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Cassava Peel Extract as Raw Materials for Making Paper : Utilization of Waste as Environmental Conservation

Yogi Kurnia*
Department of Biology Education,
Universitas Islam Negeri Raden Intan Lampung,
INDONESIA

Durrul Jauhariyah
Teacher of Physics Education,
MAN 1 Model Bandar Lampung,
INDONESIA

Madiyo
Teacher of Physics Education,
MAN 1 Model Bandar Lampung,
INDONESIA

Yoga Nugraha
Department of Biology Education,
Universitas Islam Negeri Raden Intan Lampung,
INDONESIA

Muhammad Akhmansyah
Fakultas Tarbiyah dan Keguruan,
Universitas Islam Negeri Raden Intan Lampung,
INDONESIA

Nurhaida Widiani
Department of Biology Education,
Universitas Islam Negeri Raden Intan Lampung,
INDONESIA

***Correspondence: E-mail:** yogikurnialogi@gmail.com

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Abstract

Today, the continuous use of paper makes various countries experience a tree crisis due to continuous logging. Therefore, the obstacle faced in making paper is the lack of availability of wood raw materials used in the manufacturing process. Currently, various countries are starting to think about other alternatives in paper making. In this study, the use of cassava peels in papermaking can be a solution in meeting the needs of raw materials for papermaking because the content contained in cassava peels can be used as material for making pulp. The experiment of making cassava pulp was carried out using the organosolv process, which is cooking to separate the fibers using organic chemicals. The chemical used in the cooking process is ethanol. The research method used was Completely Randomized Design (CRD). The experiment was carried out with 3 treatments and 3 repetitions. with each concentration of ethanol in the cooking treatment that is 50%, 70% and 90%. Data analysis was carried out by measuring the thickness, gram, age, and tensile strength of the paper. From the experiments conducted, it is proven that using cassava peel can be used as an additional material in making paper. The most effective concentration of ethanol is at a concentration of 90%.

Keywords: paper; cassava (manihot utilissima); pulp; organosolv; ethanol; completely randomized design (CRD)

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INTRODUCTION

Currently, most of the wood for the paper industry comes from natural forests. This is because many pulp industries do not carry out their obligations to replant, so that the pulp industry continues to consume wood from natural forests. To overcome this problem, the government is encouraging the development of short-cycle pulp and paper industrial forest plantations (HTI) as well as community forests to meet the demand for these raw materials. However, until January 2003, of the five HTIs belonging to the large group of pulp and paper industries in Indonesia, namely PT. Riau Andalan Pulp and Paper (RAPP), PT. Indah Kiat Pulp and Paper (IKPP), PT. Kiani Kertas (KK), PT. Toba Pulp Lestari (TPL) and PT. Kertas Kraft Aceh (KKA), is only able to fulfill 13,823,118 m^3 per year (61.63%), while the installed capacity of the five industries is 22,430,340 m^3 per year. Overall, the five industries experienced a raw material shortage of 8,607,222 m^3 of wood per year. In 2003, the Ministry issued only 6.8 million m^3 of cut natural forest (Pramesti et al., 2017).

The availability of raw materials in the form of wood in the form of wood in nature which is starting to decrease requires the existence of additional materials or alternative substitutes, in order to minimize the use of wood raw materials in paper making. therefore it is possible to develop composite products from agricultural waste with the same quality as wood raw materials (Martin et al., 2010). This is what underlies research on the manufacture of paperboard which uses mixed ingredients in the form of cassava peels which can be used as ingredients in the manufacture of pulp or paper pulp. Pulp raw materials usually contain three main components, namely: cellulose, hemicellulose, and lignin (Akbar et al., 2013).

Recently, it is known that cassava peel waste has a fairly high cellulose content. The results of research conducted by X, obtained information that the cellulose content in cassava peel waste reached 43.626% (Akpabio et al., 2012). This content is what makes this research carried out as a goal in making pulp raw materials (**Table 1**). Cassava is one of the leading agricultural commodities in Indonesia. Based on the Central Statistics Agency (BPS) specifically for the province of Lampung, Indonesia in 2014, the total area of land planted with cassava was 252,984 ha with a total production of 4,806,254 tons, which means land productivity was around 18,998 tons/ha.

Tabel 1. Cassava peel components

No	Component	Content (%)
1.	Cellulose	43,626
2.	Starch/amylum	36,580
3.	Hemicellulose	10,384
4.	Lignin	7,646
5.	Other	1,764
	Total	**100%**

Source: (Kumar et al., 2021)

Based on the classification, the taxonomy of cassava (cassava) plants is as follows: 1). Division : Spermatophyta, 2). Class : Dicotiledoniae, 3). Order: Geraniales, 4). Family : Euphorbiaceae, 5). Genus : Manihot, 6). Species : Manihot utilisima. Based on its morphology, cassava stems are old and woody, cylindrical in shape, and consist of cork in the middle (Cock J, H.,1982). The cassava stem has segments between 10-15 cm long at each segment boundary (node), there are budding eyes, and when it is old, the buds swell. These stems are prepared for seeding (cuttings). Old stems are 2-8 cm in diameter, and each stem has 22-96 segments. After old cassava plants, cassava often branches with two, three, or even four branching buds (Cheng & Logan., 2011). From these stems flowers will emerge which form seeds and become seeds, so it is called reproductive branching. Plant height ranges from 1.20-3.70 m, stems are light green, dark, and some are yellowish, depending on the type of cultivar and its variety. Cassava leaves are very unique, shaped like a finger split. The number of leaf divisions varies, from 3 to 9. The size of the leaf blade is 0.5-1.0 cm wide, 5-12 cm long, and the petiole length ranges from 5-30 cm, sometimes even up to 40 cm. The leaf surface contains a thin layer of wax. Cassava leaves contain chlorophyll of around 2.18-2.86 mg/g leaves (wet weight).

Cassava peel is a cortex composed of parenchyma tissue which plays a role in storing food reserves, the shape of the cortex is relatively round (isodiametric) with clear intercellular spaces (Fan et al., 2007). Water and mineral salts from the root hairs will pass through the cortex cells through the intercellular space, this event is called apoplast extra vascular transport. Cortical cells contain food reserves in the form of starch and other substances (Cheng et al., 2006a; Cheng et al., 2006b).

METHOD

Location and time of research

The research was conducted at the Biology Laboratory, Faculty of Tarbiyah and Teacher Training, UIN Raden Intan Lampung, Indonesia and the Laboratory of the Faculty of Engineering, University of Lampung, Indonesia. The time of research is February 2022.

Tools and Materials

The tools used in this study include: nylon sieve, screen printing, cloth, cooking pot, stirrer, blender, pipette, washing bowl, scales, measuring cup, micrometer, digital scales, scissors, and Tensile Strength. wood, waste paper, 90% ethanol, PVAc (Polyvinyl Acetate), and water.

Research design

The design used in this study used 3 treatments and 3 repetitions so that there were 9 experimental units. The 3 treatments used variations in the concentration of the ethanol cooking solution, namely 50%, 70% and 90%. In each treatment each cooking pot contained 50 g of cassava peel and 1000 ml of ethanol.

The process of making pulp from cassava peels

Cut the cassava skin into cubes with a diameter of about 2-3 cm and blend until smooth, then soak and wash to reduce the starch content in order to maximize the cooking process later. Then the cassava peels were dried in the sun to reduce the water content contained in the cassava peels, then the cassava peels were weighed and grouped into 3 groups, each group weighing 50 g. To do a comparison in cooking, in order to find out the best results from each cooking. Then the dried cassava peels were cooked using 1000 ml of ethanol at concentrations of 50%, 70% and 90%, at 80° for 30 minutes, as this was considered sufficient to degrade unnecessary compounds. Then the cassava skin that has been cooked is washed with running water to remove the remnants of the solution used in the cooking process, the water used is 5 liters. The pulp produced from cassava skin is then filtered to produce fine fibers.

The process of making paper from cassava peel pulp

The cassava peel pulp that has been made is then mixed with PVAc suspension using a blender of 5% of the total pulp weight. PVAc suspension is made using wood glue because this glue is made from polyvinyl acetate, then mixed with water in the ratio of 10 grams of glue and 60 cc of water. Then the pulp is printed using screen printing and dried in the sun for 4 hours, because 4 hours is enough to reduce the water content in the paper. Then aerate the paper for 24 hours to get maximum results.

Measurement of thickness and mass of paper

The formed paper is expected to reach the target of 0.52-0.56 mm and the paper thickness test is based on the Indonesian national standard (SNI). The equipment used in this test is a micrometer consisting of a presser foot and a circular base with a contact surface area of 10 cm^2 ± 0.2 cm^2. The pressure feet can be moved perpendicular to the anvil with a constant pressure of 20 kPa ± 0.5 kPa. Thickness value indicating device with accuracy up to 0.01 mm, and sample cutting tool and ruler. The procedure for measuring paper thickness is to make sure the tool shows the thickness value at the zero position. Place the test sample horizontally between the pressure feet and the anvil. The measurement is carried out at a minimum area of 50 mm from the edge of the test sample. The pressure foot is slowly lowered until it touches the surface of the sample (2-3 mm/sec). Avoid additional pressure by hand when the measurement takes place, read and record the thickness value of the test sample on the micrometer scale, then raise the pressure foot and measure the thickness of the same test sample in another measurement area.

Next is the process of measuring the grammage or mass of the paper. Grammage is the mass of a sheet of paper in grams divided by its area in meters squared, measured under standard conditions (SNI 14-0440-2006). The formed paper is expected to reach the target grammage of 300-350 grams/m^2 and the equipment used in this test is a digital scale and scissors. While the procedure for measuring the thickness of the paper, namely cutting the sample with a size of 10 cm x 10 cm, then the area of the sample piece is measured and the mass of the sample piece is weighed.

Paper tensile resistance test

The tensile resistance test is the resistance of a sheet of paper or cardboard to the tensile force acting on both ends of the paper which is measured under standard conditions based on Indonesian national standards (SNI 0436-89). The formed paper is expected to reach the target of 19.71 Nm/g and in this test a tensile tester is used whose experimental procedure is to set the tool in a stationary state, the distance between the two clamps is 180 mm, avoid touching the clamps that are between the two clamps. Then the end of the line is installed at the top then the other is installed at the bottom. The clamps at both ends of the strips are hardened and maintained so that the two strips are installed evenly and twisted. Loosen the setting to determine the tensile strength, then run the motor to swing the pendulum, the swing will stop when the paper path breaks.

RESULTS AND DISCUSSION

Based on the results of the study, the effect of several concentrations in the paper-making process can affect the quality of the paper produced. From the experiments carried out, it can be seen that the addition of cassava skin in the paper-making process has proven to be in accordance with the physical properties of paper according to the Indonesian national standard. The results of research on the use of cassava peels as paper can be seen in **Table 2** as follows:

Tabel 2. The average result of the paper test

No	Concentration	Thickness (mm)	Gramatur (Gram/m^2)	Tensile Resistance (Nm/g)
1	50%	0,62	366	14,69
2	70%	0,65	346	16,84
3	90%	0,52	328	17,75

Source : Data of this study

Paper thickness

From the results of measuring the thickness of the paper in **Table 2** it can be seen that the ratio of each concentration of ethanol given during cooking makes a difference in thickness. This is because the higher the concentration of the cooking solution the finer the fiber produced and the greater the quantity of fiber printed in one container, the greater the thickness obtained.

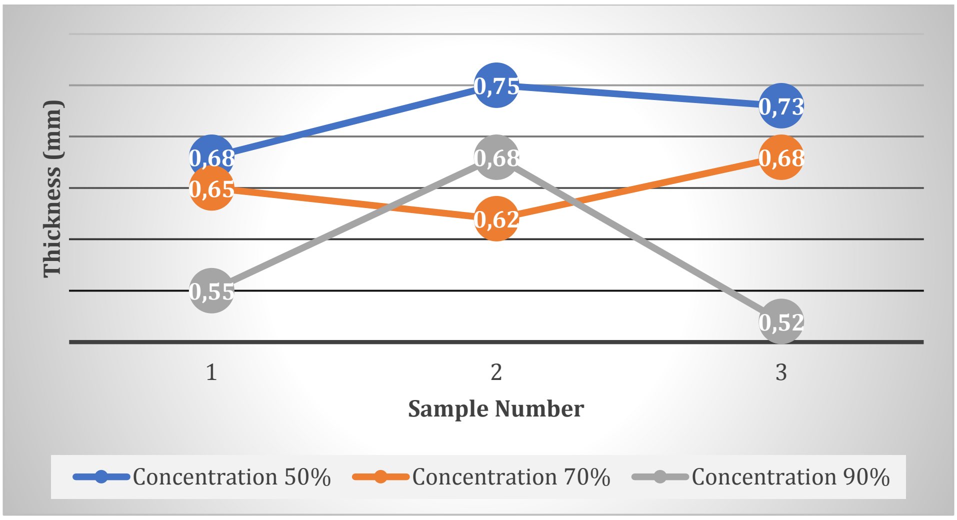

Figure 1. Diagram of the relationship between concentration and paper thickness

Based on **Figure 1**, it shows that the concentration ratio of the cooking solution affects the thickness as seen at a concentration of 50% which has a greater thickness due to the less optimal cooking process so that the degradation process of compounds that are not needed in cassava peels, namely non-fiber materials, does not run perfectly (Prasertsung et al., 2012). Whereas at a concentration of 90% which showed the best results, because at this concentration the degradation of non-fiber materials went better than the other comparisons because the higher the concentration of the cooking solution, the more perfect the process of degradation of non-fiber materials in cassava peels.

Grammage (mass) of paper

The grammage calculation is done by cutting the sample to be tested with a size of 10 cm x 10 cm, showing the results of the paper grammage test shown in **Table 2** which shows the greatest result is at a concentration of 50% while the smallest is shown at a concentration of 90%. The difference in concentration during cooking has an influence on the grammage measurement results with a striking average difference, as shown in **Figure 2**.

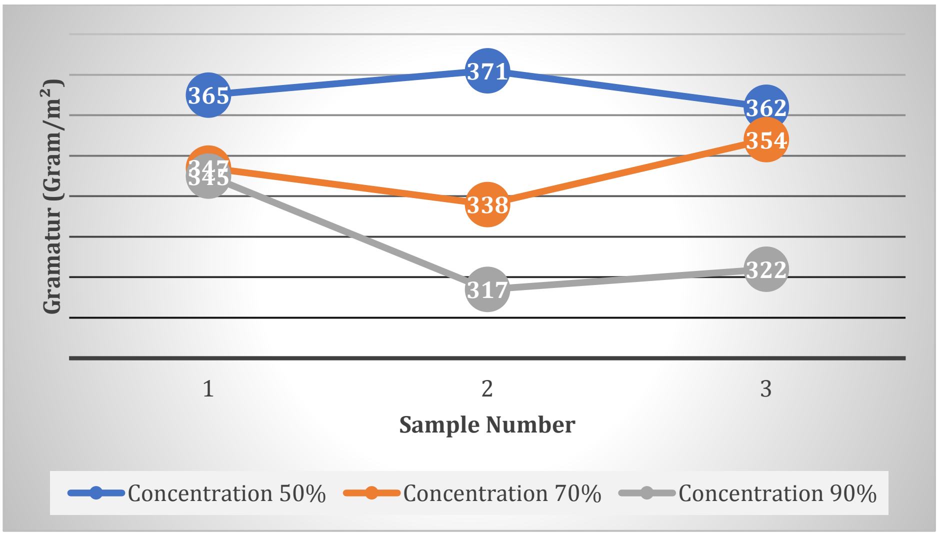

Figure 2. Diagram of the relationship between concentration and grammage of paper

Based on the diagram in **Figure 2**, at a concentration of 50% where the degradation of unnecessary compounds is not perfect which causes an increase in the load on the test sample so that the grammage results become greater. Meanwhile, at the highest concentration, namely 90%, the results were directly proportional to the higher concentration given during cooking, where the more compounds that were not needed, such as non-fiber materials, were degraded (Okpako et al., 2008; Pant et al., 2010). This decrease in the levels of degraded compounds gives a smaller grammage result in the test sample.

Paper tensile resistance

Measurement of the tensile strength of paper is used to determine the paper's resistance to tensile forces using a tensile tester as shown in **Table 2** which shows the strength of the paper at each concentration and from the paper tensile strength test it can be seen the results of each concentration, the difference in each concentration shows the bond between fibers in the test sample at each concentration, this can also be seen in **Figure 3**.

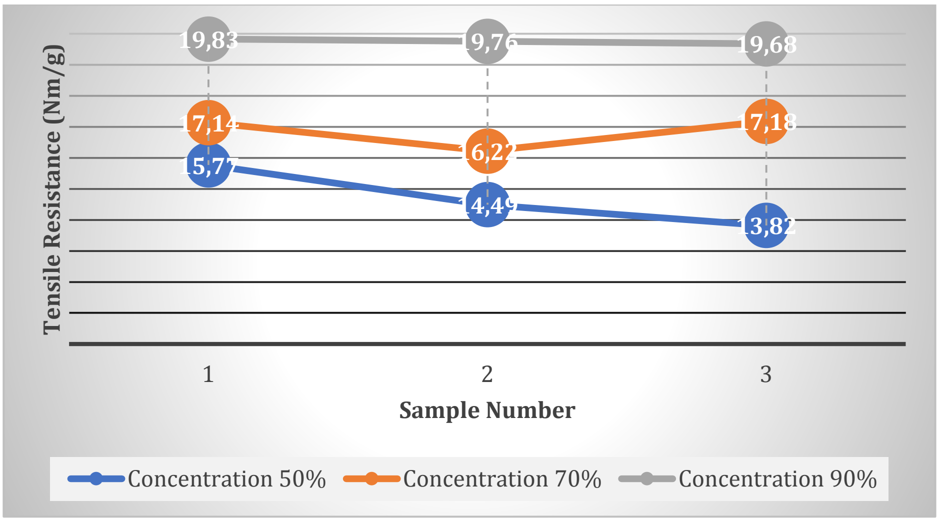

Figure 3. Diagram of the relationship between concentration and tensile strength of paper

Based on the diagram in **Figure 3**, it shows the difference in the results of each cooking concentration, at a concentration of 50% it shows lower tensile strength, this is due to the less optimal cooking process where non-fiber material is still present in the paper so that the bonding process between fibers does not occur perfectly. whereas at a concentration of 90%, the tensile strength is closest to the desired target. This is because the higher the concentration of the cooking solution, the more optimal the process of degradation of unwanted compounds so that it allows the bonds between fibers to be stronger, thus affecting the quality of the paper produced (Min et al., 2005; Oboh, G. 2006).

Based on the research that has been done, cooking cassava peels using ethanol of various concentrations can affect the quality of the paper produced (Madiraju et al., 2012). Because the results obtained show that the greater the concentration of ethanol, the breaking of bonds between cellulose polymer chains in wood increases and the amount of lignin broken down from cellulose also increases. This makes it easier to separate fiber and non-fiber materials and allows the delignification process to take place evenly (Leano & Babel, S. 2011).

Based on the thickness analysis shown in **Table 2**, it shows that at the highest concentration, namely 90%, it gives a better thickness, because at the highest concentration the cassava peel obtained is smoother and softer (Kaewkannetra et al., 2011). This is due to the more perfect degradation process of compounds that are not needed. From the data in table 4 it can be seen that only the highest concentrations meet the standards, because at lower concentrations such as 50% and 70% there are more non-fiber materials which are in the paper printing process. Non-fiber materials provide additional volume on the surface of the paper where the fibers in the paper should be intertwined (He et al., 2008; Quan et al., 2014; Raghavulu et al., 2009). Apart from the concentration of the cooking solution, another thing that affects the thickness of the paper is the large quantity of pulp printed in one container which affects the thickness of the paper produced.

The results of measuring the grammage of the paper from each comparison of the cooking solution can be seen that the concentration of the cooking solution affects the grammage of the paper. Because at concentrations of 70% and 90% degradation goes better, where the non-fiber material is reduced so as to provide a smaller fiber mass which causes a decrease in the grammage of the paper produced (Yang et al., 2013). At the lowest concentration, which is 50%, it is not in accordance with the expected target because during cooking, the non-fiber material is not completely degraded so that during the paper forming process this non-fiber material gives excess mass to the paper (Rocha et al., 2008). The thickness of the paper also affects the grammage measurement results where the greater the value of the paper thickness measurement, the greater the grammage of the paper produced (Ting & Lee., 2007).

On the other hand, the tensile strength of the paper can be seen that at the highest concentration, namely 90%, it is closest to the target paper tensile strength because the bonding between the fibers takes place more optimally. This is because the reaction of releasing lignin bonds and other non-fiber materials from cellulose is more perfect. the high levels of lignin and non-fiber material left in the pulp after the cooking process will affect the tensile strength of the paper, resulting in a decrease in the binding activity between the fibers which causes the quality of the paper to be lower. The mixture of paper pulp also affects the tensile strength of the paper, where the used paper pulp is able to carry out a more optimal bonding process between the fibers between the pulps. As well as paper pulp and cassava skin pulp can bond with each other so that the tensile strength of the paper produced is better. while at lower concentrations of 70% and 50% it has lower tensile strength as well. This is because the amount of non-fiber material at lower concentrations is still present in the paper produced, so the bonding process between fibers does not go well and the paper becomes more brittle. Where the tensile resistance increases along with the increasing quality of mixed pulp.

CONCLUSION

Based on the three analyzes of paper made from cassava peel pulp, it appears that cassava peel can be used as a mixed ingredient in paper making. From the data obtained, it can be seen that the concentration of the cooking solution has an effect on the resulting paper, in previous research it can be seen that the increasing concentration of the cooking solution used will affect the cellulose content obtained. The greater the concentration of the cooking solution, the greater the cellulose content, where cellulose is the main component in paper making. And the cellulose content also affects the quality of the paper produced where the binding capacity of the fibers in a sheet of paper will be determined by the intensity of the bond, the number of fibrillations, and the arrangement of the cellulose molecules, so that it can cause bonds to occur. but other things such as the type of solution, adhesive material, cooking temperature, and how to print paper that still uses the manual method, also affect the quality of the paper. Where the processing method of the paper is not as good as the processing carried out in the large-scale paper industry, so the results obtained have different values for each sample. Although the results of the analysis show that the paper made meets the standards, the quality of the paper is no better than the paperboard on the market and still requires further research. because paper making in this study still uses the manual method, where this method is expected to be used as enrichment material in practicums for students. In this study, paper made from cassava peels could not only be made into cardboard, but also used as wrapping paper, packaging paper, art paper, or the like.

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CONFLICTS OF INTEREST

The authors declare no conflict of interest concerning the publication of this article. The authors also confirm that the data and the article are free of plagiarism.

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