A review: The utilization and its benefits of liquid smoke from lignocellulosic waste

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Abstract. In the integrated charcoal technology, the smoke arising from the process is flowed into a pipe which is cooled, so that the smoke turns into a liquid, so it is called liquid smoke. Therefore, the technology to produce liquid smoke is environmentally friendly. The raw material used in the process of making wood vinegar is generally in the form of lignocellulose waste which contains lignin and cellulose such as wood waste, bamboo waste, oil palm shell waste, coconut shell waste and others. With simple technology input, liquid smoke can be produced from this waste, which has many benefits. The method to produce the liquid smoke was through a process of charcoal or pyrolysis which produces three forms of solid products, namely charcoal, products in the form of gases, namely smoke, and products in the form of liquids, so called tar and liquid smoke; and the main component as a characteristic of liquid smoke were acetic acid, phenolic and carbamic acid. Phenol is the compound that plays the most role in liquid smoke, because it is antibacterial and antifungal and inhibits fat oxidation. Therefore, liquid smoke with its various benefits can be a solution for the problems of pets and bacteria in agriculture or environmental pollution.

1. Introduction
Since 2003 the Forest Products Research and Development Centre has been developed and socialized the Integrated Charcoal Technology (TAT) for making charcoal. In the carbonization process of making charcoal, by product will be produced in the form of smoke and will cause air pollution and damage the environment. However, with TAT technology, the smoke arising from the process is flowed into a pipe which is cooled, so that the smoke turns into liquid, so it is called liquid smoke. Liquid smoke or wood vinegar is yellow-brown to black distillate obtained from the carbonization process of making charcoal is part of product which. The applications are mostly for the growth of various types of crops, both forestry and agricultural and plantation crops with significant yields [1-3]. Therefore, the technology to produce liquid smoke is very environmentally friendly, moreover the materials used are various types of waste.

According to [4] the result of the main ingredient of three kinds of liquid smoke commercials showed that Gas Chromatography-Mass Spectrometry (GC-MS) analysis of liquid smoke dichloromethane extracts revealed that carbonyl-containing compounds were major constituents of the samples liquid smoke, in which 1- hydroxy-2-butanone, 2(5H)-furanone, propanal and cyclopentenone predominated. The prospect of implementing liquid smoke is very broad, including the food industry as a preservative, the health and cosmetics industry, plant fertilizers, bio-insecticides, pesticides, disinfectants, herbicides and so on [5]. The main ingredients of liquid smoke are acetic acid, phenol and methanol Liquid smoke
can be utilized as a skin disease drug, bio-pesticide, plant growth promoters, food preservative, wood preservative, room cleaner, absorbent of toxins in the body, anti-oxidant, anti-microbial, coagulant and deodorizing in rubber processing, fungal prevention and others.

Several areas in Japan, such as Shitara in Aichi Province and places in the Togo Islands, have become the centre for producing liquid smoke. In Togo Prefecture the liquid smoke also used as fertilizer and pesticide, not only for health. As a fertilizer for juvenile plants, the liquid smoke was sprayed over the leaf surface with a concentration of 1:1000. On the other hand, the liquid smoke solution is watered on around the plants every two weeks, for grown-up plants [6]. Meanwhile, European Union people and American countries are accustomed to eating grilled meat which is first soaked in a liquid smoke solution which has been purified through several times distillation, so that removed the harmful oil and tar and using this method will last longer in the storage process of the meat [7]. This paper presented about information of several research result of the various benefits of liquid smoke from lignocellulosic waste.

2. Raw Materials for Liquid Smoke Production

Forest Products Research and Development Center (P3HH) from 1995 to 2000 starting focusing on the waste utilization method which was the main method of the Integrated Charcoal Technology (TAT) and it is a technological innovation of choice and a solution to overcome various types of lignocellulosic waste. The technology which in the process and application is carried out in an integrated manner and it is a technological innovation that produces liquid smoke, charcoal and bioactive compost charcoal (arkoba) [1].

The quality of liquid smoke depends on the raw materials we used. The lignocellulose waste was abundant and potential is all around us. Whether originating from forestry, agricultural, plantation or industrial timber waste (Figure 1). Even dry leaf waste or litter can also produce liquid smoke to get liquid smoke, the method is done through a process of charcoal or pyrolysis which produces three forms of solid products, namely charcoal, gaseous products, namely smoke, and products in the form of liquids, namely tar and liquid smoke. If the smoke from the coking process is cooled through the cooling pipe/condenser, the smoke will change form into a liquid called liquid smoke (Figure 1) [9].

![Liquid smoke stove developed and socialized by P3HH](image-url)
Figure 2. Several types of lignocellulosic waste as raw material for liquid smoke [12].

Liquid smoke has many uses in household, small business and industrial life such as food preservatives, wood preservatives, sap freezing agents, pesticides and fertilizers. According to [10] said that the diversity of raw materials and production methods of liquid smoke produces complex chemical components with various structures, reactivity and sensory activities. According to [11] stated that during pyrolysis cellulose will undergo hydrolysis to produce glucose and further reactions produce acetic acid, water and a little phenol. Lignin in pyrolysis produces phenol compounds and their derivatives and pyrolysis at high temperatures will produce tar. During pyrolysis, cellulose will produce furfural, furan with carboxylic acids.

3. The Ingredients of Liquid Smoke

Liquid smoke of three species of bamboo investigation has been conducted by using modified drum furnace. The materials used are three types of bamboo which comes from West Java, namely black bamboo (Gigantochloa atriviolacea Widjaja), spotted bamboo (Bambusa maculata Widjaja) and bamboo betung (Dendrocalamus asper (Schult. F) Backer ex Heyne. The results showed that the range Ph of the samples between 2.70-3.36 (Japan standard); the yield of the samples ranged from 5.00 to 24.00%; acetic acid contains between 31.37-83.59%, the value of methanol content was 1.37-2.07% and 0.99-1.03 value of gravity; and the total phenol were 0.56-1.24%. Phenol, methanol and acetic acid content of the liquid smoke of black bamboo has the highest value, followed by the spotted bamboo and bamboo betung [14].

Acetic acid (acid group) is the important contains in liquid smoke which can stimulate plant growth. Phenols, quinols and pyrogallols act as antioxidants, antiseptics and anti-bacteria. On the other hand, propionic acid can prevent fungal growth and is also a fish preservative. while Acid compounds contained in liquid smoke are organic acids that are formed as a result of the pyrolysis of wood chemical components such as lignin, cellulose and hemicellulose [13]. Alcohol, phenol and acetic acid are indicated as compounds that have a synergistic function as protein denature and can cleaved lipids, so that they can damage cell membranes in fungal body tissues and inactivate enzymes secreted by fungi [15] in [16,17].

Phenol is a compound that smells unique, has antiseptic properties, phenol functions, among others, in regulating the activity of certain enzymes, is poisonous to insects, is poison for plant-eating animals [18]. In addition, phenol has an effect on the development of termites, has anti-fungal and bacterial properties. Other compounds besides phenol, namely furfural compounds, function as pest control for the nematode animal group. According to [19], said that liquid smoke contains alkaloids and secondary metabolites that can be used as pesticides.

Acetic acid and furfural are compounds that have the ability to drive off the snail pests. Rejection of pests is due to the presence of these compounds simultaneously [13]. Liquid smoke contains alkaloids and secondary metabolites which can be used as pesticides, [20] also states that liquid smoke contains chemical components which functions to accelerate plant growth and prevent plant diseases. The results of other studies indicate that liquid smoke is useful for improving soil quality and helping plant growth to be better and stronger and more resistant to pests and diseases [20,21]. The potential demand for
liquid smoke products increases with the emergence of a government ban on the use of formaldehyde as a preservative food.

![Figure 3. Liquid smoke produced by P3HH (A) and by Lakitan FMU (B) [2].](image)

4. The Benefits of Liquid Smoke
From several trials and research results, it turns out that there are many benefits of liquid smoke that can be used in everyday life, including: (a) Promote growth and strengthen plant roots, (b) Fertilize the soil and inhibit the growth of pests and plant diseases, (c) Improve quality and multiply fruit up to 70%, (d) Increase the number of microbes that are useful for soil and plants, (e) Increasing the success in seeding plants, liquid smoke dosage of 0.125% mixed in the media before sowing seeds can kill pests and diseases in seedlings, (f) Reducing pests and diseases in the planting hole, so that the roots are healthy, (g) Reducing miscarriage on fruit, by spraying a mixture of liquid smoke and water on the pistil of the fruit, (h) Absorb toxins in the body (detox), (i) For cosmetic and other medicinal ingredients, (j) Inhibit the growth of fungi and bacteria, (k) Especially in the rubber industry, liquid smoke is used as deodorize. Also used to coagulate latex and keep rubber from changing color. The dosage used is 5 ml of liquid smoke dissolved in 1 L of water [17].

Phenol is antibacterial and anti-fungal and can inhibit the fat oxidation. Other compounds also have the same properties as phenols. In addition to preserving fish and meat, liquid smoke can also be used as a wound healing drug, a mixture of animal feed, antioxidants, and pesticides. Liquid smoke produced from coconut coir is sold at various prices, starting from from IDR 30,000/liter to IDR 10 million/liter, depending on the distillation process (re-filtering) being carried out [2].

Liquid smoke has many benefits and has been used in various industries. As in the food industry, where liquid smoke has enormous uses as a specific flavor and aroma agent as well as a preservative because of its antimicrobial and antioxidant properties. Liquid smoke can also replace the traditional fish smoking process that was previously directly smoked, so it can disturb the environment. In addition, liquid smoke can also be used in food processing such as tofu, wet noodles and meatballs. Phenolic compounds are responsible for the formation of flavors in smoking products and also have antioxidant activity that affects food storage [11]. The components of phenolic compounds that play a role in flavor formation are guaiacol, 4-methylguaiacol and 2,6-dimethoxyphenol. Guaiacol plays a role in giving a smoky taste, while syringol gives a smoky aroma [23]. [11] also suggests that the chemical components in smoke play a major role in determining the quality of smoking products because in addition to forming a distinctive flavour, texture and color.

In the plantation industry, liquid smoke can be used as a latex coagulant with liquid smoke functional properties such as antifungal, antibacterial and anti-oxidant, which can improve the quality of the rubber products produced. A mixture of liquid smoke and water (1:300) can accelerate the breakdown of compost and prevent ammonia gas from forming. Therefore, liquid smoke also has the effect of eliminating unpleasant odors when sprayed on garbage piles. What is extraordinary is that the liquid smoke which is rich in hydrocarbons is able to kill certain pests in vegetable cultivation [8].
5. The Success Stories of Liquid Smoke Development

5.1. Socialization and dissemination of liquid smoke development

P3HH has carried out development activities related to TAT that have been carried out since the 2000, which are packaged in socialization and dissemination activities as well as technology degrees, technology transfer and training in various places and regions, both in government and private agencies as well as in community organizations and forest farmer groups and women farmer groups (KWT). Among KWT that have implemented this technology are the women’s groups that are members of one foundation, namely YPPK (Village Women’s Association Foundation), Toraja, and KWT Dewi Sri Bojongpicung, Cianjur Regency. YPPK Toraja started training on integrated charcoal technology in 2013, while KWT Dewi Sri Bojongpicung, Cianjur Regency has started since 2010. In 2015, the focus of the study was KWT Dewi Sri Bojongpicung, Cianjur Regency. In addition, the implementation of TAT has also been socialized in Karo District (Siosar, Sugihen, Munte, Simpang Selakar, Buluhnaman, and Singa) and applied by the community to eradicate fruit fly pests that attack citrus and vegetable crops. In addition, it is also applied as a skin disease medicine and a mixture of refreshing drinks [2].

5.2. Liquid smoke and fire control

So far, the land clearing process carried out by the community is by directly burning branches, grass and other materials in the field with the aim that the land becomes clean and fertile and the smoke is discharged directly into the air (25% charcoal yield, 75% smoke). However, if uncontrolled, it will cause forest and land fires. With a touch of a little technology, the smoke released can be captured by condensing the smoke into liquid (controlled burning) so that it can be of better use to increase land fertility, land productivity and reduce use [1]. chemical fertilizers and pesticides and can generate additional income. The implementation of smoke control in overcoming forest fires has been carried out by Manggala Agni in Ketapang in collaboration with P3HH by educating people around the forest about proper and correct land clearing (controlled burning), namely by technological methods two in one with the following stages.

Farmers collect flammable materials such as twigs, dry grass and other flammable lignocellulosic materials and put them in a stove equipped with a cooler made of bamboo. The material is then burned with limited oxygen so that charcoal is produced and the resulting smoke is passed through the bamboo (3-4 meters long) into a liquid called liquid sap. If the materials in the furnace run out, new raw materials can be added until they run out [3]. This technology can be done individually or in groups. The liquid smoke produced by these community groups is applied to agricultural crops (chilli, eggplant, etc.) and added to animal feed. The results of this liquid smoke application have been shown to significantly increase farmers' income. The same thing is done in KPH Ketapang and Lakitan on peatlands where land fires often occur, with the same technology, the community around the peatland feels the benefits of the liquid smoke produced which is also applied to latex as a coagulant which has been using chemicals (acid ant). It is hoped that the community will no longer need to open fire in clearing land that can cause fires, and the community will protect the forest and its ecosystem so that it can produce wood vinegar so that they can get additional income.
5.3. **Cancer care halfway house in simalungun introducing TAT bambu products**

TAT used for cancer patients is specifically charcoal and liquid smoke made from bamboo. In the form of herbal medicines that have been combined into simpler dishes such as teabags, liquid smoke, and capsules. In addition, there is also bamboo carbon embedded in the vest. The results of this study are in collaboration with Edwar Technology. This herbal drug kills cancer cells will soon be marketed to the public at Environment and Forestry Research and Development Institute of Aek Nauli. Each visitor can check his/her body for cancer cells at the cancer care shelter. Visitors can also try or buy bamboo charcoal which has been packed into various types. Visitors can see whether there is active cancer or not [24].

Bamboo charcoal has been tried in the last few months. Hopefully while on tour as well as health checks. Wear a vest and drink charcoal coffee while therapy. Bamboo plants have advantages, namely fast growing, short cutting cycle of 3-5 years, various benefits, especially for health, high holocellulose content, closely related to Indonesian culture, the ability to absorb high N and CO₂ so that they play an important role in reducing climate change [25]. Its distinctive root shape allows bamboo to withstand water and erosion, making it very good for forest and land rehabilitation, especially around Lake Toba. In addition, bamboo charcoal is unique with its infrared light emitting properties, so it will accelerate the body's metabolism for the wearer [25]. The development of open houses is motivated by the condition that cancer is a major public health problem in Indonesia. The death rate from cancer in Indonesia reaches an average of 50 percent with the burden of cancer treatment costs continuing to increase [25] Suhemi from Edwar Technology revealed that the product in the form of a vest has been marketed to four countries. He said that these four countries used this discovery to be given to cancer patients. However, he regretted that many Indonesians went abroad for medical treatment at a high cost. In fact, the recommended medicine is sourced from Indonesia. In Indonesia, this bamboo carbon vest is sold for around Rp 20 million a set. However, when buying abroad the price can be quadrupled. The inauguration of the Cancer Care Halfway House was marked by cutting the ribbon by the Secretary of Forestry and Environment Research, Development and Innovation Agency, Sylvana Ratina at the Environment and Forestry Research and Development Institute of Aek Nauli [26].
Figure 5. Cancer Care Halfway House and supporting products, cooperation between P3HH and CTECH Labs Edwar Technology at Environment and Forestry Research and Development Institute of Aek Nauli [25].

Figure 6. Application of liquid smoke on chocolate plants [1].
Figure 7. Application of liquid smoke in the pine nursery at PT TBP Halmahera [1].

Figure 8. Demonstration of Liquid Smoke Application at KPH Lakitan (South Sumatra) [1].
Figure 9. Application of TAT products to cassava plants grown in pots [1].

Figure 10. Production and application of liquid smoke at PT TIA [25].
Figure 11. TAT application on peatland in KPH Lakitan, P3HH cooperation with BRG and KPH Lakitan in order to control peatland fires [25].

Figure 12. Application of liquid smoke on guava plants attacked by stem borer [1].

The secret and uniqueness of liquid smoke is obtained through the cooling process of smoke arising from the coking process. Behind the dark color and pungent odor, it turns out that it contains many beneficial benefits for humans, animals and plants. If smoke is allowed to escape into the air, it will become a pollutant, but with a little technology input it can be turned into a multifunctional resource [5].

With various chemical contents contained in liquid smoke such as: alcohol, aldehyde, ketones, organic acids such as furfural, formaldehyde can be used as a preservative. Meanwhile, phenols, quinols and pyrogallols act as antioxidants, antiseptics and anti-bacteria. In Indonesia, there are many potential raw materials for liquid smoke such as wood waste, bamboo waste, palm oil waste, coconut shell waste and others. With simple technology input, liquid smoke can be produced from this waste, which has many benefits [4].
6. Conclusion
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