Characteristics of organic fertilizer derived from fleshing waste with teak (*Tectona grandis*) wood scrap

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ABSTRACT

The processing of leather tanning industry wastes into useful products is a one way to solve the industrial problem. This research aimed to evaluate the characteristics of organic fertilizer after the composting process of skins/hides fleshing waste with the addition of teak wood scrap as rice husk substitution. The study was an initial research to analyze the organic fertilizer, quantitatively and qualitatively. The compliance of SNI 19-7030-2004, regarding the specification of compost from organic domestic wastes, was set as the reference. Rice husk, which is commonly added in the composting process, was used as a comparison. The materials used in this study were fleshing waste, rice bran, bio-activator, rice husk, and teak wood scraps. The results showed that the organic compound, moisture, C organic, carbon, and total N content of teak wood scraps and rice husk were similar. Thus, the resulted fleshing waste-based fertilizer has similar value of macro and micro element. Through comparing the parameter quality of organic waste in the Indonesian national standard of SNI 19-7030-2004, teak wood scrap can be used as an alternative to substitute rice husk in the composting process of fleshing waste to support the sustainability of the leather tannery.

Keywords: composting process, limed fleshing waste, organic fertilizer, rice husk, teak wood scrap.

INTRODUCTION

Hide or skin is one of the by-products of livestock that have high added value after being processed into new products, both food and non-food products. Leather tanning industry processes raw hides or skins, through the tanning process into leather that is well-known for its exclusivity and quality. Generally, one of problems faced by leather tanneries is waste management. Leather tanning industry generates wastes in the form of liquid, solid, and gas. Among the wastes generated by the industry, solid waste is the most challenging to overcome because of its unique dimensions and characteristics. According to Kanagaraj *et al.* (2015), the industry generated solid waste in the form of skin trimming, hair, flesh, shaving scrap, and buffing dust.

Flesh is commonly known as tissue of muscle or fat which is attached to hide/skin outer layer. This tissue should be removed to achieve the

successful of tanning process. Fleshing is a mechanical action to remove the flesh from hide/skin outer layer. The process can be done either manually, with a flesh beam, or semi-automatically with fleshing machine. Figure 1 shows the fleshing machine used in PT. Usaha Loka which generates fleshing waste. In general, tanneries apply fleshing process after soaking process (Jiang *et al.*, 2016) or liming process (Beghetto *et al.*, 2013). The fleshing process of hides/skins, after soaking process, results green flesh, while limed flesh is the waste generated from fleshing process after liming process. An attempt to utilize fleshing waste had been investigated by researchers for several outputs, such as sound absorber (Selvaraj *et al.*, 2019), biodiesel feedstock (Kubendran *et al.*, 2017), surfactant (Nawaz *et al.*, 2012), and organic fertilizer (Sutyasmi *et al.*, 2008).

The manufacturing of organic fertilizer becomes a potential to be developed by utilizing

fleshing waste. Moreover, a concept of circular economy has widely spread and leather tanning industry is targeted to apply the concept (Moktadir *et al.*, 2020). Indonesia, as an agricultural-based country, needs a product to support the sustainable development of agricultural production. The application of organic fertilizer is one of the efforts to improve the agricultural production. Generally, there are 2 (two) types of fertilizer used in the agricultural production, i.e. organic fertilizer and inorganic fertilizer. According to Supartha *et al.* (2012), organic fertilizer had better impact on the environmental aspect compared to inorganic fertilizer.

Rice husk is the major by-product of rice production. It could be the eco-benign raw material for composting process (Anda *et al.*, 2008). It has good substances for plant, i.e. carbon (C) and nitrogen (N) (Anda *et al.*, 2008; Demir & Gülser, 2015). Teak wood scraps known as a waste of paper or furniture industries that offers high durability (Ramirez *et al.*, 2020). Besides, it also contains good nutrient for corps, such as carbon (C), hydrogen (H), and nitrogen (N) (Kongsomart *et al.*, 2015). Furthermore, the availability of teak wood scraps as logging residues is increasing since global furniture market is keep growing. Previously, Sutyasmi *et al.* (2008) composted fleshing wastes with the addition of rice husks as the source of carbon. To the best of our knowledge, there is no investigation on the characteristics of organic fertilizer composed by fleshing waste

and teak wood scrap. Hence, the research aimed to evaluate the characteristics of organic fertilizer after the composting process of hides fleshing waste with the addition of teak wood (*Tectona grandis*) scraps.

MATERIALS AND METHODS

Materials

The limed flesh of tannery residues from PT. Usaha Loka, Malang, East Java, Indonesia were used in this study (Figure 2). It was generated from a fleshing process of cow hides after liming process and washed prior to use for composting process. Rice husks were obtained from agricultural store in Malang. Meanwhile, teak wood scraps were wood processing waste obtained from PT. Usaha Loka wood processing division. Other materials used for composting were rice brans and Protebak 57 (bio-activator) obtained from local supplier in Malang. The major equipments in this research were plastic drum with capacity of 25 L, wooden stirrer, and 50 kg mechanical scale.

Composting Method

The composting process were conducted by modifying the method of Sutyasmi *et al.* (2008). The process protocol was started by mixing the fleshing waste (85% w/w), rice brans (1.2% w/w), rice husks/teak wood scraps (13.8% w/w), and 1 L of bio-activator for 10 kg of the mixture. The treatments were identified with codes, i.e. LFH (limed flesh with rice husks) and LFW (limed

Figure 1. The semi-automatic fleshing machine in PT. Usaha Loka.

Figure 2. The waste of cow hides fleshing waste after washing.

flesh with teak wood scraps). After the completion of mixing process, the mixture was placed in plastic drums with identification label. In order to optimize the composting process, the mixture was stirred three times a week to maintain the aeration. An observation of pH and temperature were held twice a day for 35 days.

Quality Evaluation of the Samples

The quality of resulted fertilizer was evaluated based on SNI 19-7030-2004, regarding the specification of compost from organic domestic wastes. The evaluation parameters consisted of C/N ratio, the content of organic substances, organic carbon, total nitrogen, P_2O_5 , as macro elements, which were analyzed by using gravimetric and Kjeldahl method. Meanwhile, micro elements evaluation included the content of Co, K, Ni, Cr, and Pb. Micro elements were identified by an atomic absorption spectroscopy, qualitatively and quantitatively.

FTIR Analysis

Fourier-transform infrared (FTIR) analysis was conducted to identify the functional groups of the resulted organic fertilizers. The FTIR analysis was performed using a Thermo Scientific Nicolet iS10. KBr pellets were made by weighing 100 mg of samples. It was measured at the range of $4000 - 400 \text{ cm}^{-1}$ wavelength.

RESULTS AND DISCUSSION

Rice Husks and Teak Wood Scraps Characterization

Composting is a process of reducing the carbon-to-nitrogen (C/N) ratio of organic matter to be as low as the C/N ratio of soil. The C/N ratio of organic matter is the quantity of carbon relative to the quantity of nitrogen and usually written as C:N or C/N ratio (Brust, 2019). Anda *et al.* (2008) has promoted that the use of rice husk, in composting, as an effort to solve the problem in waste disposal. Furthermore, the content of carbon, nitrogen, iron, magnesium, calcium, and potassium, support its function in supplying nutrients for crops.

Table 1 shows the results of organic compound, C/N ratio, moisture, C organic, carbon, and total N content of teak wood scraps and rice husks. It was observed that teak wood scraps had higher moisture, organic compound, C organic, and C/N ratio than those of rice husks. Meanwhile, the content of C organic and total nitrogen of the

rice husks was higher than the wood scraps. The discrepancies between teak wood scraps and rice husks, in the content of moisture, C organic, and carbon, were discovered at 5%. It was also found that teak wood scraps had more organic compound than rice husks. It could be caused by the fact that rice husks are mostly composed by silica at around 87-97% (Handayani *et al.*, 2014; Trivana *et al.*, 2015).

Previous research found that rice husks had moisture content of 9.5%, 48.1% of total carbon, 0.78% nitrogen total (Wu *et al.*, 2015), and C/N ratio at 73.4 (Bian *et al.*, 2019). As shown in Table 1, teak (*Tectona grandis*) wood scraps sample displayed a relatively similar character with rice husks, except C/N ratio. Therefore, when teak wood scrap has similar percentage of content with those of rice husk, it was indicated that teak wood scraps could be utilized in composting process as rice husk.

The Quality of the Resulted Composting Process

Nowadays, composting is getting more popular among other waste treatment due to cost effectiveness, value-added of the product, and the simplicity. Beside pH and temperature, moisture content is one of the crucial parameters in the composting process (Onwosi *et al.*, 2017). Kubendran *et al.* (2017) stated that fleshing waste contributed up to 85% from processing raw hide into leather. Furthermore, it was characterized by high moisture content (80%) and had substances such as protein (63%), fat (7-30%), and ash (8%) (Kanagaraj *et al.*, 2006).

From the Table 2, it was observed that the moisture content, pH, and temperature of organic fertilizer composed by limed-flesh and rice husk (LFH) and composed by limed-flesh and wood scrap (LFW) were similar. The Indonesian Standard of SNI 19-7030:2004 stated that organic compost from domestic waste required 50% moisture F content, at maximum, with pH 6.8 – 7.49 (BSN, 2004). Both LFH and LFW samples of this study did not meet those requirements. The usage of washed limed fleshing waste resulted in the starting pH of LFH and LFW at 7 and 8, respectively. The high moisture content of the samples could be caused by the origin of fleshing waste which has high moisture content (80%) and the time of composting, that was insufficient.

Since the composting period of this study was

Table 1. Characteristics of the teak wood scraps and rice husks.

Parameter	Teak wood scraps	Rice husks
Moisture content (%)	18.83	13.96
Organic compound (%)	92.20	77.53
C organic content (%)	27.80	22.36
Carbon content (%)	17.82	22.31
Total N content (%)	0.13	0.31

Table 2. Temperature, pH, and moisture content of resulted organic fertilizer.

Samples	LFH	LFW
Moisture (%)	68.58	67.53
pH	8.6	8.52
Temperature (°C)	27.15	27.10

only 35 days, the composting process might not finish yet. The temperature of the resulted mixture found approximately at 27 °C. According to Meng *et al.* (2018), temperature had an important role in determining the successful of composting process. It related to the microorganism activities in degrading organic matters, where the temperature should be maintained 30-40 °C at the end of composting process. Generally, composting period may take 12 weeks of fermentation and 4 weeks of maturation (Khalil *et al.*, 2011). Bian *et al.* (2019) suggested that better quality of compost could be engendered by prolonging the time of composting. Taking into this account, the period of composting method should be extended to gain the optimum pH. Thus, this high pH organic fertilizer should be considered if it would be apply for plants sensitive to alkaline condition (Benito *et al.*, 2006).

Composting is a technique to manage organic waste through biochemical process to reduce the negative effects that might emerge when the organic is applied to the soil (Das *et al.*, 2011; Onwosi *et al.*, 2017). In this study, composting is a technology to transform animal fleshing waste into organic manure that recycles macro and micro element. Those elements could be utilized to improve soil health thus provide nutrients for plants.

An investigation on macro elements of resulted organic fertilizers (Table 3) indicates that all of the samples met the requirements of Indonesian Standard SNI 19-7030:2004, excluding the organic matter. Both resulted fertilizers with rice husk (LFH) and teak wood scrap (LFW) has 73.77% and 77.23% of organic matter, respectively, while The Indonesian Standard SNI 19-7030:2004 required minimum organic matter at 27% and maximum at 58% (BSN, 2004). The organic matter, organic

C, carbon, and nitrogen total of LFH and LFW had very similar value. On the other hand, the C/N ratio of LFH was slightly higher than LFW, whereas C/N ratio of rice husk was lower than the teak wood scraps (Table 1).

The higher C/N ratio caused the longer period of composting process occurred. C/N ratio is a comparison of Carbon (C) and Nitrogen (N). This ratio represents the activity of microbes to breakdown the organic compounds to gather energy for their metabolism in the composting process. Yang *et al.* (2015) stated that when the value nitrogen mineralization is lower than organic carbon thus C/N ratio is decreasing. It indicates that LFW showed better composting process as the C/N ratio of teak wood scraps significantly decreased when it became organic fertilizers.

In order to grow and develop, normally plant only needs very small part of microelements. Nowadays, most microelements are artificial and applied together with natural organic fertilizers, e.g. manure and slurry (Jakubus & Graczyk, 2020). According to Table 4, the amount of Co, Ni, and Pb for both LFH and LFW were similar. However, the potassium (K) amount of LFH was slightly higher than that of LFW. Meng *et al.* (2018) explained that one of important nutrients for plants was pottasium. Hence, both LFH and LFW could provide sufficient nutrient for plants growth. As a result, all samples were acceptable in fulfilling the requirements of Indonesian Standard SNI 19-7030-2004 for micro elements (Badan Standarisasi Nasional, 2004).

FTIR Analysis

Both LFH and LFW were analyzed with FTIR in the frequency range 4000 – 500 cm⁻¹. This was used to investigate the functional group of each

Table 3. The macro elements of resulted organic fertilizer.

Macro elements	LFH	LFW
Organic matter (%)	73.77	77.23
Organic C (%)	13.40	12.32
C (%)	12.65	12.54
N Total (%)	0.79	0.91
C/N Ratio	16.96	13.54
P ₂ O ₅ (mg/kg)	2,452.23	754.22

resulted organic fertilizer. FTIR spectra of the two type of compost, LFH and LFW were given in Figure 3. This data evaluation was based on the absorption bands concerned with the identification wave numbers of functional groups. According to these results, some differences were found between limed flesh fertilizers with rice husk and teak wood scrap. The band at 3400 and 3421 cm⁻¹ for LFH and LFW respectively was clearly recognized in organic fertilizer spectra. Those broad band was attributed to O-H stretching frequencies of alcohol and phenol (Pike, 1960). Besides, those wide bands at 3800 – 3000 cm⁻¹ was assigned as O-H stretching of water and

Table 4. The micro elements of resulted organic fertilizer.

Micro elements (mg/g)	LFH	LFW
Co	0.010	0.010
K	0.242	0.189
Ni	0.022	0.022
Cr	0.017	0.037
Pb	0.027	0.027

humate molecules (Karpukhina *et al.*, 2019).

At the band between 3200 and 2700 cm⁻¹, both LFH and LFW samples showed peaks that caused by aliphatic C-H bonds in CH₃ and CH₂ groups. The band at 1700 – 1725 cm⁻¹ was attributed to the C=O stretching vibration that caused by carbonyl groups (ketone). Intense band at 1680 – 1450 cm⁻¹ was assigned to C=C vibration of aromatic structures that caused by alkene and/or C=C bonds caused by benzene. The observed spectra confirms the investigation of Meng *et al.* (2018), where they indicated that there were an incomplete displacement of the hemicellulose, for the case of LFH.

Figure 3. The FTIR spectra of LFH and LFW of organic fertilizer

CONCLUSIONS

Reuse of industrial waste is important in order to create sustainability of the industry. Furthermore, circular economy concept in leather tanning industry is essential to develop the economic and environmental aspects of the industry, as well as the social aspect. The utilization of industrial waste, i.e. fleshing waste, rice husk, and teak wood scraps, could minimize the negative environmental impact. Teak (*Tectona grandis*) wood scraps had similar characteristics with rice husks, in terms of moisture, C organic, carbon, and nitrogen content. The fleshing waste composted by teak wood scraps provided an alternative in composting process. The composting of fleshing waste and teak wood scraps could meet most of the parameters required by the Indonesian standard SNI 19-7030-2004, compared to the composting of fleshing waste with rice husks.

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