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Exploration of bioplastic from kepok banana corm starch reinforced with fiber of pineapple crown and bamboo

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ABSTRACT

The increasing use of plastics, driven by global population growth, has led to significant environmental challenges due to plastic waste. To address this issue, many studies have explored natural resources for developing bioplastics that are more degradable and renewable. This research utilized starch extracted from kepok banana corm waste as the primary base material, reinforced with cellulose derived from pineapple crowns and bamboo fibers. The objective was to evaluate the mechanical properties and biodegradability of the resulting bioplastics. A completely randomized design was applied with two factors: fiber type (pineapple crown or bamboo) and fiber mass. The findings revealed that the bioplastics produced exhibited relatively low tensile strength, moderate elongation, high water absorption, and strong degradability. Furthermore, bioplastics reinforced with pineapple crown fibers demonstrated superior structural performance compared to those reinforced with bamboo. These results highlight the potential of this bioplastic to be further developed toward achieving standardized properties.

Keywords: bioplastic; cellulose; degradability; elongation; tensile strength

INTRODUCTION

Conventional plastics derived from petroleum have been widely used for decades because of their convenience and practicality in daily life. However, global population growth, urbanization, and economic development have significantly increased plastic consumption worldwide, including in Indonesia (Putri et al., 2025). In 2025, Indonesia generated approximately 4.2 million tons of plastic waste, ranking among the highest globally (World Population Review, 2026). Since this waste requires many years to degrade, it contributes to severe environmental pollution that is difficult to manage (Jannah et al., 2021).

Synthetic plastics are composed of a very long carbon chains that resist microbial degradation in the environment (Zhang et al., 2021). To overcome this limitation, bioplastics derived from natural polymers have been studied as alternatives. They can be produced from abundant resources such as collagen, casein, proteins, lipids, starch, and cellulose (Faiz et al., 2025). Extensive research has focused particularly on starch-based bioplastics reinforced with cellulose, due to the low cost and wide availability of these materials (Jannah et al., 2021).

Starch is widely used as the primary biopolymer in bioplastics because its amylose and amylopectin content provides tensile strength and flexibility comparable to conventional plastics (Nurjannah et al., 2020). Various starch sources have been explored, including cassava tuber skin (Muzayanah, 2025), Ambon banana corm (Faiz et al., 2025), weevil banana corm starch (Putra et al., 2025), and kepok banana corms (Nasution, 2025). However, limited information is available regarding the application of kepok banana corm in bioplastic production. This type of banana corm contains approximately 76% starch and 20% water(Rahmawati et al., 2023). Therefore, the present study utilized kepok banana corm as a starch source for bioplastic development.

Although starch is a versatile base for bioplastics, it has several limitations such as brittleness, high water absorption, and rigidity, which restrict its use in packaging applications (Nasution, 2025). To overcome these drawbacks, reinforcing fillers are often incorporated to improve the structural performance of starch-based bioplastics. For example, Sriyana and Indrasmara (2022) reported that adding 2% bamboo cellulose into tapioca based bioplastic increased tensile strength to 5.93 MPa and elongation to 224.41%. Similarly, Zulferiyenni et al. (2023) demonstrated that incorporating 2% cellulose from pineapple leaves produced bioplastics with a tensile strength of 113.52 MPa and elongation of 12.71%. These findings highlight that different cellulose sources can significantly influence the mechanical properties of bioplastics, with variations in fiber composition and bonding capacity leading to distinct performance outcomes.

This study was designed to compare bioplastics produced from kepok banana corm starch reinforced with cellulose fibers from Apus bamboo and pineapple crowns, using different fiber mass levels. The inclusion of these natural fibers was intended to strengthen the bioplastic matrix, reduce its susceptibility to moisture, and improve its mechanical performance. Subsequently, the research aimed to offer insights into optimizing bioplastic formulations for practical applications such as packaging.

METHODOLOGY

Preparation of Banana Corn Starch

Kepok banana (*Musa acuminata balbisiana Colla*) corm was obtained from Sumbawa region. The starch was prepared according to the method by Faiz et al. (2025) with modification. The corm was weighted for 3 kg and cleansed using water then chopped (± 5 cm). Chopped corm then immersed in 3 L of 50% citric acid for 10 minutes to prevent browning reaction. The strained corm then dried in a household oven at 90°C for 3 hours.

Dried corm then blended into a banana corm flour. Following that, 3 L water was added into the flour then mixed into a colloidal solution. Subsequently, the solution was filtrated to separate the pulp and starch solution then settled for 24 hours to extract the starch. The starch then dried in oven at 70°C for 2 hours and grounded into fine particles (60 mesh) and stored in airtight container for further purpose.

Preparation of Pineapple Crown and Bamboo Fiber

Fiber preparation was performed according to method by Sriyana and Indrasmara (2022) with modification. Yellowed Apus bamboo stem (Gigantochloa apus) and pineapple (Ananas comosus (L.) Merr.) crown waste were obtained from Sumbawa region. Each material was carefully cleaned using water to ensure all unwanted residuals are removed.

The bamboo stem was grinded into a bamboo dust (48 g of dust) and mixed with 500 mL of 5% of NaOH solution (delignification) then heated at 85°C for 1 hour. The strained fiber then hydrolyzed using 500 mL of 5% HCl solution for 3 hours and rinsed. After that, the fiber was bleached using 500 mL of 5% NaOCl for 90 minutes at 60°C then rinsed. Next, the fiber was dried at 100°C for 1 hour.

The pineapple crown fiber was prepared using 350 g of pineapple crown that was chopped into (± 5 cm). the steps afterward were similar to the bamboo fiber.

Preparation of Bioplastic

The bioplastic was prepared using the method by Faiz et al. (2025) with modification where 12 g of banana corm starch, fiber (1 g and 2 g for each fiber type), 2.5 mL gliycerin, and 130 mL of aquadest were mixed and heated until 80°C for 15 minutes. The mixture then poured into a 27x27 cm of aluminium mold and heated for 2 hours at 70°C. subsequently, the bioplastic sheet was dried in room temperature for 24 hours to allow easy removal of the sheet from the mold. The sheet was stored stored in airtight container for further analysis.

Water Absorption Test

Water absorption capacity was assessed according to the method by Sriyana and Indrasmara (2022). A sheet of bioplastic (2 x 8 cm) was weighted (w0). The sheet then fully soaked into water for 10 seconds weighed (w) until a constant weight was obtained. The value then calculated using following formula:

$$\text{WA}\ (\%) = \frac{w - w_0}{w_0} \text{ x } 100\%$$

Tensile Strength and Elongation Test

Tensile strength and elongation at break were tested using Universal Testing Machine HT-2402 according to ASTM D882-02 as performed by Purbasari et al. (2020). A sample of 3 x 12 cm of bioplastic sheet was placed into the grips and the machine pulled the sheet until it breaks. Tensile strength and elongation value were automatically recorded in the machine software.

Degradation Test

Degradation test were performed using the method by Faiz et al. (2025) where a 2 x 8 cm of bioplastic sheet was weighed (w0). The sheet was buried in fertile soil (500 g soil in thinwall) at 5 cm for 7 days at 29-33 °C. After that, the sheet was weighed (w) and the degradation ability were measured using the following formula:

$$\text{Degradation}\ (\%) = \frac{w - w_0}{w_0} \text{ x } 100\%$$

Stages Statistical Analysis

Each sample was performed in 3 replications (12 samples in total). Every data obtained was statistically tested for assumptions (normality and homogeneity test) followed by ANOVA test at 95% confidence level (α= 5%). Duncan multiple range test (DMRT) was also performed on the data. The test was performed using IBM SPSS 30.

RESULTS AND DISCUSSION

Tensile Strength of Bioplastic

The tensile strength was assessed to evaluate the load-bearing strength and durability under handling of bioplastic for packaging applications. Figure 1 showed that the tensile strength was significantly affect by the type of fiber and its mass. Overall, the tensile strength of bioplastic in this study ranged from 0.52-5.78 MPa, which means a relatively low structural strength.

It is noticeable that the bioplastic reinforced with pineapple crown fiber has significantly higher tensile strength compared to that of bioplastic with bamboo fiber (Pvalue= 0.00003). It might be caused by higher α-cellulose content of pineapple crown fiber (73.01%) than the bamboo Apus fiber (48.91%) which facilitates fibrillation into finer microfibrils with higher surface area and aspect ratio. Therefore, the interfacial adhesion and stress transfer within the bioplastic matrix was increased then consequently enhance the tensile strength (Augustina et al., 2025; Permatasari et al., 2023).

The bioplastic also showed significant increase of tensile strength as an increase of fiber mass was rised from 1 g to 2 g (Pvalue= 0.016). Increasing the cellulose content within the bioplastic matrix enhances crystallinity because cellulose, being inherently rigid and strong, reinforces the composite's load-bearing capacity. In addition, stronger hydrogen bonding interactions promote a more ordered and regular molecular network. These combined effects facilitate the formation of crystalline regions, where higher crystallinity translates into improved tensile strength (Jannah et al., 2021; Putri et al., 2024).

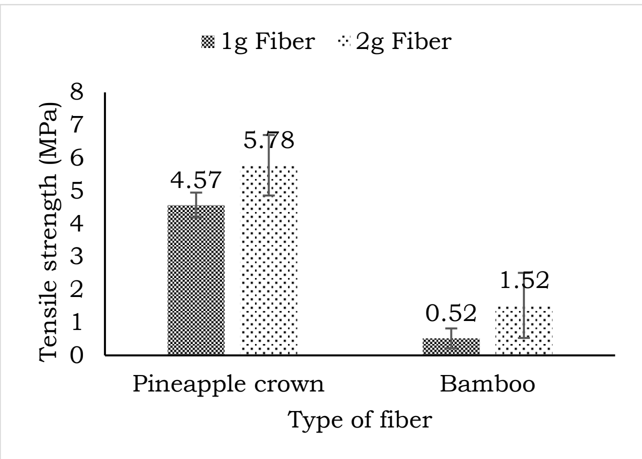

Figure 1. The tensile strength of bioplastics generated from banana corm starch with different fiber type and mass (3 replications).

Elongation at Break of Bioplastic

Elongation at break tested the flexibility of bioplastic which also important to assessed the durability of the product for future application. Figure 2 showed that reinforcement of cellulose affected the elongation properties of bioplastic in this study. Overall, the elongation varies between 8.47% to 22.67%, which indicates that the bioplastic exhibits moderate flexibility (neither excessively brittle nor highly extensible) making it suitable for lightweight, non-structural, or biodegradable film-type applications, but less appropriate for packaging that requires high toughness and durability (Yusuf et al., 2025).

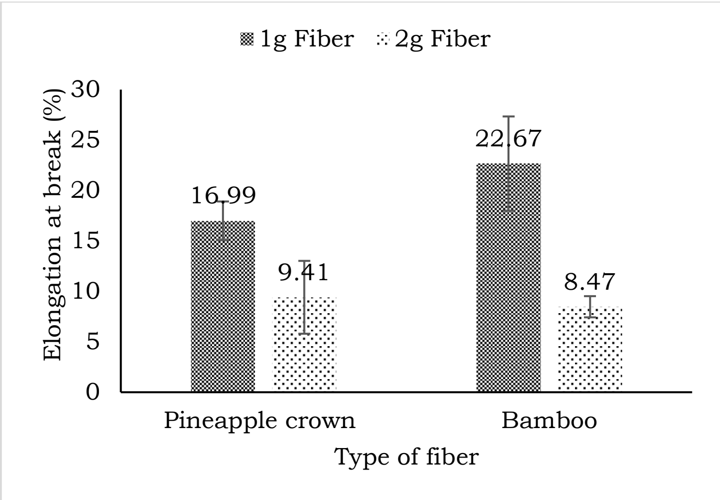

Figure 2. The elongation of bioplastic generated from banana corm starch with different fiber type and mass (3 replications).

Figure 2 showed that the type of fiber slightly affected the elongation value of bioplastic, though statistically insignificant (Pvalue= 0.565). this result might be caused by the sufficient adhesion of filler and bioplastic matrix for stress transfer but not so strong as to cause agglomeration then retains the capacity for plastic deformation and chain slippage, resulting in statistically similar elongation values, even though tensile strength may vary slightly depending on the cellulose source (Fitriani et al., 2023; Putri et al., 2024).

In contrast, the different mass of cellulose fiber was significantly reduced the elongation of the bioplastic (Pvalue= 0.025). this trend might be due to the establishment of a rigid within the bioplastic matrix as the fiber mass was increased from 1g to 2g. this rigidity enhance tensile strength but simultaneously reduces elongation due to increased brittleness and diminished capacity for plastic deformation (Putri et al., 2024).

Water Absorption of Bioplastic

Assessing the water absorption capacity of bioplastic in this study was conducted to evaluate stability, durability, and overall suitability for packaging applications. Figure 3 showed that the bioplastic has high water absorption capacity, though low value was also measured. This means that the bioplastic might be unsuitable for wet or humid environments use.

Figure 3 also showed that bioplastic reinforced with pineapple crown fiber exhibit low water absorption capacity compared to bamboo fiber (Pv_{alue}= 0.000027), which also means it has a moderately high water resistance and more stable. This result might be caused by the polymer matrix that bound the by the amorphous surface of pineapple crown cellulose, creating compact and homogenous dispersion. Thus, reduced water absorption because the ordered, tightly packed molecular arrangement restricts the penetration of water molecules Higher water absorption in bioplastic with bamboo cellulose might be cause by poor dispersion of cellulose in the matrix which then form interfacial gaps within the bioplastic and subsequently create space for water binding (Negoro et al., 2016).

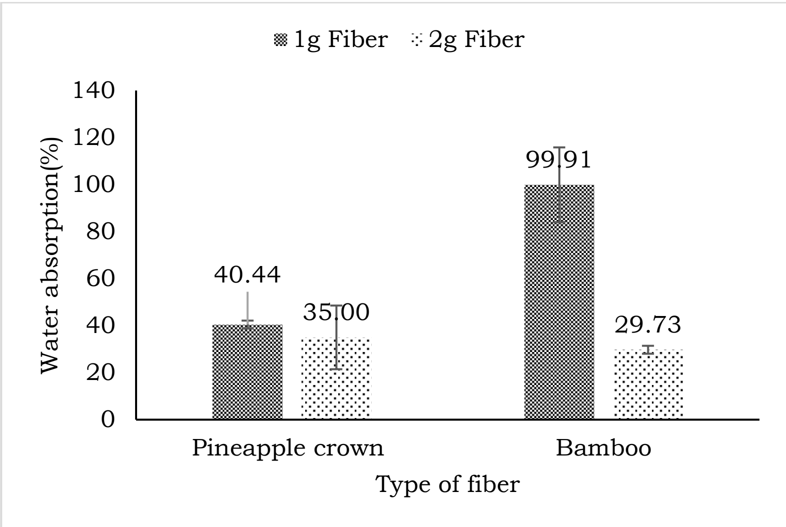

Figure 3. Water absorption capacity of bioplastic generated from banana corm starch with different fiber type and mass (3 replications).

Similarly, higher mass of cellulose fiber was significantly reduced the water absorption capacity of the bioplastic (Pvalue= 0.00002). the increasing of cellulose mass might reinforce the polymer matrix, increasing crystallinity, and limiting the free volume available for water molecules and hinders its penetration (Puspita et al., 2024).

Degradation of Bioplastic

Assessing bioplastic degradability is important to understand their breakdown in the environment. Figure 4 showed that the bioplastic in this study has high degradability which is promising, though a fast degradation rate could mean the bioplastic may be too weak for storage or handling applications.

Figure 4 showed that bioplastic reinforced with pineapple crown fiber has significantly high degradability compared to that of bamboo fiber (PValue= 0.0023). This result might be caused by the higher α-cellulose content of pineapple crown fiber (73.01%) than the bamboo Apus fiber (48.91%) (Augustina et al., 2025;

Permatasari et al., 2023). This molecule is highly hydrophilic by which it attracts more water molecules into the bioplastic matrix (Putri et al., 2024).

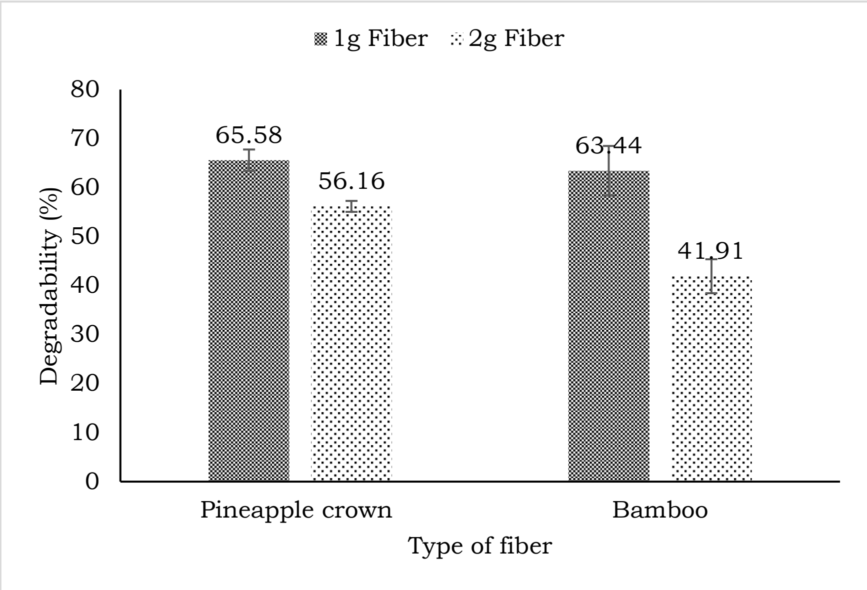

Figure 4. Degradation of bioplastic generated from banana corm starch with different fiber type and mass in 7 days (3 replications).

In contrast, increasing the mass of the cellulose reduced the degradability of the bioplastic (PValue= 0.0002). This might be caused by the increased rigidity of the bioplastic matrix as the cellulose mass increased. A more rigid polymer matrix tends to slow biodegradation because its compact structure restricts the penetration of water, oxygen, and microorganisms, thereby delaying the breakdown process (Ruggero et al., 2022).

CONCLUSION

The addition of cellulose into the banana corm starch bioplastic enhanced its tensile strength, elongation, water resistance, and degradability. The bioplastic with pineapple crown cellulose exhibited the highest tensile strength (5.78 Mpa) and highest degradability (65.58%). In contrast, the highest elongation (22.67%) and the highest water resistance (lowest water absorption) capacity (29.73%) obtained from bioplastic with bamboo cellulose. Meanwhile, in term of mass addition, 2g of cellulose was considered as the relatively optimal reinforcing agent in this study.

REFERENCES

Augustina, S., Anggraini, R., Charisma, F. S., Ridho, M. R., Kemala, P., Lee, S. H., Iswanto, A. H., Antov, P., & Fatriasari, W. (2025). Comparative Analysis of Fiber Characteristics and Chemical, Physical, and Mechanical Properties of Six Indigenous Bamboo Species from Indonesia. BioResources, 20(4).

Faiz, A., Triastuti, D., Fauzan, M., Alyasa, D., Rizky, M., & Zanetti, M. (2025). Pembuatan Plastik Biodegradable Berbahan Pati dan

Selulosa dari Tanaman Pisang Ambon (Musa paradisiaca var. sapientum L.). Agritech: Jurnal Fakultas Pertanian Universitas Muhammadiyah Purwokerto, 27, 42-51. https://doi.org/10.30595/agritech.v27i1.24630

Fitriani, F., Bilad, M. R., Aprilia, S., & Arahman, N. (2023). Biodegradable hybrid polymer film for packaging: A review. Journal of Natural Fibers, 20(1), 2159606.

Jannah, N. R., Jamarun, N., & Putri, Y. E. (2021). Production of Starch-Based Bioplastic from Durio zibethinus Murr Seed Using Glycerol as Plasticizer. Jurnal Riset Kimia, 12(2). https://doi.org/10.25077/jrk.v12i2.398

Muzayanah, N. (2025). Pemanfaatan Pati Kulit Singkong dan Selulosa Bonggol Pisang Sebagai Bahan Baku Pembuatan Bioplastik. CHEMTAG Journal of Chemical Engineering, 6(1), 18-19.

Nasution, H. M., Budi Holfrid , Nofifah, Nofifah (2025). Effect of Glycerol Concentration and Filler Addition on the Properties of Bioplastics Derived from Kepok Banana Corm Starch. Journal of Chemical Engineering and Environment, 20(1), 196 – 207. https://doi.org/https://doi.org/10.23955/rkl.v20i1.42461

Negoro, T., Thodsaratpreeyakul, W., Takada, Y., Thumsorn, S., Inoya, H., & Hamada, H. (2016). Role of Crystallinity on Moisture Absorption and Mechanical Performance of Recycled PET Compounds. Energy Procedia, 89, 323-327. https://doi.org/https://doi.org/10.1016/j.egypro.2016.05.042

Nurjannah, N. R., Sudiarti, T., & Rahmidar, L. (2020). Sintesis dan karakterisasi selulosa termetilasi sebagai biokomposit hidrogel. al-Kimiya, 7(1), 19-27.

Permatasari, D. S., Risky, P. H., & Kusumaningrum, W. B. (2023). Pembuatan Bahan Dasar Pulp dari Mahkota Nanas dengan Proses Soda. CENDEKIA EKSAKTA, 8(2).

Purbasari, A., Wulandari, A. A., & Marasabessy, F. M. (2020). Sifat mekanis dan fisis bioplastik dari limbah kulit pisang: pengaruh jenis dan konsentrasi pemlastis. Jurnal Kimia dan Kemasan, 42(2), 66.

Puspita, I., Sari, P., Roehafi, F., Novita, Junaidi, & Latupapua, F. (2024). Bioplastics based on waste paper cellulose, glycerol, and chitosan: the evaluation of mechanical properties. IOP Conference Series: Earth and Environmental Science,

Putra, E. P. D., Larassati, D. P., Wijayani, R. A., Thamrin, E. S., Sylvia, T., Subara, D., & Laksono, U. T. (2025). Karakteristik Bioplastik Pati Bonggol Pisang dengan Variasi Konsentrasi Gliserol. Jurnal Rekayasa Dan Manajemen Agroindustri, 13(2), 293-308.

Putri, A. M., Sudrajat, A., Hadzami, F. A., Razak, G. R., & Muna, N. (2025). Analisis pengaruh indeks pembangunan manusia dan jumlah penduduk terhadap timbulan sampah plastik di Indonesia. Triwikrama: Jurnal Ilmu Sosial, 10(4), 41-50.

Putri, F. A., Rianjanu, A., & Sipahutar, W. S. (2024). Cellulose impact on bioplastic performance: A study on mechanical strength, physical properties, and degradation of water hyacinth and kepok banana peel-derived materials. Jurnal Teori dan Aplikasi Fisika, 12(02).

Rahmawati, T. E., Cahyani, I. M., & Munisih, S. (2023). Karakterisasi Pati Bonggol Pisang Kepok Kuning (Musa paradisiaca L.) sebagai Bahan Tambahan Sediaan Farmasi: Characterization of Sucker Starch of Yellow Kepok Banana (Musa paradisiaca L.) as Pharmaceutical Excipient. Jurnal Sains dan Kesehatan, 5(2), 100-108.

Ruggero, F., Belardi, S., Carretti, E., Lotti, T., Lubello, C., & Gori, R. (2022). Rigid and film bioplastics degradation under suboptimal composting conditions: A kinetic study. Waste Manag Res, 40(8), 1311-1321. https://doi.org/10.1177/0734242x211063731

Sriyana, H. Y., & Indrasmara, B. P. (2022). Bioplastik Berbahan Dasar Tepung Tapioka dengan Modifikasi Gliserin dan Serat Bambu. Chimica et Natura Acta, 10(2), 60-65.

World Population Review. (2026). Plastic Pollution by Country 2026. https://worldpopulationreview.com/country-rankings/plastic-pollution-by-country

Yusuf, M., Fatah, G. A., Wibowo, R. K. K., Pradiza, R. R., Ilyas, R. A., & Asrofi, M. (2025). Mechanical Characteristics of Stearic Acid Addition in Polylactic Acid (PLA) and Cassava Starch Bioplastic Blends. Journal of Fibers and Polymer Composites, 4(2), 121-130.

Zhang, K., Hamidian, A. H., Tubić, A., Zhang, Y., Fang, J. K. H., Wu, C., & Lam, P. K. S. (2021). Understanding plastic degradation and microplastic formation in the environment: A review. Environmental Pollution, 274, 116554. https://doi.org/https://doi.org/10.1016/j.envpol.2021.116554

Zulferiyenni, Z., Putri, M. M., Suharyono, S., & Nurainy, F. (2023). Formulation of Glycerol and CMC in Making Biodegradable Film Pineapple Leaf based (Ananas comosus). Jurnal Agroindustri Berkelanjutan, 2(2), 274-283.

