Bioscientia Medicina: Journal Of Biomedicine & Translational Research

eISSN (Online): 2598-0580

Bioscientia Medicina: Journal of Biomedicine & Translational Research

Journal Homepage: www.bioscmed.com

Capability of Rice Husk Silica on Flexural Improvement in Metal Ceramic Restoration

Sopan Sinamo[1*], Mourent Miftahullaila[1], Hendrik Steven[2]

[1] Department of Prosthodontic, Faculty of Medicine, Dentistry and Health Science, Universitas Prima Indonesia, Medan, Indonesia
[2] Dentistry Education Program, Faculty of Medicine, Dentistry and Health Science, Universitas Prima Indonesia, Medan, Indonesia

A R T I C L E I N F O

Keywords:
Silica
Rice husk
Opaque porcelain
Flexural strength
Metal-ceramic restoration

***Corresponding author:**
Sopan Sinamo

E-mail address:
sopannamo@gmail.com

All authors have reviewed and approved the final version of the manuscript.

https://doi.org/10.37275/bsm.v6i5.500

A B S T R A C T

Background. Metal ceramic restoration (MCR) is a gold standard due to its ability to withstand masticatory forces and aesthetics. However, it frequently appears to experience a fracture in the oral cavity. The ceramics in MCR consist of an opaque dentin and enamel layer, which contain silica to give the ceramic strength. Silica is an abundant material, mainly synthesized from rice husks. The study was aimed to investigate the effect of silica added to commercially opaque porcelain powder in increasing the flexural strength of MCR. **Methods**: The research sample was rectangular Co-Cr metal [(25±1) mm × (3±0.1) mm × (0.5 ± 0.05) mm], and opaque porcelain powder and dentin [(8±0.1) mm× (3±0.1) mm ×(1.1±0.1) mm]. White silica powder was synthesized from rice husk by sonication for 270 minutes, characterized by x-ray fluorescence (XRF). Silica was mixed with commercial opaque porcelain powder with various concentrations of 0, 0.5, and 1%, porcelain coating procedure on the centre of the surface metal, followed by sintering at 9500C. **Results:** Characterization with XRF showed that the elemental content of pure silica was 83.9%. The average flexural strength value with three-point bending in each sample is 109.67±12.163; 131.26±3.817; and 108.35±4.26. The results of statistical tests using One Way ANOVA stated a significant increase in the flexural strength of MCR ($p<0.05$) post added the rice husk silica to the commercial opaque porcelain powder. **Conclusion:** Adding 0.5% silica resulted in the optimal flexural strength of MCR.

1. Introduction

Metal ceramic restoration (MCR) can withstand masticatory forces and produces excellent esthetics because of its metal coping support and ceramic material coating.[1] Nonetheless, the MCR has low flexural strength, which increases fracture risk, especially in the posterior area with excessive grinding forces.[2] Galiatsatos et al., reported 106 units of MCR fractured within three years inserted in the oral cavity.[3] Fractures in MCR presented in the form of cohesion and adhesion fractures. Cohesion fractures occur due to damage between the porcelain layers, and adhesion fractures occur due to the loose bond between the porcelain and metal.[3] The MCR consisted of opaque, dentin, and enamel layers. The opaque layer is the first layer that plays an essential role in bonding ceramic materials to metal. The composition of silica particles in commercial opaque porcelain is around 52-55% and acts as a filler material that is hard and stable so that it can endure large masticatory forces in the oral cavity.[1]

Silica is an abundant material and is widely used for various applications, including food manufacturing, medicine, industrial materials, and dental materials. The primary source of silica is rice husks, a waste product that is less useful in Indonesia.[4] Rice husk has a relatively high silica content compared to other minerals.[5] Flexural strength can be intensified by adding low-concentration silica. Wongwitthayakool et al. stated that the addition of 0.25% silica from rice husk to polimethyl-methacrylate (PMMA) acrylic base material showed the most optimal flexural strength.[6] Hasran et al., identified the flexural strength value of rice husk silica in composite resin as 83 Mpa, which is suitable as a filling material for posterior teeth.[7] The study objective was to investigate adding silica from rice husks to opaque porcelain on increasing the MCR flexural strength.

2. Methods

An experimental laboratory design was applied in this research. The sample used was Co-Cr metal [(25±1) mm × (3±0.1) mm × (0.5 ± 0.05) mm] and porcelain [(8±0.1) mm × (3±0.1) mm × (1.1±0.1) mm] plated over the centre of the metal surface.[8] The equipment used to test the sample was the Universal Testing Machine (TENSILON). Rice husks were dissolved with HCl 1N, stirred at a temperature of 90^{o}C for an hour, filtered, dried in an oven at 80°C overnight, dissolved in NaOH 1N at 80^{o}C for an hour, until a solution of sodium silicate was formed, added with HCl 1N to reach pH 7, centrifuged to obtain a white precipitate, dried, and by ultrasonic for 270 minutes to form white silica powder. Characterization of the chemical structure of the white powder by x-ray fluorescence (XRF). Then the silica is mixed into commercially opaque porcelain powder (Vita VMK Master) with varying concentrations of 0%, 0.5%, and 1%, coating the MCR sample with silica opaque porcelain powder and dentin then burning at a temperature of 950^{o}C.[9,10] Flexural test with three-point bending on all samples to determine the difference in flexural strength of each sample. One way ANOVA test determines the significance of each MCR sample's increase in flexural strength.

3. Results

XRF test results show the elements present in rice husk and silica powder. Silica elements in rice husk and white silica powder were 63.7% and 83.9%, respectively (tables 1 and 2). In this study, the average value of flexural strength with three-point bending on the samples of commercial and rice husk silica MCR were 109.67±6.212; 131.26±3.817; and 108.35±4.265 (table 3). We found that adding 0.5% silica from rice husks to opaque porcelain powder increased the flexural strength of the MCR sample, but the addition of 1% silica resulted in a decrease in flexural strength.

Table 1. X-ray fluorescence (XRF) analysis of rice husk particles

Composition	**Si**	**P**	**K**	**Ca**	**V**	**Cr**	**Mn**	**Zr**	**Ba**
Percentage (%)	63.7	1.7	5.75	2.5	0.47	1,7	15.0	1.1	4.4

Table 2. X-ray flourescence (XRF) analysis of rice husk silica powder

Composition	**Si**	**P**	**Ti**	**Cr**	**Mn**	**Ba**	**Nd**
Percentage (%)	83.9	0.61	0.09	0.75	4.6	1.8	8.2

Therefore, the one-way ANOVA test was performed to determine whether rice husk silica addition increased the flexural strength of MCR. The one-way ANOVA test showed a significant increase in the flexural strength of MCR post added the rice husk silica to the commercial opaque porcelain powder (table 3) with $p<0,05$. The most optimal flexural value was found in the 0.5% silica group, while the lowest was the 1%.

Table 3. The effect of adding rice husk silica to the opaque layer on the flexural strength of MCR

Addition of silica	Flexural Strength (Mpa)		
	Mean	Standard deviation	p-value
0%	109.67	12.163	0.001*
0.5%	131.26	3.817	
1%	108.35	4.265	

*one-way ANOVA test, p<0,05

Table 4. Comparison with post-hoc LSD analyzed

Silica	Silica		
	0%	**0.5 %**	**1 %**
0 %		0.001*	0.792
0.5 %	0.001*		0.001*
1 %	0.792	0.001*	

*Post-hoc LSD Test, p<0.05

Table 4 showed a significant increase in the flexural strength of MCR post added the rice husk silica to the commercial opaque porcelain powder between 0 % to 0.5 %; 0.5% to 0%; 0.5% to 1%; and 1% to 0.5 % ($p<0.05$), while silica 0% to 1 % and 1% to 0 % is not significant ($p>0.05$).

4. Discussion

This research was conducted in an experimental laboratory using MCR samples per ISO 2012. We found that silica synthesized by the sonication method can produce pure silica powder (83.9%). The sonication method was carried out with time variations of up to 270 minutes. The VMK master brand of opaque porcelain and dentin were combined with metal through a sintering process at a temperature of 920 °C according to the manufacturer's instructions to achieve a homogeneous union and form an MCR sample.

Ceramics are solid compounds of inorganic, non-metallic, and metalloid atoms held together mainly by mixed bonds consisting of ionic and covalent bonds. Ceramics have several distinctive properties that metals do not, including stable chemical inertness, high-temperature stability, brittleness, high melting point, and electrical insulating ability.[11-14] Because of these properties, ceramics offer a wide range of applications to modern society, including being used in ceramic mixtures to repair tooth decay. In the ceramics industry, silica (SiO_2) is essential for production. Silica is believed to be the main backbone of the ceramic industry. Most manufacturers use silica sand, gravel, sandstone, granite, quartz, and quartzite as a source of silica for the manufacture of ceramics. Sources of silica are found in nature, one of which is rice husk.[15-17]

Rice is the second most-consumed food source globally. Rice production reaches almost 800 million tons per year, and Indonesia is one of the world's largest rice producers and consumers. Indonesia is the largest producer and consumer of rice globally, which is correlated with the high amount of residue left from rice processing, namely rice husks. Rice husk is a by-product of the rice processing industry, obtained from 20% by weight of bulk seeds. The main content of rice husk is 70-80% organic substances such as cellulose lignin, and the remaining 20-30% consists of mineralogic components such as silica, alkali and trace elements. Rice husk is waste from rice processing through the combustion process.

Processing 1000 kg of grain produces 200 kg of rice husks (20%). Rice husk (200 kg) can produce about 45 kg of amorphous silica. Amorphous silica under various conditions is considered to be more reactive than crystalline silica and has a complex spherical structure. Silica can be used as a catalyst, an admixture in inks, concrete hardeners, detergents, soaps, and as a hardening element in brick making, including as a potential admixture in the manufacture of dental porcelain to repair tooth decay.[7,18-20]

Mixing of 0.5% silica to commercially opaque porcelain powder resulted in the optimal flexural strength of the MCR ($p<0,05$). The higher silica concentration (1%) added to the porcelain powder decreased the flexural strength of MCR because agglomeration occurred at a large amount of silica concentration. The results of this study were in line with the research conducted by Wongwitthayakool et al., which stated that the addition of 0.5% silica powder to an acrylic resin base of polimethyl methacrylate acrylic (PMMA) resulted in the optimal flexural strength of the PMMA base.[6]

5. Conclusion

There was an increase in flexural strength in MCR samples with 0.5% rice husk silica on commercial opaque porcelain, but a decrease in flexural strength with 1% rice husk silica on commercial opaque porcelain.

6. References

1. Paramarta G, Inayati E. Manufacturing technique of metal ceramic restoration with implant-abutment at gingival resorption case. J Vocation Health Stud. 2019; 3(1): 22-31.
2. Vafaae F, Firooz F, Heidari B, Khoshhal M, Fotovat F, et al. Comparative study of flexural strength and fatigue resistance of 2 nanoceramic composite resin cad/cam blocks (lava ultimate and vita enamic) and a lithium disilicate glass ceramic (Ips E. Max Cad). Biomed Pharm J. 2017: 10(1).
3. Galiatsatos AA, Galiatsatos PA. Clinical evaluation of fractured metal-ceramic fixed dental prostheses repaired with indirect technique. Quintessence Int (Berl). 2015; 46(3): 229–36.
4. Permatasari N, Sucahya TN, Nandiyanto ABD. Review: Agricultural wastes as a source of silica material. Indones J Sci Technol. 2016; 1(1): 82–106.
5. Singh D, Kumar R, Kumar A, Rai KN. Synthesis and characterization of rice husk silica, silica-carbon composite and H_3PO_4 activated silica. Ceramica. 2008; 54(330): 203–12.
6. Wongwitthayakool P, Sintunon T, Tanagetanasombat W, Soonthornchai P, Abbas AA. Flexural strength and dynamic mechanical behavior of rice husk ash silica filled acrylic resin denture base material. Key Eng Mater. 2019; 824: 94–9.
7. Hasran MAR, Imam DNA, Sunendar B. Addition of rice husk nanocellulose to the impact strength of resin base heat cured. J Vocation Health Stud. 2021; 4(3): 119-24.
8. Yoldan EE, Turker N, Buyukkaplan US, Ozarslan MM, Karali R, et al. Evaluation of the bond strengths between dental porcelain and cobalt-chromium metal frameworks manufactured with different techniques after thermal aging process. Scanning. 2020; 9315236.
9. Akram Z, Aati S, Ngo H, Fawzy A. pH-dependent delivery of chlorhexidine from PGA grafted mesoporous silica nanoparticles at resin-dentin interface. J Nanobiotech. 2021; 43.
10. Vakalova TV, Pogrebenkov VM, Karionova NP. Solid-phase synthesis of wollastonite in natural and technogenic siliceous stock mixtures with varying levels of calcium carbonate component. Ceramics International. 2016; 42: 16453-62.
11. Naga SM, El-Maghraby HH, Sabed M. Highly porous scaffolds made of nanosized hydroxyapatite powder synthesized from eggshell. J. Ceram. Sci. Technol. 2015; 6: 237–244.

12. Zhu M, Ji R, Li Z. Preparation of glass ceramic foams for thermal insulation applications from coal fly ash and waste glass. Construction and Building Materials. 2016; 112: 398-405.
13. Carrasco-Hurtado B, Corpas-Iglesias FA, Cruz-Pérez N. Addition of bottom ash from biomass in calcium silicate masonry units for use as construction material with thermal insulating properties. Construction and Building Materials. 2014; 52: 155-65.
14. Balos S, Pilic B, Markovic D, Pavlicevic J, Luzanin O. Poly (methyl-methacrylate) nanocomposites with low silica addition. J Prosthet Dent. 2014; 3(4): 327–34.
15. Al-Jabbari Y, Koutsoukis T, Barmpagadaki X, Zinelis S. Metallurgical and interfacial characterization of PFM Co–Cr dental alloys fabricated via casting, milling or selective laser melting. Dental Materials. 2014; 30(4): e79-88.
16. Choi YJ, Koak JY, Heo SJ, Kim SK, Ahn JS, et al. Comparison of the mechanical properties and microstructures of fractured surface for Co-Cr alloy fabricated by conventional cast, 3-D printing laser-sintered and CAD/CAM milled techniques. J Korean Acad Prosthodontics. 2014; 52(2): 67–73.
17. Sun J, Zhang FQ. The application of rapid prototyping in prosthodontics. J Prosthodontics. 2012; 21(8): 641-4.
18. Davidowitz G, Kotick PG. The use of CAD/CAM in dentistry. Dental Clinic. 2011; 55: 559-70.
19. Vásquez V, Özcan M, Nishioka R, Souza R, Mesquita A, et al. Mechanical and thermal cycling effects on the flexural strength of glass ceramics fused to titanium. Dental Materials J. 2008; 27 (1): 7–15.
20. Zhou Y, Li N, Wang H, Yan J, Liu W, et al. Effects of the rare earth element lanthanum on the metal-ceramic bond strength of dental casting Co-Cr alloys. J Prosthetic Dentistry. 2019; 121(5): 848-57.