

Biomass of cocoa and sugarcane

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Abstract. The role of the agricultural sector is very important as the upstream addressing downstream sectors and national energy needs. The agricultural sector itself is also highly dependent on the availability of energy. Evolving from it then it must be policies and strategies for agricultural development Indonesia to forward particularly agriculture as producers as well as users of biomass energy or bioenergy for national development including agriculture balance with agriculture and food production. Exports of biomass unbridled currently include preceded by ignorance, indifference and the lack of scientific data and potential tree industry in the country. This requires adequate scientific supporting data. This study is necessary because currently there are insufficient data on the potential of biomass, including tree biomass detailing the benefits of bioenergy, feed and food is very necessary as a basis for future policy. Measurement of the main estate plants biomass such as cocoa and sugarcane be done in 2015. Measurements were also conducted on its lignocellulose content. Tree biomass sugarcane potential measured consist of leaves, stems and roots, with the weight mostly located on the stem. Nevertheless, not all the potential of the stem is a good raw material for bioethanol. For cocoa turned out leaves more prospective because of its adequate hemicellulose content. For sugarcane, leaf buds contain a good indicator of digestion of feed making it more suitable for feed.

1. Introduction

Biomass is organic material produced by photosynthetic processes, either in the form of products or effluent. Examples of biomass include plants, trees, grass, potatoes, agricultural waste, forest waste, urban sewage, feces and animal manure. The use of biomass as a renewable energy source is a way out of human dependence on fossil fuels. National energy policy through the issuance of Presidential Decree No. 5 of 2006 on the National The energy policy set targets for biofuels use to more than 5% of national energy consumption by 2025. The policy followed by Presidential Instruction No. 1 in 2006, which among other things instructed the Minister of Agriculture to encourage the provision of the plant including the facilitation of the provision of seeds and seedlings, counseling, and integrating the activities of development and post-harvest of plant material to support the provision of biofuels. Modernization of agriculture ahead, including agro-industry and agricultural mechanization will increasingly play a role in agriculture development in the future and also adds to the strategic environment of the agricultural sector. Agricultural mechanization that most of its operations rely on the availability of fuel-based oil and fossil energy (fuel) is increasingly scarce will face a big problem. Bioenergy, including biofuels which its raw materials from agricultural biomass are abundant in agricultural and forestry sectors, be an alternative that should be considered to address the problem.



In Indonesia, hundreds of million tonnes of agricultural waste such as straw, bran, litter, sugarcane, oil palm empty fruit bunches and others generated annually. Most of the waste is untapped or more that just burned in the land. As the solid fuel, agricultural waste and other biomass can be effectively optimized in a way to convert them into fuel gas through a reactor. A study that the appointment of gaseous fuels from biomass materials containing a very high calorific value which is 3.5 to 5.5 MJ Nm³, which consist of carbon monoxide (25% v / v) and hydrogen (15-20% v / v) , This gas can be burned by a burner and generate temperatures reached more than 1000°C which can be used for heating in industrial applications[1].

Waste utilization is expected to reduce the problem and generates revenue by making the high added value of the waste. The problem recently, the selection of waste biomass which has lignocellulosic as raw material for bioethanol still has obstacles to the process of hydrolysis to produce glucose. However, the hydrolysis of lignocellulose to glucose and xylose can be done using the enzyme β -glucosidase[2]. Sunarti and Richana conducted a study for lignocellulosic ethanol from corn cobs with a yield of 14.22%[3]. Technically the technology is here, so what is needed is kind and how many raw materials are available. Therefore the main plant biomass plantation trees need to know including the potential for bioenergy as well as in support of agricultural development bioindustry forward.

Search alternative materials that do not compete with food and feed is necessary and urgent to think about. This occurs because the technology development of first generation biofuels require or utilize the results of the primary agriculture or plantations, such as palm oil, coconut oil, castor oil, molasses, cassava and others. On the other hand, the available agricultural and forestry waste as a source of lignocellulose to be a promising source of energy. Waste utilization is expected to reduce environmental problems and generates revenue by making the high added value of the waste. There are currently more potential calculated or known biomass is the only potential macro, therefore to the next, the tree biomass and its potential for bioenergy needs to be known, so it will known quantitatively the usage of biomass as organic material, feed or for bioenergi that will not disrupt the environmental sustainability of agriculture.

Based of that explanation the objective of this research are to know the biomass trees and the potential biomass of estate crops (cocoa and sugarcane) as a source of bioenergy feedstock. The output will be gained are the biomass trees and potential biomass of cocoa and sugarcane plants for bioenergy supporting agriculture bioindustry, and the outcome are the ease and provided a quantitative basis which is a clear potential for the development and utilization of biomass from estate crops and its economic viability as a source of bioenergy raw materials in support of agricultural development bioindustry.

2. Methodology

The research will be conducted through a methodology:

- A literature study on the activities (including research) that has been done by others so that can be arranged as a biomass tree of plantation.
- Field studies and measurements.

Estimation of biomass can be using Allometri with mathematical models[4,5]. The activities are not using Allometri, but with a destructive method, by direct measurement as much as possible components of plant biomass through field studies. Measurement of lignocellulose or lignin and cellulose, which are useful for the determination of the potential of biomass for the manufacture of bioethanol and other bioindustry products[6,7]. Lignin and cellulose content analysis performed in the laboratory of Agricultural Research Agency in Cimanggu, Bogor.

Field studies conducted to determine and obtain the data included for reconfirmation literature, as well as perform the necessary measurements if for no libraries or secondary data that support the tree industry. As an example of the biomass weight data of stems, roots, branches and other. Measurement for the field is required to obtain those data, by pulling, cutting and weighing individual components of the biomass.

- Interview

Interviews were conducted only if necessary, to confirm and to obtain information regarding the allotment of biomass, based on the experience of farmers in the field. An example is the use of cocoa biomass that during this outcome of events pruning of old leaves, and how far the benefits of the biomass. As well as the methodology to a literature study on the activities), this activity depends on the activities of field studies and measurements) on this methodology.

Field data collection include:

- The biomass of plant parts, including: leaf, rod stands, branch / Twig Trimming, stem from demolition, skin and flesh, crude oil (yield juice), roots and others. Derivative type of tree biomass can also be developed in accordance with field observations.
- Criteria for potential : There is a chance utilized as fertilizer, feed, energy (burnt or conversion into oil, etc.), but the real number relative precedence which utilized for bioenergy (eg flowers fall was not recorded because it was too little). It will be confirmed by desk-study and field confirmation (statement of farmers etc)

To know the characteristics and potential of biomass, analyze were carried out to several parameters which include moisture content, ash content, fiber content including lignin, hemicellulose and cellulose.

2.1. Water Content

Aluminum cup dried in an oven for 15 minutes and cooled in a desiccator for 10 minutes and weighed (A). The sample is weighed as much as ± 2 g in the cup (B). Cup and its contents were dried in an oven of 100°C for 6 hours. Grail was transferred to a desiccator and then cooled and weighed. Cup and its contents dried again to obtain a constant weight (C).

$$\text{Calculation: Water content (\%)} = \left[\frac{B - (C - A)}{B} \right] \times 100\% \quad (1)$$

2.2. Ash Content

Prepared dish to ashing, and then dried in an oven for 15 minutes and then cooled in a desiccator and weighed (A). The sample is weighed as much as ± 3 g in the cup (B), and then burned in the smoke chamber until no smoke anymore. Furthermore, the ashing in an electric furnace at a temperature of $400\text{--}600^{\circ}\text{C}$ for 4-6 hours until a white ash or has a fixed weight. Ash along with the cup cooled in a desiccator and weighed (C).

$$\text{Calculation: Ash content (\%)} = \frac{C - A}{B} \times 100\% \quad (2)$$

2.3. Crude fiber content

Five (5) g sample put in a 500 ml Erlenmeyer flask was then added 100 ml of H_2SO_4 0.325 N and boiled for approximately 30 minutes. Added another 50 ml 1:25 N NaOH and boiled for 30 menit. In hot conditions is filtered with Whatman No. 40 after a known weight of the dry. Filter paper used consecutively washed with hot water, 25 ml of H_2SO_4 and 95% ethanol. Then dried in an oven at $100\text{--}110^{\circ}\text{C}$ until constant weight. The filter paper is cooled in a desiccator and weighed.

$$\text{Crude fiber content (\%)} = \frac{\text{weight of dry sludge}}{\text{Weight of sample}} \times 100\% \quad (3)$$

2.4. Lignin content

A sample of 1 g was weighed in a 250 ml Erlenmeyer flask then added 20 ml H₂SO₄. Subsequently allowed to stand for 2 hours and shuffled slowly. Samples were then added 250 ml of distilled water, heated in a water bath at a temperature of 100 °C for 3 hours. Further filtering using filter paper of known weight (A). Erlenmeyer and funnel rinsed with distilled water 3 times. Filter paper along with residue at 105 °C for 12 hours or at a temperature of 500 °C for 24 hours. Cooled and weighed filter paper weight (B). Filter paper with residue dried with muffle furnace at a temperature of 600 °C for 34 hours. Then cooled and weighed (C).

$$\text{Lignin content (\%)} = \frac{B-A-C}{\text{Weight of sample}} \times 100\% \quad (4)$$

Note:

A = weight of filter paper (g)

B = weight of filter paper and the residue after the oven (g)

C = weight of ash (g)

2.5. Contents of hemicellulose and cellulose

2.5.1. Hemicellulose content

Content of NDF (Natural Detergent Fiber)

Sample of A g, put in a 500 ml beaker and added with a solution of NDS. NDS solution consists of the following chemicals: 1 l of distilled water; Sodium sulfate 30 g; EDTA 18.81 g; Sodium Borate 10 g; H₂O 6.81 g; NaHPO₄ 2-tetakis anhydrous 4.5 g and 10 ml of pure ethanol. Then weighing G3 glass filter (B). Samples were added to NDS solution is filtered with the aid of a vacuum pump, rinsed with hot water and acetone. The screening results were dried in an oven of 105 °C, after which it entered in desiccator for an hour, then do last weighing (C).

$$\% \text{ NDF} = \frac{C-B}{A} \times 100\% \quad (5)$$

Note :

A = weight of sample (g)

B = weight glass filter (g)

C = weight of glass filters and samples after oven (g)

2.5.2. ADF Content (Acid Detergent Fiber)

Sample of A g, was put into a beaker and added with 50 ml solution of ADS. ADS solution consisting of: H₂SO₄; CTAB (cetyltrimethyl ammonium bromide). Samples were added to the solution is heated for an hour on the electric bath. Filtering is done with the aid of a vacuum pump with a glass filter also uses weighted (B). Washing was done with acetone and hot water. Drying and screening results enter into the oven. After it was put back into the desiccator to cool and weighed (C).

$$\% \text{ ADF} = \frac{C-B}{A} \times 100\% \quad (6)$$

Note :

A = weight of sample (g)

B = weight glass filter (g)

C = weight of glass filters and samples after oven (g)

$$\text{Hemicellulose content (\%)} = \% \text{ NDF} - \% \text{ ADF} \quad (7)$$

2.5.3. Cellulose content

The residue ADF (C) inside the glass filter is placed on the tray containing water high about 1 cm. Then added H₂SO₄ as high as $\frac{3}{4}$ of the glass filter and left for 3 hours while stirring. Filtering carried out with the aid of the vacuum pump also uses glass filter. Washing is done with acetone and hot water. Drying and screening results enter into the oven. After it is put back into desiccator to cool and weighed (D).

$$\% \text{ Cellulose} = \frac{D-C}{A} \times 100\% \quad (8)$$

Note :

A = weight of sample (g)

D = weighting of filter glass and ADF residues after the oven (g)

C = weighting of filter glass and ADF residues early (g)

3. Results and Discussion

Collecting of data from the cocoa plant biomass and sugarcane have been carried out successively in the location: Jatitujuh, Majalengka and Sumedang for sugarcane and Sukabumi to cocoa. Samples of the plant are plants belonging to local farmers.

3.1. Weight of Biomass

3.1.1. Biomass of Sugarcane Plant

Weight measurements of sugarcane biomass was performed in sugarcane plantation belonging to farmer in Palasa village Kertajati District of Majalengka regency and subdistrict Cibuluh Ujung Jaya village Sumedang regency, West Java. Samples are taken from sugar cane plantation with PKP (center to center) 120 cm, is a PC plant (plan cane) planting in 2014, varieties grown is BL (Bululawang). Yield of sugar cane is sold in the form of fresh stem to PG Jati Tujuh Majalengka. Observations in sugarcane age of 12 months gained an average number of stems per clump 5.6, plant height 310 cm, stem diameter 1.6 cm, number of fresh leaves per stem 9. While for the sugar cane 6 months age was obtained the number of stems per clump 6, trunk diameter of 1.7 cm, high plant 172 cm with the number of leaves is 12 sheets.

The measurement results of biomass weight of sugarcane are mostly on the stem/rod, either of aged 6 months and 12 months (table 1). The weight of the stem is 84.76 to 92.0% of the weight of the sugar cane crop biomass as a whole. Although later processed into bagasse and its nira, bagasse weight is still the greatest weight in comparison with the leaves and roots.



Figure 1. Sugarcane age of 12 months and the process of observation cane biomass

Table 1. Weight of Sugarcane Biomass Plant

Plant part	Weight per plants		Hemicellulose (%)	Cellulose (%)	Utilization by Farmers			
	Green (kg)	Green %			Energy	Feed	Fertilizer	others
6 months Age								
leaves	0.82	13.5761	11,45-14,01	12,57-14,50	V	V	V	
Rod/stem	5.12	84.76821	10,93	10,51	V			
Root	0.1	1.655629	9,31	13,80	V			
Weight/clump	6.04	100						
Weight/ha	120.800							
12 months Age								
leaves	0.64	6.808511	12,00-12,63	11,67-14,38	V	V	V	
Rod/stem	8.65	92.02128	14,70	11,84	V			
Root	0.11	1.170213	11,54	15,67	V			
Weight/clump	9.4	100						
Weight/ha	188.000							

Note: Trunk have crushed and dried.

To be converted into bioethanol is actually the biomass which contain high hemicellulose and cellulose. The roots are high cellulose but low weight. So on sugarcane biomass is the stem which became the major known so far is utilizing its bagasse. Shoot of sugarcane apart from the small quantities, this biomass is suitable for feed, because the ADF (acid detergent fiber), which is an indicator of forage digestibility is lower than stems and roots. Fiber digestibility of feed ingredients will be strongly influenced by the content of the cell wall constituent materials such as fibers, lignin, cellulose and hemicellulose and the indicators include a low content of ADF[8]. In the future utilization of sugarcane shoots biomass preferably for livestock feed as long as it has been practiced by farmers in Indonesia.

3.1.2. Biomass of Cocoa Crop

First sampling of 5 cocoa plants aged of 30 years old was carried out in Ubrug village, Warung Kiara District, Sukabumi. Second sampling of 5 cocoa plants aged of 5 years old was carried out in Pakuhaji village, Parung kuda district, Sukabumi. Potency of cocoa plant biomass including roots, leaves, stem, twigs, and fruit waste of cocoa (pod husks). Assumptions planting space of 4 x 4 m, so the population per hectare = 625 trees. Until now the use of pod husks on cocoa plantations as fertilizer for the crops by stacked under cocoa plants. Pod husks of cacao weighing up to 75% of the entire weight of the fruit, so it can be said that the main waste processing cocoa fruit is the pod (fruit shell). Each of the cocoa plant produce average of 30 fruits/year with a weight of 300-500 g / fruit. Cocoa fruit produced about 7.5 tonnes/ha /year. Weight pod husks reached 75% whole weight of the fruit or the equivalent of 5.6 tonnes/ha/year[9].

In cacao plant, the biomass mostly of twigs, small branches, branches to the main stem, respectively 7.89%, 26.93% and 32.11% as well as a branch root, tap root consecutive weighs 6.87 % and 3.47% (table 3). When summed weight is approximately 77% of the weight of plant biomass aged 30 years and about 74% for plant biomass of 5 years old cocoa plant. This number can be obtained when the rejuvenation of plantations, while its leaves are usually for feed materials as well as organic fertilizer.

Table 2. The weight of the Biomass of Cocoa Crop Age 5 Years

Plant part	Weight per plant (kg)				Hemicellulose (%)	Cellulose (%)	Utilization by farmers			
	Green (kg)	Green %	Dry %	Dry (kg)			Energy	Feed	Fertilizer	Others
5 years Age										
Weight of dry leaves	0.85	1.56	3.10	0.85			v		v	
Weight of green leaves	8.45	15.46	21.89	6.01	9,80-14,97	9,04-12,85	v	v	v	v
Weight of small twigs	6.64	12.14	12.25	3.36	9,23	10,63	v			
Weight of branches (2)	16.11	29.48	26.44	7.26	10,19	11,19	v			
Weight of main stem	13.43	24.57	23.84	6.55	9,81	21,19	v			
Tap roots	5.72	10.47	8.40	2.31	12,79	5,51	v			
Secondary roots	1.89	3.45	3.46	0.95	7,66	24,63	v			
Fruits	1.58	2.89	0.61	0.17	7,92	11,51	v	v	v	v
Weight per plant	54.66	100.0	100.0	27.46						
Weight plant per ha (625 plt/ha)	34,16			17,16						

Table 3. The weight of the Biomass of Cocoa Crop Age 30 Years

Plant part	Weight per plant (kg)				Hemicellulose (%)	selulose (%)	Utilization by farmers			
	Green (kg)	Green %	Dry %	Dry (kg)			Energy	Feed	Fertilizer	Other
30 years Age										
Weight of dry leaves	3.94	5.23	10.92	3.94			v		v	
Weight of green leaves	7.74	10.27	11.20	4.04	7,31-8,71	23,13-25,29	v	v	v	v
Weight of small twigs	6.76	8.98	7.89	2.84	3,28	23,62	v			
Weight of branches	23.10	30.68	26.93	9.71	3,90	27,45	v			
Weight of main stem	23.28	30.92	32.11	11.58	3,24	30,77	v			
Tap roots	5.61	7.45	6.87	2.48	3,05	25,32	v			
Secondary roots	2.77	3.68	3.47	1.25			v			
Fruits	2.10	2.79	0.62	0.22			v	v	v	v
Weight per plant	75.29	100	100	36.05						
Weight plant per ha (625 plt/ha)	47,056			22,531						

3.2. The Content of the Lignocellulose Biomass Plant

3.2.1. The content of Lignocellulose Biomass of Sugarcane

Sugarcane waste made up of young leaves, old leaves, stems, roots. In this event be reviewed if any changes during planting (the effect of plant age). It has been observed when sewage plants aged 6 and 12 months. Observations fibers with properties derivatives are Neutral detergent fiber (NDF) and acid detergent fiber (ADF). Lignin, hemicellulose and cellulose.

Table 4. The content of the lignocellulosic biomass sugarcane age 6 months

Waste material	% Fiber	% ADF	% NDF	% Lignin	% Hemicellulose	% Cellulose
6 months age						
Old leaves	32.12	15.16	26.84	6.84	11.68	13.60
Old leaves no.2	33.34	14.15	28.94	4.64	14.79	13.91
Old leaves no.3	32.51	12.51	27.36	6.22	14.85	11.44
Old leaves no.4	30.33	13.73	28.47	4.62	14.74	10.97
Old leaves no.5	33.2	15.17	29.17	6.24	14.00	12.96
Average of old leaves	32.3	14.14	28.15	5.71	14.01	12.57
Young leaves	31.19	13.84	25.29	5.24	11.45	14.50
Stem	30.16	21.11	32.04	8.72	10.93	10.51
Root	34.12	24.42	33.73	11.01	9.31	13.80

Table 5. The content of the lignocellulosic biomass sugarcane age 12 months

Waste material	% fiber	% ADF	% NDF	% Lignin	% Hemicellulose	% Cellulose
12 months age						
Old leaves 1	30.82	15.32	28.11	7.12	12.79	10.91
Old leaves 2	30.71	17.16	29.63	5.8	12.47	12.44
Average of old leaves	30.76	16.24	28.87	6.46	12.63	11.57
Young leaves	32.49	15.32	27.32	6.11	12.00	14.38
Stem	38.06	19.75	34.45	11.52	14.70	11.84
Root	38.85	19.27	30.81	11.64	11.54	15.67

Van der Meer and Van Es, 2001 reported that the digestibility of feed ingredients will be greatly influenced by the fiber content of the cell wall constituent materials such as fibers, lignin, cellulose and hemicellulose.

Crude fiber is divided into two parts: neutral detergent fiber (NDF) and acid detergent fiber (ADF). neutral detergent fiber (NDF) is the fraction of a cell wall composed of cellulose, hemicellulose and lignin. The content of NDF linked to the consumption of feed, because all the components take up space and slow rumen digestibility, lower NDF content can be consumed more feed.

The content of ADF is an indicator of forage digestibility, because the content of lignin is part of a faction that can be digested. NDF is always greater than the ADF, for the ADF does not contain hemicellulose.

The results showed that the leaf has a sugar cane waste for NDF lower than stems and roots (table 4 and table 5). Likewise to ADF which is an indicator of forage digestibility lower than sugarcane leaf stems and roots. Meanwhile, the longer the time of planting, the NDF and ADF increased. It shows that sugarcane waste from the leaves, stems and roots contain lower NDF and ADF is less than 50 then all can be used for animal feed, and young and old cane leaves better than stems and roots.

Hemicellulose found in almost all plants, especially in food crop waste such as corn cobs, sugarcane bagasse, rice straw, wheat bran and cotton seed. These materials containing hemicellulose between 16-

40%, this observation is smaller than ranges from sugar cane waste hemicellulose 9.31-14.7% [10]. The older the plant hemicellulose tends to wane while cellulose increased.

Hemicellulose can be used for several products including:

- Xylitol sugar, through the process of hydrolysis of hemicellulose/xylan into xylose, then hydrogenated into xylitol. Xylitol has advantages over sugar (sucrose) is a low-calorie sweetener, is much lower glycemic index that does not raise blood sugar in the body, so it is good for diabetics. Xylitol can be used to make products such as chewing gum and others [11]. Besides, xylitol is currently widely used for toothpaste because it can strengthen the gums [12].
- hemicellulose in the form of xylan can produce furfural which can be used as an industrial solvent oil, solvent reactive phenol resins, disinfectants as well as starting materials for producing various chemicals and other polymers [13,14].
- As a substrate to produce xylanase enzyme, which is very useful in the food and feed industry. Xylanase for food can be used for animal feed mixes, syrup purification and manufacture of sugar xylose, while for non-food which is to process paper bleaching [15,16]. In the paper-bleaching process used thermostable xylanase and alkali resistant pH (6). In addition, to the hydrolysis of lignocellulose in the production of bioethanol.

The observation of sugarcane waste cellulose ranges from 10.51 to 15.67%. The young leaves and old leaves at the age of 6 and 12 months is not much different from hemicellulose and cellulose content. Based on its NDF and ADF, the young leaves and old leaves are excellent for feed and food. For raw materials of xylitol sugar and furfural is also a high potential since the requirement as those raw materials is a material with a higher hemicellulose content of 12%. According to the rules UNCTAD / Gatt, 1979 is recommended for raw materials are materials that contain a minimum of 12-20% hemicellulose / xylan. In addition to sugar as a food product can also be used as raw material of functional foods, as probiotics that are cello-oligosaccharides (SOS) and xilo-oligosaccharides (XOS).

With the content of cellulose and hemicellulose were higher than sugar cane waste is also potential for second-generation bioethanol. Utilization of lignocellulose to ethanol in addition to not disrupt the food supply can solve environmental problems and improve the efficiency and competitiveness of waste. Key of the production process of bioethanol from the lignocellulosic raw material, pretreatment is necessary to reduce. Hydrolysis of lignocellulose can also be done with acids and bases, combined with high temperature or high pressure. Cellulose is hydrolyzed by means of chemical and enzymatic cellulase is to produce glucose, while hemicellulose to produce xylanase xylose. Glucose and xylose are fermented into ethanol.

3.2.2. The Content of Lignocellulose of Cocoa Biomass

Table 6. The content of lignocellulose of cocoa biomass age 5 years

Cocoa 5 years age	% Fiber	% ADF	% NDF	% Lignin	% Hemicellulose	% Cellulose
Branches	32.64	14.23	24.42	11.26	10.19	11.19
Tap roots	30.45	15.46	28.25	12.15	12.79	5.51
Old leaves	28.63	12.17	27.14	4.62	14.97	9.04
Young leaves	25.41	12.48	22.28	2.76	9.80	12.85
Roots	41.72	28.25	35.91	9.43	7.66	24.63
Stem	44.41	35.14	44.95	13.41	9.81	21.19
Dry fruit	26.27	15.57	23.49	6.84	7.92	11.51
Twigs	29.13	20.29	29.52	9.27	9.23	10.63

Table 7. The content of lignocellulose of cocoa biomass age 30 years

Cocoa 30 Years age	% Fiber	% ADF	% NDF	% Lignin	% Hemicellulose	% Cellulose
Twigs	37.52	23.17	26.45	10.62	3.28	23.62
Leaves	33.11	20.41	27.72	5.67	7.31	23.13
Young leaves	31.45	18.23	26.94	3.45	8.71	25.29
Branches	45.07	25.27	29.17	13.72	3.90	27.45
Roots	39.48	30.18	33.23	11.11	3.05	25.32
Stem	48.73	30.23	33.47	14.72	3.24	30.77

Fiber of cocoa waste is higher than sugar cane waste but lower than palm oil waste. Fiber ranged between 25.41-48.73% (table 6 and table 7). Stems and roots had high levels of fiber and cellulose, whereas hemicellulose low. The stem and roots are not feasible for feed. Physically observations may also be difficult in enzymatic hydrolysis because it was too hard. Young and old leaves and tap roots still feasible for feed. As for bioethanol process leaves, dried fruit and twigs are eligible.

4. Conclusions and Recommendations

The biomass tree of sugar cane which measured potential detailed of leaves, stems and roots, with the weight mostly on the stem at around 84.76 to 92.0% of the weight of the sugar cane biomass as a whole. The leaves or shoots are few in number and are more suitable for feed because the content of ADF (acid detergent fiber) is quite low and is lower than the stems and roots. This is an indicator of forage digestibility of sugarcane leaves are suitable for feed.

The biomass tree of cocoa plant consists of leaves, fruits, small twigs, branches to the main trunk and roots. Biomass mostly of small branches, twigs branch to the main trunk and the total weight is around 77% of the biomass weight of plant age of about 30 years and about 74% for the plant of approximately 5 years age. Cocoa biomass contain fiber is higher than sugar cane biomass but lower than palm oil biomass. Fiber ranged between 25.41-48.73%. Stems and roots had high content of fiber and cellulose, whereas hemicellulose is low. The roots and stems were not eligible for the feed. Based on physical observations may also be difficult hydrolyzed enzymatically for being too hard. Young and old leaves still contain hemicellulose from 9.8 to 14.97% and cellulose from 9.04 to 12.85%, which is adequate for the manufacture of next bioethanol. Young and old leaves and tap roots still feasible for feed, while for bioethanol eligible process that leaves, dried fruit and twigs.

5. Suggestion

For other major estate plants that have the opportunity to bioenergy feedstock ie. coconut, rubber, coffee and jatropa should be immediately observable also to complement the data already gathered from the results of activity in 2015.

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References

- [1] Rajeev J and Rajvanshi A K 1997 Sugarcane leaf-bagasse gasifier for industrial heating application *Biomass and Bioenergy* **13** 141-146
- [2] Koesnandar 2001 Biokonversi selobiosa langsung menjadi etanol menggunakan Ko-immobilisasi sel *Lipomyces starkeyi* dan *Saccharomyces cerevisiae* secara Fed-Batch *J Mikrob Ind* **6** 15-18

- [3] Sunarti T C and N Richana 2006 Bioethanol production from corncob residue by two successive fermentations *Final report of Osaka Gas Foundation of International Cultural Exchange Research Grant* FY 2005/2006
- [4] Sah J P, M S Ross, S Koptur and J R Snyder 2004 Estimating aboveground biomass of broadleaved woody plants in the understory of Florida Keys pine forests *Forest Ecology and Management* **203** 319–329
- [5] Makungwa S D, Abbie C, David L S, George Y K-P and Iain H W 2013 Allometry for biomass estimation in *Jatropha* trees planted as boundary hedge in farmers' fields *Forests* **4** 218-233
- [6] Richana N and Bambang P 2012 Teknologi biofuel generasi kedua: bioetanol dari lignoselulosa tandan kosong kelapa sawit *Warta Penelitian dan Pengembangan Pertanian* **34** 19-20
- [7] Bambang P dan Richana N 2014 *Biofuel generasi 1, Generasi 2 dan Generasi 3* (Jakarta: IAARD Press)
- [8] Van Der Meer J M and A J H Van Es 2001 Optimal degradation of lignocellulosic feeds by ruminants and *in vitro* digestibility tests *Proceedings of a Workshop, Degradation of Lignocellulosics in Ruminant and Industrial Processes* March 17-20 1986 Lelystad, Netherlands pp 21-34
- [9] Wulan S N 2001 Kemungkinan pemanfaatan limbah kulit buah kakao (*Theobroma cacao*, L) sebagai sumber zat pewarna (B-Karoten) *Jurnal Teknologi Pertanian* **2** 22 – 29
- [10] Jaeggle W 1975 Integrated production of furfural and acetic acid from fibrous residues in a continous process *Escher Wyss News* **2** 1-15
- [11] Anonymous 2004 Alternative sweeteners: a balancing act *J Asia Pacific Food Industries* September pp 51-54
- [12] Saha B C and Bothast R J 1998 Enzymology of xylan degradation [<http://www.usda.gov/ttich/tektran/data/000009/20/0000092095html-2.9kb> 18 Dec 98]
- [13] Sjoström E 1995 *Wood Chemistry Jilid II* (Yogyakarta: UGM Pres)
- [14] Mansilla HD, Baeza J, Urzua S, Maturana G, Villasenor J and Duran N 1998 Acid-catalysed hydrolysis of rice hull: Evaluation of furfural production *J Bioresource Technol* **66** 189-193
- [15] Ruiz-Arribas A, Fernandez-Abalos J M, Sanches P, Gardu A L and Santamaria R I 1995 Over production, purification and biochemical characterization of xylanase I (xys 1) from *Streptomyces halstedii* *JM8 Appl And Environ Microbiol* **61** 2414 - 2419
- [16] Stassen H E 1995 Small-scale biomass gasifier for heat and power; a global review *The World Bank* pp 49-50.