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THE EFFECT OF VARIATION IN POLYPROPYLENE CONCENTRATION ADDED TO GONGGONG (*Laevistrombus Canarium*) SHELL POWDER COMPOSITE MATERIAL ON TENSILE STRENGTH CHARACATERISTICS AS A FILLER

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ABSTRAK
Pemanfaatan limbah cangkang kerang sering kali belum optimal meskipun memiliki potensi sebagai bahan pengisi komposit. Penelitian ini bertujuan untuk mengembangkan material komposit ramah lingkungan berbasis bubuk cangkang gonggong yang dikombinasikan dengan polipropilena. Metode penelitian melibatkan pembuatan sampel komposit dengan mencampurkan bubuk cangkang gonggong dan polipropilena pada variasi konsentrasi tertentu, kemudian dicetak menggunakan metode pencetakan tekan panas (hot press molding). Spesimen yang dihasilkan diuji sifat mekaniknya melalui uji tarik berdasarkan standar ASTM D638, dan data dianalisis menggunakan uji ANOVA untuk menentukan signifikansi perbedaan antarvariasi komposisi. Tahapan penelitian meliputi observasi, pengumpulan limbah cangkang, pembersihan, sterilisasi menggunakan larutan NaOH, pengeringan, penggilingan, dan pengayakan hingga diperoleh serbuk halus. Hasil analisis XRF menunjukkan bahwa cangkang gonggong didominasi oleh kalsium oksida (65,108%) yang mengindikasikan kandungan kalsium karbonat tinggi sehingga berpotensi sebagai filler komposit. Hasil uji tarik pada spesimen dengan variasi polipropilena 2,5%, 5%, 7,5%, dan 10% menunjukkan adanya perbedaan yang signifikan secara statistik ($p < 0,05$), di mana nilai kekuatan tarik optimal sebesar 35,03 MPa diperoleh pada konsentrasi 5%. Hasil ini menunjukkan bahwa formulasi komposit berbasis bubuk cangkang gonggong dan polipropilena memiliki potensi sebagai material pengisi ramah lingkungan dengan sifat mekanik yang kompetitif.

Kata kunci: Cangkang Gonggong; Material Komposit; Polipropilene; Kekuatan Tarik; Pengisi filler.

ABSTRACT
The utilization of shell waste is often suboptimal, despite its potential as a composite filler material. This study aims to develop an environmentally friendly composite material based on gonggong shell powder combined with polypropylene. The research method involved the preparation of composite samples by mixing gonggong shell powder and polypropylene at various concentrations, followed by specimen fabrication using the hot press molding method. The

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resulting specimens were mechanically characterized through tensile testing based on the ASTM D638 standard, and the data were statistically analyzed using ANOVA to determine the significance of differences among composition variations. The research stages included observation, shell waste collection, cleaning, sterilization using NaOH solution, drying, grinding, and sieving to obtain fine powder. XRF analysis showed that gonggong shells are predominantly composed of calcium oxide (65.108%), indicating a high calcium carbonate content and strong potential as a composite filler. Tensile test results for specimens with polypropylene variations of 2.5%, 5%, 7.5%, and 10% revealed statistically significant differences ($p < 0.05$), with the optimal tensile strength of 35.03 MPa achieved at 5% concentration. These findings demonstrate that the developed composite material based on gonggong shell powder and polypropylene has strong potential as an environmentally friendly filler material with competitive mechanical properties.

Keywords: Gonggong Shell; Composite Material; Polypropylene; Tensile Strength; Filler.

INTRODUCTION

Composite materials became a popular choice in various industrial applications due to their good mechanical properties, lightweight nature, and ease of processing (M et al., 2022); (Sunarsono et al., 2023). One type of composite material that attracted attention was composites used as fillers from renewable natural resources, such as shell waste (Nayiroh & Kusairi, 2021). Shells contained a high amount of calcium carbonate, so they had the potential to serve as a filler that improved the mechanical properties of composites. In this study, the composite material used consisted of gonggong shell powder as a filler in the composite material (Material & Energi, 2023); (Nayan & Hafli, 2022). Gonggong shell powder was used as an alternative filler material in composites due to its local availability and high calcium carbonate ($CaCO_3$) content. Marine animal shells, such as clams and snails, were shown to contain more than 90% $CaCO_3$, which contributed to improving the mechanical properties of composites (Suci Fitriani Sammulia, Hasyrul Hamzah, Chaerul Fadly Mochtar & Oktaviani, 2021). Based on previous studies, composites made from clam shells and siput sedut shells exhibited compressive strength higher than the standard specified by the Biro Klasifikasi Indonesia, making them suitable for application as deck lamination materials to enhance durability and extend the service life of ships (Thahir, 2024) (Hery Sunarsono1), Taufiq Rahman2), Yopy Mardiansyah3), 2023). To improve mechanical properties such as tensile strength, the addition of additives such as polypropylene was required.

Polypropylene was a thermoplastic polymer that had good tensile strength and heat resistance, so it could function as a matrix or binder in composites. As a comparison, commercial calcium carbonate filler was used, which was one of the most common filler materials in the production of thermoplastic composites such as polypropylene. This selection was based on its widespread use in industry and its ability to improve the mechanical strength of composite materials (Liao et al., 2020). The concentration of added polypropylene was expected to influence the tensile strength characteristics of the gonggong shell powder composite material (Rahmiati et al., 2024). Therefore, an analysis was conducted to determine the effect of variations in polypropylene concentration on the tensile strength of the composite. This study was expected to produce an optimal formulation that combined gonggong shell powder and polypropylene to obtain a composite material with good tensile strength as a filler (Abral, Ariksa, Mahardika, Handayani, Aminah, Sandrawati, Pratama, et al., 2020); (Sunarsono et al., 2024); (Abral, Ariksa, Mahardika, Handayani, Aminah, Sandrawati, Sapuan, et al., 2020); (Abral et al., 2022). The problem formulation in this study focused on the effect of variations in the concentration of added polypropylene on the tensile strength characteristics of gonggong shell powder composite material, and on determining which concentration of polypropylene addition produced the optimal tensile strength for the composite as a filler.

The urgency of this study arose from the fact that shell waste was often an environmental problem because it was underutilized and simply discarded. This led to the accumulation of shell waste, which could pollute the environment if not properly managed. Therefore, efforts were needed to utilize this shell waste so that it was not wasted and did not cause negative environmental impacts (Brebu, 2020). One solution that could be applied was to utilize shell waste, particularly gonggong shells, as a raw material in the production of composite materials. The development of environmentally friendly composite materials based on gonggong shell powder combined with polypropylene had the potential to produce sustainable and eco-friendly materials. The use of materials derived from renewable natural resources like this helped reduce dependence on non-renewable resources, which were limited in availability (Rahmiati et al., 2024); (Rahmiati et al., 2023). By using composite material based on gonggong shell powder as a filler, this study not only contributed to efforts to utilize shell waste but also reduced the environmental impact caused by its accumulation. In addition, the use of shell waste in the production of composite materials served as an initial step toward the development of a circular economy, in which waste was processed into value-added products (Simatupang, 2019); (Mahendra et al., 2023); (Islamiyah et al., 2021).

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METHOD

The study was conducted from May to December 2025 using a quantitative method. The samples used were gonggong shells from the Arcidae family, with the scientific name Laevistrombus canarium, which were analyzed at the Chemistry Laboratory of Institut Teknologi Batam and the Integrated Laboratory of Universitas Negeri Padang.

The stages of the composite material fabrication process using gonggong shell as the raw material were as follows: (1) the collected samples were cleaned and separated from the flesh and shells; (2) the shells were sun-dried and oven-dried to remove their moisture content; (3) the dried shells were ground using a grinder machine; (4) they were then sieved using a mesh to obtain gonggong shell powder; (5) the shell powder was mixed with polypropylene using four variations of shell content, namely 2.5%, 5%, 7.5%, and 10%, based on the polypropylene composition.

Procedure

Preparation Sample

Field observations were conducted to identify gonggong shell waste in seafood restaurants in Batam City. A literature study was carried out by selecting the research object, namely gonggong shells. The shell preparation process was conducted by washing the shells, followed by drying them under sunlight. After that, they were oven-heated at a temperature above 500 °C. The shells were then crushed using a grinding process to obtain nanoscale particles. The crushed shells were prepared and subsequently stored in sample plastic bags.

Material Powder Content Analysis

The elemental content analysis of gonggong shells was conducted using Field Emission Scanning Electron Microscopy–Energy Dispersive Spectroscopy (FESEM-EDS) to observe the morphology and elemental composition on the sample surface at the Integrated Laboratory of Universitas Negeri Padang. Furthermore, the chemical composition of the gonggong shells was analyzed using the X-Ray Fluorescence (XRF) method.

Effect of Polypropylene Addition on Gonggong Shell Composite Material

The gonggong shell powder containing calcium was mixed with polypropylene resin at various concentration levels using ultrasonication. The polypropylene concentrations used were 2.5%, 5%, 7.5%, and 10%. The mixing process was carried out until a homogeneous mixture was obtained. The homogeneous samples were then poured into molds to form specimens for testing, followed by a curing process.

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Subsequently, tensile testing was conducted by cutting the composite specimens according to standard tensile test specifications, and each specimen was tested based on different polypropylene concentration variations. After that, data such as maximum tensile strength, elongation, and elastic modulus were recorded. The data obtained from the tensile tests were analyzed using ANOVA. This analysis was performed to determine the significant effect of polypropylene concentration variations (2.5%, 5%, 7.5%, and 10%) on the composite material as a filler.

RESULTS AND DISCUSSION

The results of this study included several aspects that were aligned with the methods used in the study entitled 'The Effect of Variations in Polypropylene Concentration on the Tensile Strength Characteristics of Gonggong Shell Powder Composite as a Filler,' carried out in several stages. The initial stage of this study was a field observation conducted to identify gonggong shell waste. The sample preparation stage began with the collection of gonggong shell waste obtained from various seafood restaurants and food stalls in the surrounding area. The gonggong shells used were the waste that had been completely separated from the shell meat. The collection process was carried out selectively by choosing shells that were still intact and not damaged to ensure optimal raw material quality. The shape of the gonggong shells could be seen in Figures 1 and 2, which showed the gonggong shell processing stages.

Figure 1. The cleaning process of gonggong shell material

(a) (b)

Figure 2. (a) Soaking of gonggong shell material in NaOH;
(b) Oven-drying of gonggong shell material

After collection, the gonggong shells were cleaned of remaining flesh, mucus, and adhering impurities using running water and a soft brush. This cleaning process aimed to remove organic materials that could interfere with subsequent processes and prevent contamination. The sterilization process was carried out by soaking the cleaned gonggong shells in a 0.1 M sodium hydroxide (NaOH) solution for 2 × 24 hours at room temperature. The NaOH solution functioned as an effective sterilizing agent to eliminate pathogenic microorganisms, bacterial spores, and residual organic proteins that might still adhere to the shell surface. During the soaking process, the NaOH solution dissolved the remaining organic components and destroyed microorganisms through protein denaturation, ensuring that the shells were sterile and free from contaminants. After sterilization, the shells were rinsed repeatedly with sterile distilled water until the pH returned to neutral. The drying process of the gonggong shells was conducted using an oven at a temperature of 40–50°C for 24 hours to remove all remaining moisture after sterilization. This temperature range was selected because it was sufficiently high to evaporate water effectively without damaging the calcium carbonate ($CaCO_3$) mineral structure, which was the main component of the shells. During drying, the shells were placed on aluminum trays and evenly spread to ensure uniform heat distribution across the entire surface. This process aimed to reduce the moisture content to an optimal level (moisture content < 5%) required for the next stage, while also making the shells more brittle and easier to crush. After drying, the shells were allowed to cool in a desiccator to prevent moisture absorption from the air before proceeding to the grinding process.

The grinding process of the dried gonggong shells was carried out using a high-speed grinder to produce fine and uniform particles. The shells, which had become brittle after drying, were crushed gradually by controlling the grinding speed and duration to prevent overheating that could damage the mineral structure. After grinding, the resulting shell powder was sieved in stages, using meshes of various sizes, starting with mesh 200 (75 µm), mesh 60 (250 µm), and mesh 100 (150 µm) to obtain particle fractions of the desired size. The sieving process was conducted manually with consistent shaking for 15–20 minutes at each mesh level to ensure optimal particle separation. The shell powder that passed through mesh 60 was then collected and stored in an airtight container as ready-to-use raw material for further applications, while the retained particles were reground until the desired size was achieved. The grinding and sieving processes were shown in Figure 3.

(a) (b) (c)

Figure 3. (a) Grinding of gonggong shells using a grinder, (b) Sieving using mesh, (c) Gonggong shell material in powder form

After the grinding and sieving processes, gonggong shell powder that was ready for application was obtained. The next step involved identifying the elemental composition of the gonggong shell powder using the X-Ray Fluorescence (XRF) method. The chemical composition analysis of the gonggong shell using XRF showed that the main component was calcium oxide (CaO), with a very high content reaching 65.108%, indicating the dominance of calcium carbonate ($CaCO_3$) as the primary mineral. Other compounds detected included Na_2O at 0.476%, SrO at 0.450%, and Fe_2O_3 at 0.160%. The high calcium content in gonggong shells made them a potential natural source of calcium carbonate for various industrial applications, such as raw materials for cement production, fillers in the paper and plastic industries, and calcium supplements in the animal feed industry. The calcium content in gonggong shells was illustrated in the graph shown in Figure 4.

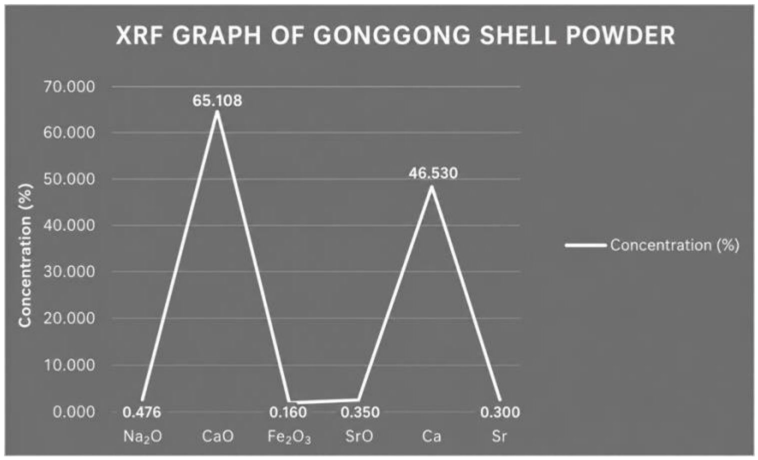

Figure 4. Composition of gonggong shell powder analyzed by XRF

Based on the graph above, it was explained that the shells contained a high amount of calcium carbonate, making them a potential filler to improve the mechanical properties of composites. In this study, the composite material used consisted of gonggong shell powder as a filler in the composite material (Material & Energi, 2023); (Nayan & Hafli, 2022). Gonggong shell powder was used as an alternative filler material in composites due to its local availability and high calcium carbonate ($CaCO_3$) content. Marine animal shells such as clams and snails were shown to contain more than 90% $CaCO_3$, which contributed to improving the mechanical properties of composites (Suci Fitriani Sammulia, Hasyrul Hamzah, Chaerul Fadly Mochtar & Oktaviani, 2021). Composite materials became a popular choice in various industrial applications due to their good mechanical properties, lightweight nature, and ease of processing (M et al., 2022); (Sunarsono et al., 2023). One type of composite material that attracted attention was composites used as fillers derived from renewable natural resources such as shell waste (Nayiroh & Kusairi, 2021). This was also supported by data obtained from the FESEM-EDS method to observe the surface morphology of the shell material and the most dominant elemental composition, as shown in Figure 5:

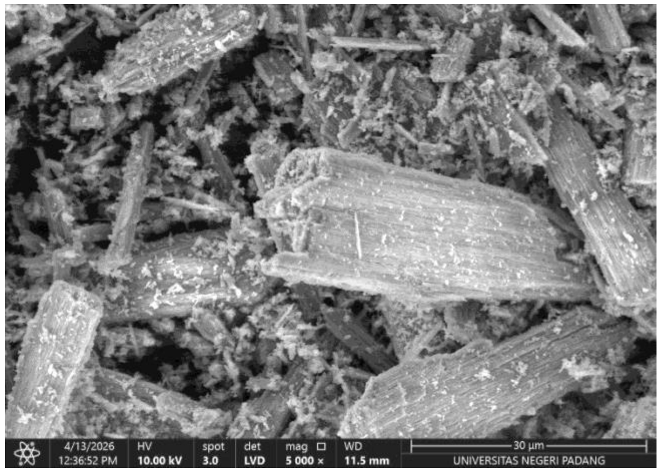

Figure 5. Surface morphology of gonggong shell powder

Polypropylene was a thermoplastic polymer that had good tensile strength and heat resistance, so it could function as a matrix or binder in composites. As a comparison, commercial calcium carbonate filler was used, which was one of the most common filler materials in the production of thermoplastic composites such as polypropylene. This selection was based on its widespread use in industry and its ability to improve the mechanical strength of composite materials (Liao et al., 2020). The concentration of added polypropylene was expected to influence the tensile strength characteristics of the gonggong shell powder composite material (Rahmiati et al., 2024) (Oladele et al., 2025). Therefore, an analysis was conducted to determine the effect of variations in polypropylene concentration on the tensile strength of the composite. This study was expected to produce an optimal formulation combining gonggong shell powder and polypropylene to obtain a composite with good tensile strength as a filler (Abral, Ariksa, Mahardika, Handayani, Aminah, Sandrawati, Pratama, et al., 2020); (Sunarsono et al., 2024); (Abral, Ariksa, Mahardika, Handayani, Aminah, Sandrawati, Sapuan, et al., 2020); (Abral et al., 2022).

Tensile testing was conducted on composite specimens with variations in polypropylene (PP) concentrations of 2.5%, 5%, 7.5%, and 10% in accordance with the ASTM D638, as shown in Table 1:

Table 1. Variations in PP concentration with gonggong shell powder

Seri	Target (%)	Polypropylene (PP) (gram)	Powder of gonggong shell (gram)
A	0%	0	96,5
B	2,5%	2,5	94
C	5%	5	91,5
D	7,5%	7,5	89
E	10%	10	86,5

The average test results showed tensile strength values of 30.30 MPa (2.5%), 35.03 MPa (5%), 32.50 MPa (7.5%), and 28.38 MPa (10%), as shown in Figure 10. The statistical test results (ANOVA) indicated that there were significant differences among the treatments ($p < 0.05$). The combination of test results showed that an optimum composition occurred at a concentration of 5%. At this concentration, the best balance was achieved between maximum tensile strength, increased stiffness, and sufficient elongation at break to maintain the material's toughness. Concentrations above and below 5% led to a decrease in tensile properties because the filler tended to agglomerate, creating weak points in the matrix (Webb et al., 2024), as shown in Figure 6.

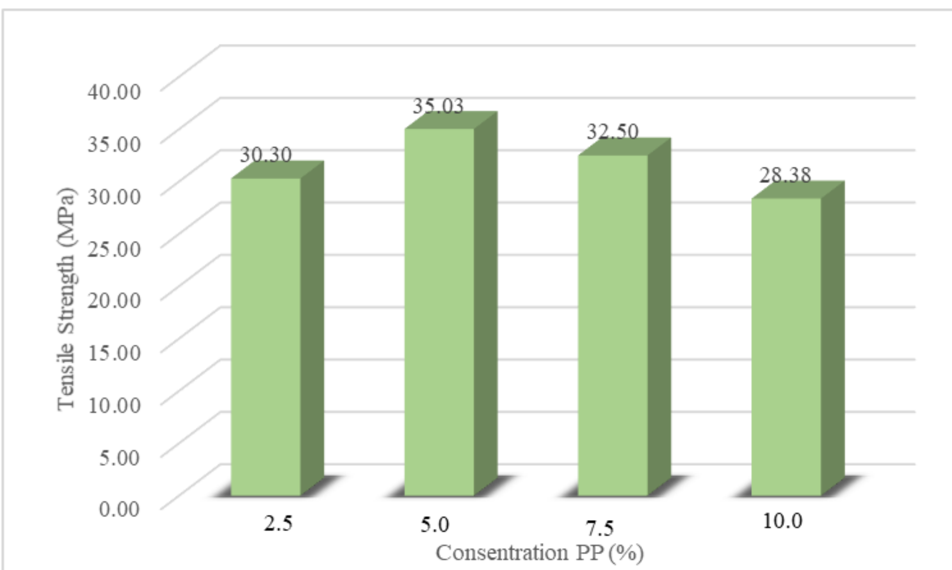

Figure 6. Tensile strength of gonggong shell powder composite reinforced with PP.

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CONCLUSION

The study on the effect of variations in polypropylene concentration on composite material based on gonggong shell powder showed that gonggong shells contained a high amount of calcium carbonate, making them a potential eco-friendly filler material. The tensile test results demonstrated a significant effect of polypropylene concentration variation on the tensile strength of the composite, with an optimal value of 35.03 MPa at a concentration of 5%. This formulation provided the best balance between strength, stiffness, and toughness of the material. Therefore, composites based on gonggong shell powder and polypropylene had the potential to be further developed as sustainable and competitive alternative materials for industrial applications.

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