16 Environment Performance Index Assessment on Food Production

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Environment Performance Index Assessment on Food Production: A Case Study in Indonesia

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ABSTRACT

Green Productivity (GP) is a strategy to increase production output while protecting the environment. The application of GP is a tool to evaluate the quality of the environment. For instance, an industry of crispy fried chicken drains the chicken's wash water, pours cooking oil, and slurries down the drain. It will diminish water quality. This research aims to assess Environment Performance Index (EPI) and prevent environmental damage by creating crispy chicken. The initial step must be identifying waste, creating a material balance diagram, calculating EPI and productivity, and proposing alternatives. This research indicates that pollution levels in this industry are extremely high. Environmental Service testing of production wastewater revealed BOD values of 769mg/l, COD values of 1699mg/l, TSS values of 2536mg/l, and an EPI Index of -31,05 exceed government standards. The result indicates that production enhancements must continue. In addition, this research generated some waste prevention alternatives, such as constructing a grease trap.

1. Introduction

Every day, the world's growing population and increasing consume food have environmental consequences [1]. Conventional packaging [2], continuous consumption of energy-water-food resources [3], and a conventional component of technology [4] had a significant environmental impact due to their lack of sustainability. Therefore, businesses must evaluate their production processes to boost productivity and environmental performance [5].

Large industries and small businesses, which are currently expanding their business, will consume clean water and energy [6]. For instance, some fried chicken industries in Sidoarjo, Indonesia, have not treated the water used to wash the chicken and the frying utensils. The sediment of cooking oil in flour is disposed of in the garbage, soil, or river. Predictions that clean water and energy availability will decrease, affecting food production [7]. Consequently, some research studies have developed a novel method for preventing environmental damage [8-10]. Moreover, the expert has established a standard

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for production activities to enhance environmental performance [11, 12]. Meanwhile, Using eco-friendly materials and optimizing production advances sustainable development goals [13-15].

Several researchers in the past have taken preventative measures, such as utilizing hybrid entropy-TOPSIS-F to select the green suppliers with the best environmental performance [16]. The criteria were weighed by experts, who chose the provider with the best environmental performance. However, the method does not identify the potential waste in production activity. Life Cycle Analysis (LCA) and integration of municipal solid waste management (MSWM) are used to determine the optimal strategy for measuring environmental impacts [17]. Combining these allows the decision-maker to select the optimal alternative solution. However, the LCA indicator for environmental impact assessment must be determined. When the indicators are inappropriate, they cannot provide an accurate evaluation. Data Envelopment Analysis (DEA) [18-20] measures energy efficiency and environmental performance [18-20]. Sustainability indicators are used to evaluate the performance of economic, environmental, and social systems [21]. In DEA, each indicator is analyzed within one decision-making unit (DMU) and compared to another. This method aims to obtain the best DMU and serve as a standard for all other DMUs. This method does not identify the generation of waste.

Another study utilized the Lean Six Sigma (LSS) methodology. It combined it with Double Loop Learning (DLL) to determine food waste loss (FWL) throughout the production and distribution processes [22]. In this instance, researchers identify the source of FLW but do not quantify the amount of waste produced. Another study [23] combines LCA with Artificial Intelligence (AI). This study uses LCA to assess the environmental impact of production activity, while AI is employed to predict the impact. However, they did not calculate environmental performance, so environmental protection efforts cannot be measured. When the factory has an achievement level (index), it will be simpler to determine the next period's increased environmental protection level.

As a result, this study aims to calculate the Environment Performance Index (EPI) and suggests an alternative solution as a prevention action. Its concept, specifically Green Productivity (GP). Due to the use of energy and water, food production is a major contributor to environmental degradation. The initial step is identifying the potential environmental impact on Sidoarjo's food production. Previous research examines the ecological impact of already-produced goods. Using the Material Balance Diagram (MBD), this study identifies waste from each process. Nonetheless, we conducted this research by identifying how food, water, and energy have been consumed. This study also quantifies the amount of inputs, outputs, and food waste generated during the production of MBD. Principle requiring the input and output quantities to be equal. The above amounts of inputs, outputs, and waste measure productivity. Low-productivity processes are assumed to generate a great deal of waste. This study concludes with recommendations for mitigating the environmental impact caused by productivity grade.

2. Methods

2.1. Case Study

This study addresses preventing environmental impacts on food production, particularly crispy fried chicken in Sidoarjo City. Fried chicken is popular because of its demand. Washing chicken and production equipment will use more water in high demand, and frying chicken requires more electricity, gas, and oil. Chicken meat and cooking utensils were washed in food waste-filled waterways. Water with fats and oils smells bad.

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Flour deposits result from frying flour-coated chicken in lots of oil. Sediment is usually separated from oil and dumped in the ground, water, or trash. Oil and grease in the watercourse harden and clog drains, killing fish and other aquatic animals. Dumped oil and food residues seep into the soil and degrade it. Crispy fried chicken production involves waste identification at each stage. Waste includes water, plastic, lumpy flour, slurry, and cooking oil.

2.2. Concept of Green Productivity (GP)

The GP will begin this research in 6 stages with 13 crucial activities [24]. The implementation steps to identify waste are as follows [25-27]. GP procedure can be seen in Fig. 1. Details procedure are as follow:

1. Production process identification from raw material preparation to the consumer using a process flow diagram.
2. Identification of inputs and outputs from the production process.
3. Create a Material Balance Diagram (MBD) to describe the input used, output, and waste generated.
4. Calculating production productivity and Environment Performance Indicator (EPI) index.
5. Propose solutions or alternatives to improve environmental productivity.

2.3. Waste Test and Environmental Impact Analyses

In this study, the waste that contributes the most to environmental pollution is liquid waste from washing chicken and cooking utensils and cooking oil waste. The Department of the Environment (DLH) laboratory will test liquid waste from crispy fried chicken production for environmental contamination. The test result will then be compared to government standards for water quality.

2.4. Material Balancing Diagram (MBD)

At this stage, the yield of the used raw material is measured. MBD is a type of Material Flow Analysis (MFA) that comprehensively measures material flow from input to output [28, 29]. MBD and MFA ensure that the amount of incoming material must equal the output and waste produced. The MBD will show the number of raw materials and waste from the production process in greater detail.

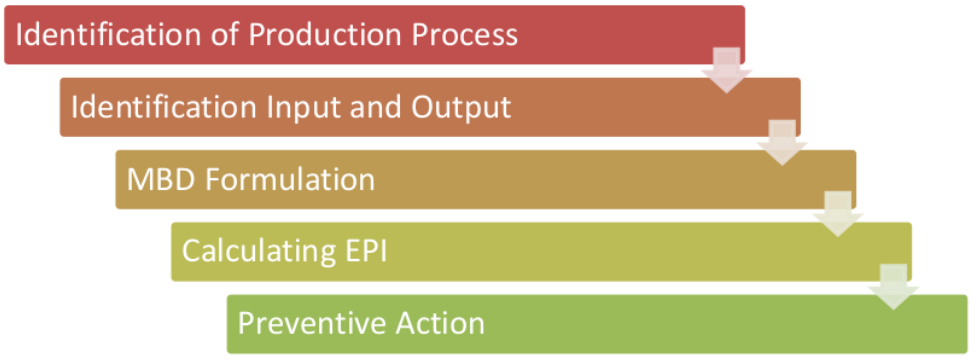

Fig. 1. GP procedure

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2.5. Productivity and EPI calculation

Generally, the meaning of productivity is the ratio of output to input [30]. It can be formulated with Y/X notation. Y is the output from the activity, and X is the input of the activity. Moreover, improving productivity requires several factors which affect the process [31]. Why do we need to calculate productivity? Because productivity correlates with competition [32]. Every business will compete and get the customer's trust by providing the best services.

Calculating the Environmental Performance Index (EPI) aims to evaluate a business or country's environmental, social, and economic conditions. The higher the EPI value, the stronger a business or country is in carrying out sustainable development (sustainable development). Furthermore, a healthy environment correlates with community prosperity and economic growth [33]. To measure the EPI index, one can follow Equation (1) and *Pi* in Equation (2) [5] :

$$\text{EPI Index} = \sum_{i=1}^{k} W_i * P_i \quad (1)$$

where

$$\text{Pi (\%)} = \frac{\text{Quality standards (mg/l) - Result (mg/l)}}{\text{Quality standards}} \times 100\% \quad (2)$$

For :
k = the number of parameter research
Wi = weight of each parameter
Pi = deviation or slack between standard and result

In developed countries such as Colombia, the environmental index in manufacturing companies is measured by applying ten parameters included in supply chain management (SCM), from resources and production processes to product distribution [34]. While in the research conducted on this crispy fried chicken seller, the parameters used to measure EPI are: Water quality, heavy metals contained in the wastewater of the production process [33], the volume of water wasted, the amount of solid waste, and the handling of liquid and solid waste that has been carried out [35], as well as the oil and fat content in the water wasted.

2.6. Alternative Proposal and Determination

Controlling the disposal of solid and liquid waste into the environment resulting from the production of crispy fried chicken is carried out by identifying the types of waste that arise from each process. Alternative proposals were obtained by involving Environmental Service (DLH) experts. The quantity and urgency of waste released into the environment determine the decision-making process.

3. Results and Discussion

Before identifying the waste production, this study was conducted with process production. Fig. 2 shows the process production of chicken crispy.

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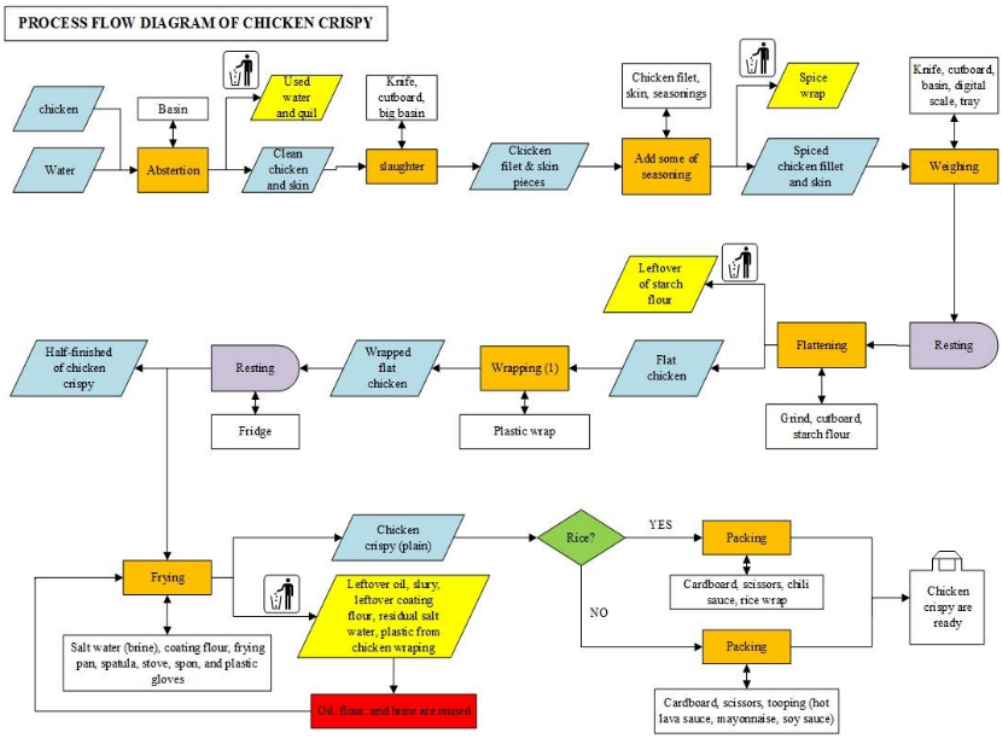

Fig. 2. Process flow of chicken crispy

3.1 Identification of Process and Waste

Several steps in the production of crispy chicken generate solid and liquid waste. Minimal solid waste is present in plastic packaging. The plastic used in chicken washing is derived from two chicken packaging items. This small amount results from the seller's decision to purchase raw materials in large quantities to reduce plastic waste. The seller typically reuses plastic gloves and chicken meat coatings and replaces them when damaged.

This washing produces wastewater containing oil/fat, soap, and chicken feathers. Because chicken is washed in the same location as cooking utensils, the effluent contains soap and oil/fat. The seller sometimes pours the slurry down the drain. If there is a small amount, dispose of it with other trash. When slurry accumulates and settles in waterways, it will prevent the water from moving and cause flooding and unpleasant odors. When the slurry is discarded, it combines with other waste, becomes drenched by rain, and then flows into the ground and rivers. It will harm the soil and river water and cause unpleasant odors.

3.2 Environmental impact analysis

The amount of liquid waste in wastewater exceeds that of other wastes. It has not been treated before being released into the water stream. As a result, a 3-liter sample was taken to be tested in the DLH laboratory. Table 1 summarizes the results of the waste.

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Table 1. The results of the wastewater test for the seller of crispy fried chicken

No.	Parameter	Unit	Results	Quality standards
1.	BOD	mg/l	769	30
2.	COD	mg/l	1699	100
3.	TSS	mg/l	2536	30
4.	Oil/fat	mg/l	2661	5

According to the results of these laboratory tests, compared to the DLH's quality standards, the waste from the production house does not go through the filtering process first. The composition of the discharged waste will accumulate and mix with other household waste, resulting in lower river water quality.

3.3 Formulation MBD

This MBD depicts the input, output, and waste composition at each stage of the production process for crispy fried chicken (fillet). At this stage of MBD, the number of inputs in the form of utilized resources and the output are calculated in detail. This MBD examines the resource yield of five kilograms of chicken meat. At the time of observation, only 15 pieces of chicken fillet weighing 7 grams were produced.

The output that dominates the production of this crispy fried chicken is 50 liters per day of wastewater. Other wastes, such as very small amounts of plastic, can be reduced by washing and reusing. The liquid waste in the slurry is disposed of with household garbage or by washing other cooking implements. The disposal of liquid waste has the potential to degrade water and soil quality.

3.4 Calculating Productivity and EPI

From Fig. 3, we can calculate the productivity of water and energy used in each production. Furthermore, According to EPI calculations, producers have prioritized environmental performance. EPI calculation is generally done by multiplying the weight of each environmental performance criterion by the amount of deviation from the waste test results with the quality standards the government sets [36].

The results of the EPI calculation show that the efforts of crispy fried chicken to protect the environment are very low [37]. However, if the EPI value is positive indicates that the environmental performance of the crispy fried chicken production house is environmentally friendly.

3.5 Preventive Action Proposal

Based on the results of the EPI calculation obtained from the waste test sent to DLH, several alternatives can be proposed as follows:

1. Buying chicken directly from the slaughterhouse to reduce the oil and fat content in the washing water
2. Filtering used cooking oil to separate the oil and flour content. Do not reuse used cooking oil, and collect it for recycling.
3. Flour mixed with oil is filtered and dried using a flour filter and dryer so that the dried flour can be used as animal feed or plant fertilizer.

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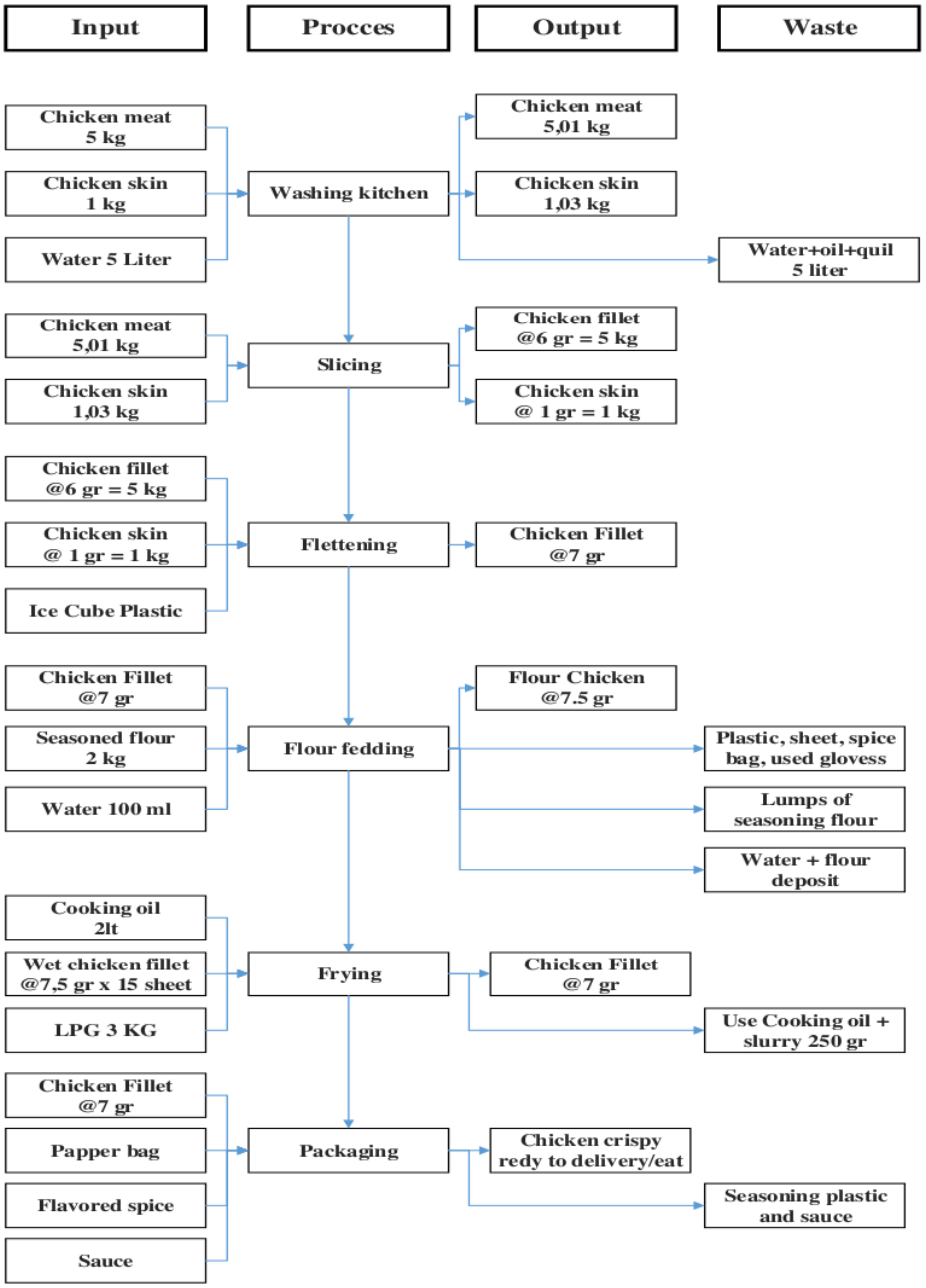

Fig. 3. MBD crispy fried chicken

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Table 2 Calculating the productivity of MBD

Input	Component	Process	Output	Waste	Productivity
5 kg	Chicken meat	Washing kitchen	5.01	Water + oil + quil	1
1 kg	Chicken skin		1.03		
5 liter	Water		5	5 liter	
5.01 kg	Chicken meat	Slicing	5		1
1.03 kg	Chicken skin		1		
6 gr	Chicken fillet	Flattening	7 gr	Ice cube plastic	1
1 gr	Chicken skin				
1 pcs	Ice cube plastic				
7 gr	Chicken fillet	Flour feeding	Flour chicken 7.5gr	Plastic sheet. Spice bag. used gloves	1
2 kg	Seasoned flour			Lumps of seasoning flour	
100 ml	Water			Water + flour deposit	
2 liter	Cooking oil	Frying	Chicken filet 5gr x 15	Used cooking oil + Slurry 250 gr	0.6
7.5 gr x 15 sheet	Wet chicken fillet				
3 kg	LPG				
7.5 gr x 15 sheet	Wet chicken fillet	Packaging	Chicken crispy	Seasoning plastic and sauce	1
1	Paper bag				
1	Flavored spice				
1	Sauce				

Table 3. EPI calculation

No.	Parameter	Wi	Results (mg/l)	Quality standards (mg/l)	Pi	EPI
1.	BOD	3.17	769	30	-24.63%	-0.78
2.	COD	3.35	1699	100	-15.99%	-0.54
3.	TSS	3.56	2536	30	-85%	-3.02
4.	Oil dan Fat	5.03	2661	5	-531.2%	-26.71
			Total			-31.05

4. Conclusion

This study aims to evaluate the Environment Performance Index (EPI) and prevent environmental damage by producing crispy chicken. In crispy fried chicken production facilities, GP yields data regarding the magnitude of the EPI value. The EPI Index calculation, which utilizes four variables, yielded negative values of -31.05. It indicates that steps must be taken to make the production process more environmentally friendly. This investigation generated several waste prevention options, such as constructing a grease trap. However, the limitations of this study are essential for accurately determining the environmental impact measurement parameters and predicting their long-term

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consistency. This study has not compared each period's productivity. Consequently, it cannot demonstrate the progress of preventive measures against environmental impacts.

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Declarations

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