Bioindustry model of cocoa plant – goat livestock

Yulius Ferry1*, Maman Herman1, Bariot Hafif2, and Lulu Suci Marhaenis2

1Badan Riset dan Inovasi Nasional (BRIN), Jakarta, Indonesia
2Borobudur University, Jakarta, Indonesia

Abstract. Biomass from cocoa plantations, such as rind, pulp, pruning of cocoa plants, and pruning of shade plants, can be processed into animal feed, forage, extracts of growth regulators, biochar. Goat manure can be processed into solid and liquid fertilizer. The purpose of this paper is to obtain some bio-industry that may be carried out by cocoa farmers who integrate farming with goats, additional income obtained, and other benefits from the integration. The results of the analysis of the goat cocoa integration model show that farmers get an additional income of Rp. 15,240,000, previous income was only Rp. 8,860,000/ha/year. Additional income from by-products of bioindustry can reach Rp. This bioindustry model is possible to be developed in various development areas, and also supports the goat population increase program.

1 Introduction

Along with the production of 1,000 kg of cocoa beans, 2,850 kg of cocoa pods were produced. Cocoa pods can be processed into animal feed (silage), or compost or processed into biochar. From plant pruning, biomass is obtained which can be used as forage for livestock or extracts of natural growth regulators, or cocoa leaf tea, and the wood can be converted into biochar. These products have economic value, so they can increase farmers' income.

The bio-industry model of cocoa cultivation with goats is an implementation of biotechnology development. Application of technology whose activities use parts of living organisms or their products. As an effort to manage biological natural resources with bio-industry technology rocks to produce various kinds of agricultural products.

Cocoa farmers can adopt cocoa bioindustry technology with goats, because most (56%) cocoa farmers are at the age of 60 years, at that age the technology adoption power of farmers is still very high [1]. This paper aims to convey several bioindustry technologies that may be carried out by cocoa farmers in cocoa development areas.

2 Bioindustry Model with Cocoa – Goat Integration System

In the bio-industry model of cocoa-goat integration, the biomass processing base is derived from cocoa plants, shade plants, and from goats.

* Corresponding author: yuliusferry@brin.go.id
In addition to the main products, namely cocoa beans and goats, biomass is also produced. Biomass can be processed into several kinds of products. Likewise, the manure produced by livestock (Figure 1).

2.1 Products from seeds

Beans are the most important component of cocoa pods. The bean weight of the cocoa pod component is about 28-29%. Cocoa beans can be processed into, among others, cocoa oil, chocolate paste, cocoa cake, and cocoa powder. Cocoa beans on the fruit are covered by placenta (pulp), which is white and sweet in taste. Fermentation in cocoa beans in addition to deactivating the embryo is also to remove the pulp in the beans, so that the beans are cleaner and of higher quality. Seeds are the only product that so far has economic value. The productivity of people's cocoa plants is <700 kg beans/ha/year, much lower than its potential which reaches 2,000 kg beans/ha/year. Processing of seeds into a more downstream form has the potential to increase farmers' income. If the price fluctuation of seeds is around Rp. 23,000 – Rp. 35,000/kg, then the price of cocoa powder reaches Rp. 100,000/kg, or with an added value of around Rp. 65,000/kg (158%).

Cocoa powder can be produced by cocoa farmers, because it does not require sophisticated and expensive equipment. The quality standard of cocoa powder has three levels, namely low fat content (10-12%), medium (13-15%), and high (15-22%). Cocoa powder is used as a raw material for chocolate drinks, ice-cream, it is also used for the production of compound chocolate. Consumption of cocoa powder will continue to increase with the increasing variety of snacks sold in the market. So that it can be marketed at the village and sub-district level.

The equipment needed in the processing of cocoa powder, among others; cauldron, blender, press machine, mortar and flour machine. The skillet is used for baking, the mortar is for breaking, the blender is for pasta, the press is for removing the fat and the flour machine is for grinding into cocoa powder. For packaging, there are many forms of packaging that are ready to use on the market, if necessary, the desired brand can be made. The price of cocoa powder in the market reaches Rp. 100,000/kg.

Fig.1. Goat cocoa integration bioindustry illustration.
2.2 Products from fresh fruit skin

Cocoa pods are the largest component of cocoa pods, reaching 75%. Cocoa pod skin consists of outer skin, kulai fruit, and shell (horn skin). Cocoa pods contain high mineral nutrients, especially potassium and nitrogen. That 61% of the total nutrients in cocoa pods are found in cocoa pods [2]. Cocoa pods have better nutritional content than other plantation wastes such as sugarcane shoots, coffee husks, drops and others [3]. Cocoa pods contain 19% protein, 6.2% fat and 16% crude fiber. Product forms that can be made from cocoa pods are animal feed (silage), compost, dyes, antioxidant extracts, and pectin extracts [4, 5].

The average feed requirement for goats from small to adult is 3 kg/head/day, so goat feed for adults (18 months) is 1,620 kg/head. The yield of animal feed from cacao pods, cocoa leaf prunings and leaves of shade plants can reach 13,000 kg/ha/year, enough to feed 8 goats/year. If the people's cocoa plantation area reaches 1.7 million ha, and 50% or 800,000 ha is integrated with cocoa, it will be able to meet the goat's feed needs of 6,400,000 goats/year.

Making animal feed (silage) is done by chopping the cocoa husk both horizontally and vertically, then mixed with fine bran, corn flour or cassava flour as much as 5-10% of the weight of the cocoa husk, then fermented for 21 days. If the fermentation is good (no leaks) on the 10th day, the feed can be given to goats. The rest of the others that have not been opened can last up to 3 years, but once opened, the feed must be exhausted for a maximum of 2 days, because it will be easily attacked by fungi, and damaged. With fermentation, the theobromine content decreased to 108.7 ppm, or lower than the minimum content allowed for consumption by livestock [6]. This feed from cocoa shells (silage) can increase the weight of goats from 57 to 80 g/day [4]. The use of silage from cocoa husks as goat feed can replace the function of forage feeds such as king grass, because the nutritional content is not much different (table 1).

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>Silage from cocoa shells</th>
<th>king grass</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry Weight (DW) (%)</td>
<td>22.1</td>
<td>20</td>
</tr>
<tr>
<td>Crude Protein (PK) (%)</td>
<td>9.2</td>
<td>6.7</td>
</tr>
<tr>
<td>Energy KJol/kg</td>
<td>4.682</td>
<td>4.082</td>
</tr>
<tr>
<td>Ash (%)</td>
<td>9.1</td>
<td>13.2</td>
</tr>
<tr>
<td>NDF (%)</td>
<td>52.2</td>
<td>67.1</td>
</tr>
</tbody>
</table>

Source: Puastuti and Susana [6].

Meanwhile, the processing of cocoa shells into compost is carried out by fermenting chopped cocoa shells, given EM4 and fermented for 21 days. Compost from cocoa pods contains 1.81% N, 26.61% C-organic, 6.08% K2O, 1.22% CaO, 1.37% MgO, C/N ratio 14.7 and 44.85 cMOL /kg CEC [7].

2.3 Products from horn skin

The weight of the horn skin reaches 16% of the weight of the cocoa pod. For every hectare of cocoa plantations, 1,120 kg/ha/year of horn bark will be obtained. The horn skin is processed into biochar and liquid smoke, biochar is the result of incomplete combustion of organic materials, while liquid smoke is a liquid resulting from the condensate of smoked vapors resulting from the pyrolysis of organic materials containing phenol and carbonyl compounds.

Liquid smoke can be used as a fungicide to control plant diseases [8], while biochar can be used as a soil enhancer [9]. Biochar can absorb CO2 from the air or retain carbon in the
soil [10-12]. Biochar can retain water and nutrients from being easily evaporated and washed out [13]. The use of biochar will balance the CO2 content in the atmosphere, and have a good impact on the environment. The price of biochar is 17,500 kg.

Liquid smoke is a vegetable fungicide that is free from chemicals, so it is organic and healthy. Liquid smoke can function as a vegetable fungicide because it contains phenols. Phenol is one of the active compounds capable of providing antibacterial and antimicrobial effects [14]. Liquid smoke as a fungicide can inhibit the growth of Phytopthora sp which causes cacao pod rot disease [15]. Phenol works by denaturing cell proteins and damaging cell membranes so that it can cause death of pathogens. 100 kg of raw materials, with a burning time of 2-3 hours, produce 15 liters of liquid smoke, and 35 kg of biochar [16].

### 2.4 Products from pulp (placenta)

Cocoa husk pulp contains 80-90% water, 0.5-0.7% albuminoids, 8-13% glucose, 0.2-0.4% non-volatile acids, 0.03% oxidized iron, 0.4 sucrose. -1%, 0.4-0.45% salts, and a little starch. Removing the pulp from the cocoa beans needs to be fermented. From every 1 kg of dry seeds obtained pulp as much as 0.1-0.2 liters. Fermentation must be done in groups, so that there are more numbers, or a small capacity fermentation place is needed. Pulp weight on cocoa pods reaches 2.6% or 182 kg/ha/year of pulp is obtained per hectare. From that amount of pulp, 136.5 kg of nata de cocoa can be produced at a price of Rp. 1.300/kg. The increasing demand for soft drinks (7.04%/year) causes the need for nata de cocoa to also increase.

The pulp processing industry into nata de cocoa is carried out by farmer groups so that they are on a business scale. It is necessary to build UPH-UPH (product processing unit), which is managed jointly by members of farmer groups. For marketing, cooperatives can be formed which are engaged in packaging and marketing that can cooperate with other private parties.

### 2.5 Products from cocoa leaves and leaves of shade plants (Glirisdia)

Biomass produced from pruning cacao plants and shade plants is in the form of leaves and woody branches/twigs. The leaves of both types of plants can be extracted and produce natural growth regulators. The results of laboratory analysis on the leaves of the two plants showed that the growth hormone content in the leaves such as IAA, GA-3 and Zeatin, for the glycerol extract, there was even kinetin (Table 2). Cocoa thereby increasing the production of cocoa plants.

In addition, biomass from cocoa and shade leaves can be used directly as forage for livestock [17]. The leaves are wilted in at least 1 day, can be given directly to goats. Giving 80% glirisidria leaves and 20% cacao leaves can increase the weight of goats by 78 g/head/day. While feeding from cocoa leaves can increase goat body weight by 112-130 g/head/day [7]. Theobromine content in cocoa leaves can be reduced through withering 1 -2 days [18].

**Table 2.** The content of growth regulators in the fresh liquid extract of cocoa leaves and glycerin leaves.

<table>
<thead>
<tr>
<th>No.</th>
<th>Natural source of hormones</th>
<th>Contains growth regulators (mg/l)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>IAA</td>
</tr>
<tr>
<td>1.</td>
<td>Cocoa leaf extract</td>
<td>0.343</td>
</tr>
<tr>
<td>2.</td>
<td>Glirisidia leaf extract</td>
<td>1.585</td>
</tr>
</tbody>
</table>

Source: Analysis at the Agricultural Environmental Research Institute.
2.6 Products made from branches and twigs of cocoa and shade plants

The more conversion of biomass into biochar, the more CO2 that can be retained in the soil, so that there will be a balance of CO2 in the atmosphere [19]. Biochar functions in addition to storing carbon as well as fertilizing the soil [20]. Cocoa plantations and their shade covering an area of 1 ha can produce 13 tons of biomass/ha or produce around 10.4 tons of biochar/year.

Making biochar and liquid smoke, you can also use the bark of cocoa pods, goat dung, and wood from shrubs such as wild weeds (temiki), and others. The manufacture of biochar and liquid smoke is also carried out collectively in groups (farmer groups) such as the nata de cacao industry.

Producing biochar and liquid smoke can be done with a distillation apparatus, in which there is a biomass combustion chamber, and a device for condensing the smoke vapor and distributing it to a reservoir.

2.7 Products from Goat Manure

The production of goat manure can reach 50 kg/head/day or 1.5 tons/head/month [21]. If every hectare of cocoa plants can be kept 8 goats, then 8 x 1.5 tons x 12 = 144 tons/year of goat manure will be obtained which can be processed into manure (compost). The dose of manure is 20 kg/plant/year, so for 1 ha of cocoa plantations only 22 tons of compost are needed/year. the remainder (122 tons) can be used as raw material for biochar or sold or used for other crops. The price of manure is Rp. 800,000/ton.

Table 3. Goat, chicken and cow manure content.

<table>
<thead>
<tr>
<th>Animal type</th>
<th>Macro Elements (%)</th>
<th>Micro Element (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>P</td>
</tr>
<tr>
<td>chicken</td>
<td>1.72</td>
<td>1.82</td>
</tr>
<tr>
<td>cow</td>
<td>2.04</td>
<td>0.76</td>
</tr>
<tr>
<td>Goat</td>
<td>2.43</td>
<td>0.73</td>
</tr>
</tbody>
</table>

Source: Organik Vegetable Cultivation in Malaysia.

Manure from goat manure is good enough to be used as organic fertilizer to replace inorganic fertilizer [22], because it has high enough macro and micro nutrients, it even has a higher nitrogen content than chicken and cow manure (Table 3).

Composting can be done permanently by building a permanent composting tank. The results of the analysis were compared with SNI 19-7030-2004. Manure analysis was carried out on days 0, 10, 20, 30, 40, and 50. The results of the analysis of manure on days 10, 20, and 30 obtained quality in accordance with SNI 19-7030-2004 (C/N ratio, content of N, P, K, water, and C-organic). Meanwhile, on the 40th and 50th days, the C/N ratio (9.74 and 9.00) was obtained which was not in accordance with SNI 19-7030-2004 where the SNI value of the C/N ratio was 10-20. The optimal time for composting goat manure with coir dust and EM4 bioactivator is <30 days.

3 Added Value of Goat cocoa integration

Low productivity, which is 700 kg/ha/year, farmers' income only reaches Rp. 16.100.000,-/ha/year. If it is processed into cocoa powder, the farmers' income can be increased to Rp. 49,000,000/ha/year. Maintenance of goats as much as 8 heads / ha, providing additional
income from goats as much as Rp. 40,000,000. While the additional income from processing side products can reach Rp. 299,965,000/ha/year (Table 4).

Table 4. Economic value of each product produced on cocoa-goats/ha.

<table>
<thead>
<tr>
<th>Product shape</th>
<th>Volume/ha/year</th>
<th>Value (Rp)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cocoa beans</td>
<td>700 kg</td>
<td>16,100,000</td>
</tr>
<tr>
<td>Goats</td>
<td>16 ekor</td>
<td>40,000,000</td>
</tr>
<tr>
<td>Cocoa + Goats</td>
<td></td>
<td>56,100,000</td>
</tr>
<tr>
<td>Cocoa powder</td>
<td>490 kg</td>
<td>49,000,000</td>
</tr>
<tr>
<td>Cocoa powder + Goats</td>
<td></td>
<td>89,000,000</td>
</tr>
<tr>
<td>Manure</td>
<td>122 ton</td>
<td>97,000,000</td>
</tr>
<tr>
<td>Biochar</td>
<td>11,520 kg</td>
<td>201,600,000</td>
</tr>
<tr>
<td>Nata de Cacao</td>
<td>136,5 kg</td>
<td>1,365,000</td>
</tr>
<tr>
<td>Side result</td>
<td></td>
<td>299,965,000</td>
</tr>
</tbody>
</table>

4 Conclusion

Some of the products that can be produced from processed biomass include cocoa pod shells for animal feed, biochar, and nata de cacao. From the pruned leaves of cacao plants and shade plants, forage is produced for animal feed or natural growth hormone extracts. Apart from meat, goats also produce solid and liquid manure. These products are of high value or can be used to save cocoa plantation maintenance or save on raising goats. The animal feed produced can meet the feed needs of 8 goats per year.

References

2. N. Nuraini and E. M. Maria, Pemanfaatan Kulit Buah Kakao Fermentasi (2009)
22. R. Samekto, Pupuk Kandang (PT. Citra Aji Parama, Yogyakarta, 2006)