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To cite this article: Sarono *et al* 2020 *IOP Conf. Ser.: Mater. Sci. Eng.* **857** 012017

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The analysis of straw mushroom potential development using an empty fruit bunches materials

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Abstract. The empty fruit bunches (EFB) known as a waste material from crude palm oil (CPO) production. It has widely studied for the potential used of EFB. One of products produced from EFB with development potentials is straw mushroom. The objective of this research was to analyze the potentials of EFB material and straw mushroom based on EFB material in Lampung province. The result showed that the EFB potential in Lampung province was 111,144 ton annually and straw mushroom was 4,835 ton annually. The biology efficiency ratio of EFB into straw mushroom in production scale was averagely 3.93%. Districts having potentials for developing straw mushroom business by using EFB material were Mesuji, Middle Lampung, Tulang Bawang, Way Kanan, and North Lampung.

Keywords: straw mushroom, EFB, and biology efficiency ratio

1. Introduction

Straw mushroom (*Volvaria volvaceae*) in Indonesia is a very popular agricultural product and its demand is increasing [1]. Many benefits of straw mushroom when it is added into meals include increasing amino content, increasing volatile component contents, reduced peroxide value, and improving food taste [2].

Straw mushroom cultivation is a most efficient and economical biotechnology process in changing agroindustry material with lignocellulose content into nutritional and functional food [3]. Many agricultural by products, that are left unusable and they even damage environment, can be used as planting media for straw mushroom.

One of by products in the conversion process of fresh oil palm bunches into crude palm oil (CPO), that is not yet optimally used, is empty fruit bunches (EFB). According to [4], about 16% - 23% of EFB is produced by fresh oil palm bunches (FFB). It means that 1 ton of processed FFB shall produce 160 kg to 230 kg EFB. [5] Suggest that the average of produced EFB is 23% from total of processed FFB.

The main compositions of EFB are 14.1%-30.45% lignin, 23.70%-65.0% cellulose, and 20.58%-33.52% hemicellulose [6]. High linin and cellulose contents make EFB is difficult to decomposed. To change into simpler elements, EFB must be decomposed [7].



Various efforts to use EFB have been done, but the potential effort to develop by people surrounding oil palm factory is using EFB for straw mushroom planting media and compost fertilizer. EFB as organic or compost fertilizer was studied elsewhere [8,9], while EFB as planting media for straw mushroom was studied by [2].

Lampung province have studied the use EFB for straw mushroom media commercially. This is because the use of EFB is more beneficial than using rice straw. Amongst EFB benefits compared to rice straw include available in huge amount, cheaper price, and sustainable supply. Therefore, further research on the straw mushroom business potential by using EFB material in Lampung province is required, especially in the aspect of raw material.

The objectives of this research were to analyse the EFB production in Lampung Province; to analyse biology efficiency ratio of EFB to produce straw mushroom in a production scale, and to analyse the potential of straw mushroom by using EFB material in Lampung province.

2. Materials and methods

Research data were primary and secondary data. Primary data were collected from laboratory and field researches. Laboratory research was used to determine EFB characteristics including contents of lignin, cellulose, hemicellulose, water, and fat. Primary data used to determine straw mushroom potentials were biology efficiency ratios collected from results of field research, interviews with business actors, suppliers, collecting traders, academicians, and straw mushroom business practitioners.

The analysis of biology efficiency ratio in production scale was done in three districts. They were mushroom business units in South Lampung district, East Lampung district, and Middle Lampung district. The specifications of straw mushroom housing in the industrial scale of this research can be seen in Figure 1. Process stages of straw mushroom making by using EFB material can be seen in Figure 2.

Secondary data can be obtained from various forms of publications including scientific journals, statistical data especially presented on *Lampung Province in Numbers Y2015, Y2016 and Y2017* respectively [10-12]. Research data were tabulated and analysed and presented in figures and tables.

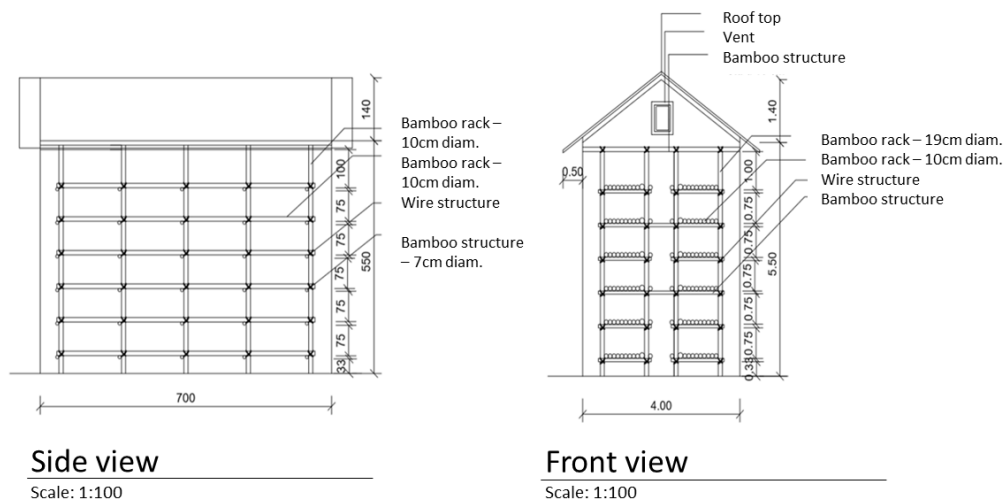


Figure 1. Specifications of Mushroom Housing for Research.

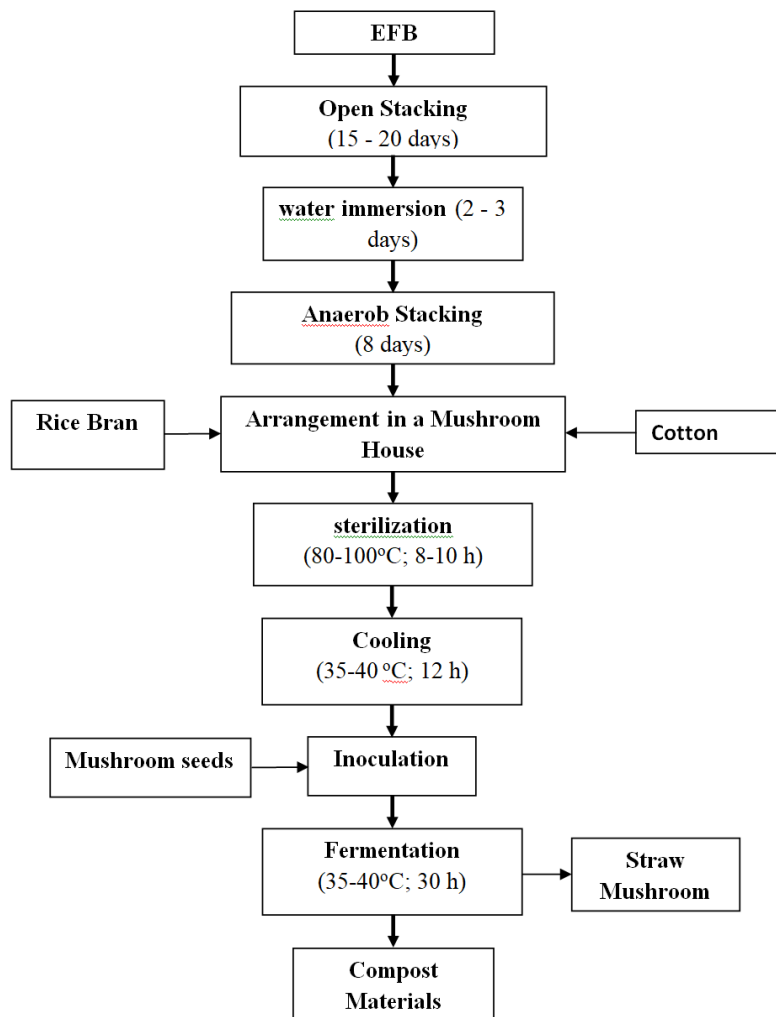


Figure 2. Stages of Production Process of Straw Mushroom from EFB.

3. Results and discussions

3.1. Productions of FFB and EFB in Lampung Province

Table 1 shows the FFB production and potential of EFB in Lampung province based on the FFB production data from each district. The table shows that during successive three years (2015 to 2017), the FFB production fluctuated. The production fluctuation was caused by seasonal factor; at long dry season the FFB production declined [13]. Other factors were harvesting area expansion and plant maintenance. The biggest FFB producers in Lampung province in order were Mesuji district with average production of 173,248 ton, Middle Lampung district with average production of 106,536 ton, and Tulang Bawang district with average production of 70,171 ton. The percentages of FFB productions from each district in Lampung province can be seen in Figure 3.

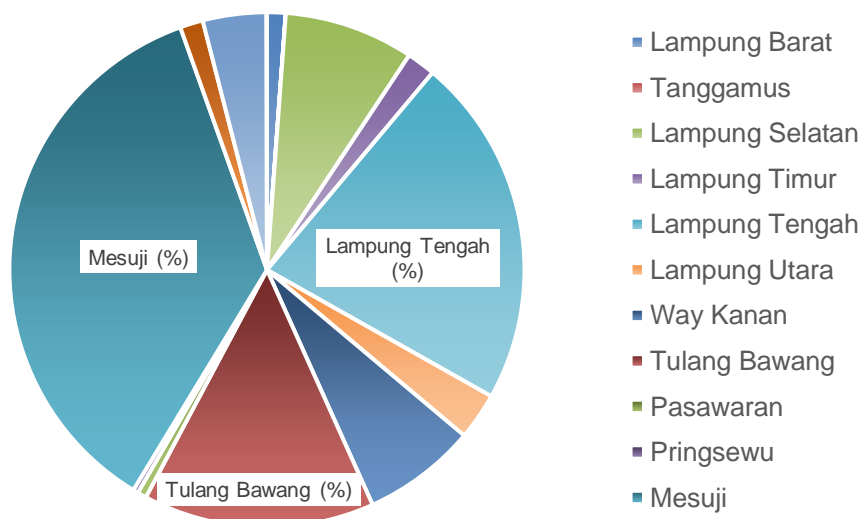
Table 1 also shows potential of EFB production in Lampung province, where the EFB value depends on the amount of produced FFB. Wicke *et.al.* (2008) suggests that the amount of FFB product is between 16.0% to 23.0% from FFB, and 23.0% averagely [5]. An oil palm factory with a processing capacity of 60 ton/hour, 10 hours/day operation time, and 300 working days annually, will produce 41,400 tons of EFB [14].

About 23% of EFB from the total waste will cause environmental problem for industry and public if it is not managed seriously. The optimal management and use of EFB can improve competitiveness and productivity of oil palm industry [15].

Table 1. Production of FFB and Potential of EFB in Lampung province (2015-2017).

No	Districts	FFB			EFB (23% from FFB)*		
		2015	2016	2017	2015	2016	2017
1	Lampung Barat	6.333	4.900	5.617	1.457	1.127	1.292
2	Tanggamus	36	37	38	8	9	9
3	Lampung Selatan	35.331	40.197	42.630	8.126	9.245	9.805
4	Lampung Timur	8.897	8.659	8.540	2.046	1.992	1.964
5	Lampung Tengah	90.589	109.725	119.293	20.835	25.237	27.437
6	Lampung Utara	19.757	8.772	14.265	4.544	2.018	3.281
7	Way Kanan	41.617	27.507	34.562	9.572	6.327	7.949
8	Tulang Bawang	95.548	44.793	70.171	21.976	10.302	16.139
9	Pasawaran	3.172	2.325	2.749	730	535	632
10	Pringsewu	1.562	1.566	1.568	359	360	361
11	Mesuji	218.238	128.258	173.248	50.195	29.499	39.847
12	Tulang Bawang Barat	10.732	6.238	3.991	2.468	1.435	918
13	Pesisir Barat	14.379	20.282	23.234	3.307	4.665	5.344
14	Bandar Lampung	48	129	170	11	30	39
15	Metro	3	2	2	1	0	0
		546.242	403.390	500.074	125.636	92.780	115.017

* From other sources [5]

**Figure 3.** Percentage of FFB Production from each district in Lampung Province.

3.2. Characteristics of EFB in Lampung Province

The analysis result of EFB compositions in Lampung province compared to some other research results can be seen in Table 2.

Table 2. The Results of EFB Analysis and Analysis Result Data of EFB from Various Sources.

No	Characteristics	Lampung Selatan	Lampung Timur	Lampung Tengah	Chan (2014)	[5]
1	Cellulose (%)	36,19	36,45	37,50	23,70 – 65,00	43,30
2	Hemicellulose (%)	18,84	16,08	22,44	20,58 – 33,52	26,20
3	Lignin (%)	22,75	24,73	23,03	14,10 – 30,45	30,50
4	Water (%)	7,41	5,25	5,08	2,40 – 14,28	N. A
5	Fat (%)	5,29	4,62	5,63	N. A	N. A

The table shows that three biggest and important components in EFB are cellulose, hemicellulose, and lignin. Table 2 also shows that cellulose, hemicellulose, and lignin components of EFB from one district compared to other districts are almost the same. The compositions of cellulose, hemicellulose, and lignin of EFB are influenced by plant age, FFB maturity level, plant varieties, and locations of oil palm planting [16]. The use or processing of EFB must pay attention to these three component characteristics.

Cellulose is a substance composing plant that is found in cellular structure. The cellulose content in the plant cellular walls is always higher compared to lignin and hemicellulose in dry weight of a plant. Cellulose is a glucose polymer with β -1binding, 4 glucosides in a straight chain [16]. The crystalline cellulose structure causes cellulose difficult to decompose properly both acid and basal ways. In order to decompose enzymatically, lignocellulose must be delignified to facilitate cellulose enzyme work in decomposing cellulose [17].

Lignin is a plant composing component together with cellulose and other fiber materials to form plant structure and cellular parts. In the plant stem, lignin function as binding material of other composing components, so that a plant is able to stand straight. Lignin is formed from aromatic clusters that are interconnected with affiliated chains that contain of 2-3 carbons. In a pyrolysis process of lignin, aromatic chemical compound will be produced in form of phenol, especially cresol [16].

Lignin structure is very hard to decompose chemically and enzymatically. Lignin, cellulose, and hemicellulose can always be found in plant cellular wall structures, so that they are often categorized as carbohydrate, even though lignin is not carbohydrate. This is proven by the higher proportion of lignin [18]. The lignin contents differ between one plant to another, for example, lignin contents were 22.65 in pine straw, 20.40% in wheat straw, and 14.88% in ramie fiber [19].

Hemicellulose is a group of heterogenous polysaccharide with lower molecular weight compared to cellulose. Hemicellulose amount is about 15 to 30 percent of lignocellulose dry weight material. Hemicellulose is relatively easier to hydrolyse with acid into monomers containing glucose, mannose, galactose, xylose, and arabinose. Hemicellulose also is crossed-binding with lignin to form complex networks and to provide strong structures. Hemicellulose contains of units of D-glucose, D-galactose, D-mannose, D-xylose, and L-arabinose that are formed simultaneously in varying glycosylic binding and combinations [19].

3.3. Biology efficiency ratio of EFB material-based straw mushroom

Another important parameter is biology efficiency ratio functioning to measure substrate efficiency use level. The higher is the biology efficiency ratio, the more efficient will be the substrate use by the straw mushroom [20]. Compare to others stated that biology efficiency ratio is the produced fresh straw mushroom weight to divide by substrate material (EFB) and multiplied by 100% [21].

The research results from three EFB material-based straw mushroom business units showed that the biology efficiency ratio of EFB material-based straw mushroom differed from one business unit to another (Figure 4). The biology efficiency value of EFB conversion into straw mushroom was about 3.00% to 4.81%. The research result by other showed that EFB could be used as white oyster mushroom planting media to replace wood sawdust with biology efficiency ratio value of more than 30% [20-21].

Also, Purindraswari and Udiantoro (2016) [21] showed that the use of media by composition of 750 gr EFB and 250 gr rice straw could produce an average of 19 straw mushrooms with 60.88 gr of weight or a biology efficiency ratio of 6.088%. The composition of 250 gr of EFB and 750 gr rice straw could

produce an average of 2 straw mushroom with 5.72 gr of weight or a biology efficiency ratio of 0.572%. Many factors influenced conversion values including mushroom seed quality, climate surrounding mushroom housing, mushroom housing maintenance, and nutrition composition in the planting media [21].

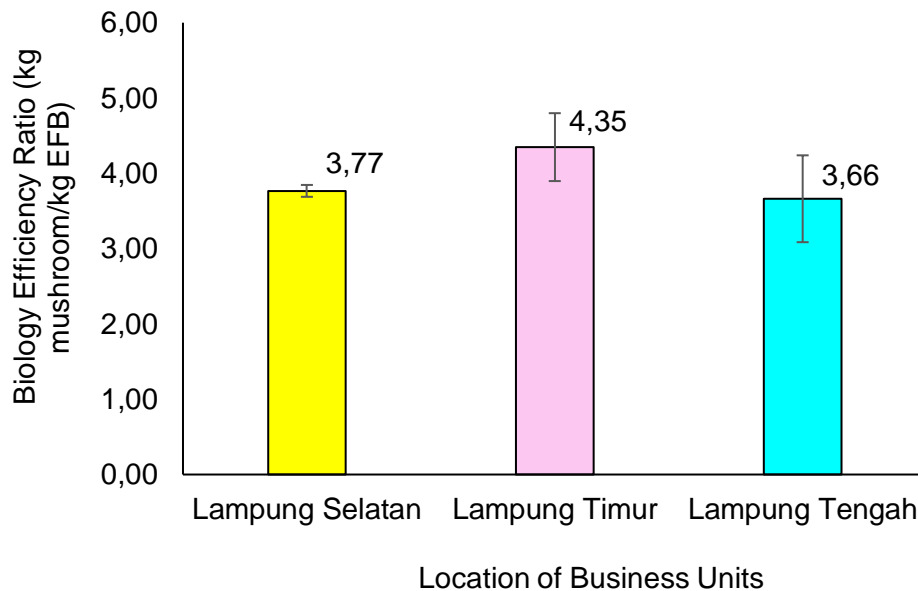


Figure 4. Biology efficiency ratio of EFB material-based straw mushroom.

Figure 4 shows that the highest EFB material-based straw mushroom efficiency is in East Lampung. This was because management in East Lampung was better compared to other districts. EFB material-based straw mushroom cultivation in East Lampung was conducted professionally, started from the experienced human resource, bigger business scale, well-established marketing and business networks [22].

Many factors influence the biology efficiency ratio value of straw mushroom. They are mushroom seed quality, planting media thickness, temperature, RH, and used media nutrition [21]. In this research, planting media thickness was 30-40 cm, temperature was 35-50⁰C, RH was about 90-95%, and rice bran was added for additional nutrition, while some business units added cotton to maintain RH.

3.4. EFB material-based straw mushroom potential in Lampung Province

Table 1 shows FFB production and EFB potential in Lampung province for three successive years from 2015 to 2017. EFB production was very dependent to amount of FFB production. Some sources said that 20-25% EFB was produced from FFB and the average was 23% [5]. EFB potential in Lampung province in 2017 reached 115,017 ton with a production average of 111,144 ton annually.

The field observation results showed that from 15 districts/municipals in Lampung province, only 5 districts had oil palm factories; 6 factory units in Middle Lampung district, 1 factory unit in North Lampung district, 2 factory units in Way Kanan district, 3 factory units in Tulang Bawang district, and 5 factory units in Mesuji district. Therefore, FFB coming from districts that do not have oil palm factory is sent to those districts with oil palm factory.

This research showed that considerations concerning FFB deliveries from a district to another were determined by distances between plantations to the oil palm factories, access into the oil palm factories, and FFB prices. FFB distributions from districts into other districts with oil palm factories can be seen in Figure 5. Amounts of FFB sent from district to other districts with oil palm factories can be seen in Table 3.

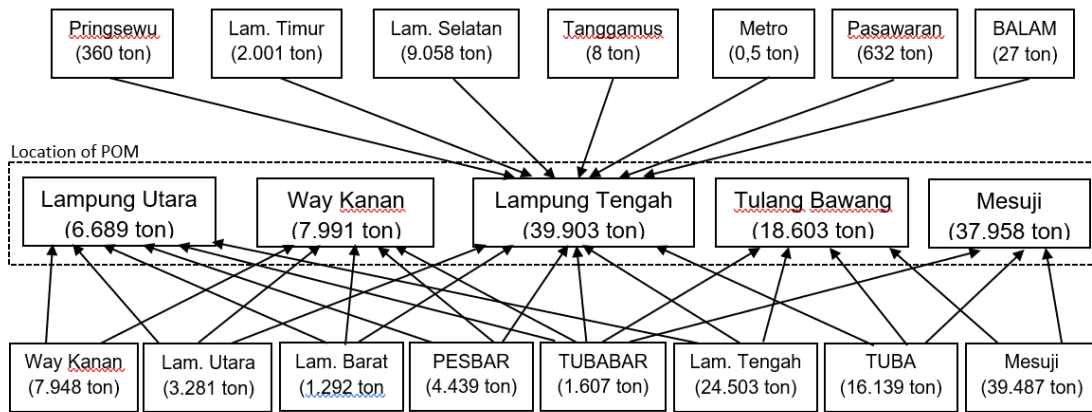


Figure 5. Distribution and transportation of FFB from districts to other districts with oil palm factories in Lampung Province.

Table 3. Amount of FFB sent from districts to other districts with oil palm factories.

Regency / City	TBS (Ton)	District that has a Palm Oil Mill (POM)									
		Lampung Tengah		Way Kanan		Lampung Utara		Tulang Bawang		Mesuji	
		(%)	(Tons)	(%)	(Tons)	(%)	(Tons)	(%)	(Tons)	(%)	(Tons)
Lampung Barat	5.617	50%	2.808	20%	1.123	30%	1.685	-	-	-	-
Tanggamus	37	100%	37	-	-	-	-	-	-	-	-
Lampung Selatan	39.386	100%	39.386	-	-	-	-	-	-	-	-
Lampung Timur	8.699	100%	8.699	-	-	-	-	-	-	-	-
Lampung Tengah	106.536	90%	95.882	-	-	5%	5.327	5%	5.327	-	-
Lampung Utara	14.265	10%	1.426	5%	713	85%	12.125	-	-	-	-
Way Kanan	34.562	10%	3.456	80%	27.650	10%	3.456	-	-	-	-
Tulang Bawang	70.171	10%	7.017	-	-	-	-	80%	56.136	10%	7.017
Pasawaran	2.749	100%	2.749	-	-	-	-	-	-	-	-
Pringsewu	1.565	100%	1.565	-	-	-	-	-	-	-	-
Mesuji	173.248	-	-	-	-	-	-	10%	17.325	90%	155.923
Tulang Bawang Barat	6.987	10%	699	20%	1.397	10%	699	30%	2.096	30%	2.096
Pesisir Barat	19.298	50%	9.649	20%	3.860	30%	5.789	-	-	-	-
Bandar Lampung	116	100%	116	-	-	-	-	-	-	-	-
Metro	2	100%	2	-	-	-	-	-	-	-	-
Number of FFB / Reg. (tons)	483.235		173.491		34.743		29.081		80.884		165.036
Production of EFB (tons)			39.903		7.991		6.689		18.603		37.958

The determination of EFB material-based straw mushroom potential was based on the research on biology efficiency ratio from EFB into straw mushroom, which was 4.35%, and the amount of EFB produced from FFB. The analysis of EFB material-based straw mushroom in Lampung province can be seen in Figure 6.

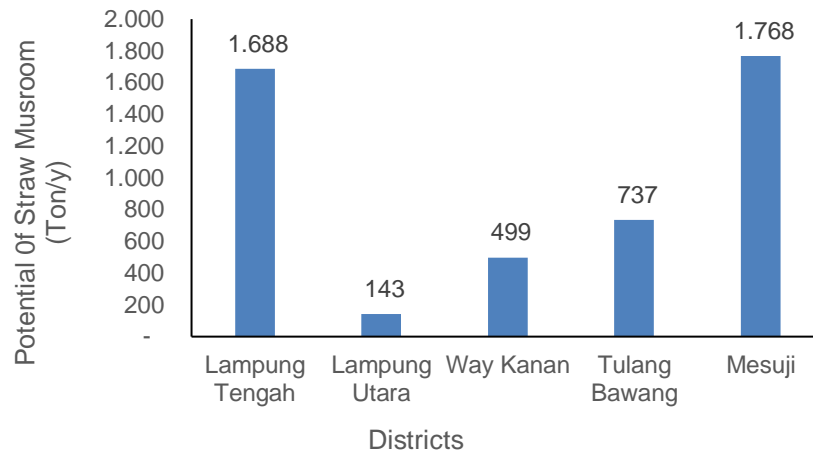


Figure 6. The EFB material-based straw mushroom potential in Lampung Province.

4. Conclusion

EFB production Lampung province reached 111,144 ton annually and it was not yet used optimally. The biology efficiency ratio of EFB into straw mushroom in production scale was 3.93%. The potential of EFB material-based straw mushroom business development in Lampung province was 4,835 ton annually; they were 1,768 ton from Mesuji district, 1,688 ton from Middle Lampung district, 737 ton from Tulang Bawang district, 499 ton from Way Kanan district, and 143 ton from North Lampung district.

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