Energy Productivity Ratio (EPR) in Producing Aren Sugar from Nira Aren Tree: Traditional Processing

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Abstract: A study on energy productivity ratio (EPR) in producing aren sugar (palm sugar) from nira solution of aren trees is the result of this paper. This study was based on the energy ratio of the input energy in comparison to the output energy in processing nira solution become palm sugar. Calculations were based on the data obtained through literature survey of nira processing into palm sugar traditionally in many parts of village areas in Indonesia. The major output energy was based on the palm sugar product compared to the input energy based on all nira price, used energy, and depreciation of instruments used. The EPR result as palm sugar product is > 3.0 for the utilization of nira solution from aren trees. The EPR result is positive information on the potential to develop the product in factory scale. It is an indication that the palm sugar product from aren trees is an energetically reasonable business enterprise based on EPR. The nira of aren tree has potential as raw material in producing the sugar.

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1 INTRODUCTION

Aren tree or sugar palm plant (*Arrenga pinnata Merr.*) is a very potential plantation crop in terms of overcoming food shortages and easily adapting to various agro-climate, starting from lowland to 1,400 m above sea level. The main products of aren as the result of nira tapping are palm sugar, beverage, vinegar and alcohol. In addition, sugar palm plants can be produced intofood products such as: *kolang-kaling* from the ripe female fruit and sugar palm flour for food ingredient in the form of cakes, breads, and biscuits that come from processing the stem part of the plant (Effendi, 2010).

Coconut nira is a part of coconut plant that is widely developed as coconut sugar (Pratama *et al.*, 2015). Palm sugar is the product of the concentration of palm sugar with heat (cooking) until the water content is very low (<6%) so that the product hardens when it is cold. Making palm sugar is almost the same as making palm syrup. The sap is heated until thick. After that, the thick liquid sugar is poured into the mold and left until it is cold. Making palm sugar is also easy and can be done using simple equipment. The sugar produced from processing is very helpful in increasing people's income. So far, the palm sugar industry is still a sideline, especially by rural communities (Radam and Rezekiah, 2015).

The demand of aren palm sugar granules is growing rapidly due to its ease in use, handle, package, storage and it contains more complete nutrition than cane sugar. One of the important nutients of palm sugar granules is the various minerals. The EDX analysis shows that the mineral content of aren palm sugar consist of potassium (2%), sodium (0.05%), magnesium (0.04%), calcium (0.01%), iron (0.11%), copper (0.75%), zinc (0,.46%), manganese (0.08%) and chromium (0.11%). Because of these advantages, palm sugar granules become popular and demanded by developed countries (Iskandar *et al.*, 2014).

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Figure 1. Aren Tree (Kartika *et al.*, 2013)

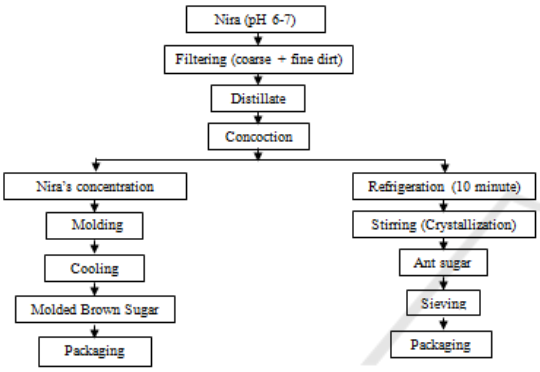

Figure 2. The scheme of making traditional palm sugar and ant sugar (Soetedjo and Suharto, 2009).

2 METHODOLOGY

In conducting this study, the required data has been collected, searching for the equal energy of dregs aren and aren sugar in calculating the value of energy productivity ratio (EPR) based on ton/year. The EPR of a product can be defined as the ratio of primary product energy plus its by-product energy compared to the total energy of raw materials, electricity and other energy used and the processing tool depreciation. The calculation is based on the production capacity per year (Haryanto, 2000; Haryanto *et al.*, 2018a). Ratio energy from ingredients biofuel can be applied as ratio of non-renewable Energy that be used on the value of energy production from fuel and some utility product side.If energy output : energy input is 1 > 1 then the production of the renewable fuel or a product could be continued, but if the ratio energy 1 < 1 then production of the product resulted in net loss, and declared as not defined source of renewable energy or the product (Batchelor *et al*., 1995).To calculate EPR, the equations that be used are (Haryanto *et al.*, 2018b).

$$EPR = \frac{Q_{out}}{Q_{in}} \quad (1)$$

$$EPR = \frac{Q_{out}}{Q_{in} - Q_{out(side\,product)}} \quad (2)$$

Study related to EPR was reported based on price of 1 liter diesel is Rp. 8,000.- (Pertamina cost) with equal energy is 42.96 MJ/kg (Pertamina, 2018; Felten *et al.*, 2013). In his study the EPR energy base on 1 kg firewood equal to 14.4 MJ/kg (Francescato *et al.*, 2008).

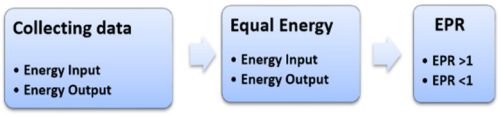

Figure 3. Research steps : collecting data, equal energy quantity and EPR calculation (Haryanto *et al.*, 2019)

3 RESULTS AND DISCUSSIONS

1. Material requirements and utilities

Table 1. The information of material requirements and utilities in producing aren sugar

No	Material Requirements and Utilities	Total
1	Nira Aren	500 liters/day
2	Water	800 liters/day
3	Electricity	70 kW/day
4	Firewood	1 m^3/day

2. Material Prices

Table 2. The information of material prices in producing aren sugar

No	Material Prices	Total
1	Nira Aren	Rp. 2,000/liter
2	Firewood	Rp. 30,900/m^3

3. Equipment Prices

Table 3. The information of equipment prices in producing aren sugar

No	Name of Equipment	Tool Prices
1	Evaporator	Rp. 20,000,000
2	Crystallizer	Rp. 15,000,000
3	Packing Machine	Rp. 4,500,000

The usage period of the three tools is estimated to be around 5 years.

The total depreciation value of the three above tools is calculated and obtained at Rp. 33.450.000,-

4. Input Energy

Table 4. The information of input energy in producing aren sugar

No	Input Resources	Priceor EnergyUsed
1	Price of Nira Aren 150,000 liters	Rp. 300,000,000
2	Electricity/Year	21,000 kWh
3	Firewood	300 m^3
4	Depreciation of Equipment	Rp. 33,450,000

Energy base = 1 kg firewood = 14.4 MJ/kg
1 m^3 firewood = 650 kg = Rp. 30,900.-
1 kg firewood = Rp. 30,900/650 kg = Rp.47.5/kg

- Energyfrom nira aren 150,000 liters/year:

$$\text{Energy} = \frac{\text{Rp. } 300{,}000{,}000.-}{\text{Rp. } 47.5\ /\text{kg}} \times 14.4\ \text{MJ/kg}$$

$$\text{Energy} = 90{,}947{,}368{,}4\ \text{MJ}$$

- Electrical energy used per year:

$$21{,}000\ \text{kWh} \times 3{,}6 \frac{\text{MJ}}{\text{kWh}} = 75{,}600\ \text{MJ}$$

- Energy from firewoods:\

$$300\ \text{m}^2 \times 650\ \text{kg/m}^3 \times \text{Rp. } 47{,}5/\text{kg} = \text{Rp. } 9{,}262{,}500.-$$

$$\text{Energi} = \frac{\text{Rp. } 33{,}450{,}000.-}{\text{Rp. } 47.5/\text{kg}} \times 14{,}4\ \text{MJ/kg}$$

- Energy from depreciation:

$$\text{Energy} = \frac{\text{Rp. } 33{,}450{,}000.-}{\text{Rp. } 47.5/\text{kg}} \times 14.4\ \text{Mj/kg}$$

Tabel 5. The information of input resources from input energy in producing aren sugar

No	Input Resources	Energy Used (MJ/Years)
1	Price of Nira Aren 150,000 liters	90,947,368.4
2	Electricity/Year	75,600
3	Firewood	2,808,000
4	Depreciation of Equipment	10,140,631.58
	Total	103,971,600

5. Output energy

The selling price of sugar products produced:

- In a day, number of packages can be produced is:
  112 packs (500 grams packaging), with a selling price per pack of Rp. 16,000.-
  56 packs (1 kilogram packaging), with a selling price per pack of Rp. 30,000.-
- In a year, number of packages can be produced is:
  112 packs × 300 = 33,600 packs
  56 packs × 300 = 16,800 packs
- Selling price:
  33,600 packs × 16,000 = Rp. 537,600,000.-
  16,800 packs × 30,000 = Rp. 504,000,000.-
  Total selling price = Rp. 1,041,600,000.-

Table 6. The information of output resources from output energy in producing sugar aren

No	Output Resources	Energy Used
1	Aren Sugar (Crystal Shape)	Rp. 1,041,600,000

- Energy produced by palm sugar

$$Energy = \frac{Rp.\ 1{,}041{,}600{,}000.-}{Rp.\ 47.5/kg} \times 14.4\ MJ/kg$$

$$\text{Energy} = 315{,}769{,}263\ \text{MJ}$$

Tabel 7. The information of output energy in produced palm sugar

No	Output Resources	Energy (MJ/year)
1	Aren Sugar	315,769,263
	Total	315,769,263

6. Calculation of EPR

- From the calculation above, the total input and output energy values have been obtained. Then the EPR calculations can be done using the formula:

$$\text{EPR} = \frac{\text{Output product}}{(\text{Input} - \text{by product})}$$

- In the process of making palm sugar, by product = *0*, thus:

$$\text{EPR} = \frac{\text{Output product}}{\text{input}} = \frac{315{,}769{,}263}{103{,}971{,}600} = 3.037$$

- From the calculation result,the EPR value obtained is 3.037.
- Which means that EPR>1. This means that the energy produced by output is greater than the energy needed for input, which indicates that factory production is profitable for the company.

4 CONCLUSION

The value of energy productivity ratio (EPR) in this study result is based on input to input and input to output the EPR was 3.037. Base on the value of the EPRs show that processing Palm Sugar from Nira in this traditional processing is feasible to be operated and developed into a factory because it gives profit to the company.

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