Environmental Analysis of Traditional Tofu Production in Ledok Kulon, Bojonegoro

ENVIRONMENTAL ANALYSIS OF TRADITIONAL TOFU PRODUCTION IN LEDOK KULON, BOJONEGORO

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Abstract. Tofu MSMEs are one of the largest food sector household industries in Bojonegoro Regency. One of the villages in Bojonegoro, namely Ledok Kulon Village, has 136 traditional tofu MSMEs that have been operating for decades. Due to their high production volume, these MSMEs generate a significant amount of waste, especially liquid waste. This study aims to determine the amount of liquid waste generated by traditional tofu production and to identify alternative waste management solutions. The research was conducted with the method of analyzing the stages of production carried out and finding the potential stages of the process that cause waste. In addition, the research will calculate the Benefit Cost Ratio obtained by handling waste by MSMEs. From the results of the study, it was found that the minimum BCR value was 2.33 so that effective waste handling would be able to provide economic value and be able to reduce adverse environmental impacts.

1. Introduction

Tofu is one of the most commonly consumed foods in Indonesia, a processed soybean product that is a mainstay for improving community nutrition because it has a vegetable protein quality reaching 7.8% every 100 grams of tofu [1]. In addition, with an affordable price, tofu consumption in Indonesian households is quite high, reaching 148 grams per capita per week. This also makes the tofu industry in Indonesia one of the types of MSMEs that are widely found in various regions including in Bojonegoro district. Bojonegoro has as many as 430 tofu MSMEs spread across various sub-districts, with the largest number in Ledok Kulon Village with 136 MSMEs.

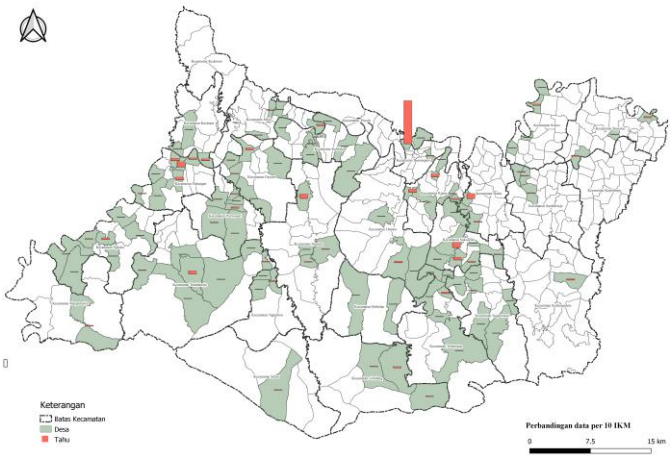

Figure 1. *Tofu Traditional Industry Distribution in Bojonegoro*

As one of the largest MSMEs in Bojonegoro, it is necessary to analyze clean and sustainable production in handling traditional tofu production, especially in the waste management process. Most of these MSMEs still use traditional equipment that requires full operators to use [2]. In addition, much of the power used comes from diesel and firewood [3]. In addition, because they still use traditional methods, MSME owners have not made proper waste management arrangements so that the waste from the tofu production process tends to be thrown away.

Figure 2. *Enceng Gondok Blooming due to the Accumulation of Organic Waste in Bengawan Solo*

This is coupled with the condition that the position of tofu MSMEs in Ledok Kulon is mostly adjacent to the Bengawan Solo river, making the position of the river a risky location for tofu liquid waste disposal. The disposal of tofu liquid waste containing vinegar will cause an unpleasant aroma and bad water view [4]. The presence of this organic waste is one of the triggers for the water hyacinth blooming phenomenon that has occurred in parts of the Bengawan Solo river. It is necessary to analyze traditional tofu production on environmental impacts to determine the potential amount of tofu liquid waste [5]. In addition, it is necessary to consider converting waste into other products in an effort to create clean and sustainable production [6]. By analyzing the economic feasibility of by-products in traditional tofu MSMEs, it is hoped that it can help MSME owners to avoid waste disposal activities and turn them into products with economic selling value.

2. Methods and Result

2.1 Research Location

The research location was conducted at one of the traditional tofu MSME locations in Ledok Kulon Village, Bojonegoro District, Bojonegoro Regency. The conditions between each MSME are almost the same because they use the same techniques and equipment in the production process. Most traditional tofu MSMEs have also been a hereditary legacy. The data analyzed at the location includes:

a) Observation of the tofu production process to find out all stages that have the potential to generate waste
b) Observations on tofu production equipment and the work environment
c) Measurement of the potential benefits of tofu waste treatment

Figure 3. *Environment Work Area of Tofu Production*

This SMEs are located in an open area, with some semi-open walls. The equipment on site includes grinding equipment, soaking buckets, stoves and cooking utensils for boiling, filtering buckets and storage buckets. The stove for the boiling process uses wood fuel, which is considered cheap in terms of cost. Meanwhile, the grinding machine uses diesel fuel.

The working environment tends to be quite noisy because there are no machine silencers and workers use radios as entertainment while working. Air circulation only relies on natural air without any additional circulation devices, so workers will sometimes feel too hot during the boiling process. Light also relies on sunlight coming through the open area. Lights are used at night only, while the production process runs from morning to evening.

2.2 Description of Research Location

The tofu production process carried out in Ledok Kulon Village is a traditional type of production with manual tools or requires machine operators. The production process carried out is listed in the following diagram:

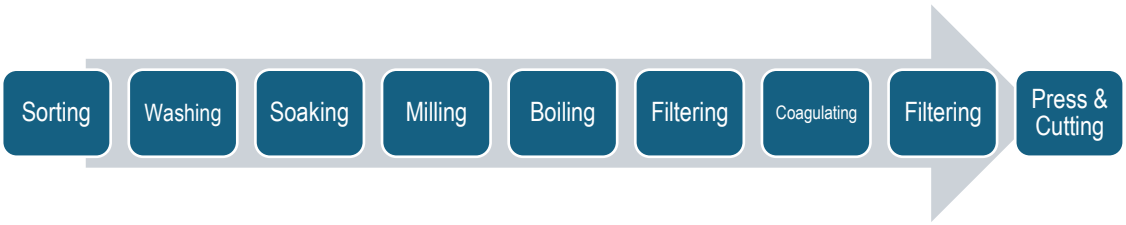

Figure 4. *Flow Diagram of Traditional Tofu Process Production*

1. Sorting, to select soybeans that are suitable for production. This process is the initial treatment of incoming raw materials. For daily production, an average of 10 kg of soybeans is used.
2. Washing, to separate impurities from the raw material. The sorted soybeans are placed in a bucket with running water so that any impurities attached to them can be removed. At this stage, a significant amount of water is used, reaching 10 liters, and is circulated through a faucet connected to a water pump.
3. Soaking, for approximately 4-6 hours to allow the soybeans to absorb water. This technique softens the soybeans, making their skins easier to peel.
4. Peeling, done manually by workers through crushing. The peeling of the skins is performed while the soybeans are still submerged in water.
5. Grinding, which is one of the core production processes. The soaked soybeans are mixed with hot water and fed into a grinding machine. The grinding machine is powered by a generator. The soybeans that come out of the grinding process become smooth and form a soft soybean paste.
6. Boiling, which is the process after the soybeans become paste, which is then collected in a large pot. The pot is heated over a stove, then a little water is added, and it is boiled for about 40 minutes. During this process, stirring is also done because foam will form from the soybean paste mixture.
7. Filtering, to obtain soy milk. The method involves placing the soybean paste on a coarse cotton cloth inside a barrel, then covering the cloth and placing it between wooden planks on the barrel's surface. The planks are secured tightly to ensure all the liquid is squeezed out. This filtering process is repeated multiple times manually.
8. Coagulation, by adding vinegar water. Vinegar water is added to the warm, yellow soybean extract, and it takes about 10 minutes to obtain perfect protein. To save production costs, the vinegar is replaced with acidic tofu waste water from the previous process.
9. Pressing, separating the vinegar water from the sediment. A sieve is placed over the sediment and pressed. The protein curds are then placed into a mold lined with muslin cloth at the bottom, covered, and weighted down with a large stone. It is left to sit for about 10–15 minutes, then cut to the desired size.

Figure 5. *Traditional Tofu Process Production*

2.3 Analysis of Block Diagram

The following is a block diagram of the production process showing the input-output analysis in the traditional tofu manufacturing process. With this block diagram, it is possible to identify each type of waste that may potentially arise from each stage of the production process.

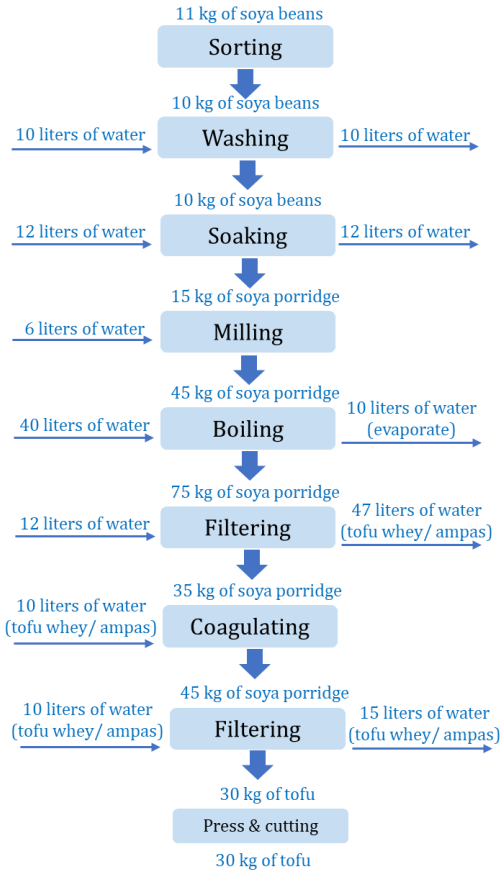

Figure 6. *Block Diagram of Tofu Production*

From the diagram, it can be seen that there is solid waste in the form of tofu porridge and liquid waste from the production process. The continuous addition of water during each stage of production also shows that water is one of the supporting materials in traditional tofu production, as well as a waste product of the production process.

2.4 Analysis of Energy and Water Usage

In addition to soybeans as the main ingredient, water is one of the most widely used materials during the production process. As shown in the diagram, the production process requires water at various stages, including washing, soaking, grinding, and boiling. In a single production run, water requirements can reach up to 80 liters. Since water is used, a significant amount of liquid waste is inevitably generated. According to the analysis, 52 liters of tofu liquid waste and 22 liters of used washing water are produced.

Table 1. Water Waste and Usage

Process	**Water Input**	**Water waste**
Washing	10 liters	10 liters
Soaking	12 liters	12 liters
Milling	6 liters	-
Boiling	40 liters	10 liters (evaporate)
Filtering	12 liters	47 liters (whey)
Coagulating	10 liters	-
Filtering	10 liters (whey)	15 liters (whey)
TOTAL	**52 liters**	**32 liters (whey)**

*Water waster and usage

The prevalence of traditional equipment means that the types of energy used in production are limited to heat, diesel, and electricity. The process that requires thermal energy is boiling, which comes from burning wood in a furnace. Meanwhile, the process that requires diesel fuel is grinding, as it is used to power the soybean grinding machine. On the other hand, the processes that use electrical energy are washing and soaking, as the water used is pumped through an electric pump. Additionally, electrical energy is also used for lighting in the UMKM building.

Table 2. Energy Resources

Energy	**Usage (per day)**
Firewoods	30 kg
Electricity	22 kwh
Diesel	3 liters

*Energi usage in tofu process production

2.5 Waste Treatment Analysis

From the production process, it is known that there are two types of waste produced in tofu production, namely:

1. Solid waste

   Solid waste in the form of tofu pulp from the filtering process. The average amount of tofu pulp produced each day is 40 kg. Tofu pulp is usually sold to farmers at a price of around Rp 3,000 per kg. As livestock feed, the nutritional content of this tofu residue is quite good, making it suitable for use by poultry, goat, cattle, sheep, and catfish farmers.

2. Liquid waste

   Liquid waste originates from the washing, soaking, filtering, and pressing processes, with a significant volume of 42 liters per day. This waste is typically channeled through ditches and directly discharged into the Bengawan Solo River, causing pollution. One option for managing this waste is to process it into Liquid Organic Fertilizer with the addition of EM4[7]. Tofu liquid waste can be transformed into organic fertilizer rich in nutrients that can enrich soil and plants [8]. Tofu waste becomes fertilizer with good nutrient content because it contains organic nitrogen, protein, potassium, calcium, and other micronutrients [9]. The presence of these nutrients indicates that tofu waste should be optimally utilized as an alternative source of organic fertilizer.

2.6 Benefit Cost Ratio Waste Treatment

Benefit Cost Ratio analysis is conducted to determine the ratio between the benefits and costs incurred during the production process [10]. In this case, the BCR calculates the ratio between the benefits and costs of processing liquid tofu waste into Liquid Organic Fertilizer (POC). The formula for calculating the Benefit Cost Ratio (BCR) is to divide the total benefits by the total costs [11].

$$BCR = \frac{\text{Total of Benefit}}{\text{Total of Cost}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

The benefit obtained is the production of POC that can be used as fertilizer for plants through the utilization of waste [12]. The estimated benefit is calculated at around Rp 35,000.00 at the lowest market price. However, the greatest benefit is actually the prevention of liquid waste from being discharged into rivers, which causes significant losses in terms of social and health aspects. Health risks that may arise from river contamination include health issues among communities using contaminated water for bathing, washing, or cooking [13]. Additionally, contaminated rivers require high costs to restore their condition.

Compared to the cost of making POC, since only 0.5 liters of EM4 is needed to make 5 liters of POC, the cost is only around Rp 15,000. As for containers and other items, used items can be utilized.

$$BCR = \frac{\text{Rp } 35.000}{\text{Rp } 15.000} = 2{,}33$$

Thus, the minimum benefit-cost ratio obtained from processing tofu wastewater is 2.33. In other words, the benefits obtained are far greater than the costs incurred.

3. Conclusion

With the management of production waste, traditional tofu MSMEs can implement clean and sustainable production patterns so that environmental impacts can be minimized. From the efforts to improve waste management, the model for improving traditional tofu MSMEs to be cleaner and more sustainable will be as follows.

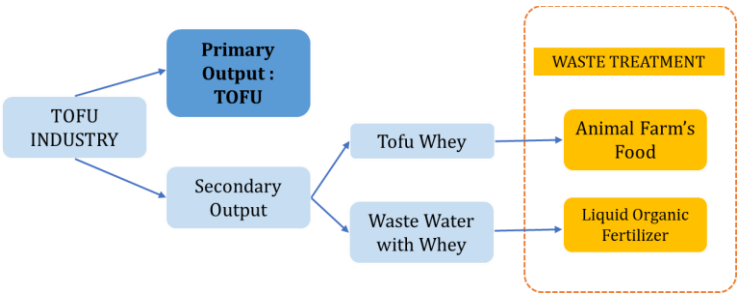

Figure 7. *Clean and Sustainabel Production Model of Traditional Tofu*

With the implementation of clean and sustainable production, MSMEs actually know that they can still profit from processed waste. In addition, saving the environment from the impact of waste greatly benefits the entire community in the area.

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