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# Fabricating Ceramic Scaffolding Nest through the additional of Calcium Carbonate ($CaCO_3$) in Ceramic Stoneware Body

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**Abstract**
Edible bird nest (EBN) is based from swiftlet's saliva and it is widely consumed as a health food due to its high beneficial effects to human health and has been considered to be one of the most precious food items by the Chinese for thousands of years. The role of a scaffolding nest is to guide the young swiftlet to build a typical form of the edible bird nest that will increase its commercial values. However, the price of edible bird nests decreased due to various shapes and sizes of EBN in the market. This study will design standard scaffolding nests followed by MS 2334:2011 and introduce the Calcium Carbonate as the main material and associate it with the stoneware body as the binder to create a natural environment to swiftlets.

Keywords: Swiftlets, Edible Bird Nest, Calcium Carbonate, Stoneware


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## 1.0 Introduction

Edible bird nest (EBN) is a dried glutinous secretion from the salivary glands of several different swiftlet species. It is widely consumed as a health food due to its high beneficial effects to human health and has been considered to be one of the most precious food items by the Chinese for thousands of years (Hamzah et-al., 2013). By 2020, this EBN industry is expected to provide more than RM 5.2 billion to the Gross National Income (GNI) and fulfil 40% of global market demand (Rabu et-al., 2015). However, The EBN price dropped due to its odd form & sizes. The young swiftlet built the EBN unguided and it led to the odd form and size. MS 2334: 2011 was the main reference for designing the scaffolding nest. This study will substitute the scaffolding nest made by plastic material and replace it with the combination of ceramic materials, which are Stoneware and Calcium Carbonate ($CaCO_3$). Calcium Carbonate was formulated neutralizing the acid and odor of swiftlet feces and uric acid. By using ceramic materials as a scaffolding nest, it will create the natural environment and bring the swiftlet close to their habitat, which is a limestone cave. Samples were sintered temperatures at 800°C to 1200°C. The physical properties test and materials characterization were conducted to verify the properties result and the characterization of the compositions.

## 2.0 Literature Review

### *2.1 Edible Bird Nest*

Edible bird nest (EBN) has substance 90-95% of edible nests and 5-10 % of plumage and purities (Manchi & Ravi, 2011). Precious nest built exclusively by male birds 7-20 g in 35 days. Fig. 1 shows construction material that consists almost entirely of glutinous substance found in saliva (Goh et al, 2001). This is supported by Syahir et al (2012) who mentioned that the form of EBN made it naturally similar

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with the human eyelid shape or oval shape and form of the 'V'. EBN shape looks like a concave shape and has its own scaffolding. Weight of the nest is approximately 1-2 times the original swiftet's weight and originally made of layers of saliva attached to the concave interior wall face. Walet spawn two white, oval and rough surfaces of the egg (Green, 2012). EBN acknowledged in the Chinese delicacy since the T'ang Dynasty (618-907) known as ' liquid gold ' in China. It is the main ingredient in the famous bird's nest soup and very luxurious, which is good to the skin and gives a good long life (Anna et-al, 2000).

Fig. 1: Edible bird nest built by swiftlet

*2.2 Scaffolding Nest*

Rahim et-al (2012) noted that the current scaffolding nest was made of plastic, silicon and rubber. By using these toxic materials, it can give negative impacts to human health. Plastic material can harm human health such as inhibition of growth, immobility or death. This statement was noted by Lithner (2011) that by using plastic materials, it will lead to skin allergic and respiratory irritation. Suppaluck et-al (2001) claims that nest sites characterized as smooth and concave with supporter (scaffolding nest) sites are the most favorable site that had been chosen by Walet. Fig. 2 shows the natural Limestone supporter (scaffolding nest) in the Limestone cave.

Fig. 2: Natural scaffolding nest in Limestone cave

*2.3 Calcium Carbonate*

According to Woode (1977), Limestone or Calcium Carbonate ($CaCO_3$) is manufactured by the carbonation of an aqueous suspension of calcium hydroxide in the presence of a complex-forming agent for Calcium ions which is added subsequently to the primary nucleation stage, and preferably during a first carbonation stage". Patent filed by Smith (1987) proved that Limestone has the advantages of neutralizing the acid. It also can reduce odors and the material is based on natural sources. Generally, it is known that the Walet are cave dwellers and their nesting areas are usually inaccessible for humans and are located against dim to completely dark sites in limestone caves.

*2.4 Standard size of Edible bird nest (EBN)*

Standard size of raw- unclean EBN was stated in MS 2334: 2011 which is < 3cm to > 4.5cm. Nugroho and Budiman (2011) added that the thickness of the nest's wall is 1mm to 2 mm. The angles were divided into 4 angles which are 90°, 135°, 165° and 180° (MS 2334: 2011). Table 1 shows the detailed size grading for raw- unclean EBN as stated in MS 2334: 2011.

Table 1. Size Grading: Raw – unclean

| α | α 180 | α 165 | α 135 | α 90 |
|---|---|---|---|---|
| L > 4.5 cm | A Large | A Large | A Large | A Large |
| 3 ≤ L < 4.5 cm | B Medium | B Medium | B Medium | B Medium |
| L < 3 cm | C Small | C Small | C Small | C Small |
| (Others) | others | others | others | others |

(MS 2334: 2011)

## 3.0 Research Methodology

This research is divided into 4 main stages which are composition preparation, test bar preparation, physical properties test and design development (Refer Fig. 3). The main materials were mixed into 4 ratios of compositions and fabricated into a test bar and fired at 5 different temperatures. (800°C, 900°C, 1000°C, 1100°C and 1200°C). Then the test bars were tested on its physical properties, which are shrinkage, water absorption and strength. Once the suitable composition was finalized, the design development started with the design analysis on standard size of EBN as mentioned in MS 2334: 2011. The designs were developed using Solidwork 2012 software and the EX Plus Rapid prototyping machine was used to fabricate the model of the scaffolding nest. After that, the mould of the scaffolding was made by Plaster of Paris. Process continued with the fabrication of scaffolding nets into 30 pieces and fired at 1100°C. The final process of this research is the installation process of the scaffolding nest in the Walet house.

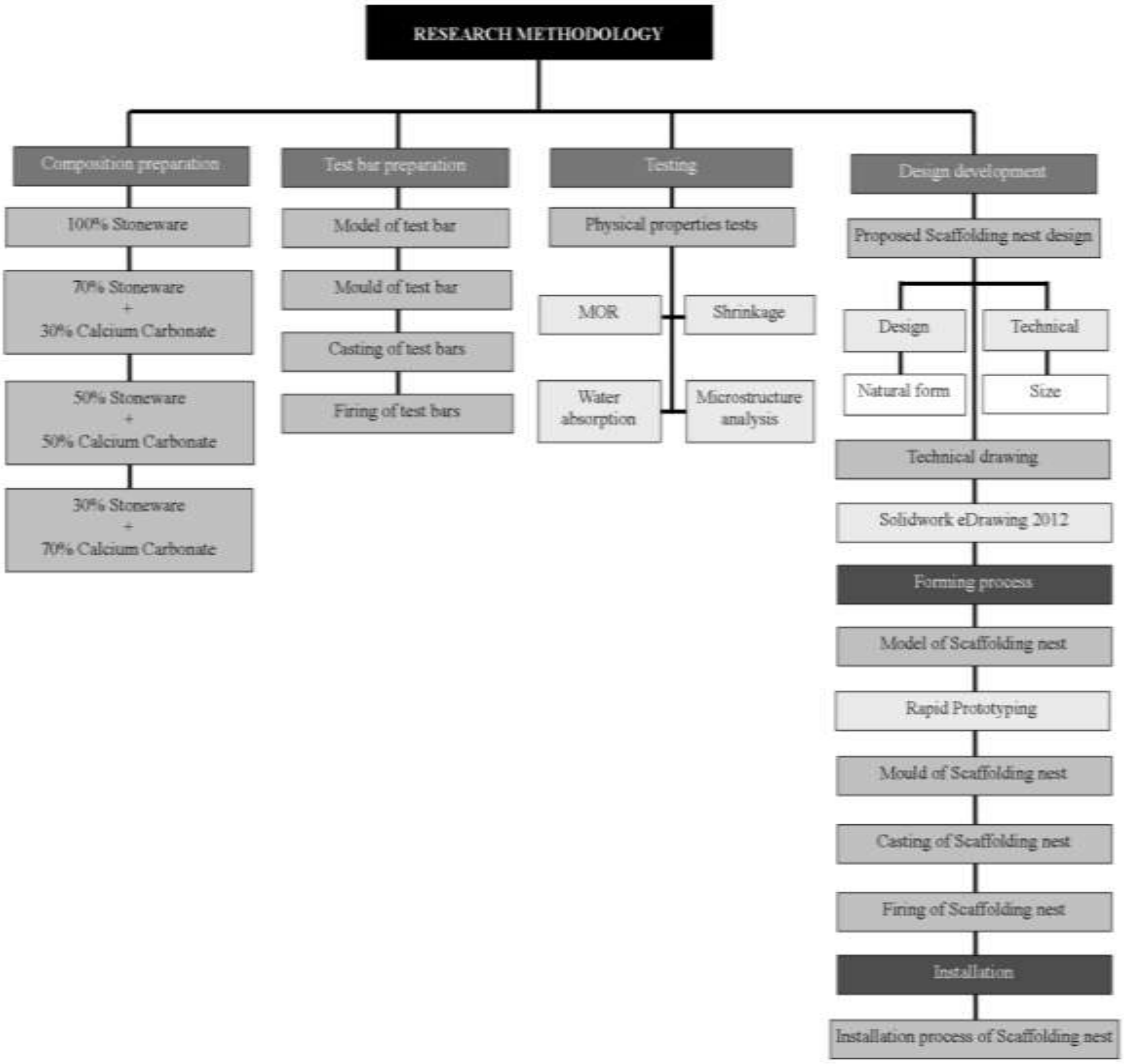



Fig. 3: Research methodology of this study

## 4.0 Results and discussion

As described earlier, the preparation of scaffolding nest materials was based on stoneware body composition. The body was mixed with ($CaCO_3$) in the order of 30%, 50%, and 70% to Stoneware body respectively. The materials were mixed and pressed into the test bars. Fig. 4 shows the firing results of the materials. The sintering temperatures are 800°C, 900°C, 1000°C, 1100°C and 1200°C. The results of the fired test were shown the physical appearance and visual conditions

*4.1 Physical appearance and visual conditions*

As sintered, the test bars of 0% of $CaCO_3$ was well sintered and the colour of test bars were changed from light orange to yellow colour due to the changes of sintering temperature from low temperature (800°C) to high temperature (1200°C) of sintering profile. The sample of 30% of $CaCO_3$ was not well sintered at 800°C for half an hour. Meanwhile, the sample of 50% of $CaCO_3$ were not well sintered and fractured into big pieces. The defects also shown in the samples of 70% of $CaCO_3$ which were fracture into small pieces with dusts. As sintered, the samples of 30% of $CaCO_3$ were well sintered at 900°C respectively. The colour was changed from light orange to light yellow. As shown in Fig. 4, concurrently, the body composition of 50% and 70% of $CaCO_3$ shows not well sintered and fractured into big pieces with dusts. at the same sintering temperature. Meanwhile, the samples of 0%, 30% and 50% of the $CaCO_3$ were well sintered at 1000°C respectively for half an hour. However, 70% of $CaCO_3$ content in Stoneware body were not well sintered and fractured into small pieces with dusts. The test bar's colour was changed from light yellow to white colour. As sintered at 1100°C, samples were well sintered and colour changed from light yellow to white. The colour of the 70% of $CaCO_3$ composition changed drastically, which were changed to white colour due to high content of $CaCO_3$ in the Stoneware body. At a temperature of 1200°C, the body was well sintered respectively and the colour changed from light yellow to white. From the discussion above, it can be concluded that the Stoneware body was lost its strength when mixed with the $CaCO_3$. The strength increased with declined percentage of $CaCO_3$ and raise of the sintering temperature.


Fig. 4: Physical appearance and visual conditions

*4.2 Shrinkage test*

Reported in Table 2 is the shrinkage result of the $CaCO_3$ content in the Stoneware body. The lowest shrinkage values were recorded of 70% of $CaCO_3$ which is 1.32% followed by 50% of $CaCO_3$ which is 1.63%. The 100% Stoneware group (control group) shows the highest rate of the shrinkage result.

Table 2. Shrinkage and sintering temperatures of $CaCO_3$ content in Stoneware body

| Temperature | Fired shrinkages of samples based on $CACO_3$ (*wt*, %) | | | |
|---|---|---|---|---|
| (°C) | 0 | 30 | 50 | 70 |
| 800 | 4.60 | 0.00 | 0.00 | 0.00 |
| 900 | 5.23 | 2.66 | 0.00 | 0.00 |
| 1000 | 5.62 | 2.49 | 1.63 | 0.00 |
| 1100 | 8.21 | 5.36 | 4.12 | 1.32 |
| 1200 | 12.60 | 9.26 | 6.90 | 2.58 |

(Source: Rahim et-al: 2014)

The flow curves of shrinkage were reported in Fig. 5. The shrinkage decreased gradually with additional percentage of $CaCO_3$ and sintering temperature of 1100°C shows the lowest percentage of the materials shrinkage. This result indicated that the presence of $CaCO_3$ in the Stoneware body was decreased the shrinkage of the composition. This result of this test will be a major guideline on the size of Scaffolding nest's model.

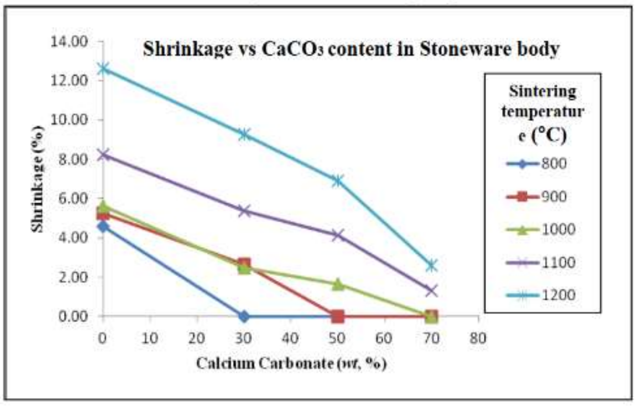



Fig. 5: Materials shrinkage of different sintering temperature

*4.3 Strength test*

Modulus of Rupture (MOR) result of the $CaCO_3$ content in Stoneware body was summarized in Table 3. The sintering temperature of 1100°C recorded the highest result of MOR which is 17.54%. Meanwhile 70% of $CaCO_3$ was verified the lowest result of MOR.

Table 3. MOR and sintering temperatures of $CaCO_3$ content in Stoneware body

| Temperature | Fired shrinkages of samples based on $CACO_3$ (*wt*, %) | | | |
|---|---|---|---|---|
| (°C) | 0 | 30 | 50 | 70 |
| 800 | 1.78 | 0.00 | 0.00 | 0.00 |
| 900 | 4.92 | 1.05 | 0.00 | 0.00 |
| 1000 | 13.68 | 11.90 | 7.05 | 0.00 |
| 1100 | 17.54 | 16.97 | 9.63 | 8.07 |
| 1200 | 18.31 | 17.02 | 11.19 | 9.23 |

(Source: Rahim et-al: 2014)

Reported in Fig. 6 is the behavior of the Modulus of Rupture as a function of percentage of $CaCO_3$ for the different range of sintering temperatures. The strength of the test bars decreases slightly with additional percentage of $CaCO_3$ at 800°C and 900°C. Nevertheless, the strength jumped rapidly started from 1000°C to 1200°C. From the result, it concluded that the Stoneware body will lose its strength when mixed together with the $CaCO_3$. The 30% of $CaCO_3$ achieved the highest result of strength test which is 17.02N/mm² as sintered at 1200°C.

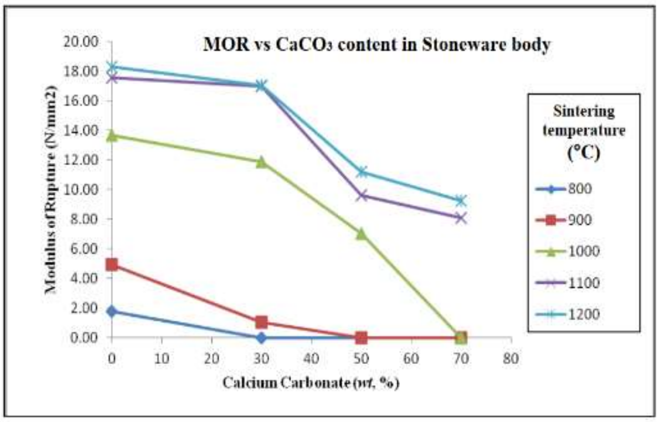



Fig. 6: MOR of different sintering temperature

*4.4 Water absorption test*

Table 4 collects the water absorption result of $CaCO_3$ content in Stoneware body. It was recorded that the lowest percentage of water absorption was recorded at 1200°C in all the compositions. 70% of $CaCO_3$ shows the highest result of water absorption due to the high content of $CaCO_3$ in the composition.

Table 4. Water absorption and sintering temperature of $CaCO_3$ content in Stoneware body

| Temperature | Fired shrinkages of samples based on $CACO_3$ (*wt*, %) | | | |
|---|---|---|---|---|
| (°C) | 0 | 30 | 50 | 70 |
| 800 | 25.06 | 0.00 | 0.00 | 0.00 |
| 900 | 24.83 | 26.24 | 0.00 | 0.00 |
| 1000 | 24.15 | 27.09 | 30.94 | 0.00 |
| 1100 | 17.62 | 24.67 | 26.44 | 32.86 |
| 1200 | 7.17 | 17.65 | 25.90 | 29.12 |

(Source: Rahim et-al: 2014)

The water absorption result of $CaCO_3$ content in Stoneware body were summarized in Fig. 7. 30% of $CaCO_3$ reached the lowest percentage of water absorption at sintering temperature of 1100°C. It can be concluded that the low temperature such as 800°C, 900°C and 1000°C were contained wide pores and high level of water. The water absorption decreased with declined percentage of $CaCO_3$.

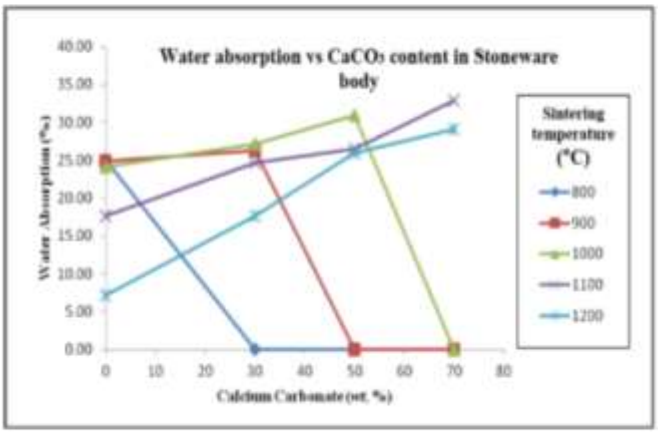



Fig. 7: Water absorption of different sintering temperature

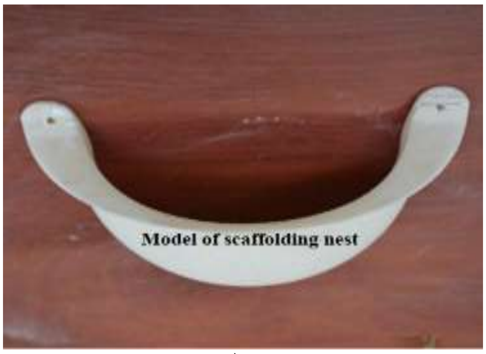
It can be concluded that 30% of $CaCO_3$ content in Stoneware body, sintered at 1100°C for half an hour respectively was the best and suitable composition for the scaffolding nest. The result is based on the high percentage of MOR record and low percentage of water absorption.

*4.5 Final design of scaffolding nest*

As shown in Fig. 8, the final design of the Scaffolding nest was selected in concave shape, strength and ergonomic of holder system. The design process was continued with a technical drawing process that explained in detail about the design and dimension of the Scaffolding nest. The dimension of the Scaffolding nest was calculated 5.36% bigger than the size of the Walet nest.


Fig. 8: Technical drawing of scaffolding nest designed by Solidwork 2012 software

*4.6 Model and mould of scaffolding nest*




a)


b)

Fig. 9. (a) Model of scaffolding nest; (b) Mould of scaffolding nest

Fig. 9. (a) show the model of a swiftlet scaffolding nest which is produced by the Rapid prototyping machine. Fig. 9. (b) presents the mould of a scaffolding nest made from Plaster of Paris and the Scaffolding nests were fabricated using press mould technique.

*4.7 Fabricated and fired scaffolding nest*

As shown in Fig. 10 (a) is the fabricated Scaffolding nest made from 30% of $CaCO_3$ content in Stoneware body. It was fabricated using the mould with hand-built technique. The dried scaffolding nests were fired at 1100°C for half an hour respectively. Figure 10 (b) shows the fired scaffolding nests, sintered at 1100°C.


a)


b)

Fig. 10. (a) Fabricated scaffolding nest; (b) Fired scaffolding nest

*4.8 Installation*

The most important in this study is the installation result. Scaffolding nests were attached against wood dim on the ceiling of the swiftlet house using 1 inch of screw. Fig. 11 illustrates the installed scaffolding nests in Swiftlet's house. The scaffolding nests made from 30% of $CaCO_3$ content in Stoneware body were successfully installed against the wood dim and the holder design was easily the removal process of the scaffolding nest.


Fig. 11: Installed scaffolding nest in swiftlet's house

Fig. 12 shows the views of the ceramic scaffolding nest that was installed against wood dim in the swiftlet house. The holder was hanged using 1 inch of screw. It also shows that the texture of the scaffolding nest was close to Walet habitat which is Limestone cave.

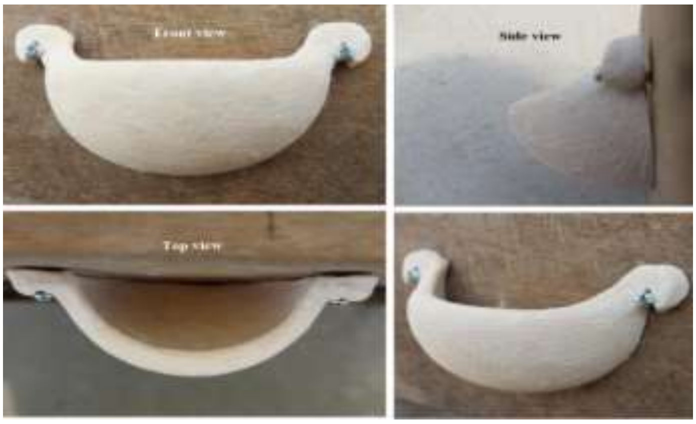


Fig. 12: Views of ceramic scaffolding nest in swiftlet house

## 5.0 Conclusion and Recommendation

This study was undertaken to design the Walet scaffolding nest and evaluate the suitability of the ceramic materials in order to substitute the present materials which are plastic. This study set out the experiment to identify the suitable compositions that will be used to produce the Walet scaffolding nest. The main materials used are Calcium Carbonate and Stoneware body. The Scaffolding nests were fabricated using press mould technique and fired at 1100°C for half an hour respectively. The ceramic scaffolding nest was successfully installed on the wood dim in the Walet house to substitute the plastic scaffolding nest.

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