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keywords

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Abstract

Malaysia and Indonesia has huge market for turning oil palm residues like oil palm fruit bunches(PFB),oil palm wood(OPW) and oil palm fronds(OPF) into fuel pellets. We supply PFB wood pellet mill and OPF feed pellet mill, welcome your inquiry!

Feasibility Analysis of Oil Palm Wood and Oil Palm Fronds Pellets in Malaysia and Indonesia

1. Current Plantation Situation of Oil Palm in Indonesia and Malaysia

According to data from the Indonesian Ministry of Agriculture, the total area of oil palm plantations in Indonesia is currently around 8 million hectares, a number which is twice as much as in the year 2000 when around 4 million hectares of Indonesian soil was used for oil palm plantation. This number is expected to increase to 13 million hectares by 2020.

Oil Palm plantations however cover over 5 million hectares of land in Malaysia, which makes Malaysia becomes the second largest oil palm plantation country in the world.

Around 85% of global palm oil production comes from Indonesia and Malaysia, so oil palm is a major driver of economic growth in these two countries. It plays an indispensable role in promoting the national economy and elevating living standards.

Since Malaysia and Indonesia have become the first two largest oil palm plantation countries and large amount of biomass residue is generated yearly, the two countries have the potential to utilize the biomass residue efficiently and effectively to other valued products, and to be a contributor of renewable energy in the world. Thus, this ensures that the oil palm biomass residue can be obtained sustainably.

2. The Urgency and Feasibility of Turning Waste to Wealth

In line with the expansion of plantation area of oil palm and the development of crude palm oil production, the oil palm industry also produces bio-waste in two forms. Namely waste from plantation and waste from mill. The waste from plantation consist of oil palm fronds (OPF) and oil palm trunks (OPT). Since the last decade, the producers of oil palm, particularly Indonesia and Malaysia have been facing a serious task concerning the utilization of oil palm solid wastes both from plantation and mill, particularly OPF and OPT.

In Malaysia, the oil palm fronds are collected during pruning and replanting activities with average generation rate of 9.8 t-dry/ha-plantation/y and 14.9 t-dry/ha-re-plantation/y respectively (Table 1). Studies reported that OPF is comprised of 25.5% (dry basis) of hemi-cellulose material, which has great potential to use as a feedstock for bio-fuel and bio-based material production. The estimated trunk generation rate is 62.8 t-dry/ha-re-plantation/y (Table 1).

Site	Residue type	Generation rate						Moisture (%)			Representative generation rate
		Unit	Ref [32]	Ref [33]	Ref [34]	Ref [35]	Ref [36]	Ref [6]	Ref [37]	Ref [38]	
Palm plan-tation	Trunk (generated at replanting)	t-dry/ha-replanta-tion/y	37	75.5	84	43	74.4	70	-	73.3	**62.8**
	Fronds (generated at replanting)		-	14.4	16.2	-	14	-	63.5	-	**14.9**
	Fronds (pruned)	t-dry/ha-planta-tion/y	9.7	10.4	11	5.7	12	-	63.5	-	**9.8**

Table 1. Generation rate of oil palm biomass from plantation site in Malaysia

2.1 Foreseeable Great demand for Utilizing Oil Palm Fronds as Ruminants Feed

In Malaysia, poultry ad swine production are heavily dependent on imported feed ingredients, mainly corn, soybean and fishmeal. Even though Malaysia is self-sufficient in swine and poultry products, and is able to export some pork, poultry meat and eggs, it is still a net importer of animal products. A major reason for the slow growth of the ruminant industry is the lack of good-quality feed resources.

Of the commercial plantation crops, oil palm produces the most abundant biomass. While currently, oil palm fronds are only left rotting between the rows of palm trees, mainly for soil conservation, erosion control and ultimately the long-term benefit of nutrient recycling. The large quantity of fronds produced by a plantation each year make these a very promising source of roughage feed for ruminants. That is to say, they can be used as a substitute for grasses in case where forage or fodder is a limiting factor.

2.1.1 Nutritive Value of Oil Palm Fronds

An OPF is made up of three main components i.e. a petiole, rachis and leaflets. About 70% of the dry matter in the OPF is from the petiole and the rest from leaves and rachis. The leaves contain a higher percentage of crude protein (CP) and ether extract (EE) than the petioles. The dry matter content of OPF is about 31% and in vitro digestibility of dry matter of leaves and petioles was uniform throughout the length of the fronds with mean values of 35.6%. OPF also contains about 18.5% hemicelluloses. The moisture content of chopped fresh OPF, solar dried chopped OPF, steam dried ground OPF and OPF pellet were 58.4, 44.6, 12.7, 14.7 respectively while the respective density values were 0.27, 0.08, 0.12 and 0.53. the chemical composition of OPF in comparison with other oil palm by-products is shown in Table 2.

Rumen degradability is an appropriate assessment of the nutritive value of a fibrous feed for ruminants because it relates to the availability of nutrients. Table 3 shows the degradation characteristics of different fractions of OPF. A degradability value of 40% or more at 48h incubation indicated that OPF could be fed directly to ruminants.

Table 2. Chemical composition (% of dry matter) and nutritive values of oil palm fronds and other oil-palm by-products

By-products	CP	CF	NDF	ADF	EE	Ash	ME (MJ/kg)
Palm kernel cake	17.2	17.1	74.3	52.9	1.5	4.3	11.13
Palm oil mill effluent	12.5	20.1	63.0	51.8	11.7	19.5	8.37
Palm press fibre	5.4	41.2	84.5	69.3	3.5	5.3	4.21
Oil-palm fronds	4.7	38.5	78.7	55.6	2.1	3.2	5.65
Oil-palm trunks	2.8	37.6	79.8	52.4	1.1	2.8	5.95
Empty fruit bunches	3.7	48.8	81.8	61.6	3.2	-	-

Notes: CP: crude protein, CF: crude fibre, NDF: neutral detergent fibre, ADF: acid detergent fibre, EE: ether extract and ME: metabolisable energy. (Wong and Wan Zahari 1992; Wan Zahari et.al., 2000)

Table 3. Rumen degradation (dry matter %) of whole and different fractions of OPF at different incubation time together with the constants of the equation $p = a + b(1-e^{-ct})$

Incubation (hours)	Petiole	Leaflet	Midrib	OPF	LSD	Sig. Level
8	23.3	24.5	14.1	22.8	3.1	P<0.01
16	34.7	30.9	27.7	27.2	3.5	P<0.01
24	40.3	34.3	30.6	30.1	3.9	P<0.01
48	43.9	42.3	35.5	36.8	2.7	P<0.01
72	44.3	46.1	36.7	38.3	2.5	P<0.01
96	46.4	54.6	40.7	47.6	4.6	P<0.01
a (g/kg)	21.2	21.7	14.4	18.4		
b (g/kg)	24.7	46.1	28.3	38.3		
c (%)	2.8	1.2	1.5	2.5		
(a+b)	45.8	67.8	42.7	56.7		

p=The actual e actual degradation at time t. (Islam et al., 1997)
a=Represents intercepts.
b=Insoluble but potentially degradable component at time t.
c=Rate of constant of b
(a+b)=Total degradability

Above all, from the scientific point of view, the chemical analysis and metabolizable energy value of oil palm fronds indicate that they are suitable as a roughage source. Recently, another digestibility study conducted using mature bulls indicates a dry matter digestibility value of about 45% for oil palm frond silage. This encouraging result is further tested for the suitability of oil palm fronds in long-term feeding or production trials on beef cattle cows.
According to these studies where the supply of grass or fodder is a limiting factor, feeding oil palm fronds to dairy cattle is a satisfactory alternative. The animals are able to perform at a level comparable to when they were fed cut grass and there were no nutritional disorders or other negative effects on the animals.

2.1.2 Improvement of Nutritive Value of OPF

a number of processing techniques have been developed to improve the feeding qualities of OPF. These include mixing other raw materials with it, preservation as silage, pelletizing, cooling and packing.
It can almost meet the maintenance requirements of ruminants for energy and protein mixing vitamin or other raw materials with it. Increasing the level of necessary materials, such as urea, in the chopped OPF (before processing) resulted in reduced digestibility, and possibly higher energy expenditure to detoxify the high plasma ammonia concentration in dairy goats (after pelletizing processing).
The demand for processed OPF began to increase after the pelletizing processes were introduced, especially when storage and ease of handling became necessary to commercial farms.

2.1.3 Advantages of Pelletizing OPF into Feed Pellets

as we all know, animal performance and feed efficiency can benefit from pelletizing the feed. Neither do the OPF. on the one hand, OPF pellets are easy to be packaged and transported so that they can be conserved as silage, which could last for several months, or even longer when properly stored.

On the other hand, OPF feed pellets make the best use of the large amount of bio-waste in Malaysia and Indonesia, ease the by-products burden of the local oil palm factories , help resolve the problem - shortage of livestock or poultry feed that the local farms are being faced, add industrial value and to some extent, boom the national economy.

Finally, a trial of feed pellets made from oil palm fronds as a source of roughage for lactating dairy cows was carried out. The cows fed 30% OPF pellets produced milk more efficiently than other groups, while generally the cows in all treatment groups were healthy. Body scoring of cattle fed 30% OPF based diets was between medium to good. Meat quality was excellent with less deposition of fat in the carcasses. The rumen were generally distended with milky or frothy rumen content. The trial confirmed that feed pellets made of oil palm fronds could be fed to lactating dairy cows as a roughage source without adverse effects on animal condition or milk flavor. Also, the feed pellets are showed to stimulate better digestibility. All in all, the OPF feed pellets stimulate the development of local animal husbandry and economy.

2.2 Feasibility Analysis of Pelletizing Oil Palm Wood into Fuel Pellets

According the projections of Indonesia Government program dealing with the oil palm industry, starting 2010, there were at least 100,000 hectares of oil plantation should be annually replanted. If there were about 128 trees remained per hectare after reaching its life spans with the average volume per tree approx. 1.638m³，therefore more than 20 million m³biomass from oil palm wood (OPW) available annually. This is a spectacular amount of natural solid waste which is potentially good for biomass resources, such as fiber, cellulose as well as raw material for substituting wood material from natural forest.

In order to turn waste into wealth, it is crucial and urgent to study and focus the characteristics and properties of OPW including physical, mechanical and chemical properties for further economical and commercial usage.

2.2.1 Analysis of Characters of OPW

As a monocotyledonous species, oil palm does not have cambium, secondary growth, growth rings, ray cells, sapwood and heartwood or branches and knots. The growth ad increase in diameter of the stem result from the overall cell division and cell enlargement in the parenchymatous ground tissue, together with the enlargement of the fibers of the vascular bundles.

2.2.1.1 physical properties of oil palm wood

Moisture content

Based on depth of the trunk, the highest moisture content was reached at the central of trunk and a gradual decrease to the outer part of trunk. These values were between 258% ad 575%. An increasing in the number of vascular bundles was caused of a decreasing in percentage of parenchyma cells which have high capacity in water absorption.

Shrinkage

The shrinkage value of oil palm wood was varies between 25% and 74%. Based on the trunk depth, the highest value of shrinkage was reached at the central part and a gradually decrease to the outer part. Whilst, based on the trunk height, from the bottom part to the height was a tendency that a gradual increase in shrinkage value is indicated along the trunk height, except at the height of 2.75m.

Density

Regarding the density value, based on the trunk depth, the density was a gradual decrease from the outer part to the inner part across the trunk, but based on the trunk height, the relation between height and density was not clear, although the density value at the bottom part was relatively lower compare to the other parts. Further, based on the average density values, the classification of strength class of the oil palm trunk that strength classⅢ for peripheral zone, strength classⅣ for central zone and strength classⅤfor inner zone.

Fiber dimensions

Oil palm wood fibers show a slight increase I length from the butt end to a height of 3 to 5 meters before decreasing continuously towards the top. Longer fibers at the butt are probably due to more matured fibrous tissue in this region.

2.2.1.2 Mechanical Properties of OPW

Mechanical properties of oil palm trunk reflect the density variation observed in the trunk both in radial as well as in the vertical direction. Bending strength values are obtained from the peripheral lower portion of the trunk and the central core of the top portion of the trunk gives the lowest strength.

2.2.1.3 chemical properties of OPW

The oil palm trunk has lignin and lignocelluloses contents markedly lower but shows higher content of extractives, as well as water and alkali soluble than coconut wood and rubber wood. The number of fibrous vascular bundles increases towards the peripheral region and thickening of the older vascular bundles gives rise to the higher lignin content of the lower trunk, the ash content also observed to be similar throughout the trunk with the range varies between 3.0% and 3.3%.


2.2.2 Low Utilization of Oil Palm Wood

Due to those special properties of OPW, several investigations have already conducted in the field of OPW uses, such as being utilized in the production of panel products-particleboard, mineral-bonded ,block board, cement board and so on. However, the scientific information and knowledge know-how of OPW is still limited as well as utilization, and a sufficient knowledge shall be achieved to design and establish the new tailor-made wood products based OPW.

Besides, OPW materials have a number of weaknesses, particularly in terms of their dimensional stability, strength, durability, and machining properties. Due to these insufficient properties, oil palm-based panel products and plywood mills utilize only about 40% of the OPW, and the other 60% is discarded as waste due to its insufficient properties. In order to control the OPW waste, it is essential to consider its alternative utilization in daily life, for example pelletizing OPW into fuel pellets.

2.2.3Advantages of Pelletizing OPW into Fuel Pellets

OPW pellets can be manufactured as fuels for electric power plants, homes, and other applications. OPW pellets are extremely dense and can be produced with low moisture content (below 10%) that allows them to be burned with a very high combustion efficiency.


2.2.3.1 Ease of Storage and Transportation

Their regular geometry and small size allow automatic feeding with very fine calibration. They can be fed to a burner by auger feeding or by pneumatic conveying. Their high density also permits compact storage and rational transport over long distance. They can be conveniently blown from a tanker to a storage bunker or silo on a customer's premises.

2.2.3.2 Air pollution emissions

Nowadays, environment issue is becoming more and more essential. It has been a hot spot to seek a balance between the air quality and economy, especially in urban countries that concentrate large amounts of oil heating systems. Here is another advantage of utilizing OPW as fuel pellets: low exhaust-emissions such as NOx, SOx and volatile organic compounds .

2.2.3.3 Other uses

Oil palm wood is not toxic to horses, so OPW pellets can be perfect horse bedding materials once they are moisturized with small amounts of water. The ease of storage and transportation also makes them be superior to traditional bedding. Besides, They have a high absorption rate which makes them ideal for the purpose.

3. Economic Impact and Commercial Potentialities

Here is the analysis on the reasons why OPF and OPW pellets are having and will own a huge potential in market demand and a sound foundation for development in Malaysia and Indonesia

3.1 Requirement of Sustainable Development Policy of Government

From the point of view of the government, use of OPW and OPF pellets has an added value in cleaning the environment and promoting additional economic activities. It offers tremendous potential to increase the growth of local livestock industries, as well as for export market. The government will make every endeavor to introduce advanced pelletizing technologies and machines from countries around Malaysia and Indonesia, such as China.

3.2 Convenience of Importing Advanced Wood and Feed Pellet Line from China

In China, with the development of artificial feed in animal husbandry, Sale Feed Pelletizer & Poultry Feed Equipment benefits are gradually highlight processing, which provides a strong impetus for grain feed machine for the development of animal husbandry.

Farms can join various additives drugs in processing pellet feed and granulation process can kill pathogenic microorganisms and parasites. Poultry Feed Pellet Mill is widely used in feed grain processing plants, livestock farms, poultry farms and individual farming households, it has become the ideal equipment for processing feed. So it is convenient for importers in Malaysia and Indonesia import advanced pellet machines from China Mainland.

3.3 Becoming one of the most Valuable Commercial Products in Oil Palm Planters and Producers` Eyes

People working in the wood industry in Malaysia struggle to obtain sufficient raw materials at a competitive price, OPW is abundantly available, and it is a less expensive lignocellulosic raw materials as compared to wood. Using oil palm biomass as a raw material to produce value-added products will not only reduce the overall costs of production but will also increase economic returns.

3.4 effectively solving the straitened swamp being faced by big enterprises and small-holders in animal husbandry

The strength of agricultural production in Malaysia lies in the large plantations of commercial crops such as rubber, oil palm, cocoa and pineapple. These crops occupy most of the arable land. Malaysia does not have natural grasslands, while improved pastures are still limited to a few commercial and government farms. Prospects for the increased use of farmland for grass or fodder production are not favorable, because national policy states that any conversion of tropical rainforest to pastures for grazing animals has no justification from either the economic or the environmental point of view. Commercial large-scale ruminant production is rare. It is smallholders who are traditionally the main ruminant producers. The smallholders have to use their limited land and capital, and diminishing communal grazing reserves, and integrate their livestock production with their rubber. This has perpetuated the pattern of low-input or low-output traditional production systems which sometimes lead to feed supply shortages.

However, with the production of OPT pellets, it is obvious that these moments of constraint will be removed at length. The product significantly contributes to the development of local livestock industry by ensuring a stable supply of feeds throughout the year. The development of pellets based on OPF can be used as complete or balance diets for fattening beef cattle, dairy cattle, goats, sheep, deer and ostriches.

4. Usage of OPW and OPT Pellets in Foreign Countries

The utilization of wood pellets for heating and power generation has received great attention due to the fossil fuel depletion crisis and concerns over the climate change issue.

4.1 Usage of OPW pellets by region

4.1.1 Europe

European countries attach importance to the rational and intelligent usage of wood fuel pellets . In Western Europe, such as Netherlands, Belgium, and the UK, fuel pellets are used mainly in large-scale power plants. In Nordic Europe, like Denmark and Sweden, pellets are used not only in large-scale power plants, but medium-scale district heating systems, and small-scale residential heat. In Central Europe, such as Germany, Austria, pellets are used mostly for small-scale residential and industrial heat.

4.1.2 New Zealand

The wood pellet market is prosperous in New Zealand. It has an expanding residential pellet market with a wide range of pellet fires now available to the householder. Commercial sector also identify wood pellets as a high quality wood fuel due to its clean and green heating characters.

4.1.3 United States

United States is a potentially large consumption market of wood pellets. There were about 800,000 Americans using wood pellets for heat. The weight of wood pellets , which were used for heat in the US, increased to 2.33 million tons in 2013.

4.2 Usage of OPF pellets

The technology developed significantly increased utilization of OPF and other by-products from oil palm industries. The use of OPF as the main fibre source in ruminant rations has markedly reduced feeding cost between 20-30%. The potential for OPF-based feeds is great in view of increasing ruminant population of 1.2 millions as targeted in 2010. The products have export potential particularly to Middle-East, Taiwan and Europe apart from Japan, Korea and China. Complete pellet or cube-based feeds will offer bigger commercialization opportunities and competitiveness in the international feed roughage markets

5. More Information about OPW and OPF pellets

5.1 Advantage of Pelletilization

high energy density: pellet has higher energy density than chip.

Constant heating value: moisture controlling is one of important factors to produce good pellet.

Easy handling: pellet is round-shape, so that it is easy to handle.

5.2 Pelletizing Processing Technology of OPF

Typically any raw material will require some form of processing prior to being pelletized.

Before processing into pellets, a hammer mill is required for further processing, depending on how it was received. If the ground fronds are wet(over 15%), they will need to be dried. After sizing and drying, the OPF is now ready to be introduced into the feed pellet machine to produce pellets. Pellets can be made in a wide range of diameters and bulk densities, which is typically determined by the end of use of the pellet, Such as OPF pellets using for the feed of goat, sheep, deer, ostrich and horse, the specification of pellets as follows:

Diameter: 3-5mm

Length:15-20mm

Bulk density:0.45-0.50

Specific gravity:0.75-0.95

Feed pellets must be cooled if the pellet mill is hot(100-170 degrees). This is done with a pellet cooler by pulling ambient air through the pellets. Once the pellets are cooled to ambient temperature, they are screened to remove any fines that may have been created during the process. Now, they can be packaged, stored or sold in bulk.

In the production of pellet, chipped OPF can also be mixed with other ingredients before undergoing pelleting process so that the products can meet nutrient requirements of various classes of ruminant livestock.