switchasia GRANTS PROGRAMME

Low Carbon Rice

Preferred by Nature

KRKP

Studi Kelayakan Pengolahan Hasil Samping Jerami dan Sekam Padi di Indonesia

EXECUTIVE SUMMARY

In the process of producing rice from paddy, it produces by-products in the form of husks during the milling process and rice straw in the fields during cultivation. In this feasibility study, an analysis was carried out on the processing of straw and husks into renewable energy products, plant fertilisers, biodegradable packaging, animal feed and food (oil), by examining the aspects of technology, environmental aspects, social aspects and investment feasibility. In general, the use of husks and straw is feasible to do, this shows that currently husks in particular are no longer waste that is underutilised, but are one of the additional incomes in the rice milling process, where industry and society have widely utilised husks for various needs. However, the business model that is developed is only in the Buy and Sell transaction, there is no binding cooperation on a large enough scale, so the most possible business model is the use of husks into organic fertiliser to help farmers implement sustainable and environmentally friendly rice cultivation.

In the process of producing rice from grain, it produces by-products in the form of husks during the milling process and rice straw in the fields during cultivation. This feasibility study analyses the processing of straw and husk into renewable energy products, plant fertiliser, biodegradable packaging, animal feed and food (oil), by examining technological aspects, environmental aspects, social aspects and investment feasibility. In general, the utilisation of husk and straw is feasible, this shows that currently husk in particular is no longer an underutilised waste, but is one of the additional income in the rice milling process, where the industry and the community have already used a lot of husk for various needs. However, the business model developed is only in the stage of buying and selling transactions, there is no cooperation that is bound on a large enough scale, so the most possible business model is the use of husks into organic fertiliser to help farmers implement sustainable and environmentally friendly rice cultivation.

TABLE OF CONTENTS

LIST OF TABLES

FIGURE LIST

CHAPTER I. INTRODUCTION

1.1 BACKGROUND

Indonesia is the third rice producing country after China and India. Indonesia's rice production must still be increased to meet the demand of around 275 million people in 2025. The existence of rice a very important thing for the community, where the need for rice becomes a primary need. The majority of people will place rice in the important needs that must be fulfilled. More than 40 per cent of Indonesians depend on rice farming and more than 60 per cent of Indonesians use rice as their staple food.

Rice is an important food crop commodity in Indonesia. Indonesians use rice as a staple food. 95 per cent of the Indonesian population consumes this food. Rice is able to meet 63% of the total energy adequacy and 37% of protein (Norsalis, 2011 in Sitohang, et., al. 2014).Based on BPS data (2023), the rice harvest area is estimated at 10.20 million hectares with rice production of around 53.63 million tonnes of milled dry grain (MDG). If converted into rice for population consumption, rice production in 2023 is estimated at 30.90 million tonnes. The rice harvest area in 2023 is estimated to be around 10.20 million hectares, a decrease of 255.79 thousand hectares (2.45%) compared to the rice harvest area in 2022 of 10.45 million hectares. Rice production in 2023 is estimated at 53.63 million tonnes of MDG, down 1.12 million tonnes of MDG (2.05%) compared to 54.75 million tonnes of MDG in 2022. Rice production in 2023 for population consumption is estimated at 30.90 million tonnes, down 645.09 thousand tonnes (2.05%) compared to 31.54 million tonnes in 2022.

In the last two years, the problems in rice have become more complex, not only in terms of high prices, but also in the fact that markets and supermarkets are running out of stock. One of the reasons is that rice productivity has declined but demand for rice has increased, which is crucial because there is an imbalance between supply and demand, Small rice millers are faced with many challenges. During the harvest season, there is a surplus of rice, but this surplus will also become a struggle for many parties and competition among rice millers, so that "grain travelling" keeps the price of grain high and the logistical costs of distribution are also high, this will certainly have an impact on the price of rice. In addition, the regulation of the National Food Agency Regulation No. 7 of 2023, which regulates the Highest Retail Price of Rice, makes small rice milling businesses unable to increase the selling price of rice. This condition makes the rice millers increasingly faced with the dilemma of high grain prices while the price of rice must be in accordance with the regulations.

The price of rice in Indonesia is inseparable from the high cost of rice production. The cost structure of rice farming in Indonesia consists of costs, costs, land rent, and other costs. Overall, these costs account for around 37.75 to 42.73 per cent of total revenue. Data from the International Rice Research Institute (IRRI) 2016 states that Indonesia has the highest cost of rice production, at USD0.34 per kg. , the cost of rice production in the Philippines, India, Thailand, and Vietnam only reached USD0.25, USD0.21, and USD0.20, and USD0.12, respectively. In the rice fields, after harvesting the grain is sold to rice mills, and the remaining straw. Currently, rice straw is used as a raw material in the manufacture of organic fertiliser and planting mulch, and is also used as a source of nutrient-rich animal feed. The utilisation of rice straw as feed has only reached 31-39%, the rest is for burning or returning to the ground 36-62% and for industry 7-16%. The enormous physical potential of straw has not been fully utilised. Only a small number of farmers use straw as an alternative animal feed during the dry season due to the difficulty of obtaining forage. On the other hand, straw as agricultural waste is often a problem for farmers, so it is often burned to solve the problem. Meanwhile, burning agricultural waste increases CO2 levels in the air which results in global warming.

Many farmers burn straw because the ash from the burning straw is considered useful for fertilising the soil. In addition, the ash is also believed to make plants more resistant to pests and diseases. In fact, according to the Rice Plant Research Centre of the Ministry of Agriculture, the opinion of

This is a wrong opinion. In fact, burning straw can have a negative impact on plants. In addition, there are other impacts that are also caused by burning straw. Straw has a large nutrient content.

According to Dobermann and Fairhurst (2022), straw contains 0.5 - 0.8% N, 0.07 - .12 P2O5, 1.2 - 1.7% K2O and 4 - 7% Si. , if straw is composted, it will improve soil properties, both physical, chemical and biological. On the contrary, if straw is burnt, the absorption rate of soil nutrients and K content will increase. This is not good for the soil and will reduce crop productivity. So far, many farmers in Indonesia think that the ash produced from burning straw can keep plants away from pests and diseases. In fact, this thought is inversely proportional to what happens in the field. This is because there is no balance in the soil, where the straw ash does not cause the addition of potassium nutrients to the soilmaking the plants susceptible to pests and diseases.

On the other hand, behind the rice milling process that produces quality rice, there are by-products that are often not optimally utilised. In producing rice, only about 55 - 65% of it becomes rice, the rest is byproducts namely husks, bran and rice bran. current conditions, this byproduct is one of the important components in covering the operational costs of rice milling. Currently, husks are sold directly to be used as planting media, but there are also those who process milled husks to be mixed with bran for feed needs. in plain , the mixed husk feed is also difficult to distinguish from the original rice bran feed. This makes the animal feed of poor quality, because rice husk contains lignin and silica that can damage the digestive tract. In fact, if managed properly, rice husk has great potential to provide significant added value to the rice milling industry.

In the future, the government will prioritise the development of food crop agriculture, focusing on increasing production and productivity. With so many

With the increase in rice production every year, there is also an increase in rice straw and husk waste. For this reason, it is necessary to make efforts to utilise by-products in rice fields such as straw and also by-products of the rice milling process such as husks, to provide added value but not damage the environment. Processing rice straw and husk can provide various economic and environmental benefits that not only benefit rice millers, but also the wider community and the agricultural ecosystem as a whole.

Economic Benefits: Processing rice straw and husk into various value-added products, such as husk charcoal, biomass fuel, organic fertiliser, and industrial raw materials, can open new business opportunities and create jobs. By optimally utilising rice husk, the rice milling industry can improve efficiency and product diversification, thereby increasing income and business sustainability.

Environmental Benefits: Straw and rice husk processing also contributes to the reduction of agricultural waste and improved environmental sustainability. By reducing the often open burning of rice husk, we can reduce greenhouse gas emissions and air pollution. In addition, products from rice husk processing, such as organic fertiliser, can help improve soil fertility and support more environmentally friendly farming practices. The utilisation of rice straw and husk expected to reduce environmental pollution, especially the burning of rice straw directly in the field which can produce high amounts of air pollutants.
For this reason, this study will analyse the derivative products from straw and husk that can provide added value and also contribute to a sustainable agricultural system.

The rice straw and husk processing feasibility study aims to evaluate various economic, technical, environmental, social, market, financial, and regulatory aspects related to the utilisation of rice straw and husk. By understanding the potential added value and challenges, the rice milling industry can make informed decisions to implement straw and rice husk processing practices.

rice husk. This will not only increase economic returns but also support environmental sustainability and community welfare.

1.2 PURPOSE

1. Analyse the use of straw and husk into derivative products that provide added value.
2. Assessing the feasibility of straw and husk derivative products
3. Analyse the benefits of derivative products to support sustainable agricultural systems.

1.3 BENEFITS

1. Become the basis for the utilisation of straw and husk into products that have added value
2. Encourage farmers and rice millers to contribute to an environmentally friendly and sustainable farming system
3. Encourage the private sector to contribute in producing and providing environmentally friendly derivative products
4. Encourage relevant agencies to develop derivative products from by-products (husk and straw).

CHAPTER II. RICE AND ITS BY-PRODUCTS

2.1. PADI

Rice (*Oryza sativa* L.) is one of the seasonal food crops in the form of grasses and is clumpy. Rice plants are widely developed in Indonesia because it has a high adaptability to various environmental conditions. Rice plants are ancient agricultural crops originating from the Asian Continent and West Africa where according to history rice cultivation has begun in 3,000 years BC in Zhejiang (China). According to (USDA, 2017) in (Kurniawan, 2020), rice is classified as follows:

Divisio	: Spermatophyta
Subdivision.	: Angiosperms Class
	: Monocotyledoneae
Order	: Poales
Family	: Graminae
Genus	: Oryza Linn
Species	: Oryza sativa L

Before becoming rice, rice is processed into grain first. Grain itself is the grain of the rice plant that has been separated from the stalk and still has the skin or husk. Grain is composed of 15-30% outer skin (husk), 4-5% epidermis, 12-14% katul, 65-67% endosperm and 2-3% institution (Koswara, 2009). Rice husk consists of hull which is the outer skin and bran which is the inner skin or seed membrane (Nursalim and Zalni, 2007).

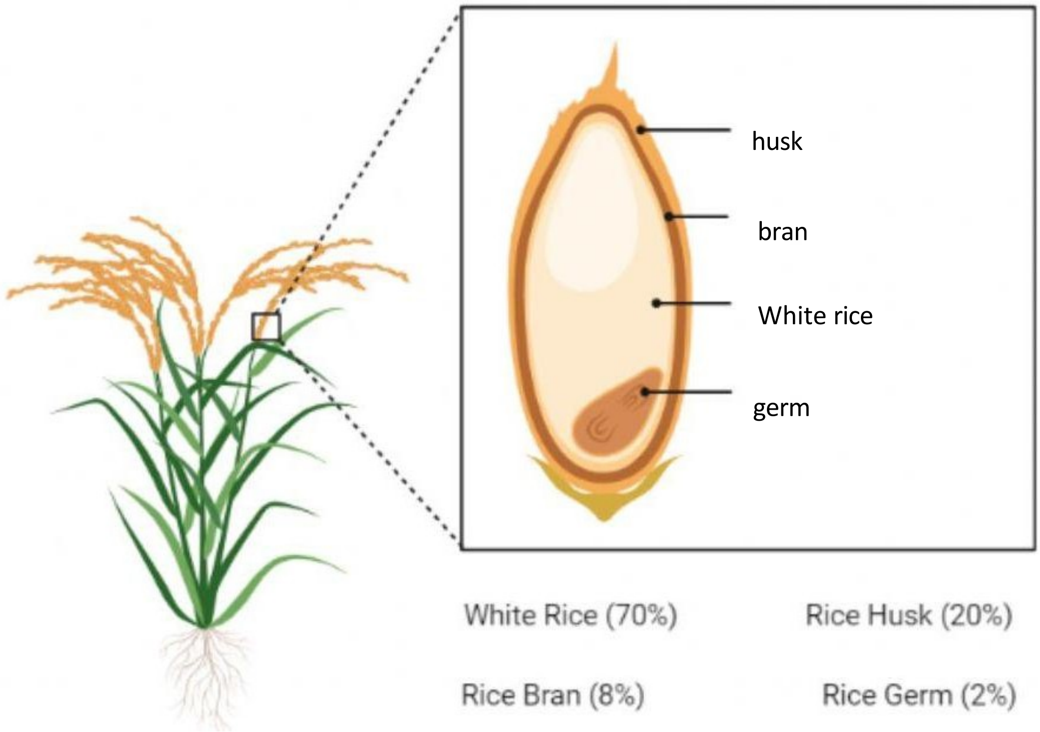
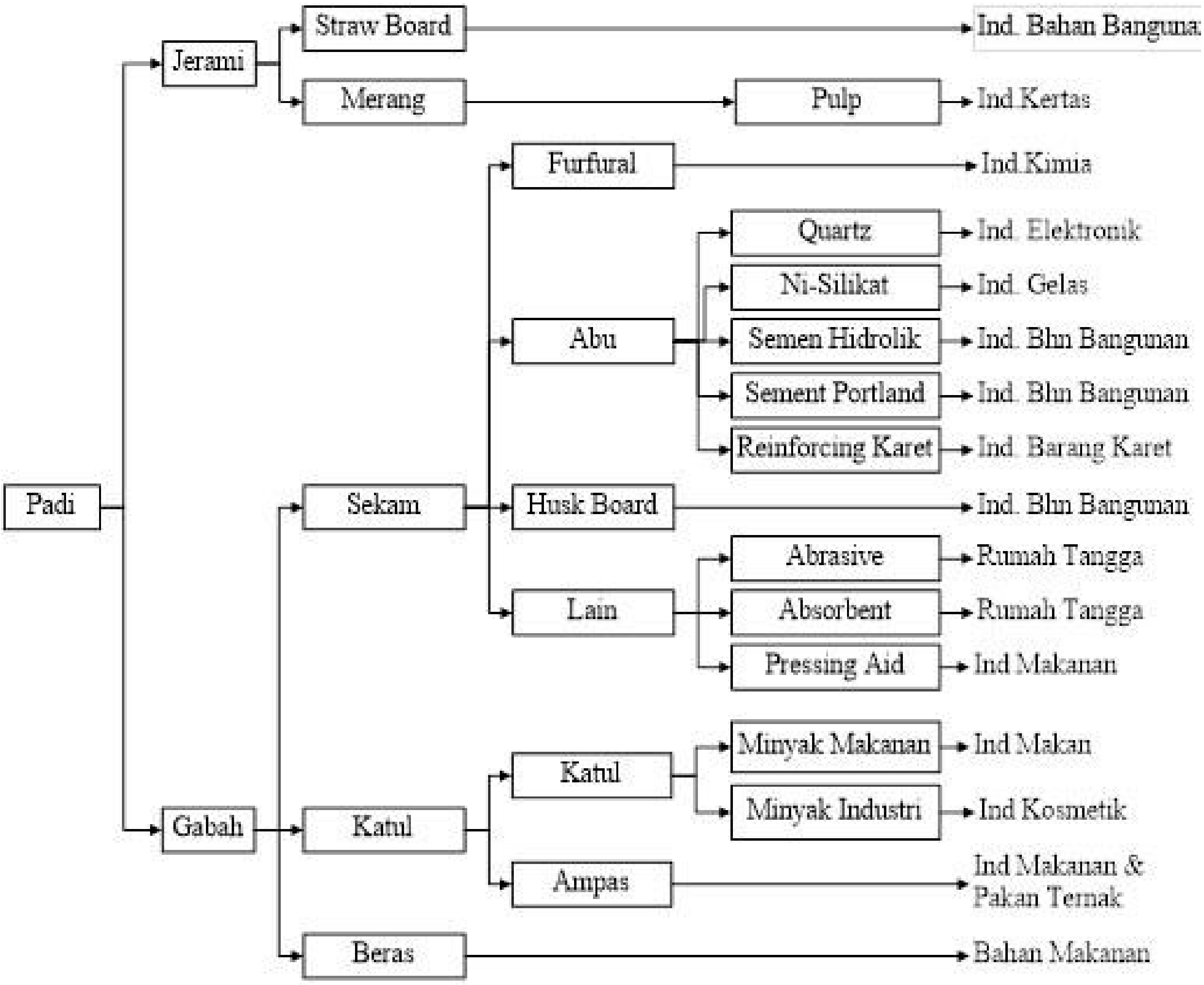


Figure 1: Structure of the Paddy (Grain) Section

The rice sector is one of the most important industries in national economic development, and is one of the sectors most supported and intervened by various government policies. The rice paddy sector uses inputs and supporting facilities needed in the production process, (*backward linkages*). The rice industry produces output in the form of rice which is used by many other industries as an intermediate input (*forward linkages*), making the rice sector one of the key sectors of economic development. These linkages can be seen from the tree of rice industries whose main products and by-products can be used as intermediate products for other industries.



Utilisation of Rice to Support Other Industries

2.2. RICE STRAW

Rice straw is a by-product of rice plants that is available in relatively large quantities. The abundant availability of rice straw is an opportunity to be utilised both upstream and downstream. In the upstream part, rice straw is widely used for agricultural and livestock purposes. In agriculture, rice straw is used as raw material in the manufacture of organic fertiliser and mulch. While in animal husbandry rice straw is utilised as a source of nutrient-rich animal feed.

Rice straw is mostly composed of lignocellulose and lignohemicellulose which are difficult to digest by ruminants and contain high silicate and oxalate, namely lignin. The high amount of silicates hinders the ability of ruminants to digest rice straw.

rumen microbes to digest it Himmel (2008). Jorgensen (2006) states that, lignocellulose itself is composed of 35-50% sellulose, 25-30% hemicellulose and 25-30% lignin. The production of rice straw varies, which can reach 12-15 tonnes of fresh straw per harvest, or 4-5 tonnes of dry straw per ha depending on the location and type of plant variety used. The characteristics of rice straw are characterised by high contents of crude fibre, lignin and silica.

The nature of rice straw has some high crude fibre content, less palatable, and high amba properties. According to research, rice straw contains 84.22% dry matter (BK), 4.60% crude protein (PK), 28.86% crude fibre (SK), 1.52% crude fat (LK), 50.80% extractable material without nitrogen (BETN). The nutrient content of rice straw varies, this is due to the age of harvest, type of rice and location. The following is the nutrient ilia of rice straw depicted in table 1.

Table 1. Composition of Nutritional Value of Rice Straw

Zat-zat makanan	**Komposisi**
EM (Kkal/kg)	3799,00
Bahan kering (%)	92,00
Protein Kasar (%)	5,31
Lemak Kasar (%)	3,32
Serat Kasar (%)	32,14
BETN (%)	36,68
Abu (%)	22,25
ADF (%)	51,53
NDF (%)	73,82
Lignin (%)	8,81

Sumber : Sarwono dan Arianto, 2003.

Rice straw in Indonesia has not been optimally utilised as a raw material or substitute material in the process of producing goods. The use of straw is mostly burned (37%) for fertiliser, used as kand ang mats (36) which are then composted and only about 15% to 22% are used as animal feed. Several types of rice straw are annually available in abundance after harvest.

Rice straw treatment in paddy field

Based on farmers' habits in the field, most of the straw from the remaining rice harvest is burned directly on the land with the aim of accelerating land preparation for the next planting period. Continuous burning of straw on agricultural land can cause an increase in air temperature on the soil surface and cause air pollution so that it can destroy microorganisms that are useful in soil biological processes, such as soil organic matter breakers, resulting in decreased levels of organic matter in the . Therefore, a solution that can be done is to utilise rice straw to be processed into compost. Composting rice straw aims to increase soil nutrients and can reduce farmers' production costs in purchasing fertilisers.

Utilisation of rice straw into compost is one alternative to substitute the use of chemical fertilisers. The nutrient content of the straw at harvest depends on soil fertility, the quality and quantity of irrigation water, the amount of fertiliser applied, and the season/climate. In Indonesia, the average nutrient content of rice straw is 0.4%N, 0.02% P; 1.4% K; and 5.6 Si. For every 1 tonne of grain (GKG) from a rice crop, 1.5 tonnes of straw is produced which contains 9 kg N, 2 kg P, 25 kg K, 2 kg S, 70 kg Si, 6 kg Ca and 2 kg Mg.

Many farmers have proven that applying straw compost to plants can increase . This is because straw compost can add nutrients to the soil. Based on the results of lab tests conducted by Balai

In agriculture, the nutrients from straw compost are more abundant than chemical fertilisers. In addition, straw compost can also make the soil fertile, break down the soil until it becomes loose, and make nutrients in the soil can be absorbed easily by plants.

Disposal of waste without proper treatment can disrupt the balance of ecosystems on earth faster. Therefore, waste treatment is very important to keep the earth beautiful and sustainable. Straw can be utilised as follows

2.2.1 Straw as Crop Mulch

Mulch is a ground cover material that is placed on the surface and serves to maintain the stability of soil moisture and temperature, suppress weed growth, change the soil microclimate, and prevent erosion of the soil surface during the rainy season. As a mulch, straw crops are very good because they are able to suppress weeds on the land when we plant in the dry season such as watermelon, cucumber, beans, chillies and so on. Besides that, it is also a barrier to direct sunlight.

The use of straw as mulch can also retain water in the soil and can suppress some weeds that develop. Rice straw is not only beneficial for secondary crops but also for plantation crops such as cloves, vanilla, coffee and tobacco.

In horticultural cultivation mulch can prevent splashing rainwater that causes infection in plants. And the provision of mulch in the dry season is able to retain solar heat on the upper surface of the soil, so that the evaporation rate becomes lower. Rice straw mulch has low heat conductivity so that heat reaching the soil surface is less than without mulch.

2.2.2 Rice straw as compost.

Making rice straw compost is very simple, where the straw is stacked approximately 50 cm thick, and sprinkled with a littlefertiliser, to accelerate the weathering process and left for approximately 15 days and then turned over. This is very good for improving soil fertility, the soil structure becomes loose and easily absorbs water. When sown evenly the plants will be better because the straw also contains NPK elements that are beneficial for growth and productivity.

Composting of rice straw waste is done by fermentation using decomposter such as effective microorganism (EM4), HCS bioactivator, and some microbes in the soil (algae, phytoplankton, fungi, and bacteria). Humic acid content in rice straw compost reached 0.126 per gram, 0.6 grams higher than compost derived from vegetables, indicating that rice straw compost is able to increase soil fertility so as to minimise the use of inorganic fertilisers that cause a lot of pollution,

Research conducted by Kusumawardhani and Titis (2015) proved that the use of rice straw compost can reduce the use of inorganic fertiliser by 125 kilograms. The addition of rice straw compost can increase crop yields by 33 per cent, this is because rice straw compost minimises the release of Nitrogen in the soil so that the supply of Nitrogen in the soil increases and the soil structure becomes good.

The addition of rice straw compost at 5 tonnes per hectare was also able to increase vegetative growth (stem height and number of tillers) by 22 percent, thus increasing the amount of rice production. The use of 10 tonnes per hectare of rice straw compost in maize cultivation was able to produce 6.20 tonnes increased 95 percent production if compared to the use of 5 tonnes per hectare of rice straw compost which only produced 3.40 tonnes.

2.2.3 Rice straw as animal feed.

Rice straw can be used in animal husbandry as a source of feed for large ruminants such as cattle and buffalo, especially as a source of fibre. The protein content of rice straw varies 3 to 5 per cent, while the available phosphorus and calcium content of rice straw is also low, resulting in low digestibility values of rice straw as dry matter and organic matterwhich are between 34 to 52 per cent and 42 to 59 cent, respectively. Constraints on the use of rice straw for animal feed include the difficulty of digesting the crude fibre of rice straw which has a lignin content of 7 per and silicate content of 13 per cent, so that several technologies are needed increase the potential digestibility of crude fibre.

For cattle and buffalo fattening areas, rice straw is used as a mixture of animal feed. Straw can be processed into 2 parts, there is a system of drying which is commonly called hay and stored in wet form called silage. What is often found in the farming community for animal feed is in dry form and stored in para-para form. This hay feeding is given when the forage feed is very lacking or in the dry season.

Another technology that can be used to process rice straw as animal feed is fermentation, which is a form of biotechnological processing. Fermentation technology of rice straw processing done by adding materials containing proteolytic, lignolytic, cellulolytic, lipolytic, and non-symbiotic nitrogen fixation microbes (using starbio, starbioplus, EM-4, and others).

In general, fermentation technology has the advantage that fermented straw has a higher nutrient content than fermented straw.

without fermentation (increased protein and decreased crude fibre) and has organoleptic properties (fragrant smell, acid) so that it is more palatable to livestock. As well as research conducted by Syamsu (2006) illustrates that the nutritional composition of rice straw that has been fermented using microbial starter (starbio) as much as 0.06 percent of the weight of rice straw, in general shows increase in quality compared to unfermented rice straw with crude protein levels fermented rice straw increased from 4.23 percent to 8.14 percent and followed by a decrease in crude fibre levels. Rice straw treated with 4 per cent urea and stored for 4 weeks increased in digestibility from 35 per cent to 43.6 per cent and nitrogentotal content from 0.48 per cent to 1.55 per cent.

While the innovation of adding probiotics starbio, the straw feed has a distinctive smell, slightly sweet and preferred by livestock (high palatability), protein levels increased from 2 to 4 percent to 12 percent, digestibility increased from 30 to 40 percent to 60 percent. This is reinforced by Soepranianondo, et al (2007), by combining ammoniation and fermentation technology using cellulolytic bacteria (Acetobacter liquefaciens) on rice straw can increase the body weight of sheep by 52.23 grams per day with a feed conversion rate derived from rice straw of 9.85 to 13.17 which shows the smaller the feed conversion rate the more profitable because less feed is consumed to achieve optimal meat products in a certain period of time, [30,31,34,35].

This indicates that the digestibility of rice straw is getting better. In general, various rice straw processing technologies, whether physical, biological or chemical, aim to 1) improve nutritional value and digestibility, and enhance ruminal fermentation by adding missing elements, 2) correct straw deficiencies by adding nitrogen or minerals, 3) increase consumption by adding nitrogen or minerals, and 4) improve the digestibility of rice straw.

improving palatability, 4) increasing energy availability, as well as
5) Reduce the amba nature of rice straw

2.2.4 Rice straw as a growing medium.

For sweet potato plants to be able to have maximum tubers and the size of the tubers, smooth and large, you must use straw as a planting medium. The method is to make a 60-120 cm wide straw bed with the bed length adjusted to existing land conditions.

Then the bed is filled with 5 cm thick soil taken from between the beds so that it covers the entire bed, then planted with sweet potato seeds. Planting sweet potatoes with a straw bed system is expected that the tubers can develop more optimally, maintenance is easier, weeds become less and harvest time does not need to use a hoe just by hand, so it does not hurt the tubers. By using rice straw media, tubers can develop more optimally, the quality and colour of the tubers are much better than soil media.

2.2.5 Rice straw as the roof of the cage.

Cattle, buffalo pens built in the middle of rice fields can use straw as a roof which is very cheap as long as it is treated well, it can last 2 - 3 years.

2.2.6 Rice straw as a growing medium for merang mushroom.

In Java, merang mushrooms are almost sold in every market. Rice straw is very useful as long as we are creative and can create new jobs for mushroom cultivation.

2.3. RICE HUSK

Rice husk is the outer shell of rice grains that has been separated from the rice through the rice milling process. Rice husk has a high fibre content and also contains several nutrients such as protein, fat, and minerals. Rice husk is also a hard layer covering the karyopsis which consists of two hemispheres called *lemma* and *palea* which are interrelated (Bhakti et al 2019). According to Ismunadji (1988), the rice milling industry produces 65% rice, 20% rice husk, and the rest is lost.

Figure 4. Rice husk

Worasuwannarak et al (2007) stated that the main components of rice husk consist of cellulose (38%), hemicellulose (18%), lignin (22%), and SiO2 (silica). Rice husk contains several important chemical elements (Suharno in Fasya 2017), as shown in Table 2 below.

Table 2: Nutrient value composition of rice husk

Component	Content (%)
Water content	9.020
Crude protein	3.027
Fat	1.180
Crude fibre	35.680
Abu	17.710
Crude carbohydrates	33.710

Along with the times, there have been many studies that discuss rice husk and its benefits, including:

2.3.1 Husk as raw material for making silica gel

Quoting from Handayani et al (2015), rice husk has the potential as a material for making silica gel, because it is one of the largest sources of silica. The husk contains as much as 87-97% silica by dry weight after undergoing complete combustion.

Silica gel is a form of silica produced by agglomerating sodium silicate sol $NaSiO2$. The sol looks like jelly, which can be dehydrated so that it turns into an inelastic solid or granules.

Silica gel is widely used as an absorbent, desiccant, and catalyst support. It is usually used to maintain moisture such as food, medicines, electronics, films, and even sensitive materials. Uniquely, this moisture-proof product can absorb without changing the shape of the substance. If we hold this gel, it will remain dry.

2.3.2 Husk as Raw Material for Charcoal Making

Rice husk charcoal has many uses in agriculture and industry. Rice husk charcoal is rich in carbon content, it is used in composting. Farmers use husk charcoal to loosen the soil.

2.3.3 Husk for Soil Media

According to Purnomo in Fasya 2017, the use of rice husk is used as an addition or mixture of planting media. The advantages of rice husk include: cheap price is easy to obtain, easy to manufacture, low manufacturing costs, utilisation of agricultural waste, easy to absorb water, and for roots can store oxygen well.

2.3.4 Chaff as a Nutrient Provider

Besides being used as a planting medium, rice husk ash can also be used to improve soil quality. Hermawan 2003, stated that rice husks are used to re-fertilise ultisol soils. Ultisol soil is one of the less fertile soils because it is acidic and contains high Al elements. Can increase the elements of P, K. and C in the soil.

Lim et al 2012, examined the transformation of rice husk as fertiliser through the *vermicomposting* process. In addition, rice husk is used as a base material for liquid fertiliser and activated carbon (Ding et al 2014).

2.3.5 Husk for Renewable Energy Source

Rice husk can be utilised as a base material for briquetting. Briquettes are solid fuels that have been compacted from non-solid materials such as powders. Briquettes are made by gluing powder with flour (rice flour, starch, and glutinous rice flour) then compacted and dried.

According to Ali et al (2016), people in Pakistan process rice husks mixed with animal faeces to produce biogas. In Cambodia, it is used as power using the gasification method. The gasification method is a system for converting raw fuel into gas using a *fluidised bed* technology gasification reactor. Then the gas is used as diesel engine fuel in power plants (Primantara et al 2017).

2.3.6 Husk as a Natural Adsorbent

Adsorption is the process of attaching certain molecules to a surface. Adsorbents are solids used in the adsorption process. Quoted from Yahya 2017, rice husk charcoal can adsorb lead (Pb) metal ions.

Besides lead, husk charcoal can remove iron (Zn) and nickel (Ni) ions in water.

Mercury (Hg), can also be absorbed by husk charcoal. Husk charcoal is also used in efforts to manage media (water and soil) that have been polluted by harmful metals such as Pb, Ag, Cr, Ni, Cu, and so on (Purwaningsih 2009).

2.3.7 Chaff for Building Materials

An interesting fact, based on research conducted by Adha (2011), rice husk has the potential as a substitute for cement in paving structures. Cement and rice husk ash (6%) mixed with low plasticity clay material has fulfilled the technical requirements as a foundation layer.

Putra (2016) stated that rice husk is also used as a mixture for making concrete so that it is not quickly damaged by magnesium sulfate compounds in seawater. In Putra's research (2016) can be concluded that, the optimal percentage of rice husk as much as 16.8% added to the concrete making process, can reduce damage due to magnesium sulfate.

According to Setiawan et al (2016), rice husk added to *pumice* lightweight concrete can be used as a substitute for ordinary concrete for building structures.

2.4 INDONESIA REGULATION

In Indonesia, various regulations have been implemented to support the utilisation and processing of agricultural waste, including rice straw and husk. These regulations cover environmental, renewable energy, and waste management aspects. Here are some of the relevant regulations:

1. **Law Number 18 Year 2008 on Waste Management**
    - **Content**: This law regulates waste management comprehensively from upstream to downstream, including waste reduction, handling, and utilisation.
    - **Relevance**: The utilisation of rice straw and husk as resources that can be processed into value-added products is in line with the waste management principles in this law.
2. **Law Number 32 Year 2009 on Environmental Protection and Management**
    - **Content**: Regulates the protection and management of the environment, including waste and pollution management.
    - **Relevance**: Encouraging the management of agricultural waste such as rice straw and husks to reduce negative impacts on the environment.
3. **Government Regulation No. 81/2012 on the Management of Household Waste and Waste Similar to Household Waste**
    - **Content**: Regulates the management of household waste and similar waste, including waste reduction and utilisation.
    - **Relevance**: Straw and rice husk can be categorised as similar household waste that can be managed and utilised further.
4. **Minister of Agriculture Regulation No. 70/Permentan/OT.140/10/2011 on General Guidelines for Organic Agriculture**
    - **Content**: Provides guidelines for organic farming, including the use of organic materials and farm waste management.
    - **Relevance**: Encouraging the use of rice straw and husk as organic materials in organic farming practices.

5. **Minister of Energy and Mineral Resources Regulation No. 12/2017 on Utilisation of Renewable Energy Sources for Electricity Supply**
   - **Content**: Regulates the utilisation of renewable energy sources, including biomass, for the provision of electricity.
   - **Relevance**: Rice husk can be utilised as biomass fuel for power generation, supporting renewable energy goals.

6. **Minister of Environment and Forestry Regulation No. P.71/Menlhk/Setjen/Kum.1/11/2019 on the Climate Village Programme**
   - **Content**: Regulates environmental management and climate change control programmes at the local level.
   - **Relevance**: Promoting environmentally friendly agricultural waste management practices, including the utilisation of rice straw and husks to reduce greenhouse gas emissions.

7. **Presidential Instruction No. 6/2017 on the Provision and Utilisation of Biofuel Raw Materials**
   - **Content**: Instructs various ministries and agencies to support the provision and utilisation of biofuel feedstocks.
   - **Relevance**: Rice husk can be processed into biofuel, supporting national renewable energy initiatives.

8. **Presidential Regulation No. 61 Year 2011 on the National Action Plan for Reducing Greenhouse Gas Emissions**
   - **Content**: Sets out national action plans to reduce greenhouse gas emissions in various sectors.
   - **Relevance**: Utilisation of rice straw and husk can contribute to emission reduction through environmentally friendly waste management.

CHAPTER III. UTILISATION AS RENEWABLE ENERGY

3.1. RICE HUSK CHARCOAL

In some areas in Indonesia, rice husks are used as fuel in the manufacture of husk charcoal. Husk charcoal is usually used as fuel in cooking or as a mixture in making organic fertiliser. Husk charcoal is an important material that is often used for agricultural raw materials, besides that husk charcoal can also be used for industrial needs as a soil looser, compost making material, bokashi, takakura, planting media and nursery media.

Chemically, husk charcoal contains important nutrients such as nitrogen (N), phosphorus (P), potassium (K), calcium (Ca) and Magnesium (Mg). Its acidity is neutral to alkalis with a pH range of 6.5 to 7. Charcoal from rice husks does not contain salts that are detrimental to plants.

3.1.1 Technology Aspects

Materials and tools required:

- Rice husk.
- Metal drum or large barrel.
- Wood for fuel.
- Shovel or tool to fill the chaff into the drum.
- Chopsticks or tools to open and close the vents on the drum.

Steps:

1. Combustion Device

- Find a cylindrical barrel made of iron, aluminium, zinc or a fire-resistant metal. Approximately 20 litres in size and remove one of the bases or lids.
- On the part of the base or lid that is not discarded, make a 10cm diameter hole in the centre of the circle.

- Make a hole with a nail in the cylinder wall with a size of approximately 0.5 cm. The function is to dissipate heat from the fuel to the pile of rice husks without burning directly.
- The sharp part of the hole should point outwards so that the flame tongue sticks out. Make a hole from the inside towards the outside of the cylinder
- Use a 1 cm long pipe with a diameter of 10 cm. Insert the pipe into the hole that has been made by the base or roof, as a combustion chimney.
- Glue the pipe by welding so that the pipe can stand upright on the cylinder. Or put the pipe in the cylinder, prop it up with nails, then tie it with beso wire so that the chimney can stand upright.

2. Combustion Process
    - Choose a burning location away from roads or housing, as the burning process produces thick smoke.
    - Build a campfire the size of the cylinder that was made earlier. Ignite the fire then cover the fire with a cylinder that has been given a chimney.
    - Stockpile the cylinder combustion chamber in which there is already a flame with several sacks of husks. stockpile approximately 1 metre high.
    - After 20-30 minutes, when the top of the chaff pile looks blackened, feed the brown chaff towards the top. Keep doing this repeatedly
    - Once everything is blackened do some watering to stop the burning process.

Figure 5: Husk charcoal making process

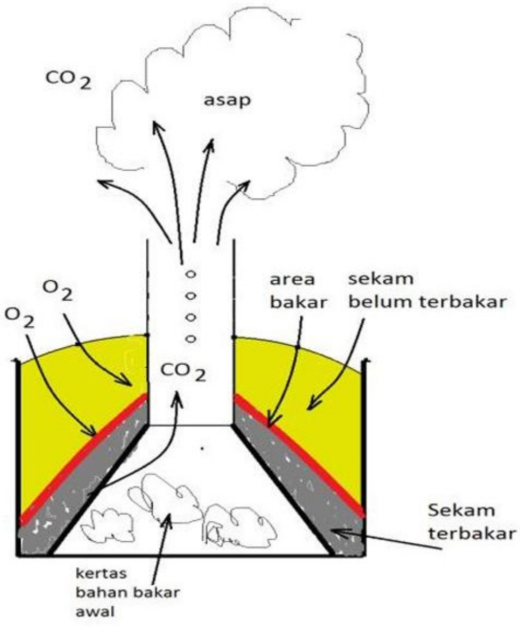


Figure 6, Mechanism of husk charcoal formation

The fire under the furnace pushes air and smoke up the chimney, so that outside air is drawn into the furnace through the unburnt chaff. Meanwhile, the chaff in contact with the furnace begins to burn and consume oxygen. As the burn area spreads outward, the inside of the chaff is burned.

The burnt material is deprived of oxygen so it does not burn into ash but into charcoal.

3.1.2 Social Aspects

The processing of husk waste into husk charcoal by the community will have a positive impact on the environment, health and the community's economy. The utilisation of husk charcoal can improve agricultural land, and environmental preservation, and can provide additional income and support the community's economy. The charring process will be a simple combustion process that is easily carried out by the community.

3.1.3 Environmental Aspects

Husk charcoal is used for soil loosening, compost, bokashi fertiliser, planting media, and nursery media. The benefits of husk charcoal spur the growth of microorganisms, regulate soil pH, retain moisture, and suppress pathogenic microbes.

Biologically, loose soil is an excellent medium for the growth of living organisms. Both microorganisms such as root bacteria and Table 1 Chemical composition of rice husk Component Content (%) Carbon (Charcoal Substance) 1.33 Hydrogen 1.54 Oxygen 33.64 Silica (SiO2) 16.98 Figure 1
Charcoal making Journal of Community Innovation Centre Vol 2 (4) 2019: 679-684 683 macroorganisms such as earthworms. Another advantage is that husk charcoal does not carry pathogenic microorganisms. Because the manufacturing process is through combustion, it is relatively sterile. Chemically, husk charcoal contains important nutrients such as nitrogen (N), phosphorus (P), potassium (K), calcium (Ca) and magnesium (Mg). The acidity is neutral to alkalis with a pH range of 6.5 to 7. Charcoal from rice husks does not contain salts that are detrimental to plants (Surdianto et al. 2015).

3.1.4 Economic and Market Aspects

The results of burning rice husks can produce charcoal called rice husk charcoal, which can be used for various purposes including as raw material for the chemical industry, building materials, as an adsorbent for heavy metals such as Pb, Cd, Cr, Fe in water (Sitanggang 2010).

- Based on observations made, the price of rice husk is Rp.1000,00/kg, and the price of rice husk charcoal is Rp.5000,00- 7,000,00/kg [10].
- Husk charcoal is also expected to increase income, the value of the selling price of husk charcoal which reaches Rp.5000.00- 7000.00/kg, compared to the selling value of husk which is only Rp.1000.00/kg.

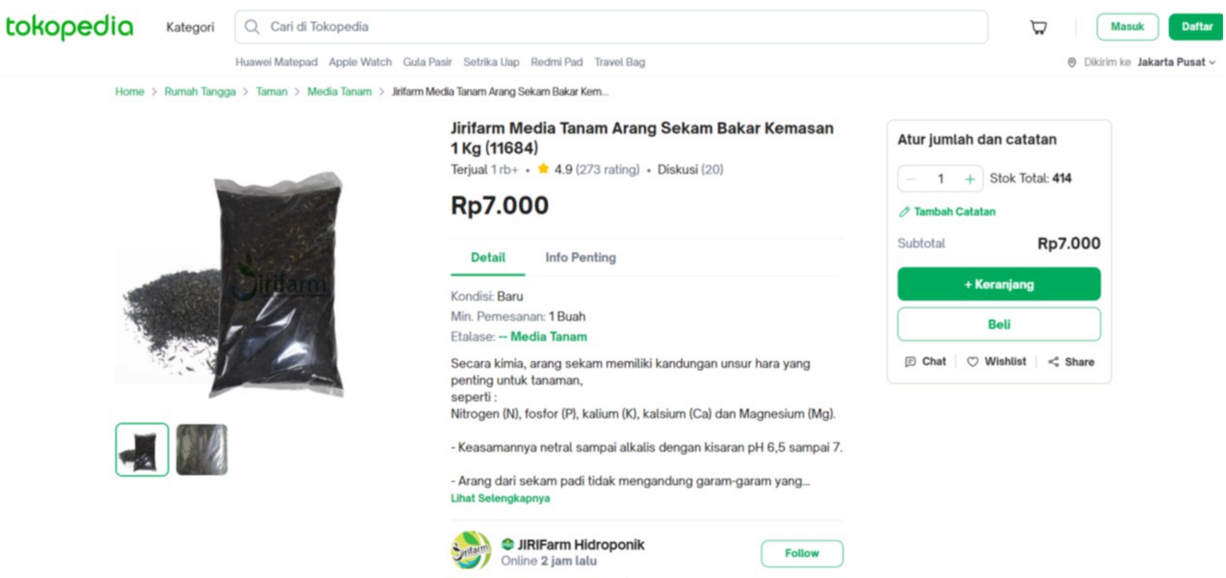


Figure 7: Price of chaff charcoal in e-Commerce

3.1.5 Investment Aspects

1. Assumption

   Discount rate for NPV calculation: 10%

2. Base Data

   - Initial Investment: IDR 50,000,000
   - Monthly Income: IDR 30,000,000

- Monthly Operating Expenses: IDR 20,000,000
- Payback period: 20 months
- Analysis Period: 2 years (24 months)

3. Cash Flow Calculation

- Cash Inflow (Monthly Income): IDR 30,000,000
- Cash Outflow (Monthly Operating Expenses): IDR 20,000,000
- Monthly Net Cash Flow
- Net Cash Flow=Revenue-Operating Expenses=30,000,000-20,000,000=10,000,000

Table 3. Rice Husk Charcoal Investment Table

Period (Month)	Cash Flow Entry (Rp)	Cash Flow Outgoing (Rp)	Cash Flow Net (Rp)	NPV (Rp)
0	0	50,000,000	-50,000,000	-50,000,000
1	30,000,000	20,000,000	10,000,000	9,090,909
2	30,000,000	20,000,000	10,000,000	8,264,463
3	30,000,000	20,000,000	10,000,000	7,513,148
4	30,000,000	20,000,000	10,000,000	6,830,135
5	30,000,000	20,000,000	10,000,000	6,209,213
6	30,000,000	20,000,000	10,000,000	5,644,739
7	30,000,000	20,000,000	10,000,000	5,131,581
8	30,000,000	20,000,000	10,000,000	4,665,074
9	30,000,000	20,000,000	10,000,000	4,240,976
10	30,000,000	20,000,000	10,000,000	3,855,433
11	30,000,000	20,000,000	10,000,000	3,504,939
12	30,000,000	20,000,000	10,000,000	3,186,308
13	30,000,000	20,000,000	10,000,000	2,896,644
14	30,000,000	20,000,000	10,000,000	2,633,313
15	30,000,000	20,000,000	10,000,000	2,393,920
16	30,000,000	20,000,000	10,000,000	2,176,291
17	30,000,000	20,000,000	10,000,000	1,978,447
18	30,000,000	20,000,000	10,000,000	1,798,588
19	30,000,000	20,000,000	10,000,000	1,635,080
20	30,000,000	20,000,000	10,000,000	1,486,436
21	30,000,000	20,000,000	10,000,000	1,351,306

Period (Month)	Cash Flow Entry (Rp)	Cash Flow Outgoing (Rp)	Cash Flow Net (Rp)	NPV (Rp)
22	30,000,000	20,000,000	10,000,000	1,228,460
23	30,000,000	20,000,000	10,000,000	1,116,782
24	30,000,000	20,000,000	10,000,000	1,015,256

Table 4. NPV, and IRR Table of Rice Husk Charcoal

Interest rate	10%
net present value (NPV)	39,847,440
interest rate of return (IRR)	20%
accepted/rejected	Accepted

3.2 HUSK BRICKS

To increase its economic value, the production of husk charcoal can be produced in the form of charcoal briquettes for cooking, lighting, and industrial needs. Husk charcoal briquettes are expected to be one of the cheap and environmentally friendly fuel solutions.

The price of husk charcoal per kg is IDR 3000 - 5000 while the price of charcoal briquettes is between IDR 15,000 - 20,000 per kg.

3.2.1 Technology Aspects

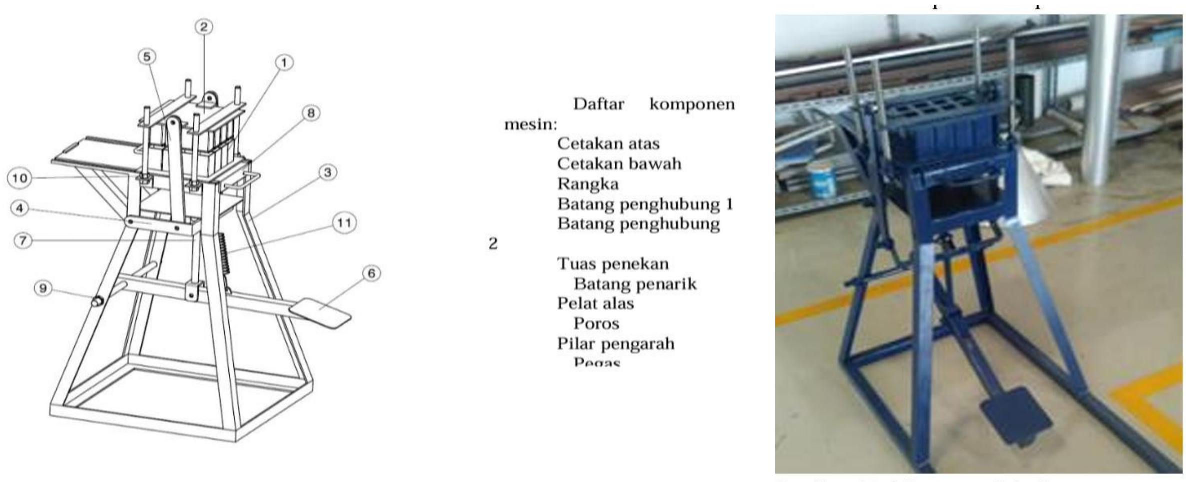


Figure 8. Husk charcoal briquette moulding machine

The mechanism of forming rice husk charcoal into briquettes is as follows.

- The resulting husk charcoal was then mixed with liquid adhesive made from tapioca starch in a ratio of 5 parts charcoal to 1 part adhesive,
- for further moulding in the charcoal briquette moulding machine
- then press so that it becomes a briquette

Chaff charcoal briquette moulding process

3.2.2 Social Aspects

Waste-to-energy activities not only provide opportunities for environmental conservation, rural development, and business. By doing this activity, it is expected to provide motivation to increase the income of farmers and increase the productivity of farmers in the village.
The method used, in addition to counselling, training with demonstrations of briquette processing, mentoring and assistance to become market-ready products.

By comparing the selling value of husk, which is only IDR 1000 per kg, with husk charcoal briquettes that cost IDR 15,000 per kg, and the capacity of a printing machine that can produce 120 kg per day or 3000 kg per month, the potential income for the community is IDR 45,000,000 per month.

3.2.3 Environmental Aspects

One print run can produce 1 kilogram of husk charcoal briquettes. As an energy source, husk charcoal briquettes have a high calorific value as revealed by (Patabang, 2012) that the calorific value of husk charcoal briquettes with 7% adhesive content is 2789 kKal/kg while Nurhilal & Tarigan (2017) stated that the calorific value of husk charcoal briquettes is 3873.5 kKal/kg. In comparison, the calorific value of coal is 6216 kKal/kg (Bono, Wahyono, & Burhani, 2017), so husk charcoal briquettes have great potential to be used as an alternative fuel.

3.2 4 Investment

Aspects Initial

Investment:

- IDR 100,000,000

Assumption:

- Production capacity: 500 kg of husk briquettes per day
- Selling price of husk briquettes: IDR 15,000 per kg
- Raw material cost: IDR 3,500 per kg
- cost: IDR 2,000,000 per month
- Overhead costs: IDR 2,000,000 per month
- Length of investment time: 5 years

Revenue Projection:

- Husk briquette production per day: 500 kg
- Husk briquette production per year (assume 300 working days): 500 kg/day x 300 days/year = 150,000 kg/year
- Revenue per year: 150.000 kg/year x Rp 7,000/kg = IDR 1,050,000,000 **Cost Projection:**

- **Raw material costs:**
  500 kg/day x Rp 7,000/kg x 365 days/year= Rp 840,000,000
- **Labour costs:**
  - Per year: IDR 2,000,000/month x 12 months/year= IDR 24,000,000
- **Overhead costs:**
  - Per year: IDR 2,000,000/month x 12 months/year= IDR 24,000,000

- **Total cost per year:**
  - Raw material cost+ Labour cost+ Overhead cost= Rp 840,000,000 + Rp 24,000,000 + Rp 24,000,000 = Rp 888,000,000

Profit and Loss Analysis:

- **Net profit per annum:**

  Revenue per year - Total cost per year= Rp 2,625,000,000 - Rp 888,000,000 = Rp 1,737,000,000

Table 5. Rice Husk Charcoal Investment Analysis Table

Period e Year	Cash Inflow (Rp)	Cash Outflow (Rp)	Net Cash Flow (IDR)	NPV (Rp)
0		100,000,000	(100,000,000)	(100,000,000)
1	1,737,000,000	888,000,000	849,000,000	771,818,182
2	1,737,000,000	888,000,000	849,000,000	701,652,893
3	1,737,000,000	888,000,000	849,000,000	637,866,266
4	1,737,000,000	888,000,000	849,000,000	579,878,424
5	1,737,000,000	888,000,000	849,000,000	527,162,203
				3,118,377,967

Table 6. Table of Analytical Results of Rice Husk Charcoal

Interest rate	10%
net present value (NPV)	3,118,377,967
interest rate of return (IRR)	849%
Accepted rejected	Accepted

3.2.5 Economic and Market Aspects

With the ability to print 1 kg of charcoal briquettes in 4 minutes, 120 kg of husk charcoal briquettes can be produced in 8 hours (a day). With the price of husk charcoal briquettes at Rp 15,000 per kg, one day can be made.

produces Rp1,800,000. Thus, with the calculation of 1 month consisting of 25 working days, one printing machine can produce IDR 45,000,000. Meanwhile, the cost of making this husk charcoal briquette printing machine is quite affordable for the community, which is IDR 6,800,000.

Briquette products are also in great demand in other countries such as Japan, Arabia, Turkey, and others. So the export potential of briquettes is very promising. In addition to exports, briquette sales can also be made to restaurants that used to use wood charcoal or coconut shell charcoal now switch to briquettes.

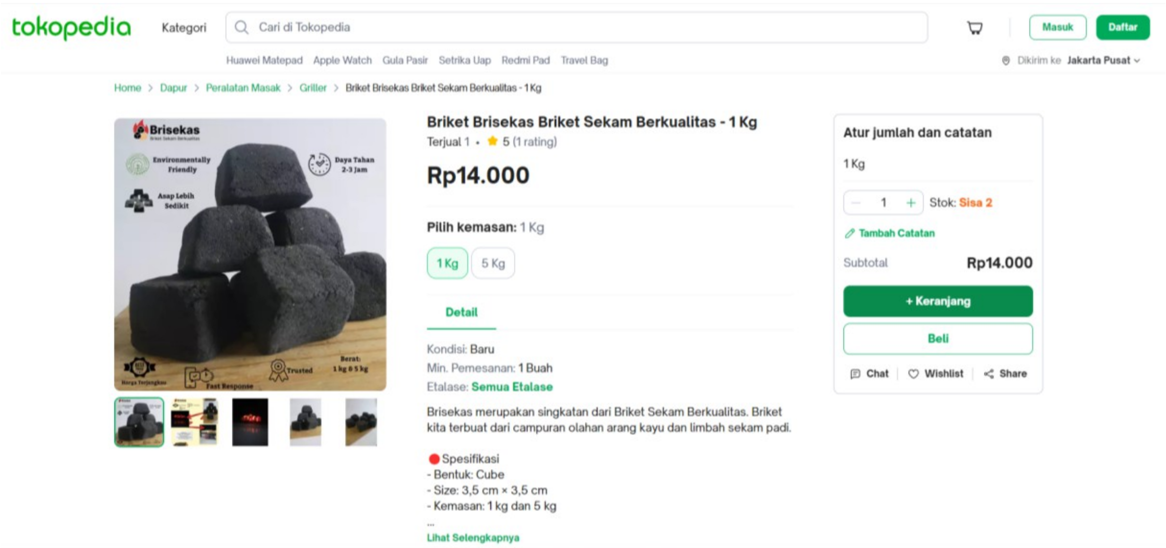


Figure 10: Price of chaff briquettes on E-Commerce

3.3 JERAMIE BRIKETS

As a lignocellulosic biomass, straw is composed of three components, viz: lignin, cellulose, and hemicellulose. This opens up opportunities for the utilisation of straw as an energy source through various conversion routes. Straw has a low density of 70-80 kg/m3 at 15-18% moisture content. Table 1 gives the properties and composition of several types of straw. Two striking features of rice straw compared to other straws are its high ash content (up to 22.1%) and low calorific value (HHV) (less than 15 MJ/kg).

3.3.1 Technology Aspects

Densification produces two types of products, namely pellets and briquettes. Pellets are cylindrical in shape with a diameter of 6-12 mm, length 50 MPa). Pressure determines the quality of the pellets, but above 200 MPa it has no significant effect on pellet density (Stelte et al., 2011). Straw particle size affects the working pressure (the smaller the particle, the greater the pressure).

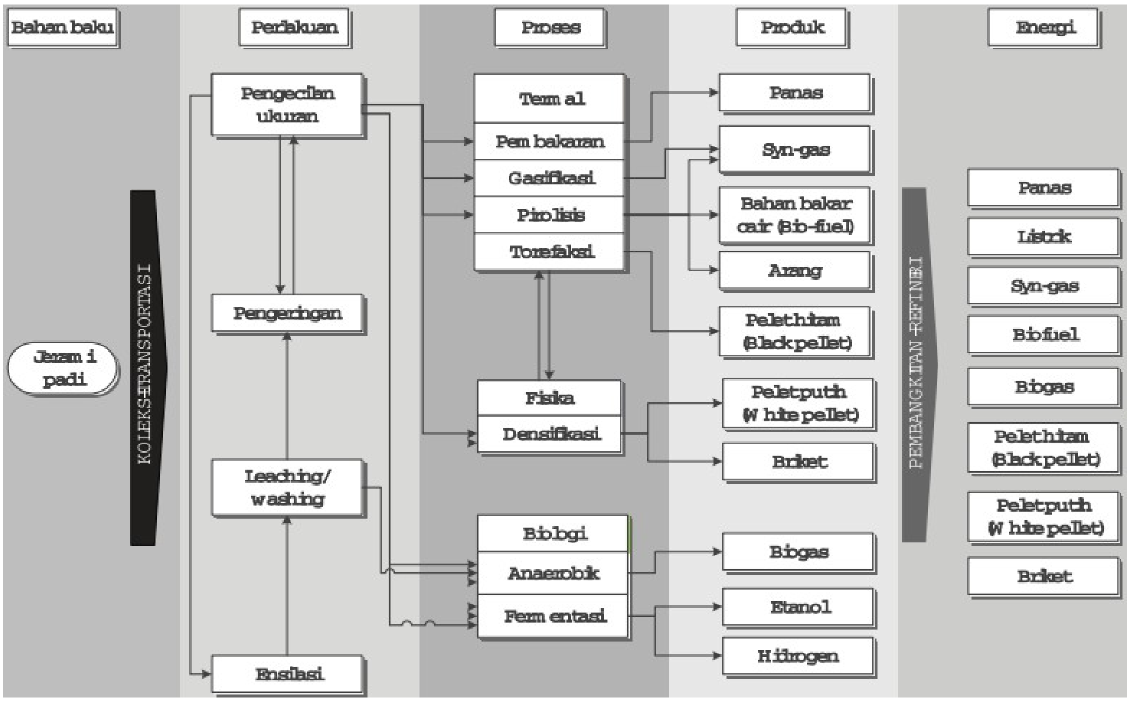
Pellets are made by adding steam without adhesives. Quality pellets are made with a temperature of 60-80ºC and a material moisture content of 13-20% (Ishii 2014). If the straw is too dry, the pellet surface may char and burn before the process is completed. If it is too wet, moisture cannot escape during pressing resulting in mechanically weak pellets. The development of rice straw pellets is commercially attractive, increases the added value of the rice process chain, and can create employment opportunities in rural areas.

Briquettes are cylindrical or block-shaped with a size of 60-100 mm and a length of 60-mm.

150 mm. Briquettes are used to fuel boilers and are less suitable for household applications. To produce briquettes, straw is simply cut into pieces and then pressed with a felt machine. Good briquettes are produced from a working pressure of about 30 MPa (Singh and Singh, 1982). The optimum conditions for straw briquetting are 12-14% moisture content, 14-16 mm particle size, and 20% adhesive. At a capacity of 1200 kg/hour, briquetting requires a power of 1.5 MPa.

(36.60 kW) and produce briquettes with high density (1030.38- 1159.22 kg/m3) and high calorific value (15.61 MJ/kg) (Gill et al., 2017).

Jenkins et al. (2000) noted that energy consumption in the densification and milling processes of rice straw reached 16 kWh/tonne or 2% and 30 kWh/tonne or 4% of the power generated by rice straw power plants, respectively. Straw briquettes to fuel power plants in remote areas or to operate grain milling machines are more likely to be developed because they do not require energy for milling and transport costs can be reduced.



Potential Rice Straw Energy Conversion Process (IRRI, 2018)

(a) (b) (c)

(a) Straw Pellets (b) cylindrical briquettes (c) Block

briquettes Figure 12 Straw Solid Fuel

3.3.2 Social Aspects

Straw collection is still a major challenge in the straw supply chain for further use. Straw needs to be collected and tied to make it more compact and easy to transport. Indonesian farmers' habit of harvesting rice when the field is still wet makes the collection process difficult and costly. In traditional harvesting with sickles, the *threshing* process (either using a *threser* or slamming on a gebot) will leave the straw collected in one area.

The transport process is usually done using trucks. In order to save money, drivers tend to transport as much straw as possible. With a decomposed condition, the loading is done by stacking and tying the straw up high. This endangers other road users because in addition to blocking visibility, the high load is also prone to causing the truck to roll over.

Nowadays, rice harvesting is mostly done using a combine harvester. With a combine harvester, the process of collecting rice straw becomes more difficult and expensive because the straw is scattered in the field.

3.3.3 Environmental Aspects

Rice straw is a poor fuel, especially for systems operating at high temperatures. This is due to the intrinsic characteristics of rice straw itself, such as high ash content and high elemental content (Si, K, Na, S, Cl, P, Mg, and Fe). High ash content lowers the energy value (Figure 5). High ash also results in an additional cost of 0.5 $/MWh on the total cost of generation to deal with issues related to ash and ammonia.

The chemical composition of rice straw ash consisting of alkali and alkaline earth metals (Si, Ca, Mg, Na and K) is responsible for various undesirable reactions in combustion systems. Ash concentration and silica content and high alkali metals in rice straw result in agglomeration, fouling, slagging of boiler components (Jenkins et al., 1998) resulting in reduced system efficiency (Jenkin et al., 2000) and failure of most furnaces and boilers. These failures have hindered the utilisation of straw for large-scale boilers, even in regions where the boiler is close to the straw source. The high silica content in rice straw causes the components of chopping or grinding machines to wear out quickly. Rice straw is also very difficult to burn, especially in furnaces designed for power generation due to the formation of deposits. These deposits inhibit the rate of heat transfer, triggering scale formation in the furnace and on the grate making fuel feeding and ash removal difficult (Jenkins et al, 1998). This increases the cost of electricity generation due to low efficiency.

3.3.4 Economic Aspects of the Market

The challenges of rice straw utilisation include socio-economic issues related to rice cultivation practices in wetlands that result in high collection and transport costs, as well as technical issues that include the intrinsic characteristics of the straw itself.

A major barrier to the utilisation of rice straw for energy is the high cost of the logistics of collection, transport, handling and storage. The cost of transporting rice straw is influenced by the distance travelled.

3.3.4 Investment

Aspects

Assumptions:

- Production capacity: 500 kg of husk briquettes per day
- Selling price of husk briquettes: IDR 7,000 per kg
- Raw material cost: IDR 3,000 per kg
- cost: IDR 2,000,000 per month
- Overhead costs: IDR 2,000,000 per month
- Length of investment time: 5 years
- Initial investment: IDR 40,000,000

Calculation:

1. Income per day:

500 kg/day x Rp 7,000/kg= Rp 3,500,000/day

2. Income per month:

30 days/month x Rp 3,500,000/day= Rp 105,000,000/month

3. Variable cost per month:

- Raw material cost: 500 kg/day x IDR 3,000/kg x 30 days/month= IDR 45,000,000/month
- cost: IDR 2,000,000/month

Total variable cost per month:

IDR 45,000,000/month+ IDR 2,000,000/month= IDR 47,000,000/month

4. Net profit per month:

Rp 105.000.000/bulan-Rp47.000.000/bulan - Rp 2,000,000/month = IDR 56,000,000/month

5. Net profit per annum:

IDR 56,000,000/month x 12 months/year= IDR 672,000,000/year Table

7. Straw Briquette Investment Analysis Table

Period Year	Cash Flow Entry (Rp)	Cash Flow Outgoing (Rp)	Cash Flow Net (Rp)	NPV (Rp)
0		40,000,000	(40,000,000)	(40,000,000)
1	672,000,000	564,000,000	108,000,000	98,181,818
2	672,000,000	564,000,000	108,000,000	89,256,198
3	672,000,000	564,000,000	108,000,000	81,141,998
4	672,000,000	564,000,000	108,000,000	73,765,453
5	672,000,000	564,000,000	108,000,000	67,059,503
				369,404,971

Table 8. Straw Briquette Analysis Results Table

Interest rate	10%
net present value (NPV)	369,404,971
interest rate of return (IRR)	270%
Accepted rejected	Accepted

3.3 JERAMIE ETANOL

Straw Ethanol Since it is rich in cellulose and hemicellulose and does not compete with foodstuffs, rice straw is also a promising feedstock for second-generation ethanol production.

Two conversion technology platforms are being developed, namely the syngas platform and the sugar platform. In the syngas platform, straw is gasified to produce syngas which is then fermented or catalytically processed to produce ethanol (Drapcho et al., 2008). In the sugar platform, cellulose and hemicellulose are hydrolysed with the help of acids or enzymes into sugars (such as glucose, xylose, arabinose, and galactose), and then fermented to produce ethanol. The sugar platform can only utilise cellulose and hemicellulose. However, cellulose and hemicellulose are bound by a layer of lignin that is difficult to hydrolyse. The presence of ash and high silica content pose problems in ethanol production from rice straw. Pretreatment is the most expensive stage (Mosier et al., 2005), so the selection of appropriate pretreatment methods is a major challenge in the development of efficient rice straw to ethanol conversion technologies that are economically viable (Binod et al., 2010). The straw-to-ethanol conversion route is the slowest to develop in Indonesia.

There is no sign that this technology will be applied in the near future. One of the obstacles is the uncompetitive cost of the ethanol fuel production process. Let alone second-generation fibre-based ethanol, even first-generation ethanol is not yet affordable. A cassava-based ethanol industry in North Lampung stopped several years ago due to the high price of raw materials.

3.4 STRAW BIOGAS

Straw Biogas Biogas production is recognised as one of the most environmentally friendly biomass to renewable energy conversion processes (Mussoline et al., 2013). Many studies have proven the vialibility of biogas production from a mixture of rice straw and other organic wastes. Kalra and Panwar (1986) reported that each kilogram of rice straw can produce about 220 L of biogas.

A mixture of rice straw and cow dung (3:1 dry weight ratio) can increase biogas production to 434.2 L/gVS degraded with methane content reaching 50.12% (Haryanto et al., 2018). Commonly used animal manures as a source of bacteria include cow manure, and chicken manure. Cow manure mixed with chicken manure can increase buffering capacity and produce synergistic effects (Wang et al., 2014). Mussoline et al. (2013) reported the optimal conditions are pH (6.5- 8.0), temperature (35-40oC) and C/N ratio of 25-35 and from a 1-m3 digester containing a mixture of 50 kg of rice straw with pig wastewater, a total of 22,859 L of biogas can be obtained for 189 days (231 L CH4/kgVS). If the system is expanded to a 100-ha rice farm, then this scenario can produce 100,000 m3CH4 per year, equivalent to 328 MWh.

Biogas can be used to generate electrical power through internal combustion engines or through boilers. Hibukawa et al. (2014) reported that the Nagaoka Wastewater Treatment Plant in Niigata city, Japan, required 1916 tonnes of rice straw (moisture content, 20%) to be mixed with wastewater sludge to produce biogas. This is a motivation that rice straw has good prospects to be used as a substrate in the biogas production process. However, a pretreatment is required for rice straw because the lignin wall of the straw inhibits digestibility, which reduces the conversion efficiency to biogas. Various rice straw pretreatment methods can be selected, such as mechanical (size reduction), chemical, thermal, and enzyme treatments (Bruni et al., 2010).

Alkali treatment is very effective in reducing lignin, thus enhancing the anaerobic decomposition process. Biogas production from NaOH-treated rice straw increased between 27.3-64.5% (He et al., 2008). Pretreatment with 0.5 M Na_2CO_3 at 110°C for 2 hours produced 292 L CH_4/kgVS, whereas untreated straw produced only 130 L CH_4/kgVS (Dehghani et al., 2015).

3.4.1 Technology Aspects

Biogas from straw involves an anaerobic fermentation process to convert biomass into methane gas that can be used as an energy source. The technology has developed rapidly with improved efficiency of biogas reactors and better pre-treatment techniques to increase gas production.

"Anaerobic fermentation technology has shown high efficiency in processing straw into biogas, especially with the application of appropriate pretreatment to improve lignocellulose digestibility (Al Seadi et al., 2008)."

3.4.2 Social Aspects

The use of biogas from straw can provide significant social benefits, especially in rural areas. It can reduce dependence on fossil fuels and firewood, and provide a sustainable source of energy for communities.

"The development of biogas projects in rural areas has been shown to improve community welfare by providing a stable source of energy and reducing pressure on local natural resources (Kossmann et al., 1999)."

3.4.3 Environmental Aspects

From an environmental perspective, biogas from straw helps reduce greenhouse gas emissions and air pollution. In addition, the solid residue from the biogas process can be used as organic fertiliser which is beneficial for agriculture.

"The use of straw as a biogas feedstock can significantly reduce methane emissions from the decomposition of straw in the open and reduce the use of chemical fertilisers in the presence of nutrient-rich digestate (Holm-Nielsen et al., 2009)."

3.4.3 Investment Aspects

- Production capacity: 2 tonnes of straw ethanol per day (equivalent to 2,000 litres)
- Selling price of straw ethanol: IDR 17,000 per litre
- Raw material cost: IDR 5,000 per kg of straw
- Production cost: IDR 3,500 per litre
- cost: IDR 2,500,000 per month
- Overhead costs: IDR 3,000,000 per month
- Length of investment time: 4 years
- Discount rate: 10%
- Initial investment: IDR 50,000,000

Calculation:

1. Annual Income:

- Annual straw ethanol production: 2 tonnes/day x 365 days/year= 730 tonnes
- Straw ethanol production in litres per year: 730 tonnes x 1,000 kg/ton= 730,000 kg
- Straw ethanol production in litres per year: 730,000 kg x 1 litre/kg= 730,000 litres
- Annual revenue: 730,000 litres x IDR 17,000/litre= IDR 12,290,000,000

2. Annual Fees:

- Raw material costs:
  - Straw requirement per day: 2 tonnes/day x 1,000 kg/tonne= 2,000 kg
  - Straw requirement per year: 2,000 kg/day x 365 days/year= 730,000 kg
  - Raw material cost per year: 730,000 kg x Rp 5,000/kg= Rp 3,650,000,000
- Production cost: 730,000 litres x Rp 3,500/litre= Rp 2,555,000,000
- cost: IDR 2,500,000/month x 12 months/year= IDR 30,000,000

- Overhead costs: IDR 3,000,000/month x 12 months/year= IDR 36,000,000
- Total annual cost: Rp 3,650,000,000+ Rp 2,555,000,000+ Rp 30,000,000 + IDR 36,000,000= IDR 6,271,000,000

3. Annual Net Profit:

- Annual net profit: Rp 12,290,000,000 - Rp 6,271,000,000= Rp 6,019,000,000

Table 9: Straw biogas investment analysis table

Period Year	Cash Inflow (Rp)	Cash Outflow (Rp)	Net Cash Flow (Rp)	NPV (Rp)
0		50,000,000	(50,000,000)	(50,000,000)
1	12,290,000,000	6,271,000,000	6,019,000,000	5,422,522,523
2	12,290,000,000	6,271,000,000	6,019,000,000	4,885,155,426
3	12,290,000,000	6,271,000,000	6,019,000,000	4,401,040,924
4	12,290,000,000	6,271,000,000	6,019,000,000	3,964,901,733
5	12,290,000,000	6,271,000,000	6,019,000,000	3,571,983,544
				22,195,604,149

Table 10: Straw biogas analysis results table

Interest rate	10%
net present value (NPV)	22,195,604,149
interest rate of return (IRR)	92%
Accepted rejected	Accepted

CHAPTER IV. UTILISATION AS FERTILISER

4.1. Liquid Biosilica

The increase in rice production in Indonesia will certainly be followed by an abundance of rice milling waste. One of the wastes is husk. One of the utilisation of rice husk is to convert it into liquid smoke or grain drying material, Not stopping there, the waste from both technologies leaves husk ash which can be used as biosilica fertiliser for various plants, By using biosilica fertiliser, rice plants become better, not easily lodged, resistant to pests and plant diseases, and resistant to dry weather/climate.

Silica (Si) is one of the nutrients needed by gramenae plants such as rice, sugar cane, corn and other plants that are silica accumulators, found on the surface of leaves, stems, and grain (rice). Plants that lack Si cause the three plant organs above to be less protected by a strong silicate layer, as a result (1) the leaves of the plant are weak and drooping, ineffective in capturing sunlight, resulting in low plant productivity, (2) evaporation of water from the surface of the leaves and stems of the plant is accelerated, (3) leaves and stems become sensitive to pests and diseases, (4) plants are prone to lodging, (5) grain (rice) quality is reduced because it is easily affected by pests and diseases so that optimal crop yields are not achieved, low yield stability (fluctuating) and low product quality.

The need for silica nutrients in gramenae crops is very high, with rice plants transporting 100-300 kg/ha of silica and sugarcane plants transporting 500-700 kg/ha of silica in one harvest. The large amount of silica taken every harvest results in poor silica nutrients in the soil which leads to reduced productivity of these plants.

4.1.1. Technology Aspects

Rice husk contains 15-20% silica while the ash contains 80-90%. Silica is widely used in the industrial world and has high economic value as a mixture of fertiliser, shoes & sandals, tyres, food, pharmaceutical & health, semicomductor, and paint.

With a simple process, liquid biosilica fertiliser can be produced from rice husk, which has an alkaline pH, and high silica and potassium content. One of the potentials that can be developed from rice husk is its silica content. Rice husk ash without pretreatment contains 90-94% silica, while those that have undergone pretreatment with acid leaching before thermal treatment, the silica content can increase to above 99%. In addition, biosilica obtained through acid leaching has a specific surface area up to 10 times higher than that without leaching.

1. Material

   Materials to be prepared include 3kg of rice husk ash, 1.8kg of technical potassium hydroxide (KOH), enough jeans filter cloth, 18 litres of water, a stove, and a 3kg gas cylinder.
2. How to make

   The for making simple scale biosilica are as follows: first heat 30 ml of water with a temperature of 30-50 degrees Celsius, put the husk ash into the KOH solution, stir until evenly distributed and leave for 2 hours, prepare a 30-litre pot / bucket, a 10-litre filter pot and a filter cloth, then evaporate until 1/2-1/3 of it, then cool and put it in a jerry can and biosilica is ready to use.

Figure 13. Biosilica manufacturing process

Table 11. Table of technological aspects of liquid

biosilica

Products	Process	Disadvantages
amorphous silica products	process to product amorphous silica from biogenic materials such as rice husk. Oxidising solutions such as hydrogen peroxide, chlorate, perchlorate, 5 nitrate and permanganate can be used to oxidise long-chain organic compounds prior to combustion at 500-950oC. Hydrogen peroxide solution is preferred as the oxidising solution and is used in the temperature range of 90-95°C. 100oC for 6-8 hours.	The drawback of this patent is that the purification process still requires a relatively high temperature and a relatively long time, making it uneconomical.

Products	Process	Disadvantages
carbon-silica products	Production of carbon-silica products from silica accumulator plants such as rice husk or straw through leaching using sulfuric acid for metal impurity removal. The use of dilute sulphuric acid of 1-5% at 94-100oC has been quite effective for the removal of metal impurities including iron. However, the use of too dilute sulfuric acid can reduce the effectiveness of the acid and an increase in reaction time is required to obtain a product with the expected characteristics. On the other hand, the use of sulphuric acid at high concentrations is more costly, more corrosive, and the possibility of forming compounds that are not expected.	The drawback of this patent is that dilute organic acids have not been used to removal of impurity metals from silica with equivalent effectiveness to strong acids, but is non-corrosive and more environmentally friendly.
amorphous silica powder	the preparation of amorphous silica powder by leaching using aqueous strong acid solutions such as nitric acid, hydrochloric acid, and sulfuric acid at a concentration of 1-5% to reduce organic matter to 20% followed by thermal treatment at 900-1100oC. This invention is capable of producing silica with a minimum purity of 96%. This Patent reveals anyway alternatives	This patent is not yet emphasised on optimising an environmentally friendly process to obtain high purity silica powder

Products	Process	Disadvantages
	35 3 leaching using organic acids such as acetic acid, oxalic acid, and citric acid with efficiencies close to those of strong acids, but the concentrations used are not described. In addition, the temperatures that were used to thermal treatment is still above 900oC.	
Enzyme-assisted biosilica	The preparation of biosilica from rice husk using enzyme assistance is followed by combustion at 1000oC. Before combustion, strong acids such as hydrochloric acid, sulphuric acid, and nitric acid were leached to remove metal mineral impurities other than silica.	The drawbacks of this patent are not yet the leaching process is carried out using organic acids that are more environmentally friendly and the combustion temperature is still relatively high 15 so that requires greater energy

Biosilica via leaching	The process of producing amorphous silica with high purity and surface area from rice husk by leaching using chelating compounds such as citric acid, ethylenediamine, EDTA, and dimercaprol followed by combustion at 500-900oC. This patent does not mention the concentration of chelating compounds used in addition to some of the chelating compounds are polymeric chemical compounds that have the potential to pollute. neighbourhood.	Disadvantages the patent, with a citric acid concentration of 5% produced amorphous silica with a purity of 99,13% while inventio n Now using citric acid with a concentration of 2% can produce amorphous silica with a purity of 99.2%.

Products	Process	Disadvantages
	The purpose of leaching is to remove impurities in the form of inorganic substances in rice husks that contain metals such as K, Na, Ca, Al, Fe, etc. in addition to the inorganic substances. silica.	

A shortcoming of existing processes is the use of strong acids such as sulphuric acid, hydrochloric acid, nitric acid or hydrogen peroxide or chelating compounds to reduce metal impurities or as oxidising agents to obtain pure silica from rice husks.

The use of conventional acids requires high costs for investment in anticorrosive equipment. In addition, the use of strong acids also requires the use of large amounts of water to rinse the rice husk, which requires special treatment for the disposal of the waste so as not to pollute the environment.

A process for the preparation of high-quality biosilica from rice husk by leaching using citric acid at a very low concentration of 0.2-2 (%b/v) followed thermal treatment involves the following steps:

a. leaching of rice husk using citric acid solution with a ratio of rice husk to citric acid solvent of 1:17, accompanied by stirring at a rotating speed of +250 rpm for the removal of metal impurities;
b. washing the leached rice husk with neutral pH distilled water;
c. dried the leached rice husk in an oven at 105oC for 1.5 hours;
d. thermal treatment at 750oC for 5 hours at a heating rate of 10 K/minute of the leached husk in a furnace for the removal of organic components.

3. The process of preparing biosilica from rice husk according to claim 1, wherein the leaching is carried out at a temperature range of 50100oC for 15-60 minutes.

The high-quality biosilica product from rice husk is characterised by the following characteristics: white in colour, amorphous in nature, purity of 98-99.2%, and specific surface area of ±300-600 m2/g.

Figure 14 Final product of Liquid Biosilica

4.1.2 Social Aspects

1. Health and Wellbeing:
   - Promotes bone health: Liquid biosilica is rich in silicon, an essential mineral for bone health. Research shows that silicon supplements can increase bone density and reduce the risk of osteoporosis.
   - Improves skin health: Silicones are also important for skin health, helping to maintain elasticity and hydration. Liquid biosilica can be used in skincare products to improve skin health and appearance.
   - Improves cognitive function: Research shows that silicone can improve cognitive function and memory, especially in the elderly.

Liquid biosilica can be used as a supplement to improve brain health.

2. Food Security:
   - Increase crop yields: Liquid biosilica can be used as a biostimulant to increase crop yields. Silicon can help plants absorb nutrients more efficiently and increase resistance to environmental stress.
   - Improving food quality: Liquid biosilica can be used to extend the shelf life of food and improve its quality. Silicone can help prevent spoilage and keep food fresh.

4.1.3 . Environmental Aspects

the provision of biosilica from husks can maintain the availability of silica in the ecosystem of rice. biosilica both liquid and powder can strengthen rice stems, resistant to pests and diseases, more nutritious grains, and resistant to dry weather. nanobiosilica products are the raw materials used and the products produced are more environmentally friendly, the production process uses lower energy and can be produced two types of products at once (liquid and powder nanobiosilica), and the performance and price of the final product can compete with commercial products on the market.

biosilica from rice straw compost significantly increased the growth and production of sorghum plants. The application of biosilica to sorghum plants in drylands at 250 kg ha-1 increased production by 78%.

4.1.4 Economic and Market Aspects

rice husk is a potential raw material as a source of biosilica from renewable sources and at the same time is able to increase the added value of rice husk. Silica is widely used for various purposes with various sizes depending on the application needed, among others: tyre industry, rubber, glass, cement, concrete, ceramics, textiles, paper, cosmetics, paints, electronics, films, toothpaste, adsorbents, etc.

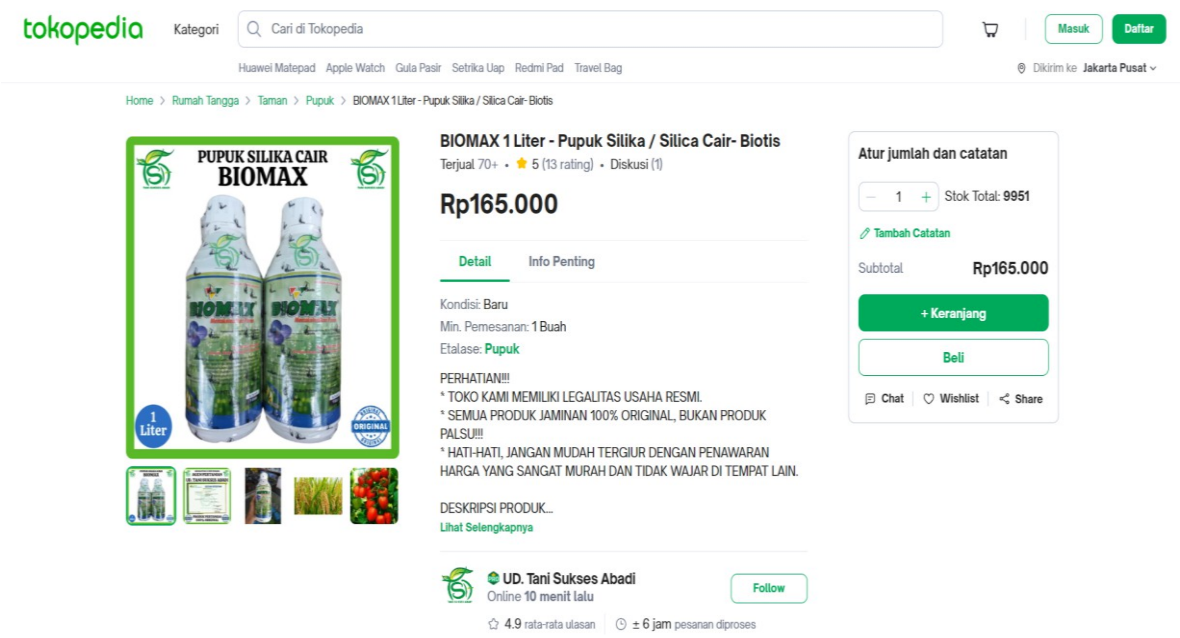


Figure 16 Straw biogas silica product

The use of liquid nanobiosilica is recommended as a plant nutrient, especially to increase resistance to pests and diseases and the effects of drought, and to improve the quality of crop yields, thereby optimising production. Meanwhile, the use of nanobiosilica powder is recommended as a reinforcing agent and functional material to improve the performance of end products, such as finished rubber goods and paints.

There has been an innovative product collaboration of environmentally friendly (biodegradable) sandals, most of which use nanobiosilica powder as a result of Balitbangtan's collaboration with PT Triangkasa Lestrari Utama. With the technological innovation developed today, from 1 tonne of rice husk, about 380-400 litres of liquid nanobiosilica or 150-175 kg of powdered nanobiosilica can be produced."

The prices of commercial liquid and powder silica products on the market are around 12-17 USD per litre and 1-6 USD per kg, respectively, depending on the quality specifications. Meanwhile, Indonesia annually produces more than 11 million tonnes of rice husk, most of which are not optimally utilised. So that the utilisation of rice husk into nanobiosilica products can provide significant economic added value.

This nanobiosilica product is on the right track because silica plays an important role in reducing the rolling resistance of tyres, while still providing good grip on wet roads. The official website of tyre manufacturer Michelin states that the use of silica can reduce the friction force of tyres on the road surface by 20% or more. A 20% reduction in friction is equivalent to a 5% fuel saving. Considering that more than one billion tyres are produced per year in the world

In paint products, silica plays a role in improving resistance to abrasion, corrosion, cracking, fungal attack, the effects of climate change, as well as helping to maintain the intensity and brightness of the colour of the paint and the product it covers. He hopes that nanobiosilica can demonstrate this role in his paint products, which have been fulfilled from non-renewable sources.

4.1.5 Investment

Aspect Analysis

The following is an estimate of the initial investment cost:

- **Tools and machinery:**
  - Raw material chopping machine: IDR 10,000,000
  - Biological reactor: IDR 20,000,000
  - Fermentation tank: IDR 8,000,000
  - Filter equipment: IDR 2,000,000
  - Packaging: IDR 1,000,000
  - **Total:** IDR 41,000,000
- **Raw materials:**
  - Rice husk: IDR 500,000 per tonne
  - Molasses: IDR 1,000,000 per tonne
  - Microorganisms: IDR 500,000 per litre
  - Other chemicals: IDR 500,000 per month
  - **Total:** IDR 2,000,000 per tonne

- **Operational costs:**
    - : IDR 2,000,000 per month
    - Electricity: IDR 500,000 per month
    - Water: IDR 200,000 per month
    - Transport: IDR 1,000,000 per month
    - **Total:** IDR 3,700,000 per month

Revenue Analysis

Gross revenue per day is IDR 90,000,000 (selling price per litre x number of litres per day).

Investment Feasibility Analysis

- **The** BEP is calculated by dividing the total initial investment cost by the net profit per day. Assume the net profit per day is 50% of the gross revenue, which is Rp 45,000,000. BEP = Rp 41,000,000 / Rp
  45,000,000= 0.91 days
- **Payback** period is calculated by dividing the total initial investment cost by the net profit per month. Payback period = Rp 41,000,000 / Rp 3,700,000 = 11.08 months

4.2. LIQUID FERTILISER

Rice husk, a waste product of rice milling, is often considered as fuel or planting medium. However, did you know that rice husk can also be processed into nutrient-rich liquid fertiliser for plants? Rice husk liquid fertiliser is an eco-friendly organic fertiliser that is easy to make at home.

Rice husk liquid fertiliser contains various macro and micro nutrients that are essential for plant growth, such as nitrogen (N), phosphorus (P), potassium (K), calcium Ca), magnesium (Mg) and sulphur (S). In , rice husk liquid fertiliser is also rich in humic and fulvic acids that help improve soil fertility and nutrient absorption by plants.

- The benefits of using rice husk liquid fertiliser include:
- Improve plant growth
- Increase crop yields
- Improves soil fertility
- Improving soil structure
- Increase plant resistance to pests and diseases
- Environmentally friendly and biodegradable

The use of rice husk as a liquid fertiliser has become an important innovation in sustainable agricultural practices. Rice husk, an agricultural waste, can be processed into a liquid fertiliser that is rich in essential nutrients for plants. The manufacturing process involves anaerobic fermentation, where microorganisms decompose the organic matter in the husk, producing a solution containing nutrients such as nitrogen, phosphorus, potassium, as well as other microelements. In addition, liquid fertiliser from husks also contains humic acid, which can significantly improve soil fertility.

4.2.1 Technological Aspects:

Research conducted by Putra (2020) showed that the use of liquid husk fertiliser can increase the productivity of rice plants by up to 20% compared to the use of conventional chemical fertilisers. This is due to the ability of husk liquid fertiliser to improve soil structure, increase water absorption capacity, and strengthen plant root systems. In addition, husk liquid fertiliser also plays a role in reducing farmers' dependence on synthetic chemical fertilisers, which are often expensive and have a negative impact on the environment.

Furthermore, studies conducted in various regions show that the application of liquid chaff fertiliser can reduce the incidence of plant diseases, as it increases the activity of soil microbes that are antagonistic to pathogens. In the long run, the use of liquid chaff fertiliser can also improve the overall health of agricultural ecosystems, reduce environmental pollution, and support organic farming practices. Hence, the development and dissemination of liquid chaff fertiliser technology has the potential to to support agricultural sustainability, particularly in developing countries that depend on the agricultural sector as a primary source of livelihood.

The use of rice husk as a liquid fertiliser represents the integration of technology in traditional agricultural practices. The main process in this technology is the anaerobic fermentation of rice husks, which involves microorganisms to decompose organic matter into plant-available nutrients. This fermentation technology not only increases the availability of essential nutrients such as nitrogen, phosphorus and potassium, but also produces humic acids that are beneficial to soil structure and health. In addition, this technology enables the use of agricultural waste that was previously considered an environmental problem to become a valuable resource in a sustainable agricultural cycle. Thus, the use of husk as a liquid fertiliser not only increases the efficiency of crop production but also strengthens the depth of technology in modern, environmentally friendly agriculture (Putra, 2020).

4.2.2 Environmental Aspects:

The use of chaff as a liquid fertiliser has a significant positive impact on the environment. One of the main benefits is the reduction of agricultural waste. Rice husks, which are usually considered as waste and are often burnt or thrown away, can be processed into a useful liquid fertiliser, reducing the amount of waste that pollutes the environment.

The fermentation process of the husk produces a liquid fertiliser rich in essential nutrients such as nitrogen, phosphorus and potassium, which helps improve soil fertility and increase crop productivity without the need to use synthetic chemical fertilisers. The use of liquid fertiliser from husks also contributes to the reduction in the use of chemical fertilisers that often cause soil and water pollution and damage the ecosystem. In addition, the husk fermentation process produces less greenhouse gas emissions compared to chemical fertiliser production, helping to reduce the negative impact on climate change. Overall, the technology

It supports sustainable agricultural practices by utilising local resources and reducing the environmental impact of agricultural waste (Putra, 2020).

4.2.3 Social Aspects:

The use of chaff as a liquid fertiliser provides various social benefits to the farming community. The technology empowers farmers by giving them the ability to produce their own fertiliser, which increases self-reliance and reduces dependence on expensive chemical products.

addition, the use of liquid husk fertiliser reduces farmers' and surrounding communities' exposure to harmful chemicals that can cause health problems. The initiative also supports the preservation of traditional environmentally-friendly farming practices, strengthening local knowledge on sustainable agriculture. Thus, this technology not only improves farmers' welfare but also increases community awareness on the importance of protecting the environment (Putra, 2020).

4.2.4 Economic and Market Aspects:

From an economic and market perspective, using chaff as liquid fertiliser offers various advantages. The cost of producing liquid fertiliser from husks is relatively lower compared to purchasing synthetic chemical fertilisers, as the raw material is easily available agricultural waste.

In addition, the use of liquid husk fertiliser can open up new market opportunities for organic agricultural products, which are increasingly in demand by consumers concerned health and the environment. The increased crop productivity generated by chaff liquid fertiliser also has a positive impact on farmers' income. With product diversification, farmers can sell chaff liquid fertiliser as an additional product, creating a new source of income and strengthening the rural economy (Putra, 2020).

4.2.5 Investment Aspects

A. **Cost Analysis**

The following is an estimate of the initial investment cost for a liquid chaff fertiliser business with a production capacity of 1 tonne per day (or 1,000 litres per day) and a selling price of IDR 20,000 per litre:

- **Tools and machinery:**
  - Chaff chopper machine: IDR 10,000,000
  - Fermentation tank: IDR 8,000,000
  - Filter equipment: IDR 2,000,000
  - Packaging: IDR 1,000,000
  - Total: IDR 21,000,000
- **Raw materials:**
  - Rice husk: IDR 500,000 per tonne
  - Molasses: IDR 1,000,000 per tonne
  - Microorganisms: IDR 500,000 per litre
  - Total: IDR 2,000,000 per tonne
- **Operational costs:**
  - : IDR 2,000,000 per month
  - Electricity: IDR 500,000 per month
  - Water: IDR 200,000 per month
  - Transport: IDR 1,000,000 per month
  - Total: IDR 3,700,000 per month

B. Revenue Analysis

Gross revenue per day is IDR 20,000,000 (selling price per litre x number of litres per day).

C. Investment Feasibility Analysis

- **The BEP** is calculated by dividing the total initial investment cost by the net profit per day. Assume the net profit per day is 50% of the gross revenue, which is Rp 10,000,000. BEP= Rp 21,000,000 / Rp
  10,000,000= 2.1 days
- **Payback** period is calculated by dividing the total initial investment cost by the net profit per month. Payback period = Rp 21,000,000 / Rp 3,700,000 = 5.68 months

CHAPTER V. UTILISATION AS BIODEGRADABLE PACKAGING

5.1 BIODEGRADABLE

Disposal of waste without proper treatment can disrupt the balance of ecosystems on earth faster. Therefore, waste treatment is very important to keep the earth beautiful and sustainable. Paper is one of the most human-generated wastes, whether generated by households, schools or offices.

In general, papermaking is made from trees. So the more paper used, the faster the earth will be filled with land that is no longer green with trees (Arfah, 2017). Environmental balance can also be disrupted due to the massive exploitation of forests, as evidenced by the production of pulp and paper, almost 90% of which uses wood as a source of cellulose fibre.

Indonesia is the 9th largest paper producing country in the world. CEPI (Confederation of European Paper Indutries) shows that the world's consumption of pulp in 2015 is 233 million/tonne and paper 458 million/tonne per year with an estimated pulp growth of 1.8% and 2.9% per year. shows that the world's pulp and paper needs still quite large and Indonesia has the opportunity to play in the world pulp and paper market (Sinuhaji et al., 2014).

In Indonesia, which is an agrarian country, it is not difficult to find rice processing places. One of the processes in rice processing is the milling process. This process aims to separate the rice grains from the rice husk. This rice husk is the residue of processing which is usually only used as animal feed or discarded. Whereas if you look at the content in the rice husk, it can be used for papermaking materials. Rice husk consists of 50% cellulose, 18.47% hemicellulose, and 25-30% lignin. Rice straw contains 37.71% cellulose; 21.99% hemicellulose; and 16.62% lignin.

5.1.1 Technology Aspects

1. Material Preparation

   The preparation of raw materials for straw and dry rice husk is grinded with a grinder and then sieved to a size of 20 mesh. the composition used is straw (J) and rice husk (S) in composition A (J :S = 1:1), B (J :S = 3:2), and C (J :S = 2:3).

2. Papermaking

   The method used is the organosolv method. The organosolv method is a fibre separation method using organic chemicals, which in this research is methanol. Pulp is the pulp resulting from the separation of wood fibres or other materials that produce lignin and cellulose. The pulp yield depends on the material used. The material used in the study is a mixture of straw containing 42.3% cellulose, 20.4 hemicellulose, and 12.1% lignin and rice husk containing 34.34-43.80% cellulose and 21.40-46.97% lignin This process is carried out in 2 stages:

   1) Pectin extraction.
      - Rice husk and straw in each sample material and citric acid ratio is 1: 12 grams.
      - Put in a three-neck flask, then stirred at 600 rpm with a mixer at an operating temperature of 80 oC with a cooking time of 75 minutes on a hotplate on the variation of the use of pectin extract.
   2) Delignification.

      Delignification aims to reduce the lignin content in the cellulosic material.

      - The material that has been extracted pecti is filtered and cleaned with distilled water 3 times so that the pH is neutral which was previously mixed by citric acid.
      - Then, in each comparison, the material samples were put back in a 3 neck flask along with 50% Methanol 100 ml,

- then stirred with a mixer at 600 rpm at 50oC for 120, 180, 210, 240 minutes.

5.1.2 Social Aspects:

1. **Raising Environmental Awareness:**
   Biodegradable encourages people to be more aware of environmental issues and the importance of preserving nature. Regular use of biodegradable products can serve as a visual reminder to individuals and communities about the negative impact of plastic waste and other non-biodegradable products on the environment. This can trigger behavioural and lifestyle changes that are more environmentally friendly, such as reducing the use of single-use plastics, recycling waste, and using environmentally friendly products.

2. **Improving Quality of Life:**
   Biodegradable helps reduce waste pollution, especially plastic waste that pollutes the ocean, land and air. It can improve people's quality of life in many ways:
   - **Reducing Health Risks:** Plastic waste pollution can harm human health in many ways, such as water and food contamination, ingested microplastics, and animal health problems that can be transmitted to humans. Biodegradable helps reduce these health risks by breaking down plastic waste naturally.
   - **Improve Environmental Aesthetics:** Plastic waste that accumulates in the environment can spoil the beauty of nature and disturb the comfort of the community. Biodegradable helps to create a cleaner and more beautiful environment, thereby improving environmental aesthetics and people's quality of life.
   - **Supporting Tourism:** A clean and beautiful environment is an attraction for tourists. Biodegradable can help boost the tourism sector by creating an attractive and comfortable environment for tourists.

3. **Creating New Jobs:**

   The biodegradable industry opens up new job opportunities in various sectors, such as:

   - **Manufacturing:** The production of biodegradable products requires to design, manufacture and market the products.
   - **Agriculture:** Biodegradable can be produced from plant-based raw materials, such as corn, sugarcane, and cassava. This opens up employment opportunities in the agricultural sector to grow and harvest these raw materials.
   - **Waste Treatment:** Biodegradable waste can be processed into compost or organic fertiliser. This opens up job opportunities in the waste management sector to process biodegradable waste into useful products.

4. **Raising Social Awareness:**

Biodegradable can be a tool to raise social awareness and drive positive change in society. For example:

   - **Environmental Care Campaign:** Biodegradable can be used as an educational tool in environmental awareness campaigns to raise public awareness about the importance of preserving nature.
   - **Waste Segregation Programme:** Biodegradable can encourage waste segregation programmes in communities by making it easier to separate biodegradable waste from non-biodegradable waste.
   - **Community Empowerment:** Biodegradable can be a source of income for local communities by encouraging the production and sale of biodegradable products.

5.1.3 Environmental Aspects:

1. **Reducing Waste Pollution:**

   Biodegradable breaks down naturally by microorganisms, thus helping to reduce the accumulation of waste in the environment. This prevents soil, water and air pollution:

- **Soil Pollution:** Non-biodegradable plastic waste can pollute the soil for hundreds or even thousands of years. Biodegradable decomposes into organic matter that nourishes the soil and increases its fertility.
- **Water Pollution:** Non-biodegradable plastic waste can pollute groundwater and seawater, endangering aquatic life and disrupting marine ecosystems. Biodegradable degrades into organic matter that is harmless to the water environment.
- **Air Pollution:** Burning non-biodegradable plastic waste produces greenhouse gas emissions and other harmful pollutants that pollute the air and contribute to climate change. Biodegradable biodegrades naturally without producing greenhouse gas emissions or harmful pollutants.

2. **Preserving Ecosystems:**

   Biodegradable does not harm animals and plants when it decomposes. This is important for maintaining ecosystem balance and protecting biodiversity:

   - **Protecting Animals:** Animals often become entangled in or ingest non-biodegradable plastic waste, which can lead to death or injury. Biodegradable does not harm animals and helps protect animal populations in the wild.
   - **Maintain Ecosystem Balance:** Non-biodegradable plastic waste can disrupt food chains and damage natural habitats. Biodegradable degrades into organic matter that can be utilised by organisms in the ecosystem.
   - **Preserving Biodiversity:** Biodiversity is threatened by non-biodegradable plastic waste pollution. Biodegradable helps preserve biodiversity by maintaining the balance of ecosystems and protecting natural habitats.

3. **Improving soil fertility:**

   Biodegradables that break down can be composted, which helps fertilise the soil and increase crop yields:

   - **Increases the Nutrient Content of the Soil:** Compost made from biodegradable is rich in nutrients that are essential for plant growth.
   - **Improves Soil Structure:** Compost helps to improve soil structure, making it looser and easier to absorb water.
   - **Reducing the Need for Chemical Fertilisers:** The use of compost can help reduce the need for chemical fertilisers, which can pollute soil and water.

4. **Accelerating the Recovery of Damaged Ecosystems:**

   Biodegradable can be used to accelerate the recovery of ecosystems damaged by waste pollution:

   - **Soil Remediation:** Biodegradable can be used to remediate soil contaminated by non-biodegradable plastic waste.
   - **Forest Restoration:** Biodegradable can be used to rehabilitate forests damaged by illegal logging and pollution.
   - **Coral Reef Preservation:** Biodegradable can be used to protect coral reefs from damage caused by plastic waste.

5.1.4 Economic and Market Aspects:

1. **Market Demand:**

The market demand for biodegradable products continues to increase along with the increasing public awareness towards the environment. This opens up promising business opportunities for companies that manufacture and sell biodegradable products. Factors fuelling the biodegradable market demand include:

- **Increased Environmental Awareness:** Consumers are increasingly aware of the negative impact of plastic waste and non-biodegradable products on the environment. This has prompted them to look for alternative products that are more environmentally friendly, such as biodegradable products.

- **Government Regulations:** More and more governments are implementing regulations and policies that favour the use of biodegradable products. This is fuelling the market demand for biodegradable products in various countries.
- **Technological Innovation:** Technological developments in biodegradable production are advancing, resulting in better quality and affordable biodegradable products. This has further attracted consumers to use biodegradable products.

2. **Selling Price:**

The selling price of biodegradable products is generally more expensive than conventional products. This is due to several factors, including:

- **Production Costs:** The production cost of biodegradable products is generally higher than conventional products because the raw materials and technology used are more complex.
- **Market Demand:** The market demand for biodegradable products is still relatively new and has not yet reached optimal economies of scale. This causes the selling price of biodegradable products to still be relatively high.
- **Branding and Marketing:** Companies producing biodegradable products need to do strong branding and marketing to build a positive product image and attract consumers. This can also increase the selling price of biodegradable products.

3. **Market Potential:**

Although the selling price of biodegradable products is generally higher, the market potential for these products is huge and growing. This is supported by several factors, including:

- **Rising Environmental Awareness:** As mentioned earlier, the increasing environmental awareness of people is fuelling the market demand for biodegradable products.
- **Rising Middle Class Population:** The middle class population in many countries continues to grow. This group generally has the purchasing power

higher and more willing to buy environmentally friendly products, such as biodegradable products.

- **Government Support:** More and more governments are providing support and incentives for the development of the biodegradable industry. This can boost the market growth for biodegradable products.

4. **Business Opportunities:**

The biodegradable industry offers promising business opportunities for various parties, among others:

- **Manufacturers:** Companies manufacturing biodegradable products can capitalise on the huge market growth opportunity by developing innovative and high-quality products.
- **Distributors:** Distributors of biodegradable products can capitalise on the opportunity by collaborating with manufacturers and marketing biodegradable products to various consumers.
- **Retailers:** Retailers can capitalise on the opportunity by providing biodegradable products in their stores to meet the growing consumer demand.

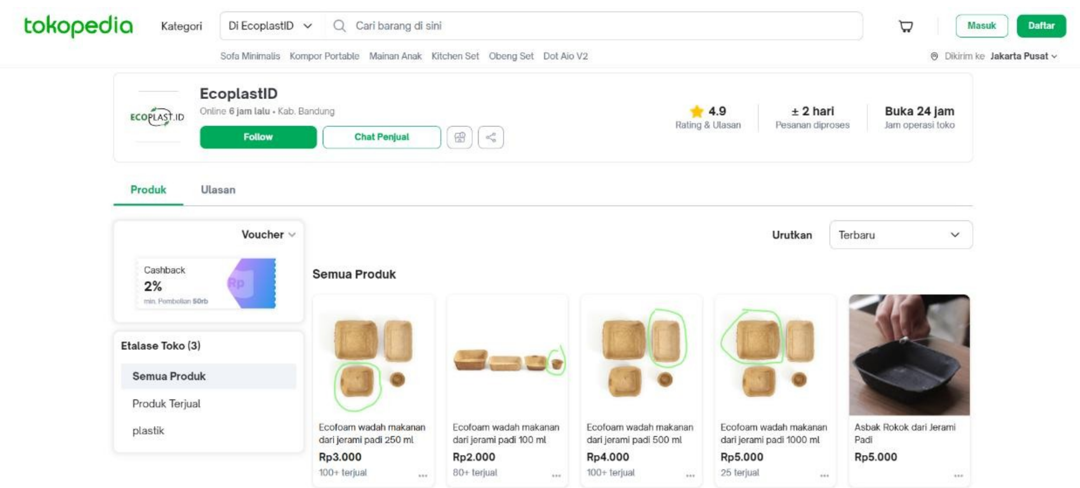


Figure 18 Biodegradable plastic bags

Biodegradable plastic bags: made from materials such as PLA (polylactic acid) and PHA (polyhydroxyalkanoates) that can biodegrade under certain conditions.

5.1.5 Aspects of

Investment Data used:

- **Initial Cost:**
  - R&D Cost: IDR 20,000,000
  - Production Equipment Cost: IDR 30,000,000
  - Infrastructure Cost: IDR 10,000,000
  - Total Initial Cost: IDR 60,000,000
- **Annual Operating Expenses:**
  - Raw Material Cost: IDR 5,000,000/year
  - Labour Cost: IDR 15,000,000/year
  - Overhead Costs: IDR 5,000,000/year
  - Total Annual Operating Costs: IDR 25,000,000
- **Annual Income:**
  - Selling Price per Bag: IDR 15,000
  - Estimated Annual Production: 100,000 bags
  - Annual Revenue: 100,000 bags x Rp 15,000/bag= Rp 1,500,000,000

Investment Analysis

1. Net Present Value (NPV)

Using a 10% discount rate and a 5-year analysis period:

Menggunakan discount rate 10% dan periode analisis 5 tahun:

$$\text{NPV} = -\text{Biaya Awal} + \sum \left(\frac{\text{Pendapatan Tahunan} - \text{Biaya Operasional Tahunan}}{(1+\text{Discount Rate})^t} \right)$$

$$\text{NPV} = -60.000.000 + \sum \left(\frac{1.475.000.000 - 25.000.000}{(1+0.10)^t} \right)$$

$$\text{NPV} = -60.000.000 + \sum \left(\frac{1.450.000.000}{(1.10)^t} \right)$$

$$\text{NPV} = -60.000.000 + \frac{1.450.000.000}{1.10} + \frac{1.450.000.000}{(1.10)^2} + \frac{1.450.000.000}{(1.10)^3} + \frac{1.450.000.000}{(1.10)^4} + \frac{1.450.000.000}{(1.10)^5}$$

$$\text{NPV} \approx -60.000.000 + 1.318.181.818 + 1.198.346.887 + 1.089.406.261 + 991.278.419 + 902.980.381$$

$$\text{NPV} \approx 4.540.193$$

2. Internal Rate of Return (IRR)

Find the internal rate of return that makes the NPV equal to zero: IRR=19.76%\text{IRR} = 19.76\%IRR=19.76%

3. Payback Period

Calculate how long it will take to return the initial investment:

$$\text{Payback Period} = \frac{\text{Investasi Awal}}{\text{Cash Flow Tahunan}}$$

$$\text{Payback Period} = \frac{60.000.000}{25.000.000} = 2.4 \text{ tahun}$$

Investment in the production of biodegradable plastic bags with a selling price of IDR 15,000 per bag shows a positive result in the Investment analysis.

- A positive NPV of IDR 4,540,193 indicates that this investment is feasible with a 10% discount rate,
- while the IRR of 19.76% exceeds the expected rate of return. The payback period of about 2.4 years also shows that this investment can be recovered in a relatively short time.

CHAPTER VI. UTILISATION FOR ANIMAL FEED

6.1.1 MILLED HUSK

Milled husk, the processed product of rice husk, has long been used in various fields, including as a raw material for animal feed, organic fertiliser, planting media, and industrial raw materials. In the scientific world, milled husk has become an interesting object of research due to its potential in various applications.

Benefits of Ground Husk:

- **Animal Feed:** Ground husk is rich in fibre and minerals, making it a good source of nutrients for livestock. Research shows that the addition of ground husk in livestock rations can improve growth performance, milk production, and meat quality (Astuti et al., 2018);
- **Organic Fertiliser:** Milled husk is high in carbon and nitrogen, making it useful as an organic fertiliser to improve soil fertility and plant growth (Hutapea et al., 2017;
- **Growing Media:** Ground husk has a light and porous texture, making it a good growing medium for various types of plants, especially hydroponic plants (Sari et al., 2019).
- **Industrial Raw Materials:** Milled husk can be processed into various industrial products, such as charcoal briquettes, bioplastics, and building materials (Indarti et al., 2016).

6.1.1 Technology Aspects

Milled husk, the processed product of rice husk, has long been used in various fields, such as animal feed raw materials, organic fertiliser, planting media, and industrial raw materials. In the scientific world, milled husk has become an interesting object of research due to its potential in various applications.

Milling Husk Processing Technology:

- **Shredding and Grinding:** Rice husk is chopped and ground into fine powder using a chopping and grinding machine. The size of the milled husk powder may vary depending on the requirement and application.
- **Separation and Sorting:** Milled chaff can be separated and sorted based on size, density, and ash content using machines

sieving or other screening. This is done to obtain the required quality of milled husk.

- **Further Processing:** Milled husk can be further processed into various products, such as charcoal briquettes, bioplastics, and building materials.

Milling Husk Utilisation Technology:

- **Animal Feed:** Ground husk can be mixed with other animal feed ingredients to increase fibre and mineral content. Fermentation technology and prebiotics can be used to improve the nutritional value and digestibility of ground husk as animal feed.
- **Organic Fertiliser:** Milled husk can be processed into organic fertiliser through composting or fermentation. Proper composting and fermentation technology can increase the nutrient content and microorganisms that are beneficial to plants.
- **Growing Media:** Ground husk can be used as a hydroponic growing medium or mixed with soil to improve drainage and aeration. Hydroponic technology and the right soil mix can enhance plant growth.
- **Industrial Raw Materials:** Milled husk can be processed into charcoal briquettes through carbonisation process. Appropriate carbonisation technology can produce high quality and environmentally friendly charcoal briquettes. Milled husk can also be processed into bioplastics and building materials through polymerisation and composite technology.

6.1.2 Social Aspects:

Milled husk, the processed product of rice husk, has the potential to be not only economically and technologically beneficial, but also from a social aspect. Optimal utilisation of milled husk can make positive contributions in various aspects of people's lives.

Social Impact of Milled Husk:

- Improved Community Economy: Milled husk can be a source of income for communities, especially in rural areas that have many rice by-products. Processing and utilisation of milled husk can create new jobs and improve people's standard of living.

- Entrepreneurship and MSME Development: Milled husk can be used as raw material for various products that can be processed and sold by the community. This can encourage the development of entrepreneurship and MSMEs in rural areas.
- Increased Food Security: The utilisation of milled husk as animal feed, organic fertiliser, and planting medium can help improve agricultural productivity and community food security.
- Environmental Preservation: Utilisation of milled husk can reduce agricultural waste and help preserve the environment. Milled husk can be used as an alternative fuel that is environmentally friendly and reduces greenhouse gas emissions.
- Community Empowerment: Utilisation of husk can be a means to empower communities, especially marginalised groups and women. Training and mentoring communities in the processing and utilisation of milled husk can improve their skills and knowledge.

6.1.3 Environmental Aspects:

Milled husk, the processed product of rice husk, has the potential to provide benefits to the environment. Optimal utilisation of milled husk can help reduce environmental pollution, improve soil fertility, and conserve natural resources.

Environmental Benefits of Milled Husk:

- **Reduction of Environmental Pollution:** Milled husk can be used as an environmentally friendly fuel alternative and reduce greenhouse gas emissions. Milled husk can also be used as a raw material for bioplastics and composites that can replace conventional plastics made from fossil fuels.
- **Improved Soil Fertility:** Milled husk can be processed into organic fertiliser that is rich in nutrients and microorganisms that are beneficial to plants. Milled husk organic fertiliser can help improve

soil fertility, improve soil structure, and increase water retention in the soil.

- **Preservation of Natural Resources:** The utilisation of milled husk can help reduce agricultural waste and conserve natural resources. Milled husk can be used as an environmentally friendly alternative growing medium and reduce the use of peat or fertile soil.

6.1.4 Economic and Market Aspects:

Milled husk, a processed product of rice husk, has significant economic potential. Optimal utilisation of milled husk can open new business opportunities, increase community income, and encourage economic growth in rural areas.

1. **Milled Husk Business Opportunities:**
   - **Animal Feed:** Ground chaff can be mixed with other animal feed ingredients to increase fibre and mineral content. This can be a business opportunity for farmers to produce cheaper and higher quality animal feed.
   - **Organic Fertiliser:** Milled husk can be processed into organic fertiliser through composting or fermentation processes. Milled husk organic fertiliser can be an environmentally friendly and beneficial alternative to chemical fertilisers for farmers.
   - **Growing Media:** Ground husk can be used as a hydroponic growing medium or mixed with soil to improve drainage and aeration. This can be a business opportunity for growing media providers to fulfil the needs of farmers and plant hobbyists.
   - **Industrial Raw Materials:** Milled husk can be processed into charcoal briquettes, bioplastics, and building materials. This can be a business opportunity for small and medium industries to produce innovative and environmentally friendly products.

2. **Economic Benefits of Milled Husk:**
   - **Increased Community Income:** Milled husk can be a source of income for communities, especially in rural areas where there are many rice by-products. The processing and sale of milled husk can help improve people's standard of living.
   - **Job Creation:** Utilisation of milled husk can create new jobs in the processing, packaging and distribution sectors. This can help reduce unemployment and improve the welfare of the community.
   - **Increased Added Value of Agricultural Products:** Milled husk can be processed into various products that have a higher added value compared to raw husk, such as charcoal briquettes, bioplastics, organic fertiliser, and growing media.
   - **Production Cost Savings:** Milled husk can be used as an alternative raw material for various products, such as charcoal briquettes and organic fertiliser. This can help reduce production costs and increase profits for businesses.

3. **Selling price of milled husk:**

The selling price of milled husk can vary depending on several factors, such as quality, location, and market demand. Here is a range of selling prices for milled husk in Indonesia:

- Coarse ground chaff: IDR 500 - IDR 1,000 per kilogram
- Finely ground chaff: IDR 1,000 - IDR 2,000 per kilogram
- Organic ground chaff: IDR 2,000 - IDR 3,000 per kilogram

6.1.5 Investment Aspects

1. Initial Cost

- **Procurement Cost of Milled Husk**: For example, milled husk can be obtained free of charge from the remaining rice production, but there are still transport and pre-processing costs.

- **Cost of Production Equipment**: Costs for drying machines, grinders, and fermentation equipment.
- **Infrastructure Costs**: The cost of building production and storage sites.
- **Research and Development (R&D) Costs**: Costs for the development of milled husk processing technology.

For example:

- Production Equipment Cost: IDR 50,000,000
- Infrastructure Cost: IDR 20,000,000
- R&D Cost: IDR 10,000,000
- Transport and Preliminary Processing Costs: IDR 5,000,000

Total Initial Cost: IDR 85,000,000

2. Annual Operating Expenses

- **Raw Material Costs**: Milled husk may be free, but there are costs for additional materials.
- **Labour Cost**: The cost to pay the workers involved in production.
- **Cost Overhead**: Costs operational Other such as electricity, water, and equipment maintenance.

For example:

- Additional Material Cost: IDR 5,000,000/year
- Labour Cost: IDR 20,000,000/year
- Overhead Costs: IDR 10,000,000/year

Total Annual Operating Costs: IDR 35,000,000

3. Annual Revenue

- Selling Price of Organic Fertiliser from Milled Husk: IDR 3,000 per kilogram
- Estimated Annual Production: 100,000 kilograms

Annual Revenue: 100,000 kg x Rp 3,000/kg= Rp 300,000,000

4. Investment Analysis

1. Net Present Value (NPV)

Using a 10% discount rate and a 5-year analysis period:

$$\text{NPV} = -\text{Biaya Awal} + \sum \left(\frac{\text{Pendapatan Tahunan} - \text{Biaya Operasional Tahunan}}{(1+\text{Discount Rate})^t} \right)$$

$$\text{NPV} = -85.000.000 + \sum \left(\frac{300.000.000 - 35.000.000}{(1+0.10)^t} \right)$$

$$\text{NPV} = -85.000.000 + \frac{265.000.000}{1.10} + \frac{265.000.000}{(1.10)^2} + \frac{265.000.000}{(1.10)^3} + \frac{265.000.000}{(1.10)^4} + \frac{265.000.000}{(1.10)^5}$$

$$\text{NPV} \approx -85.000.000 + 240.909.091 + 219.008.264 + 199.098.422 + 181.089.475 + 164.899.522$$

$$\text{NPV} \approx 859.004.774$$

2. Internal Rate of Return (IRR)

Finding the internal rate of return that makes the NPV equal to zero: IRR=211.76%

3. Payback Period

Calculate how long it will take to return the initial investment:

$$\text{Payback Period} = \frac{\text{Investasi Awal}}{\text{Cash Flow Tahunan}}$$

$$\text{Payback Period} = \frac{85.000.000}{265.000.000} \approx 0.32 \text{ tahun}$$

CHAPTER VII. UTILISATION FOR FOOD

7.1 Rice Husk for Food (Bran Flour)

Rice husk, a by-product of rice milling, is generally considered an agricultural waste. However, recent research has shown that rice husk has the potential to be processed into an alternative food source that is rich in nutrients. According to Mustofa et al. (2019) rice husk contains carbohydrates, protein, fibre, and minerals such as potassium, magnesium, and phosphorus. This nutritional content makes rice husk a potential raw material for various food products, such as flour, bread, and noodles.

Another study by Setyowati et al. (2018) showed that rice husk flour can be used for wheat flour substitution up to 30% in bread making. This substitution not only increases the nutritional value of bread, but also extends its shelf life.

Rice husk processed into flour or rice bran has great potential as a functional food ingredient that is rich in fibre and bioactive compounds. According to research by Utomo et al. (2020), the rice husk milling process produces rice bran which contains soluble and insoluble fibre that is important for digestive health and reduces the risk of degenerative diseases (Utomo et al., 2020). In addition, rice bran is also rich in antioxidants such as phenolics and flavonoids, which may provide additional benefits in reducing the risk of heart disease and cancer (Utomo et al., 2020).

The utilisation of rice bran as a food ingredient has gained attention in the food and beverage industry to increase the nutritional value of the final product. The study by Indriani et al. (2021) showed that the use of rice bran in the formulation of bread and other processed products can significantly increase the content of dietary fibre and bioactive compounds, without sacrificing the organoleptic properties desired by consumers (Indriani et al., 2021).

Therefore, the development of technology to process rice husk into rice bran not only reduces agricultural waste but also opens up opportunities to produce healthier and high value-added food products. The application of this technology requires a strong integration between food science, processing technology and industrial application to optimise the food potential of rice husk.

The utilisation of rice husk as a food source not only provides benefits for food security, but also helps in agricultural waste management. Diversification of food products from rice husk can open new opportunities for small and medium enterprises in rural areas, increase community income, and promote sustainable rural development.

Although research on the potential of rice husk as a food source is still evolving, existing evidence suggests that rice husk has promising potential to address food insecurity and improve community nutrition.

7.1.1 Technology Aspects

A. Processing of Bran Flour

Rice bran flour, also known as **rice flour**, is a processed product from rice that is rich in nutrients and health benefits. The processing process involves several important steps that transform rice bran into a fine flour ready for use in various culinary and industrial applications. Here, a more in-depth description of the bran flour processing process and the technology used:

1. **Raw Material Selection and Preparation**
   The process begins with the selection of quality bran raw materials. Fresh bran from the rice mill is selected by considering criteria such as colour, aroma, and texture. Good quality bran is brownish yellow in colour, has a fresh aroma, and has a smooth texture without lumps.
2. **Cleaning and Washing**
   The next step is to clean the bran from dirt and dust. This is done by **storing the** bran for 24 hours.

to separate the bran from the fine bran and impurities. The bran is then washed with clean water to remove dust and other impurities.

3. **Drying**

   After washing, the bran needs to be dried appropriately to prevent deterioration and growth of microorganisms. Drying can be done by various methods, such as **sun drying**, **oven drying**, or **the use of a dehydrator**. The method chosen depends on the scale of production and availability of resources.

4. **Roasting (Optional)**

   This is an optional step that aims to improve the aroma, flavour and colour of the bran flour. Roasting is done by heating the bran over **low heat** for 10-15 minutes, while stirring continuously to prevent burning.

5. **Milling and Pressing**

   The dried and roasted bran is then ground into fine flour using a **grinding machine** or **blender**. The mill results are then sieved with a **fine sieve** to obtain a fine bran flour that is free of coarse particles.

6. **Packaging and Storage**

   The refined bran flour is packed in airtight containers to maintain quality and prevent deterioration. The containers used must be **clean, dry, and free from pests**. Bran flour is stored in a **cool, dry** place **away from direct sunlight**. The shelf life of bran flour is generally around 3-6 months.

B. Bran Flour Processing Technology

Various technologies can be applied in the processing of bran flour to improve efficiency, quality, and added value of the product. Here are some examples of commonly used technologies:

- **Drying technology**: The use of **vacuum dryers** or **fluidised bed dryers** can speed up the drying process and produce better quality bran flour.

- **Depletion technology**: Application of **vibrating sieve** or **air filter device** can produce finer and more uniform bran flour.
- **Modification technology**: The addition of **enzymes** or **food additives** can improve the functional properties of rice bran flour, such as water absorption, gel stability, and emulsion ability.

7.1.2 Social Aspects:

1. Improved Farmer Welfare

Processing rice bran flour can be an opportunity to improve farmers' welfare. Bran, which is often considered as waste from rice milling, can be processed into value-added products with higher selling prices. This can provide additional income for farmers and improve their standard of living.

2. Local Community Empowerment

Bran flour processing can be an opportunity to empower local communities. Bran flour processing units can be established in rice-producing villages, thus creating jobs and improving the local economy. Local communities can be trained to process bran and be involved in the production, distribution and marketing of bran flour.

3. Social Entrepreneurship Development

Bran flour processing can be an opportunity to develop social entrepreneurship. Small and medium-sized enterprises (SMEs) can be established to produce and market bran flour. These SMEs can play a role in increasing people's access to quality and affordable bran flour.

4. Promotion of Healthy and Nutritious Food

Bran flour processing can be a means to promote healthy and nutritious food. Bran flour is rich in essential nutrients such as vitamins, minerals and fibre that are beneficial for health. Promotion of bran flour can encourage people to consume healthier and more nutritious food.

5. **Preservation of Local Food Culture**

   Bran flour processing can be a means to preserve local food culture. Bran is part of the culinary tradition in several regions in Indonesia. Processing bran flour can help preserve local food culture and increase people's love for traditional food.

7.1.3 Environmental Aspects:

Bran flour has some significant environmental benefits, which make it an environmentally friendly raw material in various applications. Here are some of its benefits from an environmental aspect:

1. **Reducing Agricultural Waste**: Bran is a by-product of milling rice or other cereals. By processing bran into flour, agricultural waste can be reutilised for value-added products, reducing the amount of organic waste that is usually discarded.
2. **Global Warming Reduction**: The use of bran as a raw material can reduce greenhouse gas emissions and overall carbon footprint. By managing agricultural waste more efficiently, bran flour processing can help reduce negative environmental impacts.
3. **Nutrient Recycling**: Bran flour can be reused in the animal feed industry or as compost. This helps maintain natural nutrient cycling and reduces the need for new raw materials that can have a greater environmental impact.
4. **Energy Savings**: The processing of recycled raw materials can in some cases require less energy than the processing of new raw materials. This more efficient use of energy can reduce the carbon footprint of industrial processes.
5. **Reduced Use of Pesticides and Fertilisers**: In some cases, the use of bekutal in animal feed production can reduce dependence on synthetic pesticides and fertilisers. This can reduce water and soil pollution and preserve agricultural soil quality.

7.1.4 Economic and Market Aspects:

Bran flour processing offers attractive economic opportunities for businesses and communities. Here are some important points to consider:

1. **Huge Market Potential**

   Bran flour has great market potential in Indonesia, both for human consumption and animal feed. The consumption of bran flour is increasing along with the increasing public awareness of a healthy and nutritious lifestyle. Bran flour can also be used as a raw material for various food and beverage products, such as bread, cakes, biscuits, and health drinks.
2. **Increased Farmer Income**

   Bran flour processing can increase farmers' income by adding value to bran, which has been considered as waste. Farmers can sell the bran at a higher price to bran flour processors, thereby increasing their profits.
3. **Local Community Empowerment**

   Bran flour processing can empower local communities by creating jobs and improving the local economy. Bran flour processing units can be established in rice-producing villages, thus providing employment opportunities for local communities.
4. **SME Development**

   Bran flour processing can encourage the development of small and medium-sized enterprises (SMEs). SMEs can produce and market bran flour in various forms and packaging, such as pure bran flour, premixed bran flour, and processed bran flour products.
5. **Improving the Competitiveness of Indonesian Agricultural Products**

   Bran flour can be a superior product of Indonesian agriculture that can compete in the global market. Indonesian bran flour has good quality and competitive prices compared to bran flour from other countries.

Selling Price of Bran Flour

The selling price of rice bran flour in Indonesia varies depending on the quality, brand, and packaging. The following is the range of selling prices for rice bran flour on the market:

- **Pure rice bran flour**: IDR 10,000 - IDR 20,000 per kg
- **Bran flour premix**: IDR 15,000 - IDR 30,000 per kg
- **Processed bran flour products**: IDR 20,000 - IDR 50,000 per product

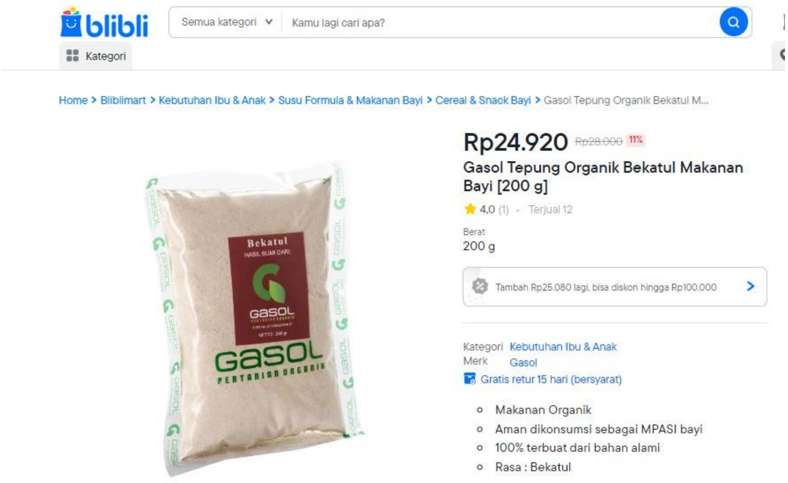


Figure 19 Bran Flour

7.1.5 Investment Aspects

1. Initial Cost

For example:

- Production Equipment Cost: IDR 50,000,000
- Infrastructure Cost: IDR 20,000,000
- R&D Cost: IDR 10,000,000
- Total Initial Cost: IDR 80,000,000

2. Annual Operating Expenses

For example:

- Raw Material Cost (rice bran): IDR 10,000,000/year
- Labour Cost: IDR 15,000,000/year
- Overhead Costs: IDR 5,000,000/year
- Total Annual Operating Costs: IDR 30,000,000

3. Annual Revenue

For example:

- Estimated Annual Production: 100,000 units of rice bran flour
- Annual Revenue: 100,000 units x Rp 20,000/unit= Rp 2,000,000,000

Investment Analysis

1. Net Present Value (NPV)

Using a 10% discount rate and a 5-year analysis period:

$$\text{NPV} = -\text{Biaya Awal} + \sum\left(\frac{\text{Pendapatan Tahunan} - \text{Biaya Operasional Tahunan}}{(1+\text{Discount Rate})^t}\right)$$

$$\text{NPV} = -80.000.000 + \sum\left(\frac{2.000.000.000 - 30.000.000}{(1+0.10)^t}\right)$$

$$\text{NPV} = -80.000.000 + \frac{1.970.000.000}{1.10} + \frac{1.970.000.000}{(1.10)^2} + \frac{1.970.000.000}{(1.10)^3} + \frac{1.970.000.000}{(1.10)^4} + \frac{1.970.000.000}{(1.10)^5}$$

$$\text{NPV} \approx -80.000.000 + 1.790.909.091 + 1.628.190.082 + 1.479.263.711 + 1.342.057.010 + 1.214.597.282$$

$$\text{NPV} \approx 6.435.016.166$$

2. Internal Rate of Return (IRR)

Finding the internal rate of return that makes the NPV equal to zero: IRR=44.98%

3. Payback Period

Calculate how long it will take to return the initial investment:

$$\text{Payback Period} = \frac{\text{Investasi Awal}}{\text{Cash Flow Tahunan}}$$

$$\text{Payback Period} = \frac{80.000.000}{30.000.000} = 2.67 \text{ tahun}$$

- **NPV**:
  Rp 6,435,016,166 shows that this investment is very profitable with a 10% discount rate.
- **IRR**: 44.98% indicating a fairly high internal rate of return.

- **Payback Period**: Approximately 2.67 years shows that this investment can be returned in a relatively short period of time.

7.2 Rice bran oil

Rice bran oil, or rice oil, is a type of vegetable oil extracted from the outer layer of rice (bran). This extraction process produces an oil rich in phytosterols, tocopherols, and oryzanols, components that provide added value in health and food applications.

According to research conducted by Aoki et al. (2007), rice oil contains large amounts of polyunsaturated fatty acids, such as oleic and linoleic acids, which have the potential to lower cholesterol levels and support heart health.

Studies conducted by Rahmanian et al. (2017) also showed that oryzanol in rice oil has strong antioxidant properties, which can protect body cells from oxidative damage. Overall, rice oil offers potential as a high-value raw material in the food and pharmaceutical industries, and has potential benefits in maintaining human health.

7.2.1 Technology Aspects

1. Oil Extraction

The extraction process aims to remove oil from rice bran. A commonly used technology is solvent extraction, where the bran is dissolved in a solvent such as hexane. The main steps in extraction include:

- **Bran Milling**: Rice bran is milled to increase the surface area and facilitate the extraction process.
- **Extraction with Solvents**: The treated bran is fed into an extractor where a solvent (usually hexane) is used to dissolve the oil from the raw material. This process enables efficient extraction of the oil.
- **Filtering**: After extraction, the oil and solvent mixture is filtered to separate the oil from other materials such as fibre and protein.

2. Oil Refining

The extracted oil needs to be refined to remove unwanted compounds and improve its quality. The refining process generally includes:

- **Degumming**: A process to remove phosphatides and gum substances from crude oil using hot water or acid.
- **Neutralisation**: The use of an alkaline solution to remove free acids in the oil produced during the degumming process.
- **Deodorisation**: The process of removing unwanted odours and flavours by heating oil under low pressure and vacuum.

3. Separation and Stabilisation

After refining, the oil is separated from the solvent (if used) and processed for stabilisation and conservation. This includes:

- **Solvent Removal**: Solvent-extracted oil must undergo a solvent removal process through heating and distillation to obtain pure oil.
- **Stabilisation**: Handling to prevent oxidation and spoilage of oil by adding antioxidants or using appropriate packaging techniques.

4. Process Control and Waste Management

Modern RBO processing technology also includes strict process control using automation and monitoring systems to ensure consistent product quality and operational safety. addition, effective and environmentally friendly waste management is important to minimise the environmental impact of the production process.

5. Innovation and New Technology Development

The oil processing industry continues to develop new innovations to improve the efficiency, quality and sustainability of the RBO processing process. These include the use of non-solvent extraction technologies, improvements in more efficient refining processes, and the development of more value-added derivative products from production residues.

7.2.2 Social Aspects:

Some benefits of Rice Bran Oil from a social perspective:

1. **Farmer Empowerment**: Rice Bran Oil production often involves local farmers in the collection of raw materials, i.e. rice bran. This provides economic opportunities for farmers in rural areas involved in rice farming. By adding value to rice bran, farmers can increase their income.
2. **Job Creation**: The Rice Bran Oil processing industry creates direct and indirect employment in local communities, including in the extraction, refining, packaging and distribution of the product. This helps to reduce the unemployment rate in the area.
3. **Infrastructure Improvement**: The growth of the Rice Bran Oil industry is often supported by infrastructure improvements in rural areas, such as transport and access to modern processing technologies. This can help improve the quality of life for local communities.
4. **Local Economic Development**: With the investment and growth of the Rice Bran Oil industry, there is wider local economic development. This can trigger the growth of other small and medium-sized businesses in the vicinity, such as packaging, distribution, and other supporting services.
5. **Women's Empowerment**: Much of the production of Rice Bran Oil involves processing work that is accessible to women in rural areas. This provides opportunities for women to participate in the household economy and supports the economic sustainability of the family.
6. **Improved Quality of Life**: By providing access to healthier and higher quality products, such as nutrient-rich Rice Bran Oil, local communities can improve their overall health and quality of life.

7.2.3 Environmental Aspects:

1. **Use of Side Raw Materials**: Rice Bran Oil is extracted from rice bran, which is a by-product raw material of the rice milling process. By utilising rice bran, the Rice Bran Oil industry helps to reduce agricultural waste that may be harmful to the environment.
2. **Waste Reduction**: Rice Bran Oil processing often includes better waste management, with the development of technologies to recycle or reuse production waste, such as solvent reuse or organic waste treatment.
3. **Energy Efficiency**: Some modern technologies in Rice Bran Oil processing, such as the use of non-solvent extraction or more efficient refining techniques, can help reduce energy consumption in the production process. This contributes to the reduction of carbon footprint and greenhouse gas emissions.
4. **Biodiversity**: The Rice Bran Oil industry can contribute to biodiversity conservation by promoting more sustainable agricultural practices. Wise soil and water management in rice production can also support the sustainability of local ecosystems.
5. **Pollution Reduction**: Rice oil has high stability at high temperatures, producing fewer pollutants when used in frying or other food processing. This reduces the potential for air and water pollution from industrial sources of oil use.
6. **Improved Soil Quality**: Improved agricultural practices to utilise rice bran as a raw material can improve soil quality by improving soil structure and nutrient availability.

Rice Bran Oil Market

Global demand for rice bran oil is expected to continue to increase in the next few years. This is driven by several factors, such as:

- **People's awareness of a healthy lifestyle is increasing**: Consumers are increasingly opting for healthy and nutritious food and beverage products, and rice bran oil is one of the popular choices due to its high antioxidant content and health benefits.

- **The increasing use of rice bran oil in industry**: Rice bran oil is used in various industries, such as the cosmetic, pharmaceutical, and biofuel industries. This is fuelling the growth in demand for rice bran oil beyond the food sector.
- **Increased rice production**: Increased rice production in various countries around the world automatically increases the amount of rice bran produced, which is the main raw material for rice bran oil.

7.2.4 Economic and Market Aspects:

Rice Bran Oil has significant market potential in various sectors of the economy, especially in the food, cosmetic, and healthcare industries:

1. **Food and Beverage Industry**: Rice Bran Oil is used extensively in the food industry for frying and other food processing. Its stability at high temperatures makes it a popular alternative to other oils such as soya oil or palm oil. Demand continues to rise in this sector as consumers increasingly opt for healthier and environmentally-friendly products.
2. **Cosmetics and Skin Care Industry**: Rice Bran Oil has good absorbing properties and is rich in antioxidants such as oryzanol, which makes it suitable for use in cosmetics and skincare products. This includes use in creams, lotions, soaps, and hair care products.
3. **Health and Wellness Industry**: In the health and wellness market, Rice Bran Oil is in demand due to its content of healthy polyunsaturated fatty acids, such as oleic and linoleic acids, as well as tocopherols and phytosterols. The oil is used in dietary supplements, vitamins, and nutrasetical products to support cardiovascular and immune system health.
4. **International Market**: The demand for Rice Bran Oil globally continues to increase due to greater awareness of its health benefits and environmental sustainability. Rice Bran Oil exports from major producing countries such as India, Thailand, and Japan have increased, with key markets including the United States, Europe, and Southeast Asia.

5. **Innovative Product Development**: The Rice Bran Oil industry continues to develop new value-added derivative products, such as oil for biodiesel feedstock, lubricants, and other chemicals. This opens up new opportunities for product diversification and market expansion.
6. **Industrial Uses**: In addition to direct consumer applications, Rice Bran Oil is also used in industry as a raw material for various products, including paints and coatings, pharmaceutical products, and other industrial chemicals.

Figure 20 Rice Bran Oil

7.2.5 Investment Aspects

1. Initial Cost

- Production Equipment Cost: IDR 100,000,000
- Infrastructure Cost: IDR 30,000,000
- R&D Cost: IDR 15,000,000
- Total Initial Cost: IDR 145,000,000

2. Annual Operating Expenses

For example:

- Raw Material Cost (husk): IDR 20,000,000/year
- Labour Cost: IDR 25,000,000/year
- Overhead Costs: IDR 10,000,000/year
- Total Annual Operating Costs: IDR 55,000,000

3. Annual Revenue

For example:

- Estimated Annual Production: 50,000 litres Rice Bran Oil
- Annual Revenue: 50,000 litres x IDR 125,000/litre= IDR 6,250,000,000

Investment Analysis

1. Net Present Value (NPV)

Using a 10% discount rate and a 5-year analysis period:

$$\text{NPV} = -\text{Biaya Awal} + \sum \left(\frac{\text{Pendapatan Tahunan} - \text{Biaya Operasional Tahunan}}{(1+\text{Discount Rate})^t} \right)$$

$$\text{NPV} = -145.000.000 + \sum \left(\frac{6.250.000.000 - 55.000.000}{(1+0.10)^t} \right)$$

$$\text{NPV} = -145.000.000 + \frac{6.195.000.000}{1.10} + \frac{6.195.000.000}{(1.10)^2} + \frac{6.195.000.000}{(1.10)^3} + \frac{6.195.000.000}{(1.10)^4} + \frac{6.195.000.000}{(1.10)^5}$$

$$\text{NPV} \approx -145.000.000 + 5.631.818.182 + 5.119.834.711 + 4.654.395.192 + 4.230.359.265 + 3.843.053.877$$

$$\text{NPV} \approx 23.634.460.227$$

2. Internal Rate of Return (IRR)

Finding the internal rate of return that makes the NPV equal to zero: IRR=50.11%

3. Payback Period

Calculate how long it will take to return the initial investment:

$$\text{Payback Period} = \frac{\text{Investasi Awal}}{\text{Cash Flow Tahunan}}$$

$$\text{Payback Period} = \frac{145.000.000}{55.000.000} = 2.64 \text{ tahun}$$

- **NPV**: IDR 23,634,460,227 shows that this investment is very profitable with a 10% discount rate.

- **IRR**: 50.11% indicating a high internal rate of return.
- **Payback Period**: Approximately 2.64 years indicating that this investment can be returned in a relatively short time t

CHAPTER VIII COLLABORATION BUSINESS MODEL UTILISATION AND VALUE ADDITION OF STRAW AND CHAFF

8.1. ECO STRAW ME

Straw Me produces biodegradable drinking straws made from rice and corn starch. Straw has a vision to raise awareness of the dangers of the continued use of plastic straws on earth, by switching to Eco Straw Me is a greener way of life. The eco straw me straws can be composted in the backyard, the straw decomposes into food for plants

Eco Straw Me straw product

From the results of the discussion, currently the production capacity is still very small, so the raw materials can still be obtained from rice flour on the market, not using a special supplier. However, another collaboration that can be done is a joint campaign related to environmentally friendly lifestyles.

8.2. Collaboration with PT PTEC on studies for biomass

PTEC Research and Development is an Indonesia-based company, whose main focus is on research and development (R&D). PTEC is a subsidiary of TESS (Total Energy Saving & Solution) Engineering. The TESS Group is conducting research and development on the effective use of crop residues as biomass fuel as part of its global energy decarbonisation efforts.

PTEC has developed technology to produce and sell fuel for biomass power generation using EFB (Empty Fruit Bunches) and OPT (Old Palm Trunks), which are unused residues from the palm oil industry, as feedstock.

Apart from swait PTEC also develops biomass from other agricultural waste products, one of which is developing biomass technology from rice husks, One of obstacles of rice husks is the silica element which will harden during the combustion process to become biomass, but currently there has been technological development to do it all.

This collaboration will begin with the preparation of a feasibility study report, but there are major considerations in addition to the stability of raw materials, such as that the agricultural waste to be developed into biomass should not interfere with the supply of food products. The biggest consideration is that some of the husks are already used by the livestock industry as mats to keep chickens warm or as ground husks for animal feed. For this reason, currently a feasibility study will still be carried out in advance from PT PTEC. The proposed cooperation is as follows:

Figure 22. Business Plan for Cooperation Model with PT PTEC

8.3. Collaboration with BRIN for the creation of BioSINTA

BRIN researchers and have developed a semi-pilot scale silica production process from rice husk. The resulting silica product is known as "Biosilica". Currently, three variants of biosilica products have been produced, namely in the form of powder, gel and liquid.

The biosilica product has been registered with the Director General of IPR under the brand name "BioSINTA" The process technology developed at this time has been able to produce powder biosilica products from rice husks with a SiO2 content of up to 99%.

Figure 23. BioSINTA products

The production of biosilica from rice husk and returning it as a nutrient to rice plants is a form of environmentally friendly bioindustrial agriculture that can increase the added value and competitiveness of rice production, rice and its processing by-products.

Although this product is the result of technology from BRIN researchers, BRIN has no authority in commercial management. BRIN's role and function is only to support innovation and researchers will get royalties from the technology produced. Currently, Biosilica products have been registered in the BUMN e-catalogue and are produced by PT Sang Hyang Sri.

PT Sang Hyang Sri already has cooperation with rice mills, so if PPK is interested, it can register as a vendor, but currently the Bio SINTA request is still in the pre-production stage, meaning that it is only made if there is a request, so a more specific collaboration cannot be done yet.

8.4. Collaboration with WasteX for BIOCHAR production

WasteX is a company that specialises in organic waste management and biochar production. The company has become a pioneer in utilising organic waste, such as agricultural waste and plantation waste, to be converted into a value-added product, namely biochar. Biochar itself is charcoal produced from the pyrolysis process of organic materials at high temperatures in the absence of oxygen.

WasteX Vision and Mission
WasteX's vision is to become a leader in the sustainable organic waste management and biochar production industry in Indonesia.

The company's mission includes:

- Reducing Organic Waste: Reducing the amount of organic waste that ends up in landfills.
- Improving Soil Fertility: Producing high-quality biochar that can improve soil fertility and agricultural productivity.
- Encouraging Circular Economy: Encourage the adoption of a circular economy by converting waste into value-added products

The biochar produced by WasteX has various applications, :

In general, biochar offers a multifunctional and sustainable solution to many challenges in agriculture and the environment, making it a valuable material in soil management practices and climate change mitigation as described below:

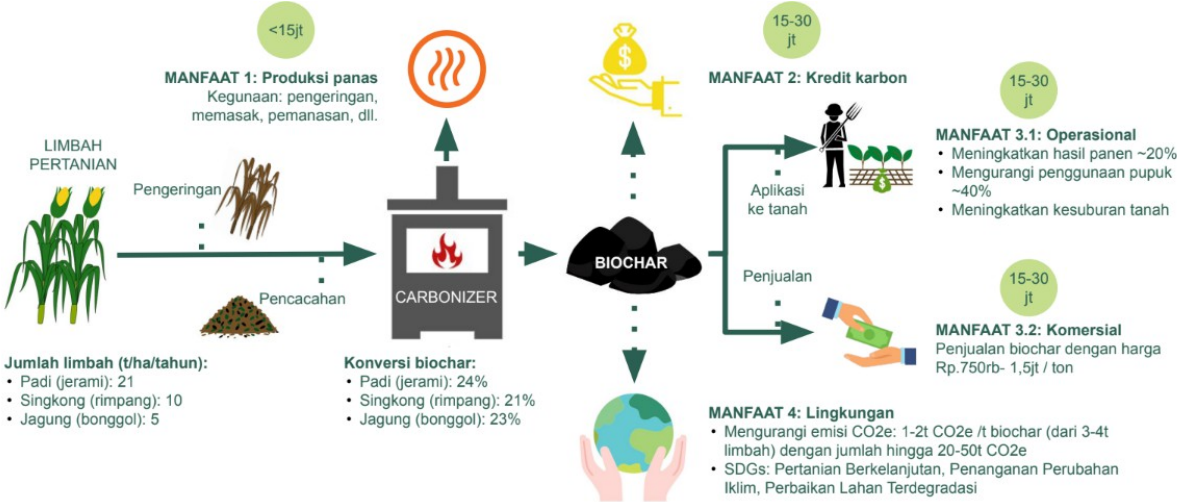


Figure. 24. Benefits of Biochar for agriculture and the Environment

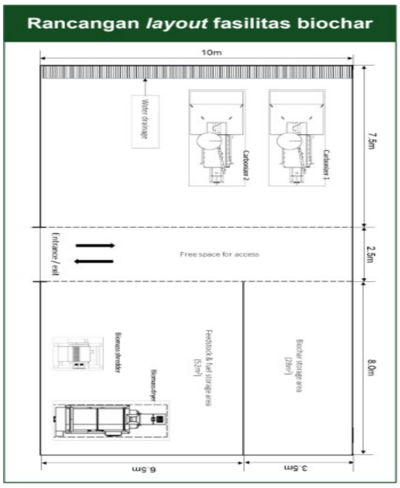
Collaboration between small rice mills and WasteX is more feasible because they have the same goal, which is to utilise the husk and straw to become Biochar products.

The proposed cooperation is as follows

WasteX	Small Rice Mill
• build a large-scale biochar production facility (~2 carboniser units) at the partner site, • WasteX will invest, build, and operate the facility at the partner's location. • handles and is responsible for the sale of biochar • The facility can treat the waste generated by the partner and provide benefits to the partner through a profit-sharing scheme.	• the partner provides a location / place adjacent to the partner's production facility • supplying raw materials (waste) for biochar production • participate in a profit-sharing scheme

For Biochar Production facility required

- carbonizer v2.2 unit with additional dryer, shredder, and pellet machine (2 units)
- Total area 180m2 (100m2 for carboniser, 80m2 for biochar storage room and raw materials)
- Raw material requirement about 900-1,200 tonnes/year (3-4 tonnes/day)
- Operational 16 hours/day for 300 days/year



The calculation of profit sharing is as follows:

Facility Monthly Fiscal Calculation (USD)	Initial scenario
Biochar price per tonne	150
Revenue	48.960
Biochar Sales	24.480
Carbon Credit Sales	24.480
Cost	-27.600
Profit	**21.360**

Annual net benefits (USD)	WasteX	Rice Mill (PbN's partner)
Initial Capital	23.000	Place
Profit Sharing Proposal	75%	25%
Profit Sharing	16.020	5.340

CHAPTER IX CONCLUSION

NO	PRODUCT TYPE	ASPECT TECHNOLOGY	ENVIRONMENTAL ASPECTS	SOCIAL ASPECT	MARKET ASPECT	INVESTMENT ASPECTS	CONCLUSIONS
1	Rice husk charcoal	Fairly easy to apply, and does not require high technology but requires proper combustion	Can improve agricultural land as a soil looser, composting material, bokashi, takakura, growing media, and nursery media	Can be an additional income to help the economy Neighbouring communities	The price of rice husk charcoal reaches Rp .5000.00-7,000.00/kg and much needed by many industries	Profit potential with a payback period of approximately 20 months	Worth
2	Husk briquettes	Easy to apply only requires husk charcoal, tapioca flour, and a briquetting machine	The calorific value of husk briquettes is much higher than that of coal, hence the potential for alternative fuels.	Increased community income due to higher selling price compared to husk charcoal	The price of bulkhead briquettes is IDR 15,000/kg. One printer produces 120kg or 3000kg/day. Then per month can produce IDR 45,000,000 / month	With an initial capital of IDR 40,000,000, prediction of net profit reaching Rp 56,000,000 and net profit per year IDR 672,000,000	Worth
3	Straw briquettes	Disinfection in the manufacture of straw briquettes produces two products, namely pellets and briquettes. Both can be used as fuel	The efficiency of the equipment is low because straw has poor fuel characteristics (high ash content, very high content of certain elements).	The process of transporting straw is usually quite dangerous for road users because it is usually transported in a decomposed condition, or tied but	Utilisation of rice straw for energy has high costs for the logistics of collection, transport, handling and storage.	With an initial capital of IDR 40,000,000, prediction of net profit reaching Rp 56,000,000 and net profit per year IDR 672,000,000	Not worth it

NO	PRODUCT TYPE	ASPECT TECHNOLOGY	ENVIRONMENTAL ASPECTS	SOCIAL ASPECT	MARKET ASPECT	INVESTMENT ASPECTS	CONCLUSIONS
				stacked very high.			
4	Straw Ethanol	Pretreatment technology is the most expensive stage, and there is no sign of this technology being utilised in the future. the near future.	Is an environmentally friendly renewable energy	There has been no large-scale development so there is no impact yet.	Not yet available in the market	development is only limited to research	Not worth it
5	Straw Biogas	Fairly straightforward involving only an anaerobic fermentation process to convert biomass into methane gas	Helps reduce gas emissions and air pollution. Solid residue from biogas can be used as organic fertiliser	Reduce community dependence fossil fuels or firewood. As well as providing a sustainable source of energy for society	In general, from the market side, community acceptance of straw biogas is still low, so further education from stakeholders to the community is needed.	In general, from the calculation of investment analysis, jarami biogas provides a good profit.	Worth
5	Liquid biosilica	Biosilica can be produced from several types of processes, but the rice husk acid leaching process has the highest specific surface area. an 10x more	Maintains silica availability in the rice ecosystem. Application of biosila to sorghum increased production by 78%.	Improves health and well-being (bone health, skin health, and cognitive function). And able to	The price of liquid biosilica is 12-17 USD/litre. And the price of biosilica powder is 1-6 USD/kg (depending on the quality of the silica). In Indonesia, it has not been optimised in	Profit potential with a payback period of approximately 11 months	Worth

					This utilisation		

NO	PRODUCT TYPE	ASPECT TECHNOLOGY	ENVIRONMENTAL ASPECTS	SOCIAL ASPECT	MARKET ASPECT	INVESTMENT ASPECTS	CONCLUSIONS
		high than without leaching. However, it requires high cost and water utilisation which is a lot.		improve crop yields and food quality			
6	Liquid fertiliser	It's pretty straightforward. The main process is anaerobic fermentation of the husk.	Reduce agricultural waste (as rice husk is utilised), improve soil fertility and increase agricultural productivity without the use of synthetic chemical fertilisers.	Empowering farmers and giving them the ability to make their own fertiliser. Reduced contamination with chemicals, resulting in community welfare can increase	Selling price of liquid fertiliser IDR 20,000/litre	Profit potential with a payback period of approximately 6 months	Worth
7	Biodegradable	Quite complicated and needs precision because there are several mixing processes with chemicals using a certain ratio	Reduce waste pollution (land, water, and air), preserve ecosystems, improve soil fertility, accelerate ecosystem recovery which is damaged,	Improve environmental awareness, quality of life, social consciousness, and generate new jobs	The market demand for biodegradable products is still relatively new and has not yet reached optimal economies of scale. This causes the selling price of the product	Potential profits with a payback period of approximately 2.4 Years	Not worth it

NO	PRODUCT TYPE	ASPECT TECHNOLOGY	ENVIRONMENTAL ASPECTS	SOCIAL ASPECT	MARKET ASPECT	INVESTMENT ASPECTS	CONCLUSIONS
					biodegradable is still relatively high.		
8	Ground Husk	Easy and fairly cheap	Reduce environmental pollution, improve soil fertility, and conserve natural resources	Improving the community's economy, developing umkm, improving food security, preserving the environment, and empowering the community.	• coarse ground chaff: IDR 500 - IDR 1,000 per kilogram • finely ground chaff: IDR 1,000 - IDR 2,000 per kilogram • organic milled husk: IDR 2,000 - IDR 3,000 per kilogram With business opportunities in animal feed, organic fertiliser, planting media, and industrial raw materials.	Profit potential with a payback period of approximately 6 months	Worth
9	Rice bran flour	Fairly straightforward. There are 3 types of technologies that are commonly used: drying, pressing, and modification.	Reduced agricultural waste, global warming, nutrient recycling, energy savings, reduced pesticide and fertiliser use	Improvement of farmers' welfare, local community empowerment, entrepreneurship development, promotion of healthy and nutritious food, conservation	It has great potential as awareness of healthy and nutritious living increases. **Rice bran flour pure**: IDR 10,000 - IDR 20,000 per kg **Rice bran flour premix**: IDR 15,000 - IDR 30,000 per kg **Product processed bran flour**: Rp	Profit potential with a payback period of approximately 2.67 years	Worth

NO	PRODUCT TYPE	ASPECT TECHNOLOGY	ENVIRONMENTAL ASPECTS	SOCIAL ASPECT	MARKET ASPECT	INVESTMENT ASPECTS	CONCLUSIONS
				local food culture	20,000 - Rp 50.000 per product		
10	Rice bran oil	It's easy enough with new technological innovations that improve the refining process more efficiently	Use of by-product raw materials, waste reduction, energy efficiency, biodiversity, pollution reduction, soil quality improvement	Farmer empowerment, job creation, infrastructure improvement, local economic development, women's empowerment, and increased quality of life	Global demand is expected to continue to increase as awareness of environmental benefits and sustainability grows. Market price in Indonesia IDR 125,000/litre	Profit potential with a payback period of approximately 2.67 years	Worth

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