%	A: 80%	A: 80%	A: 60%	A: 60%	A: 60%	A: 40%
B: 0%	B: 20%	B: 0%	B: 40%	B: 20%	B: 0%	B: 60%
C: 0%	C: 0%	C: 20%	C: 0%	C: 20%	C: 40%	C: 0%
8	**9**	**10**	**11**	**12**	**13**	**14**
A: 40%	A: 40%	A: 40%	A: 20%	A: 20%	A: 20%	A: 20%
B: 40%	B: 20%	B: 0%	B: 80%	B: 60%	B: 40%	B: 20%
C: 20%	C: 40%	C: 60%	C: 0%	C: 20%	C: 40%	C: 60%
15	**16**	**17**	**18**	**19**	**20**	**21**
A: 20%	A: 0%	A: 0%	A: 0%	A: 0%	A: 0%	A: 0%
B: 0%	B: 100%	B: 80%	B: 60%	B: 40%	B: 20%	B: 0%
C: 80%	C: 0%	C: 20%	C: 40%	C: 60%	C: 80%	C: 100%

2.6 Glaze firing

Glaze firing is a process that a glaze layer is fired until it reaches the appropriate temperature range and becomes matured. Generally, this process requires low to medium temperature in an oxidation atmosphere. High temperature glazes are fired in oxidation and reduction atmospheres by using specific techniques such as celadon glaze, copper red glaze, and temoku glaze, etc. Full maturity of glaze during the glaze firing is achieved by vitrified temperature range and 10-15 minutes of soaking time at a vitreous point (Phrompruek, 1980: 94). The steps of general glaze firing are as follows:

1. Glaze firing in an oxidation atmosphere
    - 1.1 The first period: room temperature - 900°C, at least 5 hours.
    - 1.2 The second period: 900°C - vitreous point of glaze, at least 4-6 hours.
    - 1.3 The third period: 15-20 minutes of soaking time at a vitreous point.
2. Glaze firing in a reduction atmosphere
    - 2.1 The first period: Firing in an oxidation atmosphere at room temperature - 900°C
    - 2.2 The second period: Firing in a reduction atmosphere at 900°C - 1,200°C
    - 2.3 The third period: Firing in an oxidation atmosphere at 1,200°C - 1,222°C
    - 2.4 The fourth period: 15-20 minutes of soaking time at 1,222°C in the oxidation fire.

If the glaze firing does not reach the vitreous point, the glaze will become more matte than usual, and is not mature. On the other hand, if the temperature is higher than the vitreous point requires, the glaze will be unduly glossy and watery. The excessive melt fluidity of the glaze causes defects. Therefore, the glaze firing must be controlled carefully. The Graph of the process of firing glazes at critical points is shown in Figure 10.

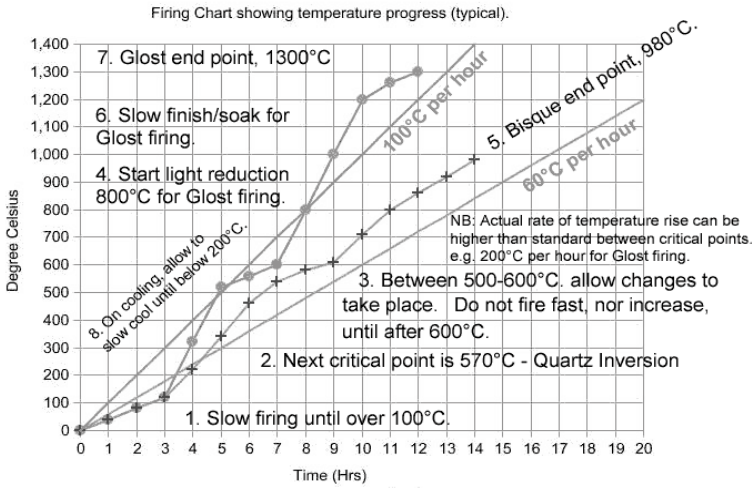

Figure 10: Firing Glazes at Critical Points in a Firing Graph Accomplished (Stephens, 2006)

3. GLAZE TEST RESULTS WITH CERAMIC CREATION

3.1 The result of durian rind ash glaze testing on stoneware clay body

Figure 11 shows the results of triaxial glazes tested with durian rind ash on a stoneware clay body chart. On the left side of the picture, they were fired at 1,222°C with an electric kiln in an oxidation atmosphere. On the right side of the picture, they were fired at 1,222°C with a gas kiln in a reduction atmosphere. Details are shown in Table 3.

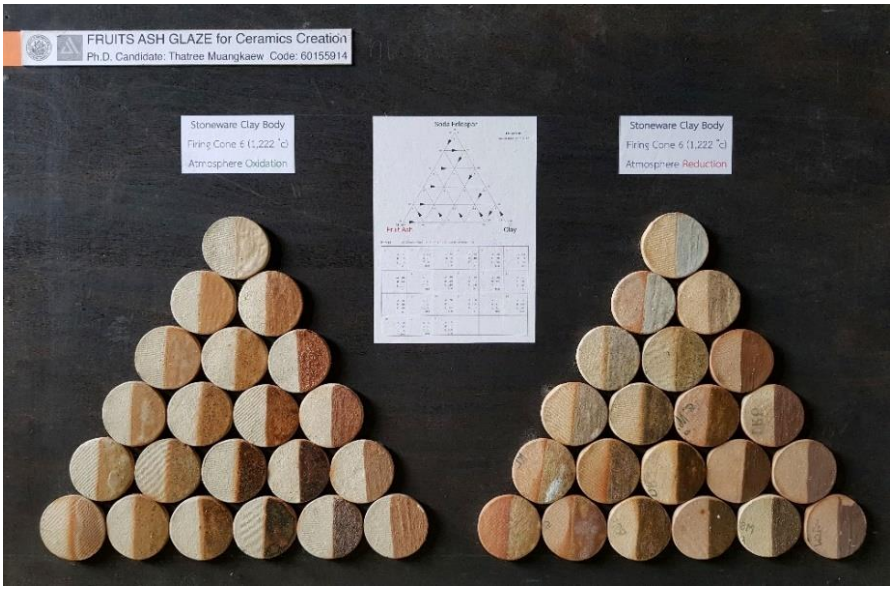

Figure 11: Triaxial Glazes Testing Chart with Durian Rind Ash on Stoneware Clay Body

Table 3: Result of Durian Rind Ash Glaze Testing on Stoneware Clay Body Firing at 1,222°C

Durian Rind Ash Glaze / Stoneware Clay Body Firing at 1,222°C Triaxial Blend formula at point number 5 (Soda feldspar 60 %+Durian Rind Ash 20 %+Clay 20%)	
Oxidation atmosphere	**Reduction atmosphere**
- Glaze melt	- Glaze melt
- Glaze surface shiny	- Glaze surface shiny
- Yellow color and brown spot	- Light green color
- Translucent	- Translucent
- Not punch	- Not punch
- No melt fluidity	- No melt fluidity

3.2 The result of durian rind ash glaze testing on earthenware clay body

Figure 12 shows the result of durian rind ash gaze testing on earthenware clay body. Details are shown in Table 4.

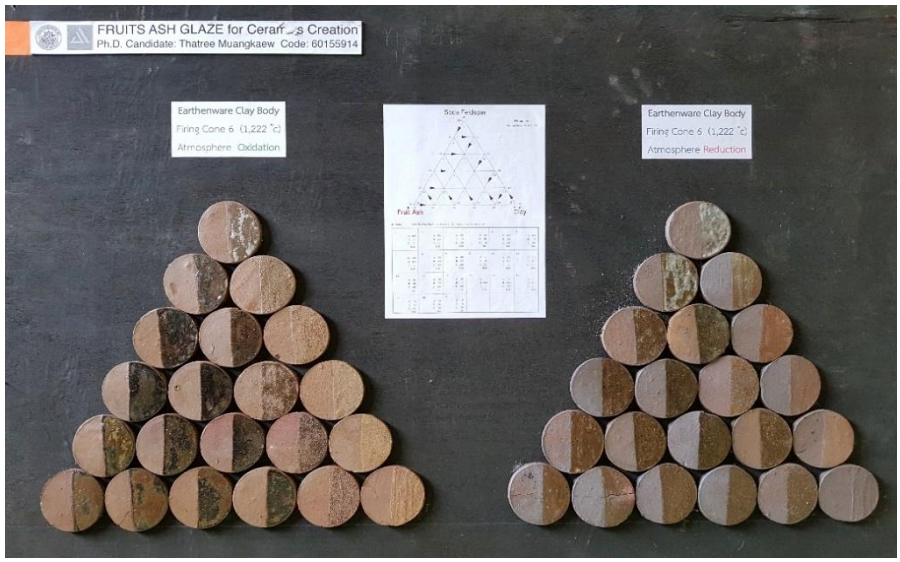

Figure 12: Triaxial Glaze Testing Chart with Durian Rind Ash on Earthenware Clay Body

Table 4: Result of Durian Rind Ash Glaze Testing on Earthenware Clay Body Firing at 1,222°C

Durian Rind Ash Glaze / Earthenware Clay Body Firing at 1,222°C Triaxial Blend formula at point number 5 (Soda feldspar 60 %+Durian Rind Ash 20 %+Clay 20 %)	
Oxidation atmosphere	**Reduction atmosphere**
- Glaze melt	- Glaze melt
- Glaze surface shiny	- Glaze surface shiny
- Dark brown color and black spot	- Dark green color and brown spot
- Translucent	- Translucent
- Not punch	- Not punch
- No melt fluidity	- No melt fluidity

All test plates which are applied with the durian rind ash glaze can be utilized depending on the purpose. For example, the durian rind ash glaze which coats the food container should be glossy for the convenient cleaning. The glaze of artworks or decorative pieces must be selected based on color and texture that are appropriate for individual ceramic form.

3.3 Ceramic creation

The researcher created various forms of ceramic works by applying the durian rind ash glaze as case study. The basic forms such as geometric form, organic form, free form, and pure form, were coated by the durian rind ash glaze with the following details:

1. The geometric forms are the basic structures of other forms. There are four major characters of geometric form including cube, sphere, cone, and cylinder. The geometric forms refer to the neutrality and structures that are expressed through emotions and ideas (Nimsamer, 2001: 212; Pichayasoonthorn, 2012: 42).

In this research, the researcher employed the cylinder containers as the case study to demonstrate the utilization of ash glaze on functional objects. The result was satisfied due to the smooth glossy glaze. Little light yellow and brown speckles appeared on the glaze. As a result, the pottery coated by the durian rind ash glaze is suitable for containing water or food. It can be concluded that the glaze is durable and resistant to acid and base. Figure 13-28 shows the creation process.

2. Organic forms are realistic representations of living things such as human, plants, and animals. The creation of organic forms comes from imitating of whole parts of selected forms from nature. However, some organic forms are designed by altering part of the original forms which distinctly results in emotions in the created works (Nimsamer, 2001: 213; Jamuni, 2016: 54; Pichayasoonthorn, 2012: 42).

In a case study on the creation of organic forms, the researcher drew inspiration in creating works from the upper parts of plants. These forms express natural plant growth by subtracting and adding simplified and rough textures that present the elegance of the glaze with which the artworks are covered.

Figure 13: The Result of Stoneware Clay Body Cup Glazed with the Durian Rind Ash Glaze[1]

Figure 14: The Result of Stoneware Clay Body Cup Glazed with the Durian Rind Ash Glaze[2]

Figure 15: The Result of Porcelain Clay Body Cup Glazed by Durian Rind Ash Glaze Atmosphere[3]

Figure 16: Stoneware Clay Body Cup Glazed with the Durian Rind Ash Glaze[4]

Figure 17: Images of Tree Sapling, Inspiration of Form Creation and Pencil Sketches of the Artwork Inspired by Organic Forms

[1] Firing at 1,222°C with electronic klin in oxidation atmosphere size 12x12x12 cm.
[2] Firing at 1,222°C.
[3] Firing at 1,222°C with electric kiln.
[4] Firing at 1,222°C with gas kiln in reduction atmosphere. Diameter 35 cm.

Figure 18: Process of Glaze Coating and Firing Artworks in the Oxidation Atmosphere[5]

Figure 19: The Achieved Artwork Inspired by the Plant Tops: Stoneware Clay Body Glazed with the Durian Rind Ash Glaze[6]

Figure 20: An Image of Dried Lotus Pods, the Origin of Form Creation and the Lotus Pod Artwork Coated by the Durian Rind Ash Glaze[6]

Figure 21: A Pencil Sketch of the Artwork Inspired by Lotus and the Lotus Artwork Earthenware Clay Body Glazed with the Durian Rind Ash Glaze[7]

3. Free forms are also known as irregular forms which depend on environmental influences and the desire of the creator. They can evoke emotions of uninterrupted mobility (Nimsamer, 2001: 213; Pichayasoonthorn, 2012: 43).

In this free form case study, the researcher created a form which was influenced by the structural direction and angle transformation of form. It shows that the glaze can be applied on the sloping direction of the ceramic surface.

[5] Firing at 1,222°C. Size 25x30x60 cm.
[6] Firing at 1,222°C with electric kiln in oxidation atmosphere.
[7] Firing at 1,222°C with electric kiln in oxidation atmosphere. Size 22x30x80 cm.

Figure 22: An Image of Northern Black Wattle Sheath, the Origin of Form Creation.

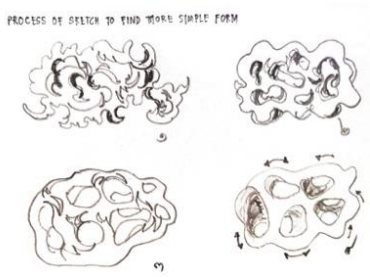

Figure 23: Pencil Sketches of the Artwork Studied from Northern Black Wattle Sheath.

Figure 24: The Achieved Artwork, Stoneware Clay Body Glazed with the Durian Rind Ash Glaze[8]

Figure 25: An Image of Morning Glory, the Origin of Form Creation, Process of Pencil Sketch Development for the Artwork, Artwork Hand Building, Biscuit Firing, Glazing and Firing with Gas Kiln.

Figure 26: The Achieved Artwork, "Message from the Universe" Earthenware Clay Body Glazed with the Durian Rind Ash Glaze[9]

4. Pure forms do not represent anything. This type of form is derived from the subtraction and addition of organic forms until the trace of the original form has completely disappeared. A new form is possibly created without references from the nature, but can also be complemented by integration of geometric forms. Pure forms emphasize the idea more than the emotion. (Nimsamer, 2001: 312; Pichayasoonthorn, 2012: 43). The researcher presented a bas-relief figure as a case study for the creation of a pure-form. This form consists of both glazed and unglazed parts. The deeply fluted part of the artwork was glazed. In contrast, the figure was partly coated by the glaze to show the beauty of the clay texture. As a result, either technique should be balanced in order to study the guidelines of pure-form creation.

Figure 27: Inspiration and Pencil Sketch on Paper

[8] Firing at 1,222°C with electric kiln in oxidation atmosphere. Size 20x27x20 cm.
[9] Firing at 1,222°C with electric kiln in oxidation atmosphere. Size 25x20x60 cm.

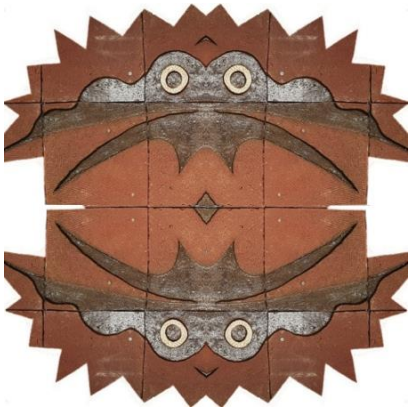

Figure 28: The Achieved Artwork Inspired by Durian: Earthenware Clay Body, Glazed with the Durian Rind Ash Glaze[10]

4. DIAGRAM MODEL OF KNOWLEDGE

The process shown in the "Diagram Model of Knowledge about Ash Glaze from Durian Waste for Ceramic Creations" (Figure 29) can be described as follows:

1. The agricultural waste from durian was utilized for the ceramic creations and typically around 0.43 and 1.82 percent of the mass of burned durian rind waste (dry basis) resulted in ash.

2. The experimental data of the research were collected as case studies because it is a new knowledge of durian rind ash glaze making. Hopefully, this research can be applied on other artwork creations. It is appropriate for people who are interested in socially responsible design, especially the use of other organic compounds or agricultural waste.

3. As a case study, the utilization of durian rind ash glaze for various forms of artwork was successful. The earth tone glaze could convey a natural feeling. The shade of the glaze, however, depended on the ash compositions and the clay bodies used for forming.

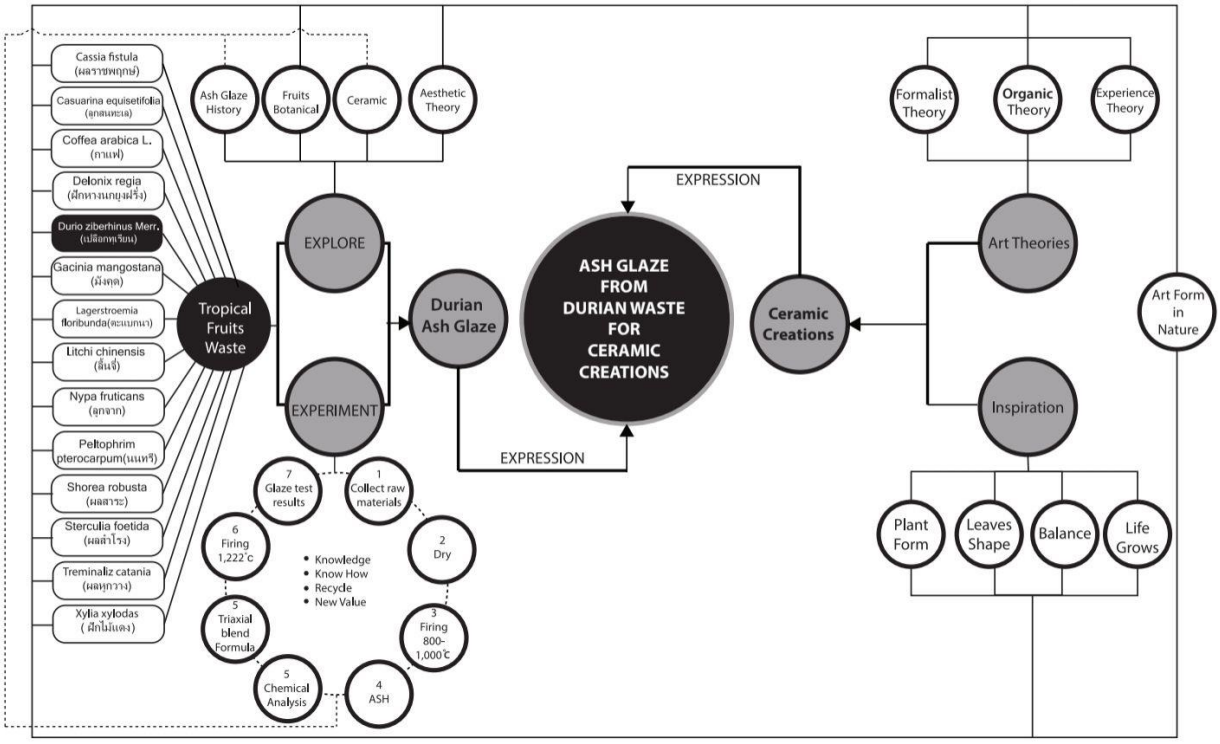

Figure 29: Diagram Model of Knowledge about "Ash Glaze from Durian Waste for Ceramic Creations"

[10] Firing at 1,222°C with electric kiln in oxidation atmosphere

4. The researcher intends to continue further studies and experiment on the use of other fruit waste from Thai agriculture, or litter fall of useless mature fruits which are available in Thailand such as coconut residues, sea almond seeds, mangosteens, cannonball fruits, bungor seeds, yellow flame seedpods, malva nuts, coffee beans, tamarind shells, longan shells, lychee shells, ironwood fruits, Pride of Barbados seedpods, nipa palm fruits, pine cones, etc. In the future, the knowledge acquired will be available for the creation of artworks for both Thai and international ceramic industries. For examples, see Figures 30 and 31.

Figure 30: Raw Materials for Future Research about Fruit Ash

Figure 31: Some of the Ceramic Creations by Fruit Ash Glaze

ACKNOWLEDGEMENTS

The researcher would like to express his thanks to the following persons: Associate Professor Son Simatrang and Professor Eakachat Joneurairatana, advisors for this research; professors in Ph.D. Design Arts International Program for improving the research; Professor Emeritus Sermsak Nakbau for the book "Plant Ash Glaze"; Assistant Professor Supphaka Palprame for advising the researcher and recommending the books; Assistant Professor Supakij Suttiruengwong, Ph.D., Department of Materials Science and Engineering, Faculty of Engineering and Industrial Technology, Silpakorn University for the chemical analysis of the ash.

REFERENCES

Cheok, C. Y., Adzahan, N. M., Russly, A. R., Abedin, H. Z., Hussain, N., Sulaiman, R. and Chong, G. H. (2018). Current trends of tropical fruit waste utilization. *Critical Reviews in Food Science and Nutrition* 58(3): 335-361.

Chiang Mai News. (2019). *Re: Durian Waste Pollution Comeback 2-3 to Per Day*. [Online URL: https://www.chiangmainews.co.th/page/archives/934511/] accessed on June 26, 2019. [in Thai]

Jamuni, P. (2016). *Western Aesthetics*. Bangkok: Plan Printing. [in Thai]

Muangkaew, T. (2021). *Creation Research: The Organic Ceramic Sculpture with Tropical Fruits Ash Glaze*. Doctoral dissertation. Silpakorn University, Thailand.

Nakbau, S. (1993). *Plant Ashes*. Bangkok: J. Film Process. [in Thai]

Nimsamer, C. (2001). *Composition of Art*. Bangkok: Thai Watana Panich Press. [in Thai]

Palprame, S. (2009). *Glaze: Ceramics*. Bangkok: O.S. Printing House. [in Thai]

Pichayasoonthorn, P. (2012). *Basic of Art and Design*. Bangkok: Chulalongkorn University Printing House. [in Thai]

Post Today. (2018). *Re: Social Network Share Picture about Mountain of Durian Waste in Chiangmai Province, Thailand*. [Online URL: https://www.posttoday.com/social/local/498074] accessed on June 26, 2019. [in Thai]

Stephens, P. (2006). *Critical Points in Firing*. [Online URL: https://www.oocities.org/peter_stephens/nteonfrg/crtpts.html] accessed on June 24, 2019.

Suttiruengwong, S. (2019, June 30). Personal Interview.

TNN. (2019). *Re: The 100 Ton of Durian Waste Pollution in Chiangmai Province, Thailand*. [Online URL: https://today.line.me/th/v2/article/DymRxX] accessed on June 26, 2019. [in Thai]