Global Warming Potential of Nata de Coco Processing using Life Cycle Assessment Approach in CV. XYZ, Yogyakarta, Indonesia

Wahyu Supartono[1], Annisa Dwi Astari [1,*], Ratnadewi Widhiarti[1], Wahyu Windayanti[1], Ika Fajriah Gama Putri[1] and Siti Fathonah Gama[1]
[1]Department of Agroindustrial Technology, Faculty of Agricultural Technology
Universitas Gadjah Mada, Jl. Flora No.1 Bulaksumur 55281, Indonesia.
Email: dwiastari.annisa@ugm.ac.id*

Abstract

Nata de coco is a well-known product in Indonesia which processed from coconut water. In the production process, the input of raw material and energy are needed to make nata de coco which the amounts are not small, as well as the amount of waste and emission which release to the environment. This study was conducted to find out how much the environmental impact in the process of making nata de coco using LCA methodology within the gate to gate scope. Analysis is carried out using functional unit on producing 1 kg of ready-to-sell nata de coco. This study was conducted by following the LCA methodology listed in ISO 14040-14043 series. The environmental impact caused by the production process of nata de coco is presented at midpoint level concentrated on global warming potential (GWP). The findings demonstrated that 0.285 kg of CO2-eq GWP were associated with 1 kg of nata de coco and firewood usage is the major contributes to the CO2 emissions.

Keywords: *Environmental impact; Life cycle assessment; Nata de coco*

1. INTRODUCTION

Nata de coco is one of products made from processed coconut water and has high fiber content. Nata de coco not only has a domestic market but also export markets especially to Europe, Japan, United States and Middle Eastern countries. In domestic market, the demand for nata de coco is quite high, besides the emergence of various diversification of ready-to-drink beverages that use nata de coco as additional ingredient which making this business very promising (Bank of Indonesia, 2018). A study reports that nata de coco has contributed to generating income for Indonesia by looking at the positive trading balance that has been maintained since 2010. Another reason that makes the business of nata de coco has bright prospect in Indonesia because of its guaranteed continuity of input supply, where Indonesia is one of the top three producer within the Asian and Pacific Coconut Community (APCC) with plantation area of 3.8 million hectares and annual production capacity of 15,429 million (Muenduaen, et al., 2016)

CV. XYZ is one of the companies in the Yogyakarta area which is engaged in agro-industry with nata de coco as a production unit. Initially CV. XYZ is a set of just a few nata de coco farmers, but over time, CV. XYZ has approximately 140 farmers scattered throughout DIY and Central Java and even has become a supplier for one of the big food companies in East Java. But despite of its contribution to improving the economy, industrial growth also has a negative impact due its potential to accelerate environmental damage through pollutant outputs produced (Nuryakin et al., 2008), as well as nata de coco in this case. In the production process, raw material and energy are needed and amount of waste and emission generated and release to the environment. On the other hand, the continuity of production must still be maintained by the need for control of environmental degradation due to industrial activity. Humans have limits to be able to use natural resources and energy, besides that there is also a limit to the amount of waste that can be generated from every activity carried out by humans. This is done to give no harm to nature, humans and the economy

(Meadows, et al., 2004). Calculation of environmental impacts is important to be able to provide an overview of the problems that must be corrected by the industry. Identification and quantification of material flows and major energy flowing in the process is needed to determine the environmental impact.

Looking to these matters, this study was aimed to provide a comprehensive picture of the environmental impacts associated with the nata de coco processing in CV.XYZ, using the life cycle assessment (LCA) tool. LCA Tools is a method used for measurement used to analyze the impact on the environment of a product or service that has a relationship related to the life cycle of a product / service (Noris, 2001). The environmental impact will be focused on the potential of global warming which later can provide information what should be improved from the industry.

2. MATERIALS AND METHODS

The study was conducted by following the LCA methodology listed in ISO 14040-14043 series. According to the ISO standards, LCA has four main phases, namely, goal and scope definition, life cycle inventory (LCI), life cycle impact assessment (LCIA), and interpretation.

2.1 Goal and Scope of The Study

From the measurement of life cycle assessment, it is expected to provide information on CV. XYZ is related to the amount of environmental impact in the use of inputs and outputs of output when producing nata de coco. Scope in this measurement is gate to gate in the production process of nata de coco.

2.1.1 Functional Unit

LCA is a relative approach which is structured around a functional unit. All the inputs and outputs data in LCI and impact scores in LCIA phase for this study were expressed with reference to this functional unit. The functional unit chosen was 1 kg of nata de coco processed.

2.2 Life Cycle Inventory

The second phase in LCA is life cycle inventory (LCI) where in the calculation of LCI shows the material needs used in units of weight and energy sources used and the process flow. The inventory analysis consists of two major steps: data collection and data analysis.

2.2.1 Data Collection

Data for nata de coco production were collected directly by interviewing the workers and observing on every stage of production process to making the nata de coco. Furthermore, the indirect data was obtained from document study.

2.2.2 Data Analysis

Material Flow Analysis (MFA) is used to describe in full, clear and transparent material flow, energy and waste used. The purpose of the MFA is to quantify the material flow rate of products produced as inventory data.

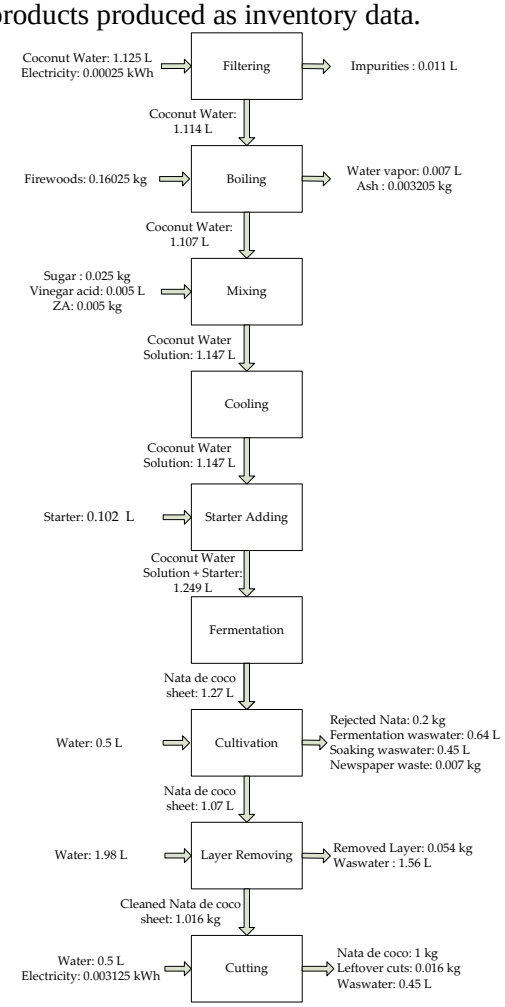

Figure 1. MFA of Nata de Coco Production

The data collected then converted to values that relate to the functional unit. The adjusted data were modeled into

environmental inputs and outputs then aggregated (Figure 1).

3. RESULTS

By reviewing the entire process of material flow from the input process to output, the amount of material, water and energy obtained is then used as inventory data. A summary of the inventory data collected is presented in Table 1

Table 1. Inputs and outputs data for the production and processing of 1 kg nata de coco

Input/Output	Amount	Unit
Input from Technosphere		
Materials		
Coconut water	1.125	Liter
Sugar	0.025 Kg/0.026	Liter
Vinegar acid	0.005	Liter
ZA	0.005 Kg/0.009	Liter
Starter solution	0.102	Liter
Water for soaking	0.5	Liter
Water for cleaning process	1.98	Liter
Energy		
Firewood	0.16025	Kg
Electricity	0.00025	kWh
Output to Technosphere		
Products		
Nata de coco	1	kg
Waste to Treatment		
Impurities from Filtration Process	0.011	Liter
Wastewater from cultivation	0.64	Liter
Rejected Nata	0.2	Kg
Soaking Liquid	0.45	Liter
Paper waste	0.007	Kg
Leather Layer	0.054	Kg
Wastewater from fermentation	0.64	Liter
Wasterwater from cleaning process	1.56	Liter
Waste from cutting process	0.016	Kg
Wastewater from cutting process	0.45	Liter
Output to Environment		
Air Emissions		
Water vapor	0.007	Liter
Ash from Firewood	0.003205	Kg

3.1 Life Cycle Impact Assessment

This step consists of classification and characterization steps following the ISO 14042 guidelines were applied to the inventory data in order to assess their potential impacts on the environment. In this study the mandatory elements (classification and characterization) were believed to be sufficient to achieve the stated goals of the study and therefore only these were considered. In the classification step, the inventory data were grouped into the environmental impacts of global warming. Emissions due to energy usage were quantified using estimation methods (IPCC, 2006). Emissions taken into account in this case study are the impact of energy use which sourced from firewood and electricity (kWh).

The classification was conducted on the emissions resulting from firewood and electricity used in nata de coco production. The potential emissions that may be generated include CO_2, CH_4 dan N_2O.

In the characterization step, all related emission in global warming potential (GWP) are converted into units of CO_2–eq. This was done by multiplying the mass value of relevant emission to the characterization factor. The calculation method of Intergovernmental Panel on Climate Change (IPCC, 2006) was used to give an indicator result. All indicators then summed as the characterization results for the GWP impact category.

In terms of energy and fuel use, based on the LCIA results, it was found that the production of 1 kg of nata de coco in CV XYZ produced emissions of 0.285 kg CO_2-eq with the following details (Table 2).

From the calculation results at the LCIA phase it is known that the biggest emission produced is CO_2, which is 0.280172 kg or covering 98% of the total GWP value, while CH_4 and N_2O are contributing to 1% each respectively. If we look at the calculations that have been done previously to determine the amount of each GHG emission, especially in CO2, it is known that the use of firewood contributes to the CO_2 emissions that is equal to 0.280 kg, while the indirect electrical usage only contribute to producing 0.0023 kg of CO_2.

Table 2. Characterization results in Global Warming Potential of 1 kg nata de coco

GHG Emission	Global Warming Potential (GWP)		
	CF	Result	Percentage
0,2801 $KgCO_2$	1	0,2801 $KgCO_2$-eq	98%
7,5048 x 10^{-5} $KgCH_4$	25	0,001876 $KgCO_2$-eq	1%
1,0026 x 10^{-5} KgN_2O	298	0,00299 $KgCO_2$-eq	1%
TOTAL		0,285 $KgCO_2$-eq	100%

CV. XYZ in fact produces solid and wastewater in its production activities (Table 1) but CV. XYZ has been sought to treat the existing waste so that it doesn't interfere with environmental health. But they are still using conventional ways by using firewood for the boiling process, where firewood is one of the high emitters. Proposed improvement for CV. XYZ is a substitute for the use of firewoods into lower emitters such as LPG or other alternative fuel which help to reduce the environmental impact potentials. Even tough the total GWP generated in this study is not comprehensive, where packaging and raw material distribution have not been considered yet, but further analysis to calculating the financial aspect to replace firewoods should be done.

CONCLUSIONS

The overall aim of conducting this LCA was to measure the potential environmental impacts in Global Warming Potential associated with the production of nata de coco in CV.XYZ. This was done to give a basis information for improvement analysis towards the sustainability. Based on the calculation, the use of firewood contributes greatly to the increase of CO_2 emissions in production process, but there are still opportunities for reducing the greenhouse gas (GHG) emissions. Further study should be conducted to measure broadly aspect of environmental impact besides on production, also GWP and other environmental aspect from procuring raw material.

REFERENCES

Bank of Indonesia. *Pola Pembiayaan Usaha Kecil (PPUK) Industri Pengolahan Nata De Coco*. (www.bi.go.id) Accessed on July 1, 2018.

Phisalaphong, Muenduen; Tran, Tien-Khai; Taokaew, Siriporn; Budiraharjo, Rusdianto; Febriana, Gabriella Gita; Nguyen, Danh-Nguyen; Chu-Ky, Son; Dourado, Fernando. 2016. Nata De Coco Industry in Vietnam, Thailand, and Indonesia. Bacterial Nanocellulos. *Biotechnology to Bio-Economy*, pp 231-236.

Nuryakin, Sutrisnanto, D; Hadiyarto, A. 2008. Studi Evaluasi Perencanaan Pengelolaan Lingkungan Melalui Pendekatan Eko-Efisiensi (Studi Kasus pada Unit Deinking Plant PT. Kertas Leces Probolinggo). *Master degree Thesis*. Semarang: Universitas Diponegoro

Donella Meadows, Jorgen Randers, and Dennis Meadows. 2004. *Limits to Growth: The 30-Year Update*. Chelsea Green Publishing Company

Norris, G.A. 2001. Integrating Life Cycle Cost Analysis and LCA. *International Journal of LCA*, 6 (2): 118-120.

IPCC. 2006. IPCC Guidelines for National Greenhouse Gas Inventories Volume 2: Energy.