



Research Article

Penaeus monodon Shell Powder Extract as A Candidate for Dental Material Restoration

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Abstract

The prevalence of dental caries in Indonesia is still high. One of the dental caries treatments is direct restoration. Biomaterial, often used as a restorative material, is glass ionomer cement which has a silica content of 35%. Silica is found in *Penaeus monodon* shells which have been a waste of production. This research aims to study the characteristic of *Penaeus monodon* shell powder extracts as candidates for dental materials restoration. The research sample used was *Penaeus monodon* shell powder extract which was then carried out by a depigmentation process by mixing acetone 1:10 (w/v) \leq 20 hours. Samples were tested with the XRD test (x-ray diffraction). SEM assessment was performed to evaluate the morphology of the particle. Data were analyzed using Mann-Whitney. The result demonstrated a significant silica content in *Penaeus monodon* shell powder extract before and after the depigmentation process with a p-value of 0,00 ($p < 0,05$). The depigmentation process can decrease silica content in *Penaeus monodon* shell powder extract. There was a different comparison of silica content in *Penaeus monodon* shell powder extract before and after depigmentation as a candidate for dental materials restoration.

Keywords: depigmentation process; *Penaeus monodon*; silica

INTRODUCTION

According to the Riset Kesehatan Dasar (Riskesdas) results in 2018, dental and oral health problems have doubled more than in 2013, from 25.9% to 57.6%. A total of 20 provinces have a prevalence of dental and oral problems above the national figure. Research using 300,000 household samples, or the equivalent of 1.2 million people, showed that around 45.3% experience dental caries disease. In addition, for the 5-9 years age group, 54% or around 92,746 people experience dental caries, while the def-t target set by WHO was \leq 2 in 2020.¹ Teeth require restoration for many reasons. Damage to tooth substance caused by dental caries results in the loss of certain parts of the enamel and dentin. In one visit, the direct filling

material is used to fill the teeth directly in the dental clinic room. The material requirements for filling materials vary, and it is not surprising that no single restorative material fits all cases. For some situations, more abrasion resistance and material strength are required. In other situations, aesthetics and adhesive properties may be more important. Glass ionomer cement (GIC) is one of the filling materials that is often used as it has important components, namely 35% silica and fluoride, which have a remineralization effect, good translucency and can inhibit plaque formation.^{2,3} One of the marine resources that can be used as dental materials is the shell of tiger prawns (*Penaeus monodon*). The advantage of tiger shrimp compared to other shrimp are the large shell size, which can produce more

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powder than other types of shrimp. Tiger shrimp contains chitin, chitosan and glucosamine, which are useful in dentistry. In addition, tiger prawn shells have compositions that can be used as candidates for dental restoration materials.^{4,5} In this study, the silica content in the shell of tiger prawns (*Penaeus monodon*) was analyzed using an X-Ray Diffractometer (XRD), depigmentation to obtain the aesthetic requirements of the filling material and SEM assessment was performed to evaluate the morphology of the particle which was then analyzed whether it was eligible to be a candidate for dental restorative materials.

MATERIALS AND METHODS

The material used was tiger prawn shell powder (*Penaeus monodon*) obtained from tiger shrimp ponds in Tarakan City, North Kalimantan, Indonesia. *Penaeus monodon* shrimp shells were washed thoroughly with water to remove impurities in a hot air oven at 90°C for 6 h. After that, it was crushed using a mortar and pestle into a powder and in a mesh.

Depigmentation Process

The depigmentation process was carried out by dissolving tiger prawn shell powder (*Penaeus monodon*) with acetone solution in a ratio of 1:10 (w/v) for 20 hours to remove the dye in the shell powder.

X-Ray Diffraction (XRD)

Penaeus monodon shrimp shell powder was put into a block-shaped container before and after depigmentation. After that, the sample was placed in the XRD test equipment for characterization. The results of the characterization with XRD tools showed the percentage of calcium carbonate with the following formula:

$$\% \text{ compound} = \frac{\sum I(\text{compound})}{I(\text{overall})} \times 100 \%$$

$\sum I$ (compound) is the number of intensities whose diffraction peaks

correspond to ICDD data for certain compounds, while I (overall) is the sum of the intensities of all sample diffraction peaks.⁶

Scanning Electron Microscope (SEM)

SEM was used to obtain information about the surface morphology of the tiger prawn shell powder (*Penaeus monodon*). The tiger prawn shell powder was first defatted with isopropanol and then removed by vacuum filtration. The remaining tiger prawn shell powder solids were placed on the sample holder with the help of double scotch tape. Then, the powder was sputter-coated with gold/palladium (2 min, 2 mBar), where it was observed at 15 kV and examined with the SEM (model:1450 EP, Carl Zeiss MicroImaging Inc, Thornwood, NY, USA). At least 5 pictures for each sample were taken at randomly selected locations.

RESULT

Depigmentation Process

The results of the depigmentation study of *Penaeus monodon* shell powder extract revealed that the color of *Penaeus monodon* shrimp shell extract showed a significant difference after depigmentation.

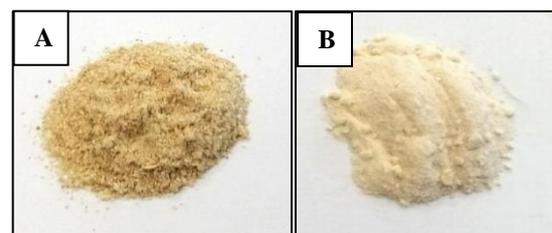


Figure 1. *Penaeus monodon* shell powder extract (A) before the depigmentation process (B) after the depigmentation process.

X-Ray Diffraction (XRD)

The results of the research data on silica content in *Penaeus monodon* shell powder extract using the XRD test showed a significant difference between before and after the depigmentation process as a candidate for dental restorative material with a p-value of 0.00 ($p < 0.05$).

Table 1. Content in *Penaeus monodon* shell powder extract before and after the pigmentation process

	Before the pigmentation process (%)	After the pigmentation process (%)
Silicon Oxide (SiO ₂)	69*	0
Calcium Carbonate (Ca(CO ₃))	31	36,6
Calcium Silicate (Ca(Si ₂ O ₅))	0	49,5*
Sodium Nitrate (Na(NO ₃))	0	13,9

*Highest content

Table 2. The mean, SD and P Value of Silica content in *Penaeus monodon* shell powder extract before and after the depigmentation process

	Mean	SD	P Value
Silicon Oxide Content	34,50	48,79	0,00*

*p-value for the Mann-Whitney test indicates significantly different (p<0,05)

Scanning Electron Microscope (SEM)

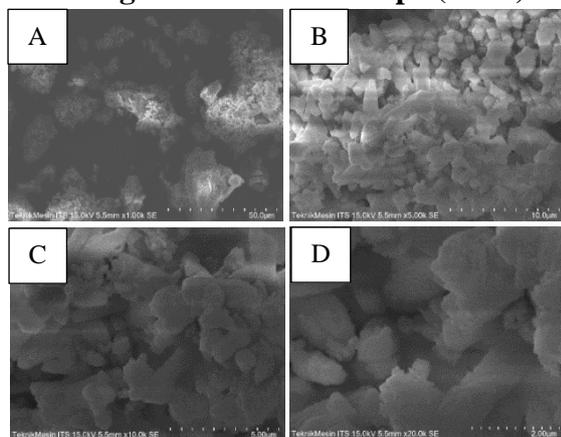


Figure 2. SEM image of *Penaeus monodon* shell powder extract (A) 1.00k (B) 5.00k (C) 10.00k (D) 20.00k Magnification

DISCUSSION

In one visit, the direct filling material was used to fill the teeth directly in the dental clinic room. Materials differ from indirect restorations, such as crowns, bridges, or inlays, as they do not require laboratory steps in restoration. Parts of the tooth that require replacement of restorative material vary in size, shape and location in

the mouth. The material requirements for these and other applications vary; therefore, it is unsurprising that no single restorative material fits all cases. For some situations, more abrasion resistance and material strength are required. In other situations, the appearance and nature of the adhesive can be more important.³

The results of the depigmentation process that have been carried out showed that the depigmented extract of *Penaeus monodon* shrimp shell powder had a lighter color than before the depigmentation process. It aligns with the requirements of dental restorative materials that require good aesthetics. Thus, restoration results with good aesthetics are obtained.⁷ The results of the morphological analysis of *Penaeus monodon* shrimp shell extract powder using SEM displayed that the shape of the particles was irregular with various sizes of 5-20 μm. The various shapes and sizes will affect a material's physical properties, including the restorative material's compressive strength, tensile strength, surface roughness, and aesthetic properties.⁸

The results of the X-Ray Diffraction (XRD) test on *Penaeus monodon* peel powder extract before the depigmentation process showed that *Penaeus monodon* peel powder extract contained 69% silicon oxide (SiO₂) and 31% calcium carbonate (CaCO₃). Meanwhile, *Penaeus monodon* peel powder extract after depigmentation contained 49.5% calcium silicate (Ca(Si₂O₅), 36.6% calcium carbonate (CaCO₃) and 13.9% sodium nitrate (Na(NO₃)). The XRD showed that *Penaeus monodon* shell powder extract could be used as a candidate for dental restoration as it contains SiO₂, which is one of the main ingredients of dental restorative materials, especially glass ionomer cement (GIC). However, after the depigmentation process, the SiO₂ compound disappears and turns into Ca(Si₂O₅). GIC is formed by an acid-base reaction between fluoro aluminosilicate glass and polyacrylic acid. Alumino silicate glass contains Ca²⁺, Al³⁺

and Si_4^+ bonded to each other with oxygen. When glass fluoro aluminosilicate and polyacrylic acid are mixed, protons from polyacrylic acid cause hydrolysis of glass bonds of Ca_2^+ and Al_3^+ , releasing and binding to the carboxyl group of polyacrylic acid to form a matrix. A silica gel layer is formed around the glass particles, which can inhibit the degradation of GIC during the setting process and can also act as an antibacterial.^{9,10}

$\text{Ca}(\text{Si}_2\text{O}_5)$ is often used as an endodontic material, especially in treating pulpal regeneration and hard tissue repairs such as pulp capping, apexogenesis, pulpotomy, apexification, root-end filling and perforation repair.^{11,12,13} $\text{Ca}(\text{Si}_2\text{O}_5)$, when in contact with oral fluids, can release calcium, silicate hydrate and calcium hydroxide.¹⁴ Calcium hydroxide releases calcium ions that play a role in cell adhesion, migration, differentiation and proliferation. Furthermore, calcium plays a role in fibroblast adhesion.^{15,16,17} The results of Prananingrum's research in 2021 revealed that *P. monodon*, which has been subjected to deproteinization, demineralization, depigmentation and deacetylation processes, can increase the formation of odontoblast-like cells in direct pulp capping treatment in experimental animal groups by giving chitosan for 7 and 28 days. It is due to the high degree of deacetylation used to manufacture direct pulp capping chitosan. The high degree of deacetylation is accompanied by a high percentage of the acetyl units that produce the acetyl-D-glucosamine dimer. If used on the injured area, it will cause inflammatory cells to release lysozyme enzymes.

CONCLUSION

Penaeus monodon shell powder extract was unsuitable as a dental restorative material due to the chemical structure that changed after the depigmentation process using acetone. However, bioactive ingredients can be used as endodontic materials, namely calcium silicate, which plays a role in tissue repair.

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