# Composite bulletproof vest reinforced rubberized coir

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**Abstract.** Bulletproof vests are safety protective equipment commonly used by the police, military, security agencies and people who are at risk of being shot targets. This study aims to create a bullet rate-resisting composite material from rubberized coir (sebutret) as a substitute for Kevlar with a cheaper and more economical price. In this study, the specimen used was a combination of a resin composite reinforced with coconut fiber and rubber latex. Then for data collection using the Brinell hardness test, the Charpy method impact test and the ballistic firing test. Then analyze the data from the results of the hardness test, impact test and firing test. Based on the results of the hardness test, it has the highest average of 22.86 BHN at a mixed variation of 40%, the result of the impact test has the highest average of 0.087 J/mm2. So it can be concluded that the 40% mixture variation is best used for making bulletproof vest panels. The results of the firing test showed that the 40% mixture variation of 1-ply panels was able to withstand the rate of bullet rotation because the mixture of resin and coconut fiber was stronger and denser.

Keywords: bulletproof vest, rubberized coir, ballistic test.

## 1. Introduction

Bulletproof vests are personal protective clothing and safety support tools commonly used by the police, military, security forces and people who are at risk of being shot targets in various countries [1]. The purpose of wearing a bullet-proof vest is to maintain the safety of body parts, especially in the chest, stomach and back from hot lead or bullet projectiles and prevent being hit by explosive debris [2].

Initially, these bullet-proof plates were made of metal, but since the introduction of *Kevlar* by *DuPont* in 1965, the innovation of bullet-proof plates made of composites has the advantage of being able to withstand the energy generated from ballistic collisions [3]. In the preparation of bulletproof vests, these fibers can be combined with certain resins to increase their ballistic capabilities. Most of the bullet-proof vest materials used in Indonesia are made from *Kevlar* and *Dyneema*, but these materials are difficult to find on the market [4]. Therefore, until now the fulfillment of the need for bullet-proof vests is still very dependent on foreign countries, because of this dependence the price of bullet-proof vests is very expensive.

To get a good bulletproof vest, a composite material from Kevlar is usually used. Composite is a combination of two or more materials that have material properties that are impossible for each of its components to have [5]. In a more in-depth definition, especially in engineering composites, it is defined based on the level of definition. At *elemental* or elementary level, where molecules and crystal cells are still single, all mixed materials of two or more dissimilar atoms can be considered as composites. In this definition a composite consists of a mixture, be it a metal alloy, a polymer or a mixture of both.

Composites now use a lot of natural fibers to replace synthetic fibers that are difficult to break down [6].environmental concerns and increasing awareness of renewable green resources have led to many efforts to provide composite products with environmentally friendly and biodegradable materials for the next generation. The increased use of natural materials in composites has led to a reduction in

greenhouse gas emissions. In addition to the benefits derived from natural materials, there are several problems encountered in the manufacture of composites from natural fibers, such as poor compatibility between natural fibers and the reinforcing matrix and the relatively high water absorption of natural fibers [7].

Several studies on metal replacement materials that are resistant to strong and compressive properties have been carried out. Material selection is not also for its function, but also price, manufacturing process, availability of materials and ease of maintenance. By considering the weakness of *Kevlar* , which is very expensive and difficult to find on the Indonesian market [8], it is necessary to develop and try to find materials with cheaper and more economical prices. One of the materials that will be developed as a substitute for Kevlar in bullet-proof vests is coconut fiber. Apart from being abundant in nature, coconut fiber is also very strong, so it is hoped that it can replace Kevlar fiber in the manufacture of the vest. To increase the strength of the coconut fiber, rubber sap will be added so that in some areas in Indonesia this mixture is called a butret, or coconut fiber and rubber latex [9].

As the name implies, a sling is coconut fiber and rubber latex or coconut fiber of the appropriate size (length, width and height/thickness) that is desired, sprayed with a compound using an air silencer gun driven from a compressor and dried with vulcanization oven and sunlight [10]. While latex is a thick rubber sap, often similar to milk, which is produced by many plants and freezes when exposed to free air. Consists of rubber particles and non-rubber materials dispersed in water. The function of the latex in this fiber is as a binder of coconut fibers to make it elastic and strong. Because latex has high friction and tear resistance [11].

## 2. Research Methodology

In this study, the specimen used was a combination of a resin composite reinforced with coconut fiber and rubber latex. Then the data analysis for data collection using the Brinellimpact Charpy firing test ballistic

a) Hardness test

   This test is defined as penetration resistance and provides a quick indication of the deformation behavior. Hardness test equipment generally presses a small ball, pyramid or cone on the surface of the specimen with a certain load size and the hardness number (Brinell, Rockwell or Vikers diamond pyramid) is used by the diameter of the trace.

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   Impact test is washing using rapid loading. Impact testing is a test that measures the resistance of the load to shock loads.

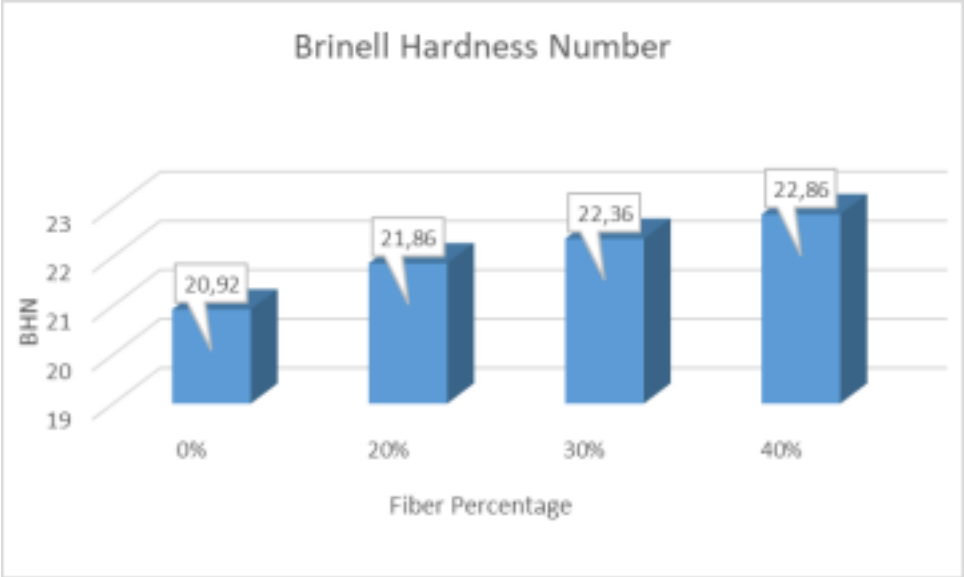
c) Shooting test

   The shooting test used is the ballistic firing test. Ballistic firing test is a science that studies the travel of a bullet (projectile) when fired from a weapon. The journey includes traveling inside the barrel of the weapon (internal ballistic), traveling in the air until it hits the target (external ballistic) and traveling to the target until penetration (terminal ballistic).

## 3. Results And Discussion

### 3.1. The average value of hardness

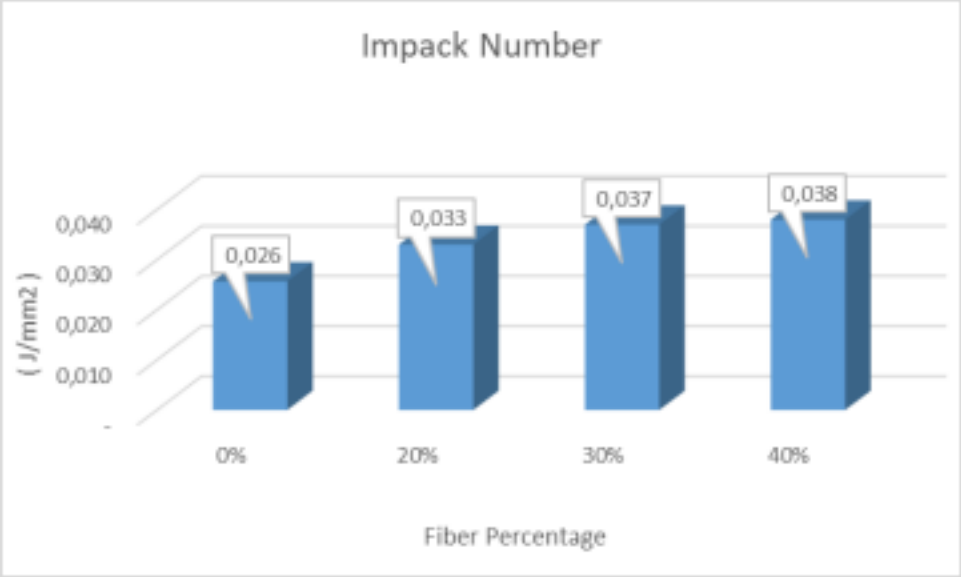
In graph 1. Below shows the graph of the hardness test for polyester composite materials reinforced with coconut fiber and rubber sap which has an average hardness value of 0% mixture variation of 20.92 *BHN*, in mixed variations 20% there was an increase of 21.86 *BHN*, there was an increase again in the 30% mixture variation of 22.36 *BHN*, and an increase again in the 40% mixture variation of 22.86 *BHN*. Then it can be analyzed that the highest average value of hardness is in the 40% mixture variation of 22.86 BHN and the lowest average value is in the 0% mixture variation of 20.92 *BHN*.




Graph 1. Average hardness value

### 3.2. Average impact

Graph 2. Shows that the impact test graph of polyester composite materials reinforced with coconut fiber and rubber latex can be analyzed for mixed variations of 0% having an average value an average of 0.059 J/mm$^2$, in the 20% mixture variation there was an increase of 0.075 J/mm$^2$, at the 30% mixture variation there was another increase of 0.085 J/mm$^2$ and there was another increase in the 40% mixture variation which was 0.087 J/ mm$^2$. Then it can be analyzed that the highest average value of the mixed variation of 40% is 0.087 J/mm$^2$ and the lowest average value of the 0% mixture is 0.059 J/mm$^2$.




Graph 2. Average Impact Value

### 3.3. Shoot test

A. Front view image


B. Rear view image

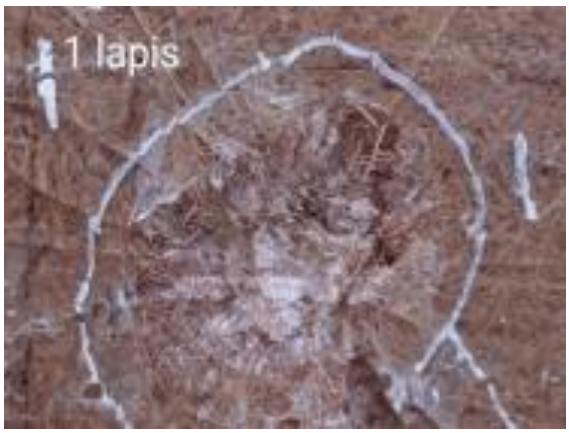



Figure 1


Figure 2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a) Figure 1. The front view of the 1 layer panel can be analyzed that the polyester resin composite material reinforced with coconut fiber and rubber latex in the mixed variation panel of 40% 1 layer is capable of withstand the rate of bullet rotation or not impenetrable by type 38 Special bullets from revolver weapons with a speed of 220 m/s and the moment of penetration / impact of bullets against the panel is 5.148 kg.m/s. The 1-ply panel on the back can be analyzed that the resin liquid permeates and fills the entire cavity of the pores of the coconut fiber layer, making the coconut fiber denser and stronger to withstand the rate of bullet rotation.
b) Figure 2. 2-layer panel, front view, it can be analyzed that the polyester resin composite material reinforced with coconut fiber and rubber latex in the 40% 2-layer mixed variation panel has not been able to withstand the rate of bullet rotation or can still be penetrated by type 38 Special bullets from Revolver weapons at high speed. 220 m/s and the moment of penetration / impact of the bullet against the panel is 5.148 kg.m/s. The back view of the 2-layer panel can be analyzed that the cause of the 40% 2-layer mixed variation panel can still be penetrated by the bullet, namely the resin liquid that was originally poured on the coconut fiber has seeped and filled the pore cavities in the coconut fiber, squeezed out of the fiber pore cavity. coconut fiber, due to the pressure treatment from the press to suppress the thickness and density of the coconut fiber, so only a little resin permeates the coconut fiber, which results in a lack of strength and density in the coconut fiber to withstand the rate of bullet rotation.

c) Figure 3. 3-layer panel, front view, it can be analyzed that the composite material of polyester resin reinforced with coconut fiber and rubber latex at a mixed variation of 40% 3-layer has not been able to withstand the rate of bullet rotation or can still be penetrated by type 38 Special bullets from Revolver weapons with a speed of 220 m/s and the moment of penetration / impact of the bullet against the panel is 5.148 kg.m/s. The back view of the 3-layer panel can be analyzed that the cause of the 40% 3-layer mixed variation panel can still be penetrated by the bullet, namely the resin liquid that was originally poured on the coconut fiber has seeped and filled the pore cavity in the coconut fiber, squeezed out of the fiber pore cavity. coconut fiber, due to the pressure treatment from the press to suppress the thickness and density of the coconut fiber, which resulted in a lack of strength and density in the coconut fiber in holding the bullet round rate. In Figure 6. the back view of the 3-layer panel is clearly visible that the resin liquid only seeps in the front.

## 4. Conclusion

4.1. After analyzing the data from the hardness and impact tests, the variation of the mixture that is suitable to be used as the main material for the bullet proof vest panel specimen in this study is a 40% mixture variation, because this 40% mixture variation gets the highest hardness value of 23,212 BHN and the highest hardness value is 23.212 BHN. the highest impact is 0.040 J/mm$^2$.

4.2. From the results of the analysis after the firing test, that the mixed variation of 40% 1 layer bullet proof vest panel is stronger to withstand the bullet, because in this 1 layer bullet proof vest panel, more resin liquid permeates and fills the entire cavity of the coconut fiber pores , so that the coconut fiber becomes denser and stronger to withstand the bullet. While the 2-layer and 3-layer bulletproof vest panels have not been able to withstand the bullets, because in this 2-layer and 3-layer bulletproof vest panel, the pore cavities in the coconut fiber are not completely filled with liquid resin due to pressure treatment from the tool press which aims to suppress the thickness of the coconut fiber to make it thinner and denser. So, the resin which originally seeped into the pores of the coconut fibers is squeezed out due to the pressure treatment on the coconut fibers, thus making the 2-layer and 3-layer vest panels not strong enough to withstand the bullet rate

## 5. Daftar Pustaka


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*by* Similaritas Uji

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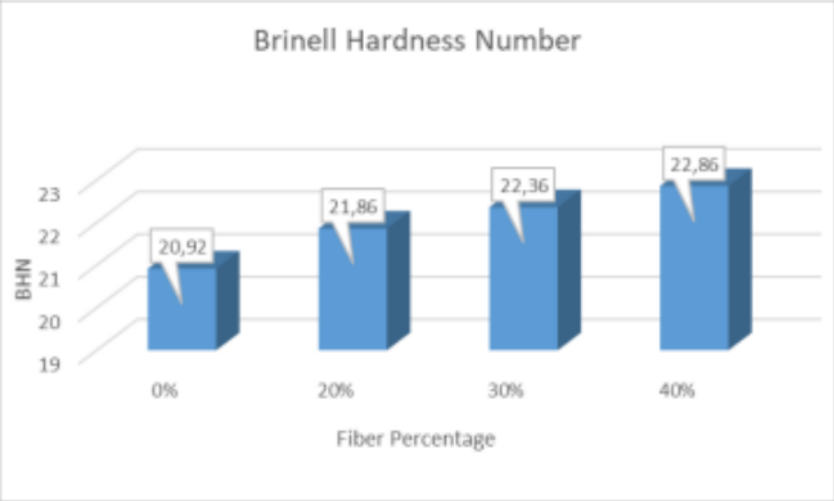


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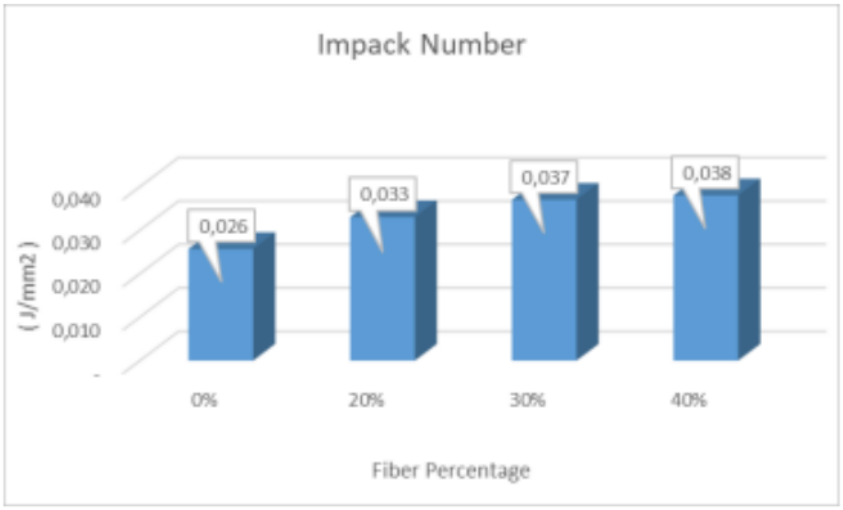
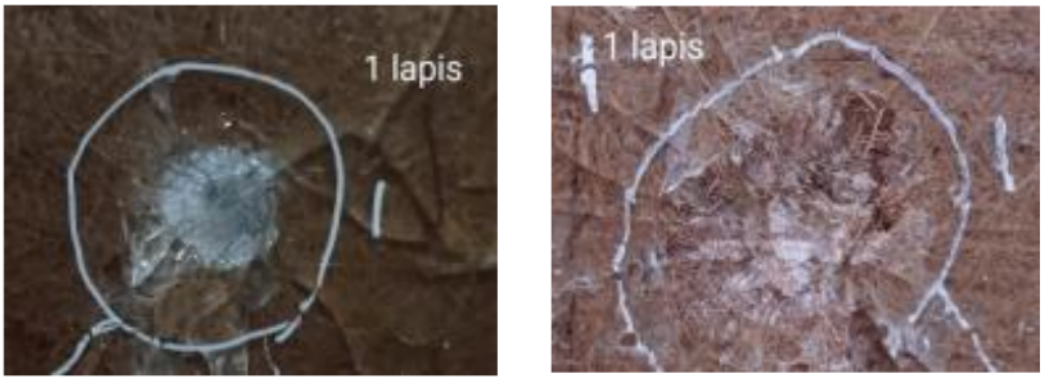



Graph 2. Average Impact Value

### 3.3. Shoot test

A. Front view image

B. Rear view image

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