Potential uses of teak leaf litter for liquid smoke and of other utilizations: A review

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Abstract. Teak (Tectona grandis) is one of the high-quality wood-producing trees. Large trees, straight trunk, large leafy, with the height reach 30-40 m. The nature and characteristics of teak trees usually drop their leaves every dry season, and this will cause problems for the surrounding community because the dry leaves fall into waste and have not been utilized properly. Waste of dried teak leaves will accumulate under the stands of teak trees, and in the dry season can be a trigger for forest fires. The teak leaves contain 48.51% bound carbon, 6.61% moisture content, 31.72% ash content, 13.17% volatile content, and density 0.65 g/cm. In addition, teak leaves also contain flavonoid compounds, protein, nine phenolic acid or tannin compounds as well as crude fiber content covered in lignin of 22.9. Based on the content in the dry teak leaf litter waste, this paper presents an effort to use it into a number of useful products, one of which is the utilization of dry teak leaf litter waste for liquid smoke, and several other uses carried out by communities around the teak forest such as for charcoal briquettes, compost, medicine, and animal feed.

Analysis of liquid smoke was carried out at the Integrated Laboratory of the Forest Products Research and Development Center using the Pyrolysis GCMS method. Meanwhile, other results are a review of several studies conducted by the community.

1. Introduction

The teak forest is a commodity whose processed wood product have been widely used for various needs. Therefore, the sustainability of forest must be maintained because it has social, economic and environmental functions, therefore the main purpose of the forest management is to produce wood sustainably. The characteristic of teak trees that shed their leaves every dry season presents a new problem for the surrounding community which has an impact on environmental pollution and the risk of forest fires due to the large number of dry teak leaves that have not been utilized. Like the case of fire in Blora teak forest on September 2015, it was caused by natural fires due to the abundance of dry teak leaf litter and rubbing against each other.

Teak (Tectona grandis) is one of the high quality wood producing trees. Large trees, straight trunk, and can grow to reach 30-40 m high. Teak wood is one of the mainstays commodities as a source of carpentry wood. Broadleaf and large, and will shed leaves every dry season, and this will cause problems for the surrounding community because these fallen dead leaves become trash and have not been utilized optimally (Figure 1a, 1b). Waste of dried teak leaves accumulate under the stands of teak trees, and farmers often burn them for land clearing. It is very dangerous because it can burn other crops (Figure 1a). In addition, burning of teak leaves also destroy the surface layer of the soil (Figure 1c), so that it will reduce the soil moisture. Decreasing soil moisture will reduce the soil water content, and the soil
becomes denser with lower soil porosity. The consequences, the lower soil porosity will increase the soil temperature and decrease soil moisture. The higher the soil density, the lower the porosity of the soil the lower the ability of the soil to bind and store and remove the water needed by plants, especially at the beginning of the rainy season. If burning organic litter which is still rather wet will not burn all of it, and will produce solid particles containing hydrocarbon compounds that will fly and are quite dangerous for humans if inhaled breathing [1,2]. Most of the people in Indonesia do not know the potential of these teak leaves and they prefer to burn teak leaves. According to Supriyono and Prehaten [3], chemical content of teak leaves contains 48.51% bound carbon, 6.61% moisture content, 31.72% ash, 13.17% volatile, and density 0.65g / cm. In addition, teak leaves also contain flavonoid compounds, low protein content of 4.9%, and nine phenolic acid or tannin compounds and crude fiber content covered in lignin which is equal to 22.9% [3]. Therefore, based on the chemical content of the dry teak leaf litter waste, several efforts have been tried to utilize them into useful products, one of which is the utilization of dry teak leaf litter waste for liquid smoke and several other uses carried out by communities around the teak forest.

Figure 1. (a) Teak leaf litter waste, (b) under stands (c) which has the potential to trigger forest fires [1,2]

Liquid smoke or also known as wood vinegar is a by-product of combustion in the process of making charcoal with raw materials containing lignin and cellulose, it can be wood, coconut shell, small twigs or other lignocellulose wastes, such as dry leaf litter teak [4-9]. Smoke from process, if it cooling will turn into liquid, so it is called liquid smoke. The main component of liquid smoke is acetic acid, and other ingredients such as phenol, alcohol, benzoic acid and other chemical compounds that has function as natural pesticides instead of chemical pesticides. Although in relatively small amounts, liquid smoke also contains nutrients such as N, P, K, Ca, Fe, Na, Ca, Mg, and other elements that function as fertilizer. Actually, this liquid smoke has long been used by Indonesian ancestors to treat various diseases. Like toothache, various skin diseases caused by fungi, viruses, bacteria by rubbing on the affected part. It is also used to prevent acute water lice, phlegm, ringworm, ringworm, and herpes.

Liquid smoke is produced by pyrolysis of incomplete combustion which involves the decomposition of polymer constituents into organic molecules with low molecular weight due to the effects of heat which include oxidation, polymerization, and condensation reactions. The cooling media used in the condenser is water that is flowed through the inlet pipe that comes out of the incomplete combustion and then flowed through the condenser and condensed into a smoke distillate. Liquid smoke is known to contain 43.02% acetic acid and 36.22% phenol which can function to prevent plants attacked by pests, especially fungi, caterpillars, and root rot both on agricultural, forestry and plantation crops. In addition,
teak leaf ash has a lot of nitrogen which can increase the availability of N elements in the soil so that it can be used by plants as macro nutrients in the growth process.

The application of teak leaf handling technology into liquid smoke is intended to provide more value to the function and market of a product. The use of N replacement sources with forestry sector biomass waste such as teak leaf litter processed into liquid smoke is an alternative solution that can be done. In this case, fertilizing with liquid smoke is one alternative to avoid chemical pollution and is considered suitable to be used as a bio pesticide. This bio pesticide is ready to be used in eradicating pests to increase the productivity of an agricultural land. Besides this liquid smoke can be promoted and sold to the market and even to the international market in the form of packaging so that it creates more value. The sale of liquid smoke in a product can increase employment opportunities so that the standard of living and welfare of the community can increase [10].

In the food industry sector, liquid smoke is used as a specific flavoring and aroma ingredient as well as a preservative due to its anti-microbial properties. Liquid smoke can also replace the traditional fish fogging process that was previously by directly fogging. Liquid smoke can also be used in food processing such as tofu, wet noodles, and meatballs. In the plantation industry, liquid smoke is used as a latex coagulant because of its anti-fungal, and anti-bacterial, as well as to improve the quality of rubber products produced [7].

In Japan, liquid smoke is now commonly used, for example for detoxification drugs. Liquid smoke is mixed with oak wood powder, then packed with filter paper bags, and then put on the soles of the feet before going to sleep. Usually the next day the bag which was originally white turns black to a sign that the poison in the body has been absorbed. Japanese residents have been using liquid smoke for hundreds of years. Some areas in Japan such as Shitara in Aichi Province and in the Togo Islands, are centers for producing liquid smoke. Not only for health, in Togo, liquid smoke is also used as fertilizer and pesticides. As fertilizer, liquid smoke is sprayed on the leaf surface with a concentration of 1:1000 (1 part of liquid smoke and 1000 parts of water) for young plants, for mature plants, liquid smoke solution is splashed around the plants every two weeks. A mixture of liquid smoke and water (1:300) can accelerate the decomposition of compost and prevent the formation of ammonia gas. Therefore, liquid smoke is also useful to eliminate unpleasant odors when sprayed on a pile of garbage, also able to kill certain pests in vegetable cultivation [11].

In the field of food, people in the European Union and the United States are accustomed to eating grilled meat that is first marinated in a liquid smoke solution. The liquid smoke used has been purified through multi-level distillation so that harmful oil and tar are lost. Meat that has been dipped in liquid smoke has a more tender meaty texture and smells delicious when grilled and durable. Liquid smoke functions as a preservative because of the acid, phenol, and carbonyl compounds. Phenol is considered the most important, although the ability of liquid smoke to preserve is the interaction of various compounds. Phenols are antibacterial and antifungal and can inhibit the fat oxidation. Other compounds are also the same as phenols. How to use sprayed on a place attacked by termites at a dose of 15-20 cc/L every three days. To accelerate vegetative plant growth, liquid smoke can be sprayed on leaves at a dose of 20 cc/L every 2 weeks. Sprayed through the roots at a dose of 20 cc/L every 2 weeks [10].

2. Method to Get Liquid Smoke
Material in the form of dry teak leaf litter/pieces of wood/twigs, coconut shell, or other lignocellulose material is roughly cut, measured, and weighed before being put into the furnace/kiln. Rough cutting is in order to facilitate the combustion process [11]. Adjusting the oxygen concentration is using an air regulating valve located at the top of the drum. The oxygen regulating valve is opened during the combustion process so that the combustion process takes place quickly, then closed if the material has been burned in the furnace/kiln (Figure 2).
Figure 2. Furnaces (kilns) for the production of charcoal and liquid smoke

Smoke from burning material is channeled through a condenser to convert smoke into liquid [11-13]. During the carbonization process, temperature monitoring is carried out using a temperature gauge mounted on the top of the furnace. The pyrolysis stage ends at a temperature of 400-450°C, where the smoke is thinner and has a clear blue color. The initial furnace section is then covered using bricks and sand to prevent complete combustion in the furnace. The pyrolysis charcoal and liquid smoke are then allowed to stand for 24 hours for the cooling and settling process. The final stage of the production of liquid smoke is filtering tar using filter paper or cloth.

3. Results and Discussion

3.1. Liquid smoke of teak leaf litter

Teak leaf litter waste which is processed into liquid smoke has a yield that is very dependent on the moisture content of the material. The drier the material the less liquid smoke obtained. The average liquid smoke obtained in this study ranged from 15-20%. Based on the Py-GCMS analysis conducted at the Integrated Laboratory for Forest Products Research and Development Center, there are 15 chemical components contained in the Liquid Smoke of Teak Leaf Litter (ACSDJ) which can be seen in Figure 3. The dominance of the analysis shows that a total of 67.51% consists of acetic acid (acetic acid), 23.2% total phenol, and 3.63% Nitrogen oxide.

The component of alcohol, phenol and acetic acid in liquid smoke is an indication of a compound that has synergy function as a protein regulation and can hydrolyze lipids, so that it can damage the cell membrane of the fungus's body tissue and inactivate enzymes secreted by the fungus [7], Pelczar in [9]. Therefore, liquid smoke has the potential to be anti-germ or anti-microbial. While phenol is a compound that has a characteristic odor and antiseptic properties, the function of phenol among others is in regulating the activity of certain enzymes, is toxic to insects and to plant predators Wawoeruntu et al. in [14]. Phenols also affect the development of termites, anti-fungal and bacterial Cowan in [14]. Other compounds besides phenols, furfural compounds, function as pest control of the Nematode animal group. According to Wiyono in [15], liquid smoke contains alkaloids and secondary metabolites that can be used as pesticides. In addition, the high content of acetic acid in liquid smoke of teak leaf litter (67.51%), is more suitable as a stimulant and fertilizer for plant growth, compared to the phenol content and its derivatives of 23.2%, but if applied together, it will be more optimal both as a stimulant and plant fertilizer, as well as prevent the attack of plant diseases by microbes (fungi and bacteria).
3.2. Utilization of teak leaf litter by the community

3.2.1. Charcoal briquettes
The Partnership of the Institute of Research and Community Service (LPPM) of IPB, the Department of Physics-FMIPA IPB and the Blora Forest Service, carried out the use of teak leaf litter into charcoal briquettes (Figure 4), bio pellet, activated charcoal, and liquid smoke, which were processed in a simple process. Teak leaf charcoal is used as an enhancer of land fertility. Active teak charcoal is used to absorb pollutant waste, so that agricultural land is not easily damaged and also improve land quality. At present, more than 50 people who are members of farmer groups in Blora are carrying out this activity, but the products produced are still limited to meeting their own needs [17].
In Purwodadi, Tepus, Gunung Kidul, there are around 1,219,059 teak trees. Teak trees that drop their leaves every dry season provide a new problem for the surrounding community. These dead leaves that fall into waste that has not been properly utilized and disrupt agriculture. Therefore, the manufacture of charcoal briquettes is an alternative use of this dry teak leaf litter [17]. Testing the calorific value of dried teak leaves is conducted in a laboratory Chemical processing and energy for non-timber forest products using a bomb-calorimeter. From the test results it was found that the calorific value of dried teak leaves ranged from 3902-4117 cal/gr. The process begins with making teak leaf charcoal waste, then mixed with adhesive and then printed. Dry teak charcoal briquette dried, and tested in accordance with national briquette standards. The parameters tested were the calorific value (cal/gr), vapor content (%), ash content (%), moisture content (%), vaporizer content (%), bounded carbon content (%), density (g/cm³), and compressive firmness (kg/cm²). The test results showed that almost all the quality parameters of dry teak leaf charcoal briquettes still did not meet the specified standards, except for the parameters of water content and briquette density, except after mixed with coconut shell charcoal which has high quality standards, the parameters of teak leaf charcoal briquettes meet national briquette standards. The calorific value has increased to more than 500 cal/gr to 5800 cal/gr, a relatively high value Laila and Arham on [17].

3.2.2. Teak leaf waste compost
CV Bahari Mitra Surya, has used teak leaf waste for compost made in Plembutan Village, Playen District. The company chose dry teak leaves because the company saw that Gunung Kidul's earth was mostly planted with teak trees. Dry teak leaves are easy to find, making it easy for farmers in Gunung Kidul to collect dried teak leaf waste. After the teak leaves are collected, farmers sell it to CV Bahari Mitra Surya at a price of IDR 325. Utilization of dried teak leaves has opened employment opportunities for local residents. Dry teak leaves are milled until smooth, then fermented for one week using water and sugar cane drops. After one week fermented, teak leaf waste is dried for two hours in the sun, then put into a sorting room. After the sorting process is complete, then packaged, then sent to Japan [29]. One week the company can produce 2560 compost fertilizer packages Wahyuni et al. in [2].

3.3.3. Benefits of Teak Leaves in the Health Sector
Some people who live around the teak forest, teak leaves are useful for treating health and reducing the symptoms of several diseases, although it has not been able to completely replace medical treatment. Some of the diseases that have benefited include the following:

a. Helps reduce asthma symptoms. Teak tree leaves have benefits to reduce and prevent asthma. Extracts from the leaves of teak plants had a significant effect as an anti-asthma

b. Help treat intestinal worms. Leaves from teak trees are believed to fight parasitic infections such as worms. Extracts from teak leaves can be used to treat intestinal worms. The study was conducted by determining the time of paralysis and death of the worms against standard piper zine citrate drugs. As a result, teak tree leaves have quite a powerful effect such as piper zine citrate against disease-causing worms

c. Skin care. Teak leaf extract can be used as an anti-inflammatory agent on the skin, which is taken by squeezing or grinding. Then the juice is used to treat various skin diseases due to inflammation, such as acne, and can help overcome itchy skin [3]

d. Diuretic agent. Teak tree leaves are believed to help diuretics in the body so that it becomes more frequent urination. According to Phalphale et al. [18] aqueous extract from teak tree leaves has the diuretic effect.

e. Rich in antioxidants. Teak leaves contain antioxidants that are good for the body against free radicals. Ramachandran et al. [19] found that phenolic components in teak leaves have excellent antioxidant agents. Free radicals themselves can be a cause of cancer cell growth and premature aging.
f. Accelerate wound healing. According to Majumder et al. [20], the front of the teak leaves can be used as a wound healer, especially for blisters or burns. This study evaluated hydrochloric extracts from teak leaves in rats. The results show that the leaves of teak tree can accelerate the repair of damaged cells and skin tissue so that the wound heals faster.

g. Stimulates hair growth. Ragasa et al. [21] found that oils from teak leaves can be used to accelerate hair growth. Then Jaybhaye [22] also found that seeds from teak plants can be used as hair tonics. So those who want to have long hair, and experience hair loss can benefit from teak leaves.

h. Antifungal. Astiti and Suprapta [23] suggested that the anti-fungal activity of *Arthrinium phaeospermum* the extracts of dried teak tree leaves showed that fungal growth could be prevented.

i. Laxative agent. Teak tree leaves can be used as a natural laxative or laxative. Teak leaves work as a stimulant and encourage the release of feces (dirt) from the intestine. Therefore, teak leaves can treat constipation.

j. Against disease-causing bacteria. Teak leaves have properties against *Listeria monocytogenes*, the bacteria that causes listeriosis, which is found in food. In addition, teak tree leaves can also inhibit the growth of *Staphylococcus aureus* bacteria and other bacteria causing infections.

3.3.4. Benefits of teak leaves for people with diabetes

Teak trees are not only the wood that is used to make household furniture, but teak leaves also have health benefits. The benefits of teak leaves in the health sector are widely used, one of which is to treat diabetes. The content contained in teak leaves are as follows:

- Saponin is a type of compound that functions as an antioxidant in the human body that is useful to fight free radical attack from outside. Antioxidants work to prevent premature aging of the skin. As is known antioxidants can prolong the aging process on the skin.
- Tannins in the health sector function as anti-bacterial agents against bacteria from the outside so that it can boost the immune system.
- Kuinon functions as an addition of vitamins to the body to meet the needs of vitamins for the body.
- Flavonoids are useful to fight allergies in the body so that the body is safe from the effects of allergies in the form of itching and swelling. Flavonoids are one of the most common groups of secondary metabolites found in plant tissue. Flavonoids are included in the group of phenolic compounds with the chemical structure of C6-C3-C6. The flavonoid framework consists of an aromatic ring A, an aromatic ring A, an aromatic ring B, and a middle ring in the form of oxygen-containing heterocyclic and oxidized form of the ring which is the basis for the division of flavonoids into the sub groups. The numbering system is used to distinguish the position of carbon around the molecule Cook in [24].
- Quercetin is used to prevent heart disease. Today's heart disease is one of the number one deadliest disease. So that awareness to care for the heart to stay healthy is needed early Cook in [24].
- The content contained in teak leaves is useful for treating diabetes. Diabetes is a complication of the body against the hormone insulin which cannot be used properly [25].

3.3.5. Benefits of teak leaves in other health areas

Not only to treat diabetes, but the decoction of teak leaves also has other health benefits such as treating diseases:

a. **Cholesterol.** The first benefit of teak leaves is to reduce cholesterol levels from the body. As it is known that high cholesterol levels in the body can cause complications for heart health. The heart is the most vital organ in human life. The heart’s duty is to pump blood throughout the body so that all organs can work properly. Many factors can increase cholesterol levels in the body one of them is food such as fat, meat, cheese and fast food. Therefore, it is important to avoid foods that have adverse effects on health in the long run. Make it a habit to include fresh fruits and vegetables in your daily menu. In general, normal cholesterol levels between 160-200 mg. And not all cholesterol is bad for health. Cholesterol also has a good function in the form of protection for the body in the health sector. Cholesterol is good for the body as long as it is within the normal amount [26].
b. **Hypertension.** High blood pressure is a type of disease that is still associated with the heart. One of the benefits of drinking teak leaves is to normalize blood pressure in the body. Teak leaves contain saponin compounds that are useful for antioxidants that are sourced from outside the body [26].

c. **Anemia.** Anemia is caused by the reduced ability of hemoglobin to bind oxygen in the blood. If this ability is reduced, the body will become weak and tired easily. Anemia can be categorized as a non-communicable disease. This anemia if left unchecked can have fatal consequences such as sudden death. Anemia can be treated with natural ingredients such as stew from teak leaves. Teak leaf stew can be made at home and more practical than using other chemical drugs. Not to mention the natural benefits of this material do not cause side effects [26].

3.3.6. Benefits of teak leaf waste for alternative animal feed

Farmers in Girisekar Village, Panggang District, Gunung Kidul Regency, DIY, succeeded in making alternative animal feed from teak leaf waste. Teak leaf waste is very easy to find in the breeders' environment because in Gunungkidul there are indeed many teak plantations. This teak leaf waste is processed into animal feed by fermentation. Assisted by 28 KKN students (Kuliah Kerja Nyata) from Gadjah Mada University, the breeders in 3 hamlets in Girisekar Village namely Warak Hamlet, Sawah Hamlet, and Bali Hamlet succeeded in processing the environmental waste around them into valuable goods. Not only teak leaf waste can be processed into alternative feed, rice waste such as corncobs, tebon, yams, straw, and banana gedebog can also be utilized. From its geographical location, the Gunung Kidul area is categorized as hilly and barren land so that in the dry season it is difficult for farmers to find forage feed such as Kolonjono grass. The breakthrough to make alternative animal feed from environmental waste is certainly very helpful for farmers [27].

The process of making alternative animal feeds by fermentation is very easy. First of all, dry teak leaf waste and other waste is chopped using a chopper then mixed with bran. Next, the ingredients are moistened with a mixture of water, molasses, and liquid organic supplements (SOC). SOC is an organic supplement made from herbal ingredients that can stimulate the appetite and growth of farm animals. All ingredients that have been mixed are then put in a closed barrel for several days until they are fully fermented [27]. The process of making alternative animal feed from dried teak leaf waste is cost-effective because it only uses molasses and SOC which is more affordable than buying feed on the market. In addition, alternative feed is also environmentally friendly because it uses organic ingredients and reduces the amount of waste. Farmers in Girisekar Village, Panggang District, Gunung Kidul Regency, DIY, succeeded in making alternative animal feed from teak leaf waste. Teak leaf waste is very easy to find in the breeders' environment because in Gunung Kidul there are indeed many teak plantations. This teak leaf waste is processed into animal feed by fermentation [27].

3.3.7. Benefits of teak leaf waste as soap material

Teak leaves are extracted by maceration method using two types of n-hexane and ethanol solvent. Liquid soap preparations from teak leaf extract with a concentration of 0.01%, 0.02%, 0.03% can inhibit the growth of *Escherichia coli* bacteria that is equal to 15 mm, 17 mm, 19 mm, whereas the inhibitory power of *Staphylococcus aureus* is 15 mm, 17 mm, and 19 mm. Increasing the concentration of teak leaf extract in liquid soap can increase the inhibition of bacterial growth. The results research of Agnes [28], showed that the quality of all teak extract liquid soap formulas proved to be in accordance with SNI standards consisting: organoleptic tests, pH measurements, homogeneity tests, and foam height measurements.
Figure 5. Process of making teak leaf waste for alternative animal feed [27]

4. Conclusion
The potential of community forests that have not been utilized at this time, such as teak leaves that can be processed into liquid smoke which is an alternative material for bio pesticides and stimulants and fertilizers in increasing the productivity of agricultural land, soil fertility, and opening new jobs. In utilizing forests, it does not have to be wood, but there are many potentials that have not been optimally utilized, such as teak leaf litter. Liquid smoke from teak leaf litter waste has a high content of acetic acid, which has the potential to be used for stimulants and plant fertilizers.

Teak leaf litter waste used for charcoal briquettes can be improved by mixing quality with coconut shell charcoal, as an alternative household energy.

Waste of teak leaf litter by the surrounding community is used to cure several kinds of diseases that are closely related to body health, used for compost which is exported to Japan, even teak leaf litter waste is also used for alternative animal feed.

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