

# The Effect of Mass Fraction of Rice Straw Fiber on the Mechanical Properties and Water Absorption of Cassava Starch Biocomposite

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DOI: <https://doi.org/10.30880/ijie.2025.17.04.007>

## Article Info

Received: 10 October 2024

Accepted: 7 April 2025

Available online: 30 August 2025

## Keywords

Rice straw fiber, mechanical properties, water absorption, egg tray, SEM

## Abstract

The massive use of plastic packaging has a detrimental impact on the environment. Alternative solutions are needed, such as replacing plastic with biocomposites. In this study, biocomposites were made from rice straw fiber and cassava starch using the solution casting method. The mass fraction of rice straw fiber was varied at 74%, 78%, 82%, 86%, and 90%. To determine the characteristics of the biocomposites, tensile testing, bending testing, water absorption testing, macro observation, and Scanning Electron Microscope (SEM) observation were conducted. The results showed that as the mass fraction of rice straw fiber increased, the mechanical properties of the biocomposites decreased and water absorption increased. The ultimate tensile strength, tensile modulus, and elongation at break in the tensile test decreased by 79.95%, 66.65%, and 40.45%, respectively. The bending test results showed a decrease in flexural strength and flexural modulus by 78.53% and 70.37%, respectively. The water absorption test results showed an increase in water absorption by 49.1%. Macro and SEM fracture morphology observations revealed the presence of voids, agglomeration, and fibers pulled out of the matrix due to weak interfacial bonding, which caused the low mechanical properties and high-water absorption. This study also compared rice straw fiber/cassava starch biocomposites with commercial egg tray samples. The results indicated that rice straw fiber/cassava starch biocomposites have superior mechanical properties and lower water absorption, suggesting their potential use as biocomposite packaging products.

## 1. Introduction

Recently, the use of plastic packaging has been very massive. Plastic packaging is widely used in packaging activities with the aim of protecting the contents in the packaging from external factors that can damage it [1]. The advantages offered by plastic packaging are that it is light, flexible, strong, water resistant and cheap [2]. Even though it is considered practical and economical, the use of plastic packaging on a large scale can have a detrimental impact on the environment and human health. The main problem is because plastic packaging has a very long ability to decompose naturally [3], even taking tens to hundreds of years [4]. Therefore, efforts are needed to overcome this problem. One effort that can be made is to reduce or replace plastic packaging products with environmentally friendly packaging products, for example biocomposites [5]. Biocomposites are composites composed of a combination of matrix and reinforcement, both of which are biodegradable [6].

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Biocomposites can be made from natural materials such as plant fibers as reinforcement and starch as a matrix. These materials are very abundant in nature and can be renewed [7]. One of the plant fibers that is very abundant and easy to find is rice straw fiber. The use of rice straw fiber is usually not utilized optimally and if left alone it will only become waste. In fact, rice straw fiber has the potential to be used as a reinforcement in biocomposite materials. The advantages of rice straw fiber as reinforcement are that it is light, strong and biodegradable [8]. Meanwhile, the matrix chosen for making biocomposites can use cassava starch. In terms of tensile strength and water resistance values, in previous research [7], cassava starch had better tensile strength and water resistance values compared to sago starch [9], corn starch [10], and yam starch [11]. Rice straw fiber can be used as pulp in making biocomposite packaging, for example by making egg tray packaging, the main component of which is usually made from recycled paper [12]. To increase the binding ability or adhesion of natural fibers to one another, a cassava starch matrix can be used [13].

The manufacture of biocomposites based on cassava starch reinforced with rice straw fiber will have potential to be developed for packaging product applications. This research was carried out to determine the characteristics of biocomposites made by varying the mass fraction of rice straw fiber and cassava starch so that the effect on their characteristics can be determined through tensile testing, flexural testing, water absorption testing, macro observations and Scanning Electron Microscope (SEM) observations. By conducting this research, it is hoped that it can provide an alternative solution to minimize the use of plastic packaging products by replacing them with environmentally friendly biocomposite packaging products.

## 2. Research Methodology

### 2.1 Material

The materials are as following: rice straw fiber, cassava starch, Sodium Hydroxide (NaOH) (technical), distilled water, and glycerol.

#### 2.1.1 Preparation of Rice Straw Fiber

Rice straw is washed thoroughly with running water and dried in the oven until constant weight, then cut into small pieces measuring ~1 cm. The alkalization process was carried out using a 5% NaOH solution concentration at a temperature of 60°C for 1 hour. The ratio between rice straw and NaOH solution is 1:10. Alkalized rice straw fibers are cleaned with distilled water until the pH is neutral, then dried in an oven until constant weight. The dried rice straw fibers were ground with an ice blender at 10,000 rpm for 10 minutes. The fine fiber is stored in a plastic clip.

#### 2.1.2 Preparation of Rice Straw Fiber/Cassava Starch Biocomposites

The initial stage is weighing ingredients such as cassava starch, rice straw fiber, glycerol, and distilled water according to the mass fraction calculation used. The glycerol used is 30% of the mass of cassava starch and the distilled water used is 4:1 of the total biocomposite material. These ingredients were put into a glass beaker and stirred for 5 minutes at 200 rpm using a mixer. The hot plate is turned on at a temperature of 60°C, then the ingredients are heated and stirred again at 200 rpm for 30 minutes until they gelatinize. The finished dough is then poured into a glass mold, then dried in the oven at a temperature of 50°C until the weight is constant. The finished specimens were cut and shaped in accordance with ASTM D638 type IV for tensile testing, ASTM D790-17 for flexural testing, and ASTM D570-22 for water absorption testing. The specimens tested contained six types of samples, five samples from varying mass fractions of rice straw fiber with cassava starch matrix (74% : 26%, 78% : 22%, 82% : 18%, 86% : 14%, and 90% : 10%), and another sample from egg tray products on the market. The number of specimens made for one variation was three specimens, so the total specimens for each test in the tensile test, flexural test and water absorption test amounted to 18 specimens.

### 2.2 Tensile Testing

Tensile testing was carried out to determine the ultimate tensile strength, tensile modulus, and elongation at break values of the rice straw fiber/cassava starch biocomposite. This test uses a Universal Testing Machine model HT-2402 with a crosshead speed of 1 mm/minute carried out at room temperature. The tested specimens were formed according to ASTM D638-14 type IV. The tensile test was carried out three times for each sample.

### 2.3 Flexural Testing

Flexural testing was carried out to determine the flexural strength and flexural modulus values of the rice straw fiber/cassava starch biocomposite. This test uses a Universal Testing Machine model HT-2402 with a crosshead speed of 1 mm/minute carried out at room temperature. The tested specimen was formed according to ASTM

D790-17 with dimensions of 127 mm (w) × 12.7 mm (w) × 3.2 mm (t). The support span ratio used is 16:1 to the specimen thickness. The samples tested for flexure were repeated three times for each sample.

## 2.4 Water Absorption Testing

Water absorption testing was carried out to determine the water absorption capacity of the rice straw fiber/cassava starch biocomposite. This test refers to ASTM D570-22. The specimen was formed to the dimensions of 76.2 mm (w) × 25.4 mm (w) × 3.2 mm (t). This test is carried out by placing the specimen in an oven first at a temperature of 50°C for 24 hours until the weight is constant to ensure that there is no free water content. Followed by weighing the specimen for the initial mass, then the specimen was soaked in distilled water for 5 minutes at room temperature. When the soaking time has been determined, the specimen is removed and the surface dried using tissue or a dry cloth, then the final mass weighing process is carried out. The final mass weighed is the water absorbed into the biocomposite. Each sample was tested three times in repetition. The water absorption value is calculated based on Equation (1).

$$\text{Increase in weight (\%)} = \frac{\text{wet weight} - \text{conditioned weight}}{\text{conditioned weight}} \times 100 \quad (1)$$

## 2.5 Macro Observations

Macro observations of the fracture surface of the specimen after the tensile test and flexural test were carried out using a Digital Microscope to determine whether or not there were cavities in the biocomposite and the shape of the fracture indicating fiber pull-out or fiber breakage. Macro observations were carried out using 70 x magnification.

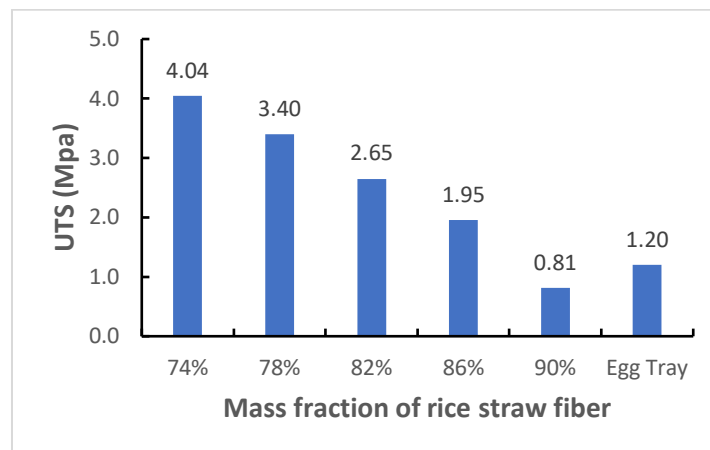
## 2.6 Scanning Electron Microscope (SEM) Observations

Observation of the fracture surface morphology of the specimen after tensile testing was carried out using a Hitachi SU3800 Scanning Electron Microscope (SEM) with a voltage of 5 kV. The tensile test fracture sample was cut and the surface was coated with gold (Au) first with a Hitachi MC1000 Ion Sputter before the imaging process was carried out. Observations were made using 400 x magnification for each specimen.

## 3. Results And Discussion

### 3.1 Tensile Testing

Tensile testing in this research was carried out to determine the properties of the rice straw fiber/cassava starch biocomposite such as ultimate tensile strength, tensile modulus, and elongation at break. Graphs of the tensile test results, such as the ultimate tensile strength, tensile modulus, and elongation at break values, are shown in Figs. 1, 2, and 3 respectively.



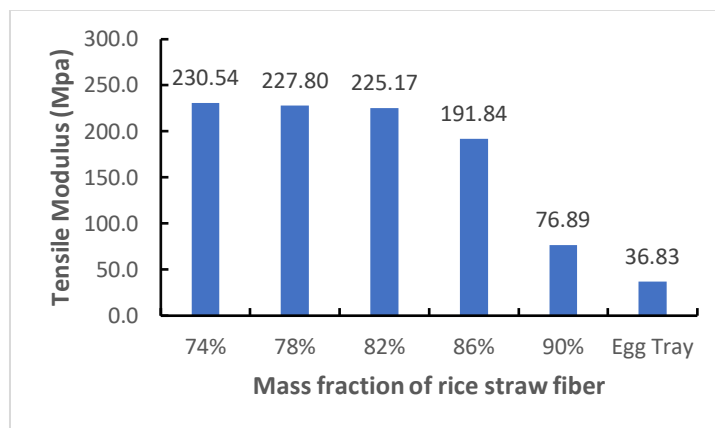
**Fig. 1** Graph of ultimate tensile strength values of rice straw fiber/cassava starch biocomposites and egg tray

Ultimate tensile strength (UTS) is the ability of a material to withstand maximum stress/load before experiencing failure or damage [14]. In Fig. 1 is a graph of the ultimate tensile strength of the rice straw fiber/cassava starch biocomposite and egg tray products. The direction of the graph of the rice straw fiber/cassava

starch biocomposite shows a decreasing graph direction as the mass fraction of rice straw fiber increases. The highest maximum tensile strength value was achieved at 74% fiber mass fraction of 4.04 MPa, while increasing the fiber mass fraction up to 90%, the ultimate tensile strength value obtained was 0.81 MPa, making the ultimate tensile strength value of the rice straw fiber biocomposite/ cassava starch decreased by 79.95%.

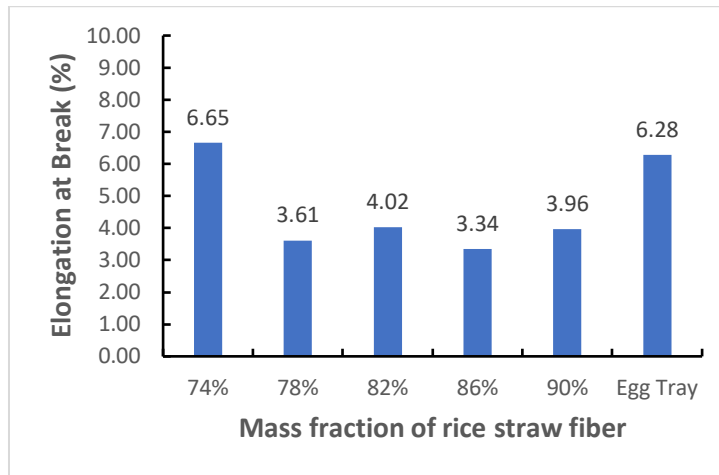
The highest ultimate tensile strength value was achieved at a fiber mass fraction of 74%, because the amount of matrix used was still greater than other variations, so the distribution was still better. The decrease in the ultimate tensile strength value as the fiber mass fraction increases can be caused by several factors such as poor adhesion between rice straw fibers and cassava starch matrix, agglomeration, and the presence of voids in the biocomposite [10]. Too little amount of cassava starch matrix used is also the reason for the low ultimate tensile strength value, because the matrix is not able to bind or wet the fibers completely, thus making the mixture of biocomposite ingredients inhomogeneous or not evenly dispersed [3]. Apart from that, the high fiber content can also cause the formation of agglomeration between fibers. As a result of these factors, when a biocomposite is subjected to a tensile load, the load received is not distributed optimally from the matrix to the fibers, so the value of ultimate tensile strength will decrease [13].

Based on the results of the tensile tests carried out, the rice straw fiber/cassava starch biocomposite was better than the egg tray product in terms of maximum tensile strength, but only at fiber mass fractions of 74%, 78%, 82% and 86%. At 90% fiber mass fraction the strength value is lower at only 0.81 MPa, while the egg tray product is 1.2 MPa. To understand the phenomenon of decreasing ultimate tensile strength values that have been described, Figs. 7 and 9 for their fracture morphology with a Digital Microscope and Scanning Electron Microscope.



**Fig. 2** Graph of tensile modulus value of rice straw fiber/cassava starch biocomposites and egg tray

Tensile modulus or tensile modulus is a measure of how stiff a material is when pulled or stressed [3]. Fig. 2 is a graph of the tensile modulus of rice straw fiber/cassava starch biocomposites and egg tray products. This graph shows the same trend as the ultimate tensile strength graph, where the direction of the graph decreases as the mass fraction of rice straw fiber increases. The highest tensile modulus was achieved at 74% fiber mass fraction of 230.54 MPa, while the lowest value was at 90% fiber mass fraction of 76.89 MPa. From this value, there was a decrease in the tensile modulus value of 66.65%. The decrease in tensile modulus is caused by the same factors as the ultimate tensile strength, namely weak bonds between rice straw fibers and cassava starch matrix, agglomeration and incomplete wetting of the fibers by the matrix, because the number of fibers used is more dominant than the matrix, so that it is not homogeneous and the resulting biocomposite becomes brittle [15]. Apart from that, another factor that causes the tensile modulus value to decrease is the presence of defects such as porosity that occur in the biocomposite during fabrication [16]. When comparing the rice straw fiber/cassava starch biocomposite with the egg tray product in terms of tensile modulus value, the rice straw fiber/cassava starch biocomposite is still higher than the egg tray product which is only 36.83 MPa.

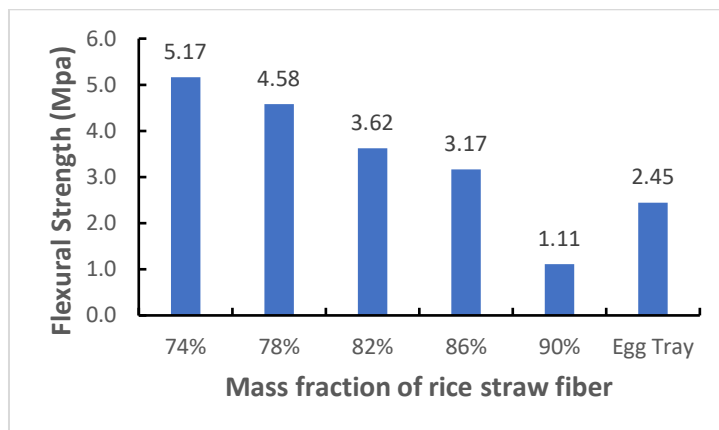


**Fig. 3** Graph of elongation at break value of rice straw fiber/cassava starch biocomposites and egg tray

Elongation at break is a measurement of the percentage change in length of a specimen when the specimen breaks or breaks which is measured in the gauge length area [7]. Fig. 3 is a graph of the elongation at break of the rice straw fiber/cassava starch biocomposite and egg tray products. The graph shows a direction that tends to decrease as the mass fraction of rice straw fiber increases. The highest elongation at break value was achieved at a fiber mass fraction of 74%, while the lowest value was at a fiber mass fraction of 86% with a decrease of 49.77%. This decrease in value can be caused by an excessive increase in fiber content, the presence of voids, and low interfacial interactions between rice straw fibers and cassava starch matrix, so that the biocomposite becomes brittle and the elongation at break value obtained is lower [8]. Apart from that, the graph shows a decreasing trend with the addition of fiber, due to the nature of natural fiber which has a lower strain value compared to the starch matrix [13]. For egg tray products, if you look at the elongation at break value, it shows that the product is quite flexible. Previous research also reported that, the more dominant the number of fibers used, the ultimate tensile strength and tensile modulus values decrease. The factors that cause the decrease in value are due to weak adhesion bonds between the fiber and the matrix and also the occurrence of agglomeration, so that the transfer of stress from the matrix to the fiber is not optimal. Apart from that, the elongation at break value is getting lower because the biocomposite becomes increasingly stiff and brittle as the fiber content increases [3].

### 3.2 Flexural Testing

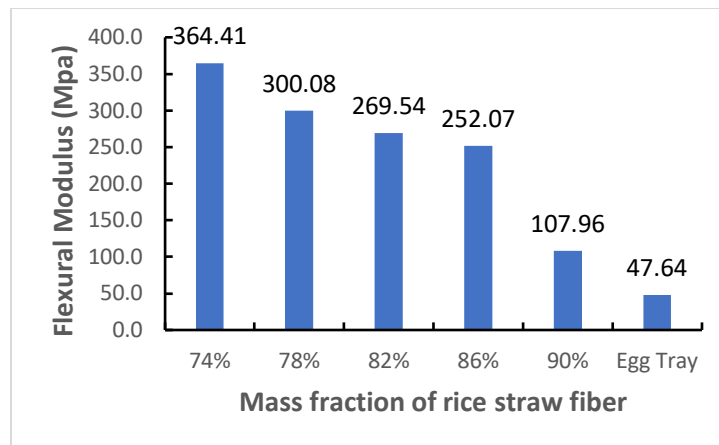
Flexural testing was carried out to determine the properties of the rice straw fiber/cassava starch biocomposite such as flexural strength and flexural modulus. Graphs of the bending tests such as flexural strength and flexural modulus values can be seen in Figs. 4 and 5.



**Fig. 4** Graph of flexural strength values of rice straw fiber/cassava starch biocomposites and egg tray

Flexural strength is the ability of a material to withstand pressure or bending force before experiencing failure or is also known as a measure of the maximum strength that a material can bear when subjected to bending or bending pressure before breaking [17]. Fig. 4 shows a graph of the flexural strength value of the rice straw

fiber/cassava starch biocomposite and egg tray. This graph shows the same trend as the tensile test graph, namely that as the mass fraction of rice straw fiber increases, the value obtained decreases. The highest flexural strength value was obtained at a 74% fiber mass fraction of 5.17 MPa, while the lowest value was obtained at a 90% fiber mass fraction of 1.11 MPa. From this value, the flexural strength value decreased by 78.53%. The decrease in flexural strength values can be caused by several factors, such as excessive rice straw fiber content used, causing the cassava starch matrix to be unable to bind or cover the entire fiber surface properly [7]. Because the amount of matrix used is quite minimal, the dispersion of the two materials making up the biocomposite becomes inhomogeneous and the resulting interfacial bond becomes weak, so that the transfer of stress between the matrix and the fibers becomes poor [5]. Apart from that, the formation of agglomeration and the presence of porosity also causes the flexural strength value to become lower [1]. When compared with the flexural strength values between rice straw fiber/cassava starch biocomposites and egg tray products, rice straw fiber/cassava starch biocomposites are still better, but only at fiber mass fractions of 74%, 78%, 82%, and 86%. At 90% fiber mass fraction, the strength value is lower at only 1.11 MPa, while the egg tray product is 2.45 MPa.

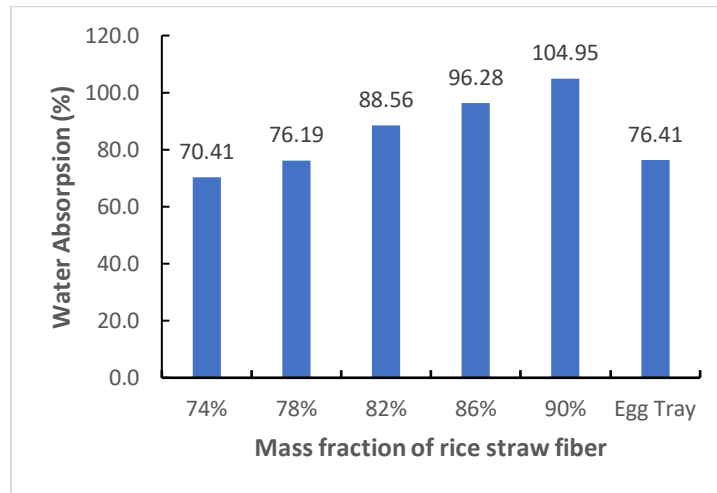


**Fig. 5** Graph of flexural modulus value of rice straw fiber/cassava starch biocomposites and egg tray

Flexural modulus is a measure of the stiffness of a material when subjected to bending stress [7]. Fig. 5 shows a graph of the flexural modulus value of the rice straw fiber/cassava starch biocomposite and egg tray. As the mass fraction of rice straw fiber increases, the value of the graph becomes lower. The highest flexural modulus value was achieved at 74% fiber mass fraction of 364.41 MPa, while the lowest was at 90% mass fraction of 107.96 MPa with a decrease of 70.37%. The factors that cause the decrease in this value tend to be the same as the decrease in the flexural strength value which is caused by too much fiber used, resulting in agglomeration between fibers and the interfacial bond between the fiber and the matrix becomes weak, because the amount of matrix used is too small as a result of which the fiber is not wetting properly, thoroughly and the biocomposite becomes brittle [18]. Based on the results of the flexural tests carried out, the rice straw fiber/cassava starch biocomposite is still superior to the egg tray product, when viewed from the flexural modulus value which is only 47.64 MPa.

### 3.3 Water Absorption Testing

Water absorption testing was carried out to determine the ability of the biocomposite when interacting with a watery or humid environment. Previous research reported that as the content of wheat straw fiber in the cassava starch matrix increases, the water absorption capacity of the biocomposite will decrease. Fiber can function as a barrier agent for water molecules so that they do not easily diffuse into the biocomposite. As the starch content decreases, water absorption decreases, because starch has very high hydrophilicity, so the water absorption ability of the biocomposite decreases. Apart from that, good interfacial bonding between the fiber and the matrix is the main factor in reducing the water absorption value. When the fibers and matrix are tightly bound together, it will be more difficult for water molecules to diffuse and require higher energy [19]. The graph of the data from the water absorption test of the rice straw fiber/cassava starch biocomposite from this research can be seen in Fig. 6.

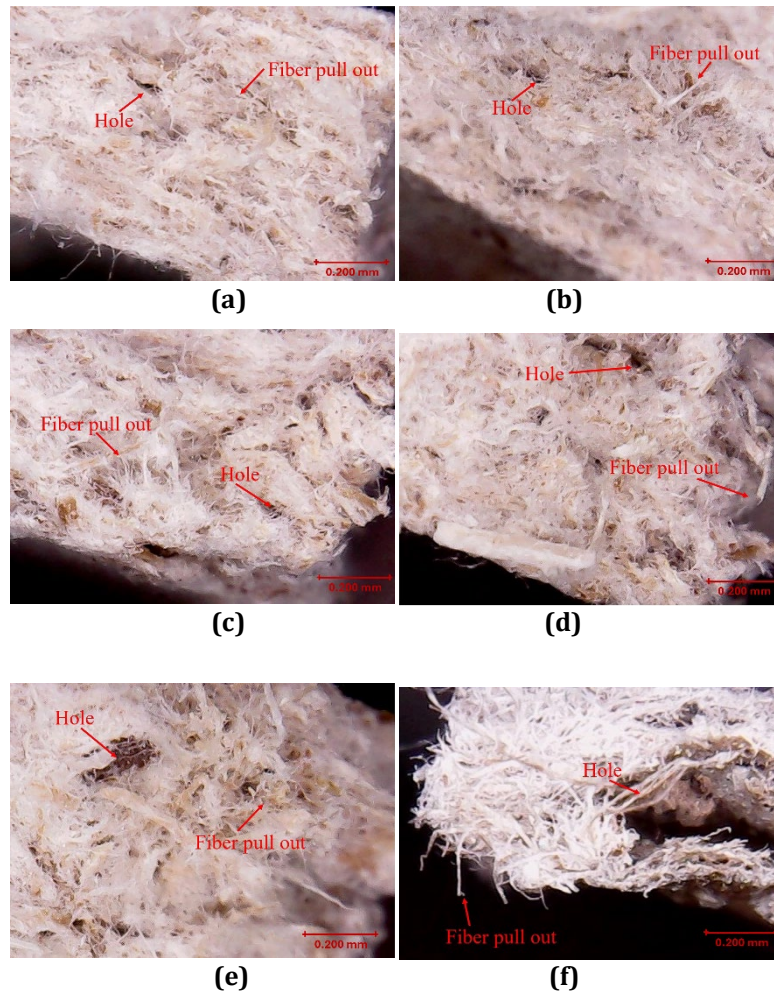


**Fig. 6** Water absorption testing graph of rice straw fiber/cassava starch biocomposites and egg tray

Fig. 6 depicts the graphical results of water absorption testing of rice straw fiber/cassava starch biocomposites and egg tray products. The graph shows an increasing direction as the mass fraction of rice straw fiber increases. The highest water absorption value was obtained at a 90% fiber mass fraction of 104.95%, while the lowest value was at a 74% fiber mass fraction of 70.41%. The increase in water absorption value was 49.1%. The cause of the increasing water absorption value can be caused by poor adhesion between rice straw fibers and cassava starch matrix and poor dispersion between the two materials, so water will be easily absorbed [10]. Apart from that, the presence of pores will also make it easier for water to diffuse into the biocomposite [1]. A similar thing was also reported by previous research which stated that increasing fiber content does not always increase resistance to water absorption. Weak interfacial bonds between the fiber and the matrix, the presence of porosity and free -OH groups in the fiber and matrix also cause increased water absorption, because both materials are hydrophilic. To find out the phenomenon of increasing the water absorption value that has been described, it can be observed and seen in Fig. 9 by observing the fracture morphology of the tensile test results with a Scanning Electron Microscope (SEM). When comparing the rice straw fiber/cassava starch biocomposite with the egg tray product, the rice straw fiber/cassava starch biocomposite still has lower water absorption than the egg tray product, but only at a fiber mass fraction of 74% and 78%. When the fiber mass fraction is increased, the water absorption value is higher than the egg tray product.

### 3.4 Macro Observations

Fig. 7 is a macro observation image of fracture results from tensile testing of rice straw fiber/cassava starch biocomposites and egg tray products with a magnification of 70 x. The fracture results show the morphology of the fracture surface which displays the presence of fibers pulled out of the matrix and the presence of cavities on the fracture surface. In Fig. 7 (a and b), at a glance the cavity is not as big as Fig. 7 (c and d), while in Fig. 7 (e and f) the visible cavity tends to be larger. The presence of voids in biocomposites and egg tray products can affect mechanical properties and poor water absorption. Apart from that, the fibers that are pulled out show weak interfacial bonds between the materials that make up the biocomposite and the egg tray, so that when a tensile load is applied they will easily come apart and the tensile strength value will be low. Therefore, the mechanical properties obtained from tensile and flexural tests become lower as the fiber mass fraction increases, because the amount of matrix used is not sufficient to wet the entire fiber surface [10].

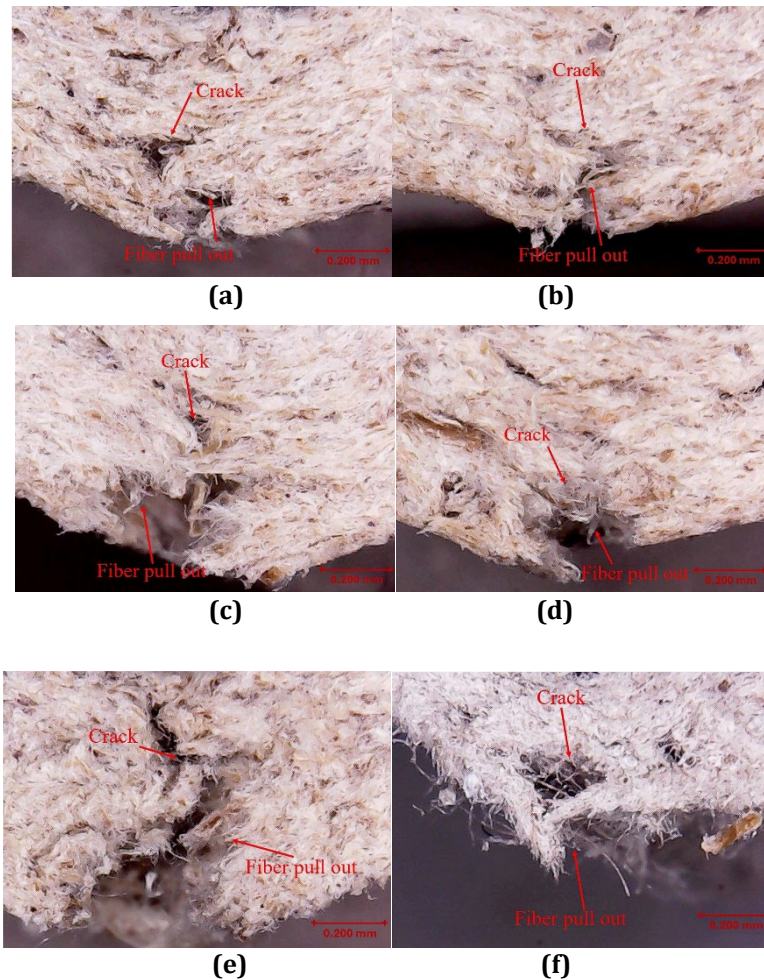


**Fig. 7** Macro observation of tensile testing fracture of rice straw fiber/cassava starch biocomposites and egg tray: (a) 74% fiber; (b) 78% fiber; (c) 82% fiber; (d) 86% fiber; (e) 90% fiber; and (f) egg tray

Fig. 8 is a macro observation image on the surface of the flexural testing results of the rice straw fiber/cassava starch biocomposite and egg tray with a magnification of 70 x. This image shows that the surface morphology tends to be the same. However, what is slightly different is only in Fig. 8 (e) at a fiber mass fraction of 90% where a wider crack can be seen compared to the other images. This can happen because the number of fibers used is too dominant compared to the matrix, so that when the load is applied to the area experiencing tension, the cracks that occur are quite extensive due to the weak adhesion of the fiber and the matrix [20]. Meanwhile, Fig. 8 as a whole shows the surface containing cracks and pulled fibers, which shows that when a load is applied to the specimen, the matrix is not able to hold the fibers optimally, so that when the load is increased again, the cracks that occur become wider and the fibers more and more people are interested. The fibers that are pulled out indicate a weak bond between the fiber interface and the matrix which causes the resulting low bending strength [17].

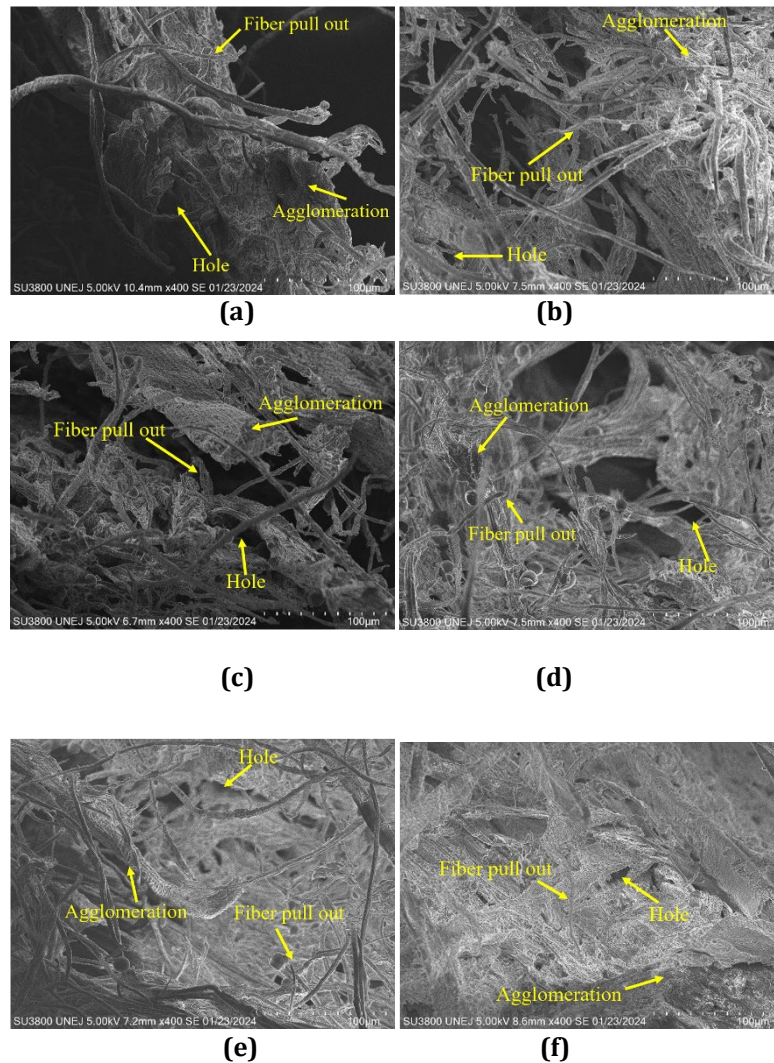
### 3.5 Scanning Electron Microscope Observations

Observing the fracture morphology of the rice straw fiber/cassava starch biocomposite is important to be able to analyze the failure phenomena that occur when the biocomposite is subjected to a load and the interactions that occur between the matrix and the fiber, because this affects the mechanical properties and water absorption. Observations were made using a Hitachi SU3800 Scanning Electron Microscope with a specimen magnification of 400 x. The results of observing the fracture morphology of the rice straw fiber/cassava starch biocomposite and egg tray products can be seen in Fig. 9.



**Fig. 8** Macro observation of the surface flexural testing results of rice straw fiber/cassava starch and egg tray biocomposites and egg tray: (a) 74% fiber; (b) 78% fiber; (c) 82% fiber; (d) 86% fiber; (e) 90% fiber; and (f) egg tray

Fig. 9 shows the fracture morphology of the rice straw fiber/cassava starch biocomposite and egg tray products. This image tends to show almost the same fracture shape, especially for the rice straw fiber/cassava starch biocomposite. Fig. 9 (a) shows the fracture of a biocomposite with a fiber mass fraction of 74% which shows the presence of defects in the fracture, such as voids, agglomeration, and the presence of fibers that are pulled out (fiber pull-out). If you look at the bond between the matrix and the fibers, it tends to be better, when compared with Fig. 9 (b, c, d, and e). This is because the amount of matrix used is quite large, so the wetting ability of the fiber is better and this has an effect on better mechanical properties and water absorption [1]. When the fiber content of rice straw is increased to 78%, the amount of cassava starch matrix will decrease, so the ability to bind fiber will decrease. This phenomenon can be seen in Fig. 9 (b) which shows the increasing number of fibers being attracted, as a result of the weak interfacial bond between the fibers and the matrix [7]. In this image you can also see the existence of cavities and agglomeration between the fibers.



**Fig. 9** Morphological observation of rice straw fiber/cassava starch biocomposites and egg tray fracture using Scanning Electron Microscope: (a) 74% fiber; (b) 78% fiber; (c) 82% fiber; (d) 86% fiber; (e) 90% fiber; and (f) egg tray

Meanwhile, Fig. 9 (c, d, and e) shows the fracture pattern which tends to be the same between the three, you can see the large number of cavities around the fibers and the presence of agglomeration. These voids have a detrimental effect on the mechanical properties and water absorption of biocomposites [8]. Previous research stated that the large number of cavities or gaps will cause water to easily diffuse into the biocomposite, so that the percentage of water absorbed will be high [20]. The presence of agglomeration between fibers can also affect the mechanical properties of biocomposites. Agglomeration occurs when too much fiber content is used and causes the fibers to clump together, thus making the fiber dispersion with the matrix inhomogeneous [15]. Apart from that, the picture also shows a large number of fibers that are pulled out (fiber pull-out) or that are separated from the matrix. This indicates that the adhesion bond between the rice straw fibers and the cassava starch matrix is weak. Considering that the amount of matrix used is also minimal, the ability to bind fibers is reduced, as a result, when the biocomposite is loaded, the load distributed from the matrix to the fibers becomes ineffective and causes its mechanical properties to decrease [13]. Thus the presence of fiber reduces its effectiveness as a reinforcing material in biocomposites [7]. Meanwhile, Fig. 9 (f) shows the fracture of the egg tray product which contains cavities, agglomerations and fibers that are pulled out, which indicates weak bonds in the constituents of the egg tray product. If viewed from previous related research, the factors that cause the low mechanical properties of biocomposites are due to the presence of voids, agglomeration, and weak interfacial bonds between the matrix and fibers, thus inhibiting the transfer of applied stress [21].

## 4. Conclusion

Based on the research findings, increasing the mass fraction of rice straw fiber causes mechanical properties to decrease and water absorption to increase. In the tensile test results, the highest ultimate tensile strength and tensile modulus values were obtained at 74% fiber mass fraction at 4.04 MPa and 230.54 MPa, while the lowest at 90% fiber mass fraction at 0.81 MPa and 76.89 MPa. The elongation at break value also decreased from 6.65% (fiber mass fraction 74%) to 3.34% (fiber mass fraction 86%). The flexural test results also show the same trend as the tensile test results, the increasing mass fraction of rice straw fibers causes the flexural strength and flexural modulus values to decrease. The highest values were obtained at a 74% fiber mass fraction of 5.17 MPa and 364.41 MPa, while the lowest were at a 90% fiber mass fraction of 1.11 MPa and 107.96 MPa. The results of the water absorption test showed an increase in the water absorption value of 49.1% from 70.41% at a fiber mass fraction of 74% to 104.95% at a fiber mass fraction of 90%. Observation of fracture morphology with a Digital Microscope at a macro level and Scanning Electron Microscope observations show fracture results that tend to be the same. It can be seen that there are voids, agglomerations, and fibers that are pulled out of the matrix due to poor interfacial bonding, these reasons are the cause of low mechanical properties and high water absorption. This research also compared the rice straw fiber/cassava starch biocomposite with one of the egg tray product samples on the market using the same tests. The results obtained are that the rice straw fiber/cassava starch biocomposite is superior in terms of mechanical properties and lower water absorption, so it has potential if used as a biocomposite packaging product. For further research, it can be done by making biocomposites from banana stem fibers and cassava starch using the solution casting method.

## Acknowledgement

The authors would like to express his deepest gratitude to the Chancellor and the Chair of the Institute for Research and Community Service at the Jember University who have provided funding support for this research.

## Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

## Author Contribution

*The authors confirm contributions to this paper as follows: research conception and design: R. K. K. Wibowo; data collection: Hauzan N. Robbani; analysis and interpretation of results: R.K.K. Wibowo, Sumarji, Hauzan N. Robbani; drafting of the manuscript: R.K.K. Wibowo, Sumarji, Hauzan N. Robbani. All authors reviewed the results and approved the final version of the manuscript.*

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