

Initial sustainability assessment of tapioca starch production system in Lake Toba area

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Abstract. This study aims to explore to what extent the principles of sustainability have been applied in a tapioca industry located in Lake Toba area and to explore the aspects that open the opportunities for system improvement. In conducting such assessment, we adopted the life-cycle approach using Mass Flow Analysis methods that covers all cassava starch production processes from fresh cassava root till dry cassava starch. The inventory data were collected from the company, in the form of both production record and interviews. From data analysis the authors were able to present a linked flow that describes the production process of tapioca starch that quantifies into the functional unit of one pack marketable tapioca starch weighs 50 kg. In order to produce 50 kg of tapioca, 200 kg cassava root and 800 kg of water are required. This production efficiency translates to 25% yield. This system generates 40 kg of cassava peel, 60 kg of pulp and 850 kg of waste water. For starch drying 208.8 MJ of thermal energy is required in the form of heating fuel. The material flow analysis is employed for impact assessment. Several options in improving the operation are proposed includes utilization of pulp into more valuable co-products, integration of waste treatment plant to enable the use of water recycled from the extraction operation for the washing process, and to application of a waste water treatment system that produces biogas as a renewable energy, which reduces the consumption of fuel in dryer unit.

1. Introduction

Creating a balance between the dimensions of development such as economics, social and environment is a necessity. With the balance of these three pillars will be able to meet the current needs without compromising the fulfillment of the needs of future generations. Development that meets the needs of the present without compromising the ability of future generations to meet their own needs [1]. To achieve this balance requires the concept of sustainability. The term “sustainable development” was first introduced into the international policy debate by the World Conservation Strategy. It became established as a new global paradigm after “Our Common Future”, the final report of the Brundtland Commission had been published and the preparatory work for its follow-up conference, and the United Nations Earth Summit 1992 had begun. This indicates that sustainability becomes a shared conversation / vision that will be applied almost in all countries in the world.

Lake Toba region is a natural ecosystem that provides strategic functions of the basic human needs and economic development. Recently, the Government of Indonesia is making every effort to



accelerate the development of Lake Toba region into a main tourist destination in the country. Even though tourism has traditionally been considered the main driver for social and economic development for the region, the development of Lake Toba region has is also marked by the rise of industry sectors, particularly the agricultural processing industry. Tapioca industry is one of the agricultural processing industries sector located in the area of Lake Toba. In many studies, tapioca industries are known to be vulnerable to environmental impacts, particularly those related to social and economic aspects. As an important area, sustainability is only possible if the management is based on a friendly approach to environmental management and integrated. Implementation of sustainability principles in strategic policy and operational practice of tapioca industry in Lake Toba area is essential.

Embarking from this reality, the authors consider it important to conduct a sustainability assessment of the starch production system in Lake Toba Area. This study aims to understand the extent to which the principles of sustainability applied in operation management of tapioca industries in the area of Lake Toba that leads to disclose various aspects that have the opportunity for system improvement. This study is a part of a larger agenda in the research roadmap of the Faculty of Industrial Technology at Institut Teknologi Del, which contributes in policy design and development of Lake Toba Area.

2. Methodology

Various tools and methods for assessing and benchmarking environmental impacts of different product system have been developed, ranging from the internationally standard Life Cycle Assessment/LCA [2] up to the contemporary integrated systems modeling framework for Life Cycle Sustainability Assessment/ LCSA [3]. In this study we apply the Material Flow Analysis/MFA technique, which is a life-cycle approach to analyze flows and stock of a coherent group of substance in a flow model, as a tool in assessing the sustainability in particular the environmental impact.

2.1. Goal and Scope

The goal of this Material Flow Analysis (MFA) study is to assess the sustainability of tapioca production system through systematic analysis of energy and material flow in a “gate-to-gate” model. The inventory data were collected from primary data gathered from a tapioca starch industry located Toba Samosir Regency during the period between February and April 2017. The scope of this study covers all stages in the production of tapioca starch ranging from cassava root until packed tapioca starch.

2.2. Functional Unit

The performance of the tapioca production system model is evaluated for the functional unit of one pack marketable tapioca starch weighs 50 kg.

2.3. System Boundary

The system boundary of the tapioca production system models cover the entire unit processes (i.e., gate-to gate) that can be grouped as follow: sieving, washing, cutting, rasping, extraction, separation, peeling, drying, shifting, and packaging (Figure 1).

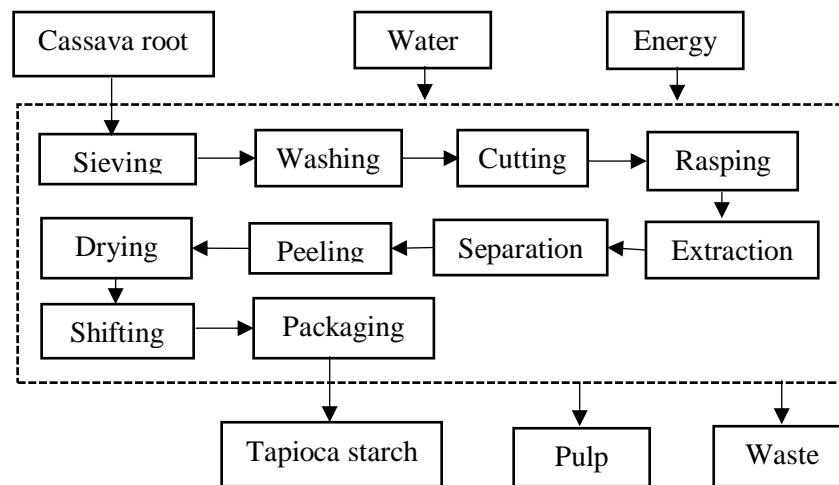


Figure 1. System boundary of the study

3. Data and Analysis

In this study, a comprehensive analysis was implemented covering all stages of tapioca starch production. The boundary of the system considered here includes the stages of the process directly related to the main product (tapioca starch). The flow model of the system is depicted in Figure 2. The following sections describe each step of the process from sieving to packaging.

Prepared cassava will be flown at loading ramp to dry sieve to be cleaned from peel, impurities in the form of soil and others. At this stage, the peel that produce of 20% of the total fresh cassava roots. The cassava is then cleaned using a washing machine. Washing machine uses constantly drained water. After that, the clean cassava will be brought to the Cutting machine through a conveyor that moves upward.

Cassava is cut into smaller pieces to facilitate the process of dissolution on rapping. Cassava that has been cut into smaller parts will be shredded on rapping machine. In this section, there is addition of water to facilitate the dissolution process and facilitate the flowing of yam porridge to the extractor.

The result of this grater will be extracted on the extractor machine so that the resulting starch is really thick. The ratio between starch and solid waste produced in the extraction process is 1: 1. Solid waste generated in the extraction process will be channeled to fiber press for reduced water content and solid waste processing will be easier. After passing the extractor, thick starch will be channeled to separator. This separator serves to increase the viscosity of starch in the liquid starch by reducing the water content contained in the liquid.

Viscous starch is turned into wet flour by using peeler. Peeler works by absorbing water. In the peeler, fine cloth is utilized to filter the starch that has been separated from the water. Wet flour is flown with steam generated by the boiler. After that, ambient air heated with superheated steam is then used to dry the wet powder. Dried flour still contains flour that has a texture that is not yet smooth and also there are still many lumps. Therefore, the dry flour will be fine sieved through a gap density up to 120 meshes. At the end, smooth flour selected from shifter will be packed of 50 kg weight. The final product has the moisture content of 12% with quality standard in accordance with SNI 01-3451-1994 [4].

The liquid waste generated from all stages of the process has the BOD and COD levels of around 5,000 mg/l and 10,000 mg/l. This waste is then channeled into a waste treatment facility, which technically consists of 8 stages of settling ponds covers an area of 1.5 ha. After the sedimentation process, the BOD and COD of the liquid waste are turned into the levels 150 mg/l and 300 mg/l, respectively.

Figure 2 depicts the linked-flow of the whole process step along with material and energy balance. Summary of the mass balance is given in Table 1.

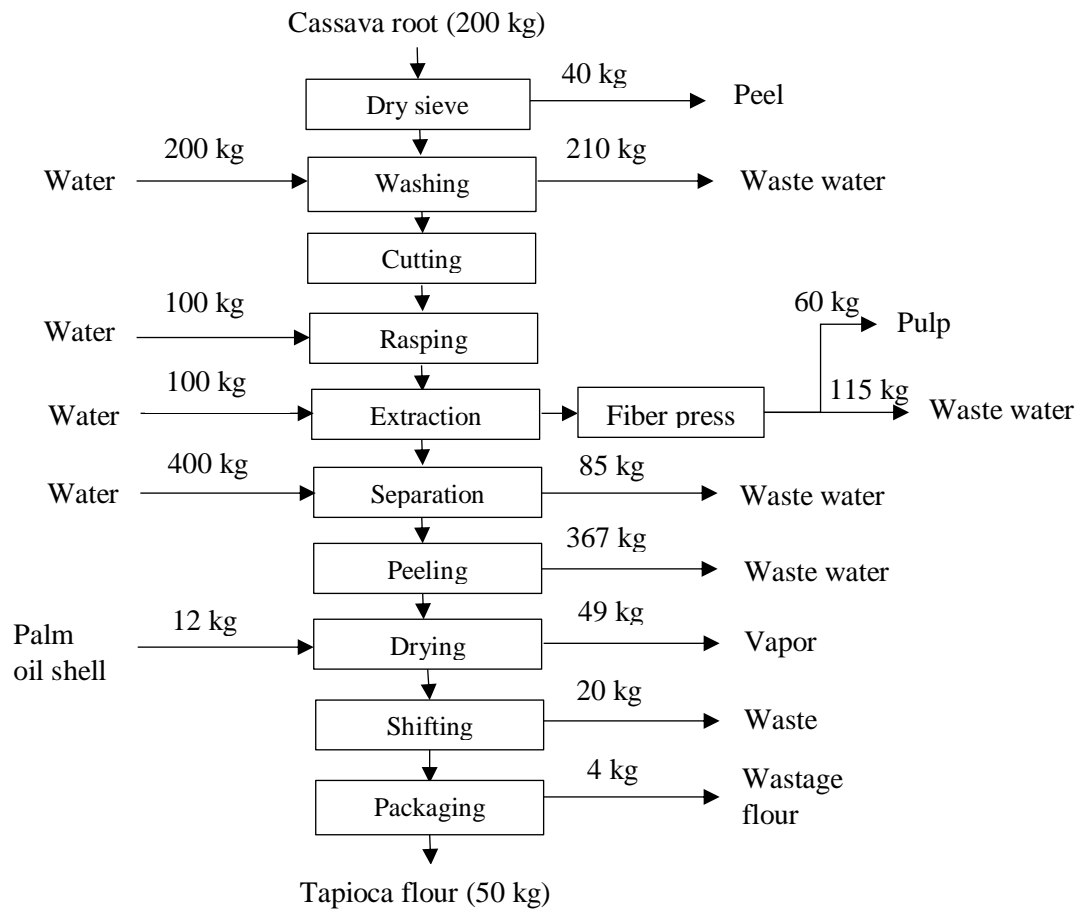


Figure 2. Linked-flow of the production model

4. Results and Discussion

Based on the inventory data explain in Figure. 2, mass and energy flow analysis were able to be summarized throughout the production of 50 kg of tapioca starch in the Table 1. For the drying process, 12 kg of oil palm shell is utilized as fuel for the boiler. Each kg of the shell is converted to 17.4 MJ / kg [5]. So that in producing 50 kg of tapioca spend energy equal to 208.8 MJ.

The productivity level of a tapioca company can be assessed from the obtained yield level. The results of the analysis show that companies in the Lake Toba region produce a yield percentage of 25%. Compared to the average yield of tapioca in Indonesia which is between 25% and 36% [6][7], the yield is considered low. The low yield is mainly attributed to the quality of raw material, which can be the factor of the variety of the cassava, the age of cassava at the time it is harvested, or conditions that leads to decrease in starch levels before entering the processing stage. [8].

Table 1. Mass balance of the production model

Table IV: Mass balance of the production model					
Inputs (kg)			Outputs (kg)		
1.	Cassava root	200	1.	Tapioca starch	50
2.	Water	800	2.	Cassava peel	40
			3.	Pulp	60
			4.	Waste Water	850

The company has been treating liquid waste through a sedimentation process prior to discharging it into the water stream to BOD level of 150 mg/l and COD 300 mg/l. Compared with the limits of Industrial Waste water that is BOD 200 mg/l and COD 400 mg/l [9], the company simply shows the quality of processed complies with the quality standard of waste water. This indicates that the processed liquid waste of the company is relatively safe. However, any failure in water treatment will be harmful to the ecosystem, considering the water stream where the post-treated waste is disposed empties directly to Lake Toba.

Several options in improving the system performance are proposed as follow. As seen on Table 1, out of 50 kg final product, 60 kg of pulp is co-produced. Currently, the pulp co-products are being sold to the community as animal feed at very low prices. Actually, the company can earn more revenue if they could create higher-value products out of the pulp, for instance as a food ingredient to make bread, substituting the commonly used flour into the basic ingredients of the cake, or other food varieties.

The use of water in the tapioca production process is considered excessive due to the lack of recycling system usage. There is opportunity to reduce the water use in the washing process. One of the possibilities is by increasing the speed of water into the washing section directly about the cassava root coming from dry sieve. This effort will provide kinetic energy that is able to accelerate the process of removing soil from the root peel.

In the processing of liquid waste, the company uses the sedimentation technique alone. This technique is not very effective in reducing the level of BOD and COD of the company. Waste water treatment can be improved by starting it with the coagulation process and then carried out the adsorption process with activated carbon. At the end, the water can be re-used primarily for the washing process, which can also minimize the water use.

5. Conclusion

This study has been able to assess some aspects on the sustainability of tapioca production system in Lake Toba area by applying is a life-cycle approach to analyze flows and stock of a coherent group of substance in a flow model. This study discloses a wide-range of shortcomings in the application of sustainability in the case study area, in particular those related to productivity (Profit) and environmental impact (Planet). However, rooms for improvement are also identified to help the stakeholders improve the system performance for cleaner production. Further research is needed to perform the impact assessment into a more detailed impact categories, such as global warming potential, eco-toxicity potential, etc. as well as to perform the assessment on the social aspects (People), which has not yet been incorporated in this study.

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