Synthesis and Compression Strength Properties of Composite Based on Sago Pulp Fiber Waste

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Abstract. Sago palm starch produced not only wild or semi-wild plant and only as a staple food for local people, but sago palm has become a commercial crop and an important source of starch for food and non-food industries. Especially for people in Sulawesi, most of the sago in some areas as a traditional food and industries material. As a local food likes kapurung, bagea, food flavoring, sago noodle, various of snacks, sago perals, and dried refining sago starch. The one of the waste generated from sago processing is sago pulp. Nowadays, the sago pulp is only used for animal feed and composite fertilizer for plants. Characteristics of waste sago waste that can be used as a renewable composite material because it has a requirement as a composite material caused the fibrous and porous material has a cellular networks with interconnected pores. The fibers of the sago pulp have strength and rigidity. Synthesis composites fiber and matrix are required. Furthermore, the gypsum on this research was needed. In this research has been made composite based on fiber of sago pulp waste in diameter variation and measured composite physical properties using loading test machine. In this research, the compression strength test using tube method. The highest water content was 13.46\% indicated accordance with Indonesian National Standard and Japan International Standard (JIS). The compression strength is intended to determine the composite resistance to loading at the bending point. It was observed that compression strength test on the ratio of fiber: gypsum: water (1:2:1) for diameter 5.5 cm, 4.5 cm, 3.5 cm and 2.5 cm were 0.1221 MPa, 0.0671 MPa, 0.1067 MPa, and 0.1091 MPa, respectively. In this case of the sample which 5.5 cm has the highest compression strength in 0.1221 MPa. It’s caused by density is poor when pressured process. The higher the density of the resulting composite board, the higher the fracture strength of the resulting particle.

1. Introduction
Composites are made by combining two or more microporous or macroparticles of different shapes, chemical compositions and properties one each other [1]. A composite is formed by different of the mechanical properties of the constituent material. Composite fabrication requires fiber and matrix. The fiber as a reinforcing element to determined mechanical properties, it extended a load from the matrix. The two materials combined to give an unique properties. However, within the composite easily tell the different materials apart as they do not dissolve or blend into each other.
Nowadays, the fiber used natural and synthesis exists. In fact, however, synthetic fibers gave environmental impact due to waste likely non-recyclable synthesis fibers. This problem gets attention if it will use as a reinforcement in composite [2]. Therefore composite fiber source easily to get from nature. One source can be obtained from plants such as sago. Since the 1990s, natural fiber composites are emerging as realistic alternatives to glass-reinforced composites in many applications. Natural fiber composites such as hemp fiber-epoxy, flax fiber-polypropylene (PP), and China reed fiber-PP are particularly attractive in automotive applications because of lower cost and lower density [3].

Sago is one of staple food in Luwu people, South Sulawesi. However, at the time of processing of sago starch produced waste which has not been utilized properly and only wasted on the processing of sago starch and river flow causing environmental pollution. Generally, sago pulp is only used for animal feed and composite fertilizer for plants. Sago pulp waste consists of 65.7% starch, 21% lignin, 20% cellulose, it depends on the age of sago tree, species, place of life and its processing [4]. The composition of sago pulp waste obtained starch content was 17-25% and pulp content ranged from 75% to 83%. Handling of this waste can be done by making a composite to provide benefits all sorts field of economy, environment, and necessities humans. The profits for economic field able to utilize unused materials into products that have a selling point. While the composite advantage of sago dregs waste to the environment is to reduce environmental pollution around sago starch production area caused by waste of sago waste that is difficult to rot and untreated.

Composite materials can be classified into several types, depending on the geometry and fiber type. In outline, the composite material consists of two kinds of particulate composite materials (particulate composite) and fiber composite materials (fiber composite). Fiber composites have many types consists of only one laminate (using one layer) or fiber reinforcement. Fiber used can be fibers glass, fibers carbon, fibers aramid (polyaramid), and etc. [5]. Therefore, many researches on strengthening biodegradable composites have been carried out by combining them with strong natural fibers [6], such as ramie [7], hemp [8], pineapple [9], henequen [10], and bamboo [11].

Composite based on natural fiber which is of great interest most developed due to the considerable enhancement in physical-mechanical properties like stiffness and strength, lower density, better process ability, compatible fiber availability with suitable sizing chemicals. Therefore fiber composites are the most widely developed till now [12]. Natural fibers are good enough to strengthen polymers (thermosets and thermoplastics) because they have relatively high strength and stiffness with low densities [13]. Natural fibers are derived from nature such as pineapple fiber, coconut fiber, sago fiber and others. According to [12] researched there are several advantages of natural fibers compared with synthetic fibers were more cheap, low density, easy release, renewable and environmentally friendly materials. Therefore, seeing the potential of sago pulp can be seen from the area of sago plant and sago production in Palopo city that produces waste that can be made as a composite.

The composite preparation based on natural fiber is required adhesive materials such as gypsum. This study uses gypsum adhesive because gypsum as mineral adhesive has better properties than other types of adhesives because it does not cause air pollution, unexpensive, mild, fireproof, resistant to deterioration by biological factors and chemical resistance. The use of gypsum is an appropriate alternative for addition in insulator test materials because it has an adhesive element [14]. The one of comprehensive composite quality analysis through compression strength test and water content quantity.

The compression strength of the sample is an illustration of the quality of the sample, as usually the increase in compression strength of the sample will be followed by the improvement of other sample properties. In the rain press will get the value of compression strength, elastic modulus, and moment of specimen. The compression strength is the voltage value of the specimen [15]. The compression strength determined by composite resistance because of loading to the bending point. Characteristics of waste sago waste that can be used as a renewable composite material because it has a requirement as a composite material because it has fibrous and porous material that has cellular networks with interconnected pores. The fibers of the sago pulp have firmness and stiffness.
The problem formulation in this research is whether the composite made from fiber of sago fiber is able to show good quality with variation of sample diameter determined by parameter through compression strength test. The purpose of this research is to make composite based on fiber of sago with variation of diameter size and measured physical properties (water content and compression strength properties) on composite material.

2. Materials
Sago pulp fiber is taken from the waste directly, gypsum as an adhesive material, hop plate, water, stir bar, mold, pressing tool, compression strength test used LTM (Loading Tester Machine).

3. Methods

3.1. Preparation of composite sago pulp fiber waste
Sago pulp was prepared from processing resources directly by washing and drying method. It will remove the water content to obtain the desired coarse fiber. Then, the waste fiber of sago pulp is cut into small pieces.

Making composites by mixing the basic ingredients of waste fiber of sago waste with adhesive and water. Comparison between fiber, adhesive, and water (1: 2: 1). These materials were homogenized using mixing method.

The composite was formed after it has been mixed homogeneously sized 5.5 cm x 11 cm, 4.5 cm x 9 cm, 3.5 cm x 7 cm, 2.5 cm x 5 cm. After forming step, sample put into the mold for compressed by high pressure (pressure applied to form by tube method process manually) according to the sample diameter which was recommended. After the pressure is applied, drying is done at room temperature.

3.2. Characterization of composites
Compression Strength. The compression strength of composite specimens was analysed using Loading Tester Machine (LTM). Specimens are given a load pressured till be broken and be fracture after drying condition. These specimens were tested and calculated using physics strength formulation (Hilda, 2012). Sample weighed and measured high as well as diameter samples to know the volume.

\[ f_c = \frac{P}{A} \]

With \( f_c \) was compression strength of objects (N/m\(^2\)), \( P \) was a maximum load (N) and \( A \) was extensive surface (m\(^2\)). Water Content. In additional compression strength test, this study analyzed content water for different diameter size respectively, used formulation:

\[ W_c = \frac{W_1 - W_2}{W_2} \times 100\% \]

\( W_c \): Water Content (%),
\( W_1 \): sample weight on air
\( W_2 \): Sample weight after drying in the oven

4. Results and Discussion
The compression strength test in this study used 4 samples was formed in cylinders which have diameter size 5.5 cm with height 11 cm, diameter 4.5 cm with height 9 cm, 3.5 cm with height 7 cm, 2.5 cm with height 5 cm, respectively.

| Sample | Diameter size of sample | Drying Time (day) | Conditions |
|--------|-------------------------|-------------------|------------|
| S 1    | Diameter (cm) High (cm) Mass (gr) |                |            |
| S 1    | 5.5 11 231.23 | 28 | dry       |
| S 2    | 4.5 9 134.23 | 28 | dry       |
The drying process during the 28 days for several variations of sample thickness. The sample 1 and sample 2 got dry rate. However, the sample 3 and sample 4 have drying rate is very dry so showed very light. The test was performed using a compression strength test (Loading Tester Machine). Furthermore, the resulting data is analyzed using the formula for compression strength in accordance with Indonesia National Standard.

### Table 2. Water Content

| Sample | Diameter Size (cm) | W₁ (gr) | W₂ (gr) | Water Content (%) |
|--------|--------------------|---------|---------|-------------------|
| S 1    | 5,5                | 231,23  | 203,8   | 13,46             |
| S 2    | 4,5                | 134,23  | 118,8   | 12,99             |
| S 3    | 3,5                | 65,44   | 57,84   | 13,14             |
| S 4    | 2,5                | 27,91   | 24,65   | 13,23             |

According to this result, sago pulp fiber contains the highest water content. So that if the composition of the sago fiber is used in making the composite more then the water content in the resulting composite will increase as well. This is in accordance with the statement of [16], the more fiber used then the water content will be greater. The overall value of the sample water content for the composite material produced meets the SNI 03-2105-2006 standard which requires a water content value of < 14% and JIS A 5905: 2003 value of moisture content for composite materials ranging from 5% to 13%.

### Table 3. Compression Strength of Sample

| Sample | Diameter (cm) | Height (cm) | Large base (cm²) | Volume (cm³) | Tension | Fc = P/A | Fc (Mpa) |
|--------|---------------|-------------|------------------|--------------|----------|---------|---------|
| S 1    | 5,5           | 11          | 23,7583          | 261,341      | 1,245    | 0,1221  |
| S 2    | 4,5           | 9           | 15,9043          | 143,139      | 0,685    | 0,0671  |
| S 3    | 3,5           | 7           | 9,6211           | 67,348       | 1,088    | 0,1067  |
| S 4    | 2,5           | 5           | 4,9087           | 24,544       | 1,113    | 0,1091  |

This study shows the compression strength of sample 1 which have 5.5 cm and height of 11 cm were sun dried for 28 days reaches compression strength 1,245 kg/cm² or 0.1221 MPa. All measurements were performed that sample 1 has greater value than the sample 2, sample 3 and sample 4.

Water content analysis in this study aims to determine the moisture content such as ambient/air temperature and drying when in the oven. The test is carried out by air drying then weighed, put into the oven for drying at 105 °C during of time 4 hours. Then, the sample was lifted and then is weighed.

The value of water content varies by the diameter sample. The value of water content in samples 5.5 cm in diameter is highest, this is caused by wood-like fibers that can absorb and release water because the more fiber is used then the water content will be greater so that the water content can change at any time according to his condition [17].

In this case, the compression strength test aims to determine the compression strength of the composite. The test is carried out by giving the compression strength of the load slowly until the specimen reaches the fragility point or fracture. The pressure was given from the top which caused the specimen to be brittle and broken due to limited withstand during loading compression.

This studies confirmed (Table 3.) the compression strength is different based on diameter size. In table 3, sample 1 has the highest compression strength in value 0,1221 Mpa, then sample 2 obtained...
compression strength decreasing to 0.0671 MPa, sample 3 has a compression strength 0.1067 MPa and sample 4 has a compression strength 0.1091 MPa. It can be seen that the sample 2 has compression strength decreases. This is influenced by the number of air cavities contained in the sample. Based on research conducted by [18] which states that the low value of compression strength is influenced by the number of air cavities contained in the composite that makes the gypsum composite becomes solid and easily fragile. The burden-loading relationship is directly proportional to the sample forming, whereby the larger diameter sample is larger [19]. Giving mass of fiber and adhesive in this research is 1: 2: 1 (water, gypsum and fiber). In general, it can be said that the function of fiber is as a reinforcement material to strengthen the composite so that its mechanical properties are more rigid, tough and stronger than with no reinforcing fibers, in addition to fiber also save the use of resin. Rigidity is the ability of a material to resist form changes when loaded with a particular force in the astatic region of the bending test. Toughness is when the force or burden that causes the materials to be broken at testing the bending point. Sturdy is a condition obtained due to flexibility and work processes that change the composite structure so that it becomes hard on the testing of flexibility [20]. Based on this table 3, sample 1 has the best compression strength compared with sample 2, sample 3 and sample 4 which have compression strength low. This is in addition influenced by high density can also be affected by the selection of fibers used. The difference in the results obtained in each diameter of the gypsum-fiber sample shows that the addition of the gypsum-fiber reinforcing material has different characteristics and will affect its strength. Fiber caused greatly affect its mechanical properties, given the fiber mostly, strength properties increases, but the addition fiber always adjust to percentage appropriated.

5. References
[1] Suantara D. dan Endah Oktaviani. 2015. Pemanfaatan Serat Kelapa Dan Serat Abaka Sebagai Bahan Baku Papan Partikel. Jurnal Fisika. Vol. 30(1): 37-44.
[2] Manurung S., Perdian S. dan M. Syukur. 2012. Pembuatan dan Karakterisasi Komposit Serat Palang Merah dengan Matriks Poliester. Prossiding. Medan. Universitas Sumatera Utara Medan.
[3] Josha S.V., L.T. Drzlb, A.K. Mohantyb, S. Arora. 2004. Are natural fiber composites environmentally superior to glass fiber reinforced composites?. Composites Journal: Part A 35 : 371–376.
[4] Kiat. L.J., 2006. Preparation and Characterization of Charboxymethyl Sago Waste and Its Hydrogel. Tesis tidak diterbitkan. Universitas Putra Malaysia. Malaysia.
[5] Sudarsono. 2010. Pembuatan Papan Partikel Berbahan Baku Sabut Kelapa dengan Bahan Pengikat Alami (Lem Kopal). Jurnal Teknologi. Vol. 3(1): 22-32.
[6] Netravalii, A.N and Chabba S. 2003. Composites Get Greener. A Review Feature. Material Today. Vol. 6 (4):22-29
[7] Goda, K., Gomes, A., Asai, T and Yamane. 2002. Development of Biodegradable Natural Fiber Composites by Press Forming Method. Proceeding of International Workshop on Green Composites. Pp.8-11
[8] Tagaki, H and Ochi, S. 2003. Characterization of High- Strength “Green” Composites Using Manila Hemp Fibers and Starch-Based Resin. Proceeding of the Third Japan-Canada Joint Conference on New Applications of Advanced Composites (JCJC-III).pp: 19-27
[9] Luo, S and Netravalii, A.N. 1999. Interfacial and Mechanical Properties of Environmentally-Friendly “Green” Composites Made from Pineapple Fibers and Poly (hydroxybutyrate-co-valerate) resin. Polymer Composites. Vol.20. pp: 367-378
[10] Chabba, S and Netravalii, A.N. 2002. Characterization of “Green” Composites Using Henequen Fibers and Modified Soy Protein. Proceeding of International workshop on Green Composites. Pp: 1-3.
[11] Jiang, J and Fujii, T. 1999. Fabrication of Biodecomposable Composites Using Bamboo Fibers and Their Strength Properties, Reinforced Plastics (in Japanese). Vol. 45. Pp: 365-371.
[12] Silalangi R., Perdinan S. dan Simbolon. 2015. Pembuatan dan Karakterisasi Komposit Serat Kulit Jagung-Poliester dengan Metode Chopped Strand Mat. Prosiding. Universitas Sumatera Utara.

[13] Suryanto H. 2016. Review Serat Alam : Komposisi, Struktur, dan Sifat Mekanis. Tesis tidak diterbitkan. Jurusan Teknik Mesin, Fakultas Teknik, Universitas Negeri Malang.

[14] Nusa, C. 2016. Studi Material Isolator Berbahan Dasar Fly Ash, Perlit, dan Gypsum. Universitas Halu Oleo. Kendari.

[15] Septian. 2017. Pengaruh Variabel Arah Serat Terhadap Kekuatan Bending pada Komposit Serat Tebu Bermatriks Gypsum dan Resin. Skripsi tidak diterbitkan. Institute Teknologi Sepuluh November. Surabaya.

[16] Jones E., 2014. Pembuatan dan Karakterisasi Komposit Serat Kulit Jagung dengan Matriks Epoksi. Medan. Universitas Sumatera Utara.

[17] Kusuma E. S. 2012. Pengujian Panel Akustik Papan Partikel Kayu Sengon (Paraserianthes falcataria). Skripsi tidak diterbitkan. Bogor. Institut Pertanian Bogor.

[18] Olanda S. dan Alimin M. 2013. Pengaruh Penambahan Serat Pinang (Areca Catechu L.Fiber) Terhadap Sifat Mekanik Dan Sifat Fisis Bahan Campuran Semen Gipsum. Jurnal Fisika Unand Vol. 2(2): 94-100.

[19] Rihayat T. dan Suryani. 2011. Pembuatan Polimer Komposit Ramah Lingkungan Untuk Aplikasi Industri Otomotif dan Elektronik. Prosiding. Jurusan Teknik Kimia. Politeknik Negeri Lhoksumawe.

[20] Oroh J., Ir. Frans P. Sappu MT dan Romels L..ST, MT. 2013. Analisis Sifat Mekanik Material Komposit Dari Serat Sabut Kelapa. Prosiding. Teknik Mesin, Universitas Sam Ratulangi Manado.