Industrial symbiosis of fragrant lemongrass distillation in West Java

A Aviasti*, N Nugraha, R Amaranti and A A Nurrahman

Department of Industrial Engineering, Universitas Islam Bandung, Jl. Tamansari No. 1
Bandung 40116 Indonesia

*aviasti82@gmail.com

Abstract. The fragrant lemongrass oil processing industry is one of the industrial activities that provides a major contribution in improving the economy of the community, especially the business actors involved, namely farmers and processing industries of fragrant lemongrass oil. Based on the results of preliminary research that has been carried out there is a major problem of lack of collaboration between industries of refined citronella oil refiners. The main objective of this study is to determine the right industrial symbiosis model for small and medium scale citronella oil processing industries so as to optimize the potential and resources possessed and be able to integrate it with other industries. The approach method used to support the success of the output target is to conduct a structured stage of research starting from preliminary studies, formulating the problem and determining the objectives of the study, literature study, determining the steps of research, gathering the required data, and designing industrial symbiosis models. The results obtained are that there are several industrial symbiosis alternative models for fragrant lemongrass (sereh wangi) distillation in accordance with the characteristics of each region.

1. Introduction
Indonesia is one of the world's leading producers of essential oils with the ability to supply around 85% of the world's essential oil needs. Indonesia also has huge potential for the essential oil industry. In recent years, essential oils have received considerable attention from the Indonesian government through various programs at the Ministry of Agriculture. Some types of essential oils produced by Indonesia are clove oil, cananga oil, patchouli oil, nutmeg oil, sandalwood oil, cinnamon oil, fragrant roots, eucalyptus oil, and fragrant citronella oil [1].

Fragrant citronella oil is a commodity in the agribusiness sector that has a good market and is highly competitive in the overseas market. Fragrant lemongrass as one of the plants that can produce essential oils can also be used as basic ingredients for soap, mosquito repellent, pesticides and even bio-additive basic ingredients, which can be useful for saving fuel on vehicles.

The development of fragrant lemongrass and essential oils processing has a very high positive value because it not only contributes to the development of agriculture, but also contributes to improving the economy of the community. The development of fragrant citronella oil processing in the countryside is one of the strategic steps in spurring regional economic growth, in addition to increasing employment opportunities, increasing added value and competitiveness, as well as the income of essential oil-producing farmers [2].
The main problem in the lemongrass oil refining industry so far has been the unclear supply chain of fragrant lemongrass products, which has caused farmers to be less interested in planting fragrant lemongrass. Other problems identified as occurring in fragrant citronella oil refineries are the lack of an advanced industrial processing of fragrant lemongrass oil, and the formation of a good refining industry system. In addition, the interaction of the fragrant oil refining industry with other industries in the utilization of raw materials, energy, water and waste management has not been clearly defined.

Therefore, it is necessary to formulate how the development of the essential oil industry in Indonesia (especially in West Java) including the development of a fragrant citronella oil processing industry must be carried out. The industrial development of this sector can be in the form of improved varieties, empowerment of farmers, assisting processing units and breeding of seeds. The most important thing in the effort to develop a fragrant lemongrass oil processing industry is to increase the competitiveness of fragrant citronella oil through quality improvements, competitive prices, continuity of supply, integrated guidance, utilization of appropriate and clear technology, and encourage the growth of advanced industries. In addition to this, efforts to develop the fragrant citronella oil refining industry must also be taken into account as to how the fragrant lemongrass refining industry can interact with other industries and cooperate in the use of materials, heat, energy, water and by-products. This interaction is known as industrial symbiosis whose ultimate goal is to build an environmentally friendly industrial system.

2. Literature review

Research related to industrial symbiosis has been carried out by Aviasti discussing how to model symbiotic simulations of the sugar industry and fertilizer industry in an eco-industrial park [3]. Several other studies discussing the symbiosis of the industry include Yazan et al., Zhang et al., and Puente et al. The study conducted by Zhang et al. discusses the three-level approach to symbiosis (the case in China's Hai Hua Group (HHG)) and the effort to combine cleaner production and industrial symbiosis in a mutually beneficial way [4]. Yazan et al. studied industrial symbiosis based on material and energy flows and the suitability of waste demands to be the main input. This analysis is useful for setting strategies for companies and local government policies on how to move towards perfect industrial symbiosis [5]. Research conducted by Puerto et al. discusses industrial symbiosis in small and medium enterprises [6]. Chertow explains that industrial ecology is divided into 3 (three) levels, namely those focused on the level of facilities, the level between companies and the level on a regional or global scale [7].

Researches on industrial symbiosis discuss more about industrial symbiosis in large industries and are well structured. This research will try to formulate how fragrant lemongrass distillation industry interacts with other industries (industrial symbiosis).

2.1. Industrial ecology

The term Industrial ecology was first introduced by Robert Frosch with Nicholas Gallopoulos in 1989 in the Scientific American Journal under the title Strategic for Manufacturing. Frosch includes the concept of Industrial Metabolism introduced by Robert Ayres to compile a systematic change of materials in the modern economy. Frosch and Gallopoulos suggest the need for an industrial ecosystem as an optimal use of energy and material, minimized waste and pollution, and there is an economic potential for each product in the manufacturing process [8].

The term industrial ecology is not limited to change, but also from the behavior of production and consumption networks, including disposal and energy materials [9]. The definition of other industrial ecology reveals that industrial ecology is an interdisciplinary framework for designing and operating industrial systems as a living system that depends on natural systems. Industrial ecology seeks to create a balance between environment and economy. The application of industrial ecology requires synergism with the production system, so that new innovations can be carried out for long-term benefits.

The concept of industrial ecology is the concept of optimal use of raw materials and energy by not damaging the environment. Integration between industries is needed to prevent environmental damage and at the same time increase profits for the industry. In designing an industrial ecology area consists of
several stages of process analysis, namely analysis of material flow and energy, analysis of the availability of regional natural resources, re-analysis of actual problems faced and determination of priority scales.

In the analysis of material flow and energy is used to identify raw materials and energy at each stage of the production process. This analysis also includes an analysis of the integration of mass and energy processes. The purpose of this analysis is to save the use of natural resources, analyze the use of raw materials that are more environmentally friendly and reduce environmental impacts. Completion of existing problems must be communicated with other related industries in the region. In the end there will be a mutually beneficial industry symbiosis between the industries.

2.2. Industrial symbiosis

Industrial symbiosis according to Ashton et al. has been used to describe the physical and shared management of material input and output material by geographical of company [10]. Companies involved in industrial symbiosis belonging to an industrial ecosystem. Symbiosis has been found because it is motivated by economic considerations, such as reducing costs for waste disposal, by environmental people, such as accessing limited water supplies. Communication and trust between managers are thought to play an important role in exchanges, but previous empirical studies have never been conducted.

Industrial symbiosis is a form of cooperation among different industries. This form of cooperation can increase the profits of each industry and ultimately have a positive impact on the environment. In this symbiosis process, the waste of an industry is processed into other industrial raw materials. This symbiosis process will be very effective if the industrial components are arranged in an integrated industrial park (eco-industrial park).

The first country to apply the principles of the industrial ecosystem in an Industrial Zone is in the Kalundborg region of Denmark (see fig. 1). The 'waste' exchange between independent industries in a sector has been going on for centuries for simple reasons, namely for better business purposes. However, the formation of 'industrial ecosystems' is still a relatively new phenomenon. An example of a symbiosis of a well-known and successful industrial area is industrial symbiosis in Kalundborg, Denmark. The symbiosis of the Kalundborg industry consists of six industries: the Asnaer power plant, the Statoil oil purification industry, Novo Nordisk biotechnology company, the Gyproc plywood industry Jordrens biotechnical soil remediation company, and residents.

![Kalundborg Industrial Symbiosis - 1995](image_url)

**Figure 1.** Example of industrial symbiosis in Kalundborg Denmark.
3. Method

There are several steps that must be taken in completing this study. These steps are preliminary studies, problem identification and problem formulation, setting goals and boundaries of research, literature study, data collection, data processing, analysis, and conclusions.

First do a preliminary study of the object to be used as research material that citronella oil refining industry. At this stage of the survey of fragrant citronella gardens in several areas in West Java to obtain an initial description of how the process of citronella cultivation, refining process, and preliminary information on the problems that had occurred in the citronella oil refining industry was fragrant.

The second stage was a literature study related to the topic of research, namely scientific journals on fragrant lemongrass, fragrant citronella refining, the benefits of citronella scented oil. Besides that, a literature on supply chains, production systems, industrial systems, industrial symbiosis, and methods for implementing industrial symbiosis.

The next activity is to identify the problems that occur in the fragrant citronella oil refining industry. Some of the problems found were then formulated to be the topic of the research to be conducted. This research focused on how the industry symbiosis in fragrant citronella oil refining in West Java.

Most of the data collection was done by field observations. Some data collection techniques will be carried out in accordance with needs, such as interviews, study of documents or secondary data, as well as studies of the results of testing tools or studies of the results of testing the quality of citronella scented oils. Based on the results obtained, data processing and analysis conducted to determine alternatives refining industry symbiosis lemongrass found in the field.

4. Result and discussion

Distillation technology used in the six locations is water and steam distillation, this technology is also called the steaming system. This steaming method, the material is placed on a hollow metal plate such as a sieve that is located a few centimetres above the water surface. In principle, this method uses low pressure steam, compared to the way the water distillation differs in the separation of materials and water. But the placement of both is still in one kettle. Water is inserted into the kettle up to 1/3 part. Then the ingredients are put into the kettle until they are solid and close tightly.

When boiled water, steam is formed through the steaming through small holes and through the cracks of material. Essential oils contained in the ingredients together with hot steam through the pipe to the condenser kettle. Then, water vapor and oil will condense and be accommodated in a separating tank. Separation occurs based on specific gravity. The advantage of this method is that the steam that enters occurs evenly into the material network and the temperature can be maintained to 100 °C. This method is compared to distillation of water, the yield of oil is greater, the quality is better and the time is shorter.

Based on the results of the survey in 6 locations there were 3 types of fragrant lemongrass, namely copper lemongrass, soap lemongrass and lemongrass Bogor. The Soap lemongrass and Bogor lemongrass can be harvested every 2.5 months, while copper lemongrass can be harvested after 3 months. Every 7 quintal of refined copper lemongrass and Bogor lemongrass can produce 4 - 5 kg of fragrant lemongrass oil, while for lemongrass soap can only produce a maximum of 3 kg of fragrant lemongrass oil.

The distillation machine has a distillation kettle with a capacity of 7 quintals of fragrant lemongrass and can produce 5% oil from refined lemongrass (about 4 - 5 ounces / quintal). But if the lemongrass is mixed with other types of fragrant lemongrass, it can only produce 3 ounces of fragrant lemongrass oil. The cooling tank has a capacity of 2000 liters, with a distillation spiral length to flow as much as 8 rounds or approximately 20 meters. Every time the distillation takes a minimum of 4 hours, which is cooking water 1 hour, filling with lemongrass 1 hour, and refining until the oil comes out 2 hours. So that every day at least 4 times can be refined fragrant lemongrass.

The symbiosis process has gone well because it has used fuel from fragrant lemongrass waste. The heating process only takes one and a half hours with fragrant lemongrass fuel until the distillation process can be carried out. Paying attention to the distillation process carried out in 6 survey locations, the symbiosis model occurs as shown in Figure 2 and 3.
Figure 2. Models of industrial symbiosis on Fragrant Lemongrass oil refining in Desa Manoko Lembang and Desa Cimungkal Wado Sumedang.

Figure 3. Models of industrial symbiosis on Fragrant Lemongrass oil refining in Desa Gunung Halu Cililin, Bojong Village, Nagrek, and Ciseupan Village, Cibodas District, Cangkuang Ciwidey.
5. Conclusion
The conclusion of the research results as follows:

- Fragrant lemongrass oil demand to Indonesia every year more than two thousand tons, and can only meet about 8%. Countries that become citronella oil markets in the world including the Middle East countries and China.
- The technology used to refine citronella oil is fragrant on 6 research locations, use water and steam distillation.
- There are two alternative of symbiosis models that can be implemented in accordance with conditions in the field.

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