

The Opportunities of Cleaner Production in Carica (*Carica pubescens*) Industry to Reduce Hazardous Waste

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Abstract: Wonosobo regency had many small and medium industries which produced carica fruit into candied carica. In the process of making candied carica by using simple technology, there tended to be inefficient in the use of materials, energy and water. It raised the amount of waste which can cause economic loss and environmental. The implementation could be used as one of the efforts to improve efficiency is cleaner production. This study aimed to identify the process of inefficiencies at each stage in the process of production and to provide alternative opportunities of applying cleaner production in the process of making candied carica. The methods were the observation, direct measurement and interview. The results showed the alternative opportunities of applying cleaner production that uses container vessel while charging syrup in the packaging process and the filtering process results boiling syrup; the application of operational standards of production use of tools and materials; application of good housekeeping; the separation between the solid and liquid waste; reuse used water from sinks, leather waste utilization for composting. The benefits of economic and environmental that derived from the application of cleaner production is the use of container vessel in the packaging process and filtered the boiled syrup IDR. 1,200,000 savings/month and reduced liquid waste as much as 240 liters/ month. Reuse of washing water used could save IDR. 380,424/ month and reduce liquid waste as much as 110.268 liters / month. Utilization of the skin as compost obtained profits IDR. 2,220,000/ month and reduced solid waste 3,600 kg/month. Thus, the implementation of cleaner production improved economic and environmental benefits of reduced waste formation.

Keywords: cleaner production, industry, carica, waste minimization

1. Introduction

Industrial development in Indonesia increased every year which influenced the increasing of the demands for goods and services. It encouraged the use of natural resources and the amount of waste that also increase. According to the Ministry of Industry (2014) the growth of non-oil industry branch in 2014 were the highest achieved by the food and beverage industry amounted to 9,54 percent, the tobacco processing industry amounted to 8,85 percent, industrial machinery and equipment amounted to 8,80 percent, as well as the processing industry more by 7,30 percent.

Wonosobo regency had many small and medium industries which produced carica fruit into candied carica. At every stage, the process of making candied carica led into inefficient use of raw ingredient, additional ingredient and water. It caused the amount of waste that can cause loss both economically and environmentally. The production of candied carica by using the raw ingredient of 500 kg also produced the solid waste such as carica fruit skins and seeds of approximately 100 kg until 3 tons in a month. Liquid waste such as used water from sinks and production reached 6000 liters in a single production process. In Sri Lanka, (State of the Environment of Sri Lanka in 2005 in Werasinghe & Shengang, 2012) states the various types of SMEs that tended to use old technology thus causing inefficiencies in the use of energy and water. This led into increasingly large volumes of waste.

An effort to increase efficiency in the production process and to minimize the formation of waste was the implementation of cleaner production. According to the Ministry of Environment (2003) cleaner production was the environmental management strategies that were preventive, integrated and applied continuously in all activities ranging from upstream to downstream related to production processes, products and services to improve the efficient use of natural

resources, prevent pollution environment and reduce the formation of waste at source so as to minimize risks to human health and safety as well as environmental damage. According Purwanto (2013) the pattern of cleaner production was an approach of the prevention of pollution from the production process in a way to see how the course of the production and the life cycle of a product. The implementation of cleaner production through increased efficiency was an approach to improve competitiveness.

Some industries in China did compulsory clean production audits as an innovative step to promote cleaner production. Compulsory clean production audit system was established and promoted in a variety of policies, regulations and national plans (Bai, et al., 2015). According to Cong & Hien (2016), an important role in the successful implementation of cleaner production was the commitment and participation of the leaders and all of the factory staff. According Bezama, et al., (2012), applying cleaner production reduced water consumption 28%, 40% solid waste, energy consumption by 24% and reduced the accident rate of 18%.

Some implementations in the cleaner production of food industry were the industry nata de coco that improved economic and environmental benefits in the form of reduction of 72,8% of waste generation, reduction of solid waste generation and lower percentage of 98,2% that was not a product output (NPO) 6,95 % (Ariyanti, et al., 2014). The soybean curd industry did not only minimize the waste and the efficiency of the performance in the form of the production process that could be completed more quickly but also increased the economic benefits of production (Khamdan, et al., 2010). The recycling industry with starch saponins reduced 45-50% and 32-35% of pollutants from waste water (Li, et al., 2010). In slondok industry improved economic and environmental benefits such as reducing the generation of waste 90.32% (Prabowo, et al., 2015).

This study was aimed to identify inefficiencies process in every stage of the production process and to provide alternative opportunities of applying cleaner production in the process of making candied carica.

2. Method

2.1. Location

The study was conducted in the industrial manufacture of candied carica namely CV. Yuasa Food Berkah Makmur at Dieng Street, Krasak, Mojotengah, Wonosobo regency, Central Java.

2.2. Data collection

Field observations: observation of the process of making candied carica started from input to output such as the use of raw materials (fruit carica), additional ingredient (sugar, salt, citric acid), water, and tools that were used in the production process. An output came from the waste that was not a product such as solid waste and waste water management. Measurement: measurement and calculation of input such as raw ingredient, additional ingredient, water that were used until the output process as product output. Interview: an interview conducted directly by using observation and a checklist of good housekeeping by the Ministry of Environment (2003).

2.3. Data analysis

Table 1. Priority scale clenaer production opportunities

Scale	Technical	Economics	Environmental
3	Easy implemented	to Without investment costs	Have a significant effect on the improvement of the environment
2	Relatively easy implemented	to Requires low cost	Little effect on environment improvement
1	It's hard to be implemented	to The high cost	There is no effect on the improvement of the environment

Data were obtained from the use of raw ingredient, additional ingredient, water, and the product output. Then, these were formulated in the process flow diagram and process flow sheet. The flow diagram was used to identify the components of the input and output as well as a source of waste generated. Mass balance was used to determine the amount of incoming materials and outgoing. Good housekeeping checklist determined the cause of the generation of waste. Data were analyzed using the concept of cleaner production strategies 1E4R (Elimination, Reduce, Reuse, Recycle, Recovery) (UNEP, 1999) and feasibility analysis of the technical aspects, economic, environmental. The determination based on the priority scale cleaner production opportunities according Indrasti & Fauzi (2009).

3. Result and Discussion

3.1. Process Flow Diagram

The process of flow diagram in carica industrial production illustrated in every stage of the production process in sequence that was accompanied by a mass balance calculation inputs and outputs of each stage of the process. Input process included the use of raw ingredient, additional ingredient, and water. Output process included finished products, intermediate products and waste. Production of the candied carica in one day required raw materials carica fruit as much as 500 kg, additional ingredient 150 kg of sugar, salt 4 kg and 0.6 kg of citric acid. Then 6175.25 liters of water usage.

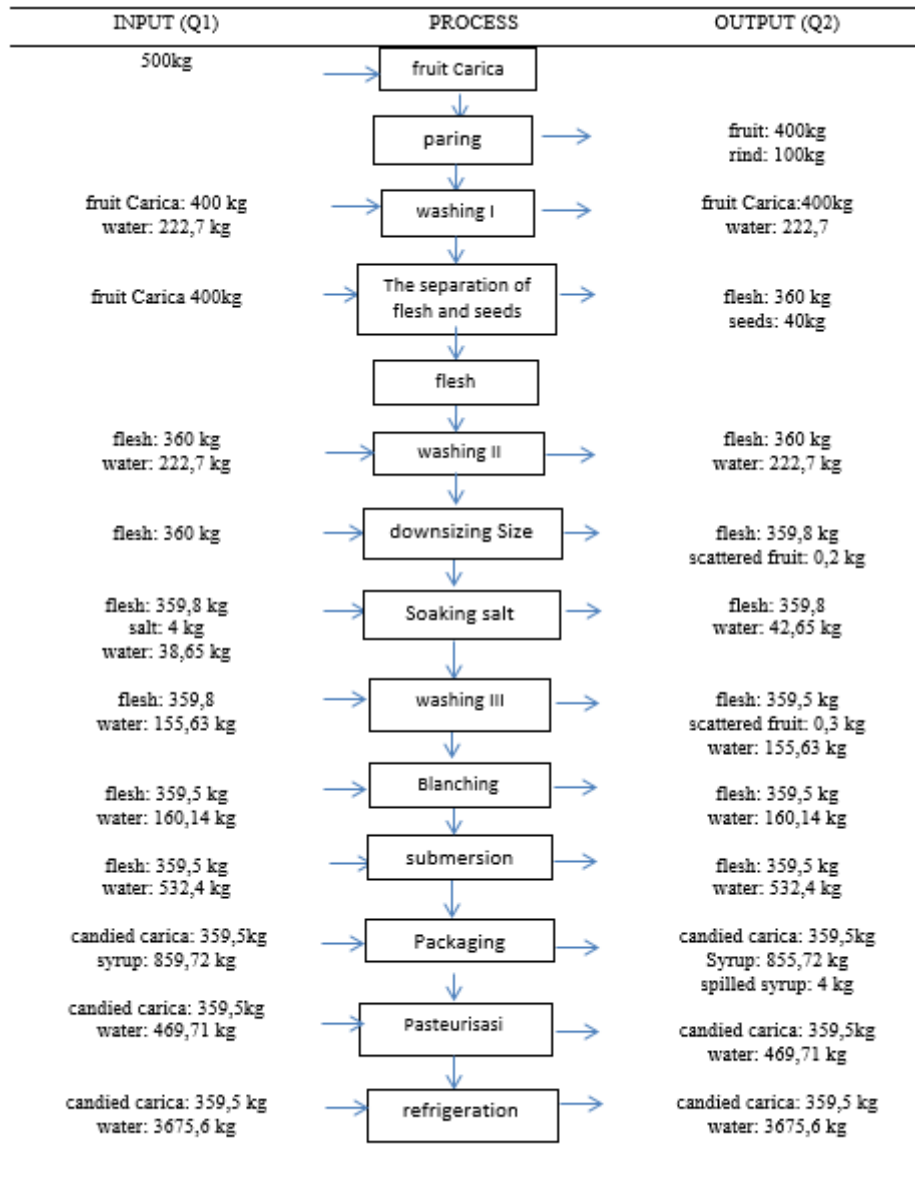


Figure 1. Flow diagram of the mass balance of the production process of making candied carica

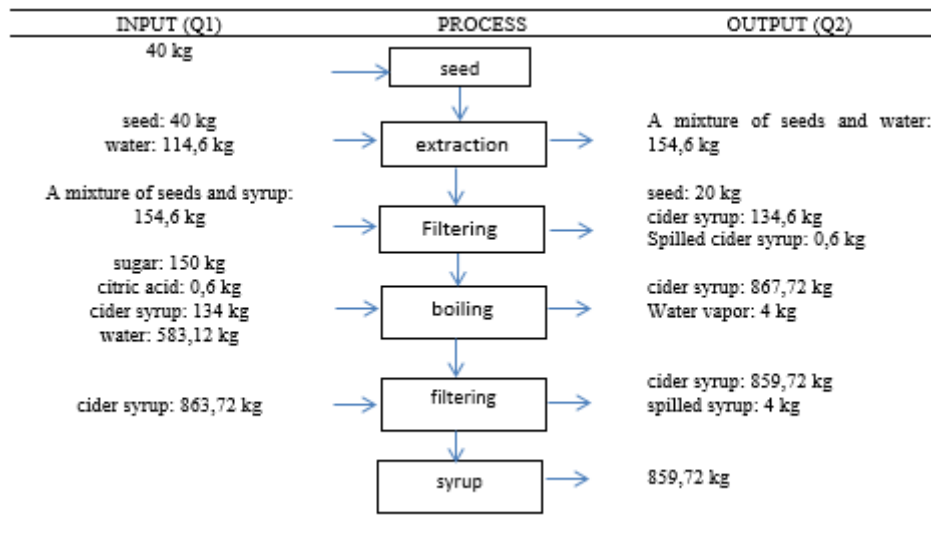


Figure 2. Flowchart of mass balance syrup candied carica

Based on the flow chart of mass balance in the process of making candied carica resulted output that was not a product in the form of solid waste and waste water management. During this time, the waste in carica industry was not processed yet, solid waste disposed of in the garbage which would be disposed of in landfill while wastewater directly discharged into the sewer.

1. Solid Waste

a. Carica rind

Based on the mass balance, it was known that carica fruit peel is resulted from stripping process is 100 kg from 500 kg carica fruit or as a percentage of 20%.

b. Carica fruit seeds

Waste seeds were resulted from the extraction process is 20 kg from 40 kg seed carica fruit or as a percentage of 50%.

c. Carica fruit flesh splattered

Scattered flesh of the fruit is produced from the process of downsizing and washing III is 0,5 kg. Based on the observations, fruit spills were gotten because of the cleanliness of stripping and cutting the fruit.

Table 2. The amount of solid waste each month.

No.	Type of Solid Waste	The amount of each day (kg)	The amount of each month (kg)
1.	Carica rind	100	3.000
2.	Carica fruit seeds	20	600
3.	Scattered flesh	0,5	15

2. Liquid waste

a. Used water from sinks

Used washing waste water came from the process washing I, washing II, soaking salt, washing III, cooling is 4319,28 liters.

b. Residual water decoction

Residual water decoction derived from the process of blanching, soaking, pasteurization is 1162,25 liters.

c. Spilled cider syrup

Cider syrup spills originated from the extraction of the screening process is 0,6 liters. Spilled syrup derived from the results of the screening process of boiling and packaging is 8 liters. Based on the observation of cider syrup spilled on filtering of the extraction was caused by the carelessness screening process and the containers that was not enough big so they would spill frequently. Besides, syrup spilled as the result of the screening process of boiling could happen because the container used was not big enough while the packaging process occurred the scattered because filling the syrup into the cup often exaggerated.

Table 3. The amount of liquid waste each month

No.	Type of liquid Waste	The amount of each day (liters)	The amount of each Month (liters)
1.	Used water from sinks	4319.28	129578.4
2.	residual water decoction	1162.25	34867.5
3.	spilled cider syrup	0.6	18
4.	spilled syrup	8	240

3.2. Opportunities of Implementation of Cleaner Production

Several alternative opportunities in the cleaner production can be done as follow:

a. Elimination

Precautions could be done during the packaging process and drying the boiled off by putting the container vessel in larger size. Thus, the volume of spills that occurred in both processes could be minimized.

b. Reduce

Reduction strategies could be done as follows:

- The implementation standard operating procedures and material used in the production (carica fruit, sugar, citric acid, and salt) could be determinate, so the wasteful use of materials also can be reduced.
- The implementation of good housekeeping can be used to identify the cause of the waste so it can be overcome odds. According Khuriyati, et al., (2015), by applying good housekeeping in the production process can reduce the generation of waste and the amount of water for washing of 22,04%.
- The separation between the solid and liquid waste there by reducing the volume of waste formation and increasing the amount of waste can be recycled.

c. Reuse

Reusable actions can be done by reusing of used water-cooling bath that could be used for process washing I & II, soaking salt and pasteurized. According Chavalparit & Ong Wandee (2009), the former waste water reuse yields can reduce production costs and water consumption in the production process.

d. Recycle

Action of recycling could be done by utilizing waste carica fruit leather for composting.

e. Recovery

The collection action could be done by reusing of used goods for disposal of solid waste, the raw and additional ingredient.

3.3. Analysis of Cleaner Production Opportunities

Analysis of the opportunities of cleaner production included the feasibility of the technical aspects, economic aspects and environmental aspects.

a. Feasibility of technical aspects

- The use of container vessel in the packaging process and the result of filtering process in the extraction was relatively easy because it could be done without any special training. Besides container vessel could be easily obtained in the market. Container for charging syrup could use any plastic plates, whereas the results of the screening process of boiling syrup could use the basin.
- The application of operational standards in the use of production tools and materials in its implementation was relatively easy to do but it needed some special training. The application of operational standards in the use of production tools such as for stripping blades should be checked regularly to be sharp and standards compliant while the use of materials could be made by check regularly the use of carica fruit, sugar, salt, and citric acid.
- Implementation of good housekeeping is relatively easy because it can be done alone but it needs little specialized training. In this case, the examination uses a checklist that includes materials, storage of raw and additional ingredient, the residue/solid waste, water and wastewater, energy, safety and health protection.
- The separation between the solid waste such as bark and seeds carica and liquid waste such as used washing water and the process of production could be done easily without any special training.
- Reuse of used water from sinks could be done easily without any special training. In this case, the reuse of used water-cooling bath could be easily used for washing I, washing II, soaking salt and pasteurized.

- The utilization of carica fruit peels for compost production was actually hardly done because it could not be done alone and needed special training. It also required tools that were not easily available in the market such as Composter Rotary Kiln.
- b. Feasibility of economic aspects
- The use of container vessel in the packaging process and filtering process could reduce the boiled syrup spilled as much as 8 liters per day. Thus, the saving that could be gotten in a month was IDR. 1,200,000.
 - Reuse of used water-cooling bath was 3675,6 liters for washing I, washing II, soaking salt, pasteurization and other necessities such as sanitary, the obtained savings of IDR. 12,680,62/ day. Thus, the saving that could be gotten in a month was Rp. 380,424.6.
 - Utilization carica fruit peels for composting using the tool Rotary Kiln Composter could hold 1000 kg with an investment of IDR. 19.500.000, then earned a profit of IDR. 2,220,000/ month. Thus, the payback period that could be calculated was 8,78 months.
- c. Feasibility of environmental aspects
- The use of container vessel for charging syrup in the process of packaging and filtering decoction had the effect of reducing the formation of environmental improvements as much as 8 liters of liquid waste each day so in a month could reduce as much as 240 liters.
 - The separation between the solid waste and liquid waste had an impact in reducing the formation of solid and liquid waste due to the way in the separation of solid waste that could be recycled.
 - Reuse of used water from sinks had an impact on the environment in the form of water usage savings of as much as 3675.6 liters/ day. In one month, it could save as much as 110,268 liters of water usage.
 - Utilization carica fruit peels for composting have any impacts on reducing the formation as much as 100 kg of solid waste per day. In a month it can reduce as much as 3000 kg.

3.4. Determination of Priority Scale in the Implementation of Cleaner Production

The result of opportunities priority in cleaner production based on feasibility technical, economic and environmental was as follow.

Table 4. Rate priority cleaner production opportunities

No.	Cleaner Production Opportunities	Scale aspects			Total	Prio
		Tech	Eco	Envi		
1.	The use of container vessel for charging syrup in the packaging process.	3	2	2	7	3
2.	The use of container vessel in the screening process stew syrup.	3	2	2	7	4
3.	The application of operational standards in the production use of tools and materials.	2	3	1	6	5
4.	Implementation of good housekeeping	2	3	1	6	6
5.	The separation between the solid waste and liquid waste	3	2	3	8	2
6.	Reuse of used water from sinks	3	3	3	9	1
7.	Utilization carica fruit peels for composting.	1	1	3	5	7

Information: Tech: Technical, Eco: Economic, Envi: Environmental, Prio: Priority

Based on the table above, the priority of ratings scale for the implementation of cleaner production based on technical, economic and environmental could be made to perform the action sequences cleaner production as follows:

1. Reuse of used water from sinks
2. The separation between the solid waste and liquid waste
3. The use of container vessel while charging syrup in the packaging process.
4. The use of container vessel in the screening process stew syrup.
5. The application of operational standards of production use of tools and materials
6. Implementation of good housekeeping
7. Utilization carica fruit peels for composting.

Following the calculation of the use of materials and water before and after implementation of cleaner production opportunities in the manufacture of candied carica presented in Table 5.

Table 5. Before and after implementation of cleaner production opportunities

No	Usage	Before (day)	After (day)	Saving (%)	Profits/ month (IDR)
1.	Water	6.175,25 liters	2.499,65 liters	59,52	380.424,6
2.	Carica rind	100 kg disposed of in landfill.	100 kg utilization of the rind as compost		2.220.000
3.	Syrup	syrup spilled as much as 8 liters	The use of container vessel could reduce the boiled syrup spilled	0,93	1.200.000

4. Conclusion

Alternative opportunities in the implementation of cleaner production could be done by reusing of used water from sinks, the separation between the solid waste and liquid waste, the use of container vessel for charging syrup in the packaging process, the use of container vessel in the screening process stew syrup, the application of operational standards of production use of tools and materials, implementation of good housekeeping and utilization carica fruit peels for composting.

Economic and environmental benefits that were derived from the application of cleaner production was the use of container vessel in the packaging process and filtered the boiled syrup IDR.1.200.000 savings / month and reduced liquid waste as much as 240 liters / month. Whereas reuse of washing water used could save IDR.380.424 / month and reduced liquid waste as much as 110.268 liters / month. Then, utilization of the rind as compost obtained profits IDR.2.220.000 / month and reduced solid waste 3.600 kg / month.

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