

Original Paper

## Cleaner Production Practices in Agroindustry: A Case of Small Scale Cheese Factory in Indonesia

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**Abstract**—The liquid of mozzarella cheese whey usually discharged directly into the environment and allegedly become one of the causes of pollution. Therefore, further handling was required to reduce waste pollution and to improve the efficiency of clean production. The purpose of this study was to evaluate cleaner production practices and to propose a high potential product made from whey waste of cheese factory. The method that used in this research are direct survey, discussion, and questionnaire addressed to some key persons for the determination of assessment scores. Clean production analysis was implemented for determine the source of pollutants and to get alternative clean production actions that are potentially to be applied. The result of the research showed that proposed alternative product were making producing of yogurt, kefir, and liquid fertilizer. Based on proposed alternatives, production of yoghurt was the highest priority scale to be implemented with the highest score and economic feasibility.

**Keywords**—cheese whey, cleaner production, yogurt

### I. INTRODUCTION

Cheese making factory is one of major industry worldwide, and much of this industry is still practiced on a relatively small scale, which accounts for the rich diversity of available cheeses. [1]. One kind of popular cheese produced by industry is cheese mozzarella. Coagulate and acidification are used in mozzarella cheese production process. Coagulate of milk continued to further processed become cheese and the liquid whey become waste of process. In case of cheese production, to produce one kilogram of cheese mozzarella requires ten liters fresh milk (raw milk) with ratio 1:10. Its mean that this process results 90% waste as liquid whey, in high quantity of waste. If the waste from cheese production discharged directly into the environment without any handling process, this condition could be a threat to damage the surrounding environment. However, increasing of production capacity, problems arise especially in managing by-products of cheese whey liquid of mozzarella product [2]. [3] explained that acid whey resulting from the production of soft cheeses is a disposal problem for the dairy industry. Other study found that an important waste which produced by the dairy cheese industry is the whey permeate, which nowadays is a strong ambient contaminant [4]. Cheese

whey disposal is a challenge for small to medium enterprises (SMEs) in the dairy industry that do not have any type of treatment plant [5]. Concerning on the environmental impact of industries increase, products like cheese have a significant environmental impact. Based on this condition, it is important to understand the environmental effect of the growing cheese production industry, to make sure that the growth does not cause deterioration of the environment [6]. CW disposal is a challenge for small to medium enterprises (SMEs) in the dairy industry that do not have any type of treatment plant [5]. In term of these environmental impact categories, raw milk production was consistently found to be the most significant contributor to the total impact, which was followed by processing. In other study, [7] stated that cheese whey is an important source of pollution that needs an appropriate treatment because of several environmental burdens. It was found that allocation between cheese and its by-products was crucial in determining the impact of cheese production and standardization or guidelines may be needed [6]. Handling process is strongly required to reduce waste from cheese making process. Cleaner production is one alternatives used to manage preventive environment, by reducing risk on human health and environment (Indrasti dan Fauzi, 2009:4) [8]. The purpose of this study was to evaluate cleaner production practices and to explore a high potential product made from whey waste of cheese factory. Further treatment to reduce waste pollution and to improve efficiency through implementing of cleaner production is needed to the cheese factory.

### II. RESEARCH METHOD

#### A. Materials

Materials used in this study were manganese sulfate 36.4%, 66% alkaline iodide acid solution, solution sodium thiosulfate 0.025 N, H<sub>2</sub>SO<sub>4</sub> concentrated 98%, and HR (High Range) COD reagents.

#### B. Methods

This study was conducted in medium cheese factory of Margo Utomo, Banyuwangi, East Java Indonesia. Several

activities in this factory were cow care, enclosure sanitation, milking cows, packaging fresh milk, flavored milk making, and cheese making. This factory produced mozzarella cheese 270 kg per week. This product was distributed to some districts in around of East Java.

In this study the evaluation of mass balance was also implemented includes the amount of raw material used, waste produced in production process, and number of produced products [9]. In term of pollution level, evaluation of waste processing industry quality standards based on the Ministerial Regulation Environment Number 5 of 2014. The evaluation implemented in this study were measurement of BOD using titration method, measurements of COD using spectrophotometer, measurement of TSS using the gravimetric method, and measurement of pH using a pH tool meters.

Evaluation to alternatives products are also implemented in this study using questionnaire with several field including technical, environmental and economically aspects. This questionnaire was addressed to key persons who has detail information and direct involvement to cheese making process in daily factory activities. Likert scale with 9 level was used to answer the question addressed to key persons. In term of economic feasibility, to measure potential of economic aspect, some analysis implemented in this study were method Net Present Value (NPV), Internal Rate of Return (IRR), Net Benefit and Cost Ratio (Net B/C), and Pay Back Period (PBP) [10]. In this study, some questionnaire were addressed to factory owner and operators to evaluate technical feasibility including raw material usage, human resources and equipment usage in cheese factory.

### C. Selection of Alternative Priority Scale

Priority scale was required to decide alternative in cleaner production activities. The table below shows priority scale in this study.

TABLE I. ASSESSMENT CRITERIAS

Creterias	Score	Explanation
No potential	21 - 35	Cleaner production doesnt has potential to be implemented
Low potential	36 - 49	Cleaner production has low potential to be implemented
High potential	50 - 63	Cleaner production has high potential to be implemented

## III. RESULT AND DISCUSSION

### A. Mass Balance Evaluation

In this study, mass balance was conducted to evaluate in several process of cheese production such as heating process, cheese lumps process, shaping, cooling and salting process. Quantity of milk used in one process was 280 kg of cheese. Temperature used in this process was 30°C to optimize rennet enzyme in coagulation process of milk. Input output of process shows in Table 2.

TABLE II. INPUT OUTPUT PROCESS OF HEATING PROCESS

Input		Out put	
Material	Weight (kg)	Material	Weight (kg)
Milk	280	Milk with 30°C	280
LPG gas	0.5		

Coagulation process was steps after additional of starter and rennet enzyme. Acidification using starter was also used to reduce pH of raw material (raw milk) to reach optimum condition of bacteria. Input output process of clumping process shows in Table 3.

TABLE III. INPUT OUTPUT PROCESS OF LUMPING PROCESS

Input		Out put	
Material	Weight (kg)	Material	Weight (kg)
Milk with 30°C	280	lumps of milk	30.5
Enzime Rennet	2.11	Liquid of milk	250
Starter	4	Loss	5.61

Shaping was the process from cooling cheese, starting form soaking of curd on hot water and pressure on the surface. Input output process of shaping process could be shown in Table 4.

TABLE IV. INPUT OUTPUT PROCESS OF SHAPING PROCESS

Input		Out put	
Material	Weight (kg)	Material	Weight (kg)
Lumps of milk	30.5	Shaped cheese	28.1
Hot water	7	Liquid waste	5
LPG gas	0.5	Loss	4.4

After shaping process, cheese soaked on cool water (cooling process), to maintain cheese still hard and does not melting. Table 5 presents input output process of cooling process.

TABLE V. INPUT OUTPUT PROCESS OF COOLING PROCESS

Input		Out put	
Material	Weight (kg)	Material	Weight (kg)
Cheese on shaping process	28.1	Shaped cheese	28.5
Cool water	50	Liquid waste	49.6

Salting process was required to rise the flavor of mozzarella cheese and extend the shelf life. In this salting process used 30 kg of salt. Input out of salting process could be shown in Table 6.

TABLE VI. INPUT OUTPUT PROCESS OF SALTING PROCESS

Input		Out put	
Material	Weight (kg)	Material	Weight (kg)
Shaped chees	28.5	Cheese ready to be packaged	29.1
Salty water	30	Salty water	29.4

B. Energy Balance in Making Process of Cheese

In this factory, manual method with high energy was still used in cheese making process. Two kind energy were used in this process were human energy as human worker and LPG or gas energy. Total energy used in this cheese factory was 19.309 MJ/ton. The detail of energy used in making process shown in Table 7. This result was also related to other study, [11] and [12] explained that consumptions of electricity, thermal energy, water, and cleaning products are the main environmental burdens on milk processing including cheese production.

TABLE VII. ENERGY USED IN CHEESE FACTORY

Process	Energy used (MJ/ton)
Heating	0.283
Clumping	1.875
Shaping	16.120
Cooling	0.519
Salting	0.512
Total	19.309

C. Pollution Level of Cheese Making Process

Regarding to the government regulations, liquid waste is the material in liquid form resulted from business, industrial or production activities [13]. In this factory, waste from cheese making process was liquid material such as whey waste from the clumping process, whey from the shaping process, and salt water from salting process. Whey waste were used for animal feed and some other was discharged directly into the environment. The characteristic of liquid waste from cheese factor presented in Table 8.

TABLE VIII. INPUT OUTPUT PROCESS OF COOLING PROCESS

Parameter	Examination Result (mg/L)	Limitation of standard (mg/L)
BOD	24,153	40
COD	75,477	100
TSS	3,389	50
pH	4.2	6 - 9
Oil and fat	2,268	10

Note: BOD (biological oxygen demand), COD (chemical oxygen demand), TSS (total soluble solid)

In this factory the waste content of BOD, COD, TSS and oil and fat higher than limitation of the government regulation standard (Table 8). This result was also relevant to other study, stated that whey discharge into the surrounding stream is potentially disruptive given the high BOD, COD and low water discharge [14], [15]. Meanwhile, on the other side, the organic material remaining in whey has the potential to utilize. This means that continuing process of liquid waste from this cheese making process is strongly required to prevent an environmental damage.

D. Implementation of Cleaner Production as Solution Alternative

The result of study showed that at the making process of cheese including clumping, shaping, cooling, and salting process produced high quantity of waste in the form of liquid waste, this need to be more continued handling process. In term of clumping process, this could produce whey as waste material with amount of 250 kg. In shaping process could produce 5 kg of whey. These waste materials (whey) could be used as raw material in making other product such as yoghurt, kefir, and liquid fertilizer. In term of cooling process, the waste water in this process could be used for washing process of equipment in cheese making process. This could reuse and reduce water usage in this cheese making process. This was relevant to other study, [16] found that water consumption were the main contributors to impacts at the dairy plant level. Related to waste water of salting process in cheese making process, the waste was containing of TSS 5.16 mg/L, salinity of 4.38 %, and pH 6.3. This content of the waste was still lower than regulation of minister of environment [13] in limitation standard of waste form milk processing, TSS and pH with content of 50 mg/L and pH of 6-9. This means that the waste content does not harm to the environment of cheese factory.

Based on discussion and result of the questionnaire addressed to key person in this study, there were 3 alternatives products could be produced from whey such as yogurt, kefir and liquid fertilizer. All of these products could be made from whey. Kefir is a fermented and carbonated beverage product with sour taste, in form of thick liquid [17]. Liquid organic fertilizer is made from organics plant residues, animal waste, and the content of the nutrients is more than one element [18]. Other study [19], explained that liquid organic fertilizer could be made from mixed waste whey and kefir whey have better nutrient content to meet the standard. The result of feasibility study on each alternatives products is presented in the Table 9 below.

TABLE IX. FEASIBILITY ANALYSIS OF YOGHURT PRODUCT

Aspects	Indicators	Score
	Workers	9
Technical	Equipments and tools	9
	Materials	8
Environmental	Waste handling	6
	Impacts	6
	NPV	3
Economical	IRR	3
	B/C Ratio	3
	Pay back period (PBP)	1
	Total	<b>48</b>

In term of yogurt product, Table 9 shows that technical aspect has high a score in workers, equipment and material. This means that the factory has high possibility to produce yogurt as alternative product made from whey waste of cheese making process. This is in line to the study of [3], stated that whey protein from cottage cheese acid whey for use in production of yogurt.

TABLE X. FEASIBILITY ANALYSIS OF KEFIR PRODUCT

Aspects	Indicators	Score
	Workers	7
Technical	Equipments and tools	9
	Materials	7
Environmental	Waste handling	6
	Impacts	6
	NPV	3
Economical	IRR	3
	B/C Ratio	3
	Pay back period (PBP)	1
	Total	45

Table 10 shows that equipment and tools in technical aspects has the highest score in Kefir product. This means that the factory has high possibility in produce Kefir from equipment aspect. Workers and material of kefir product has lower score compare to feasibility of yogurt product, means that Yogurt product has higher possibility to be produced in this factory. Kefir is a product with acidic-alcoholic fermented milk with little acidic taste and creamy. There is an increasing interest in the commercial use of kefir, since it could be marketed as a natural beverage product that has health promoting bacteria [20].

TABLE XI. FEASIBILITY ANALYSIS OF LIQUID FERTILIZER

Aspects	Indicators	Score
	Workers	7
Technical	Equipments and tools	9
	Materials	6
Environmental	Waste handling	6
	Impacts	6
	NPV	3
Economical	IRR	3
	B/C Ratio	3
	Pay back period (PBP)	1
	Total	44

In term of liquid fertilizer as one of alternative product made from whey, this is relevant to other study, [21] state that whey as cheese-making wastes which combined with cabbage wastes has shown great potential for organic liquid fertilizer as way to reduce the pollution load. It means that liquid fertilizer also has strong prospect to reduce pollution and economic value. Table 11 shows that workers and material have lower score than yogurt and kefir product. Yogurt product has highest score of feasibility analysis, it means that yogurt product has strongest possibility to be produced in the factory as a product made from whey as waste of cheese making process. Yogurt product also has the highest economic value to be produced in factory, with financial feasibility value of NPV Rp 395.043.848, IRR 49%, PBP 2 years and B / C Ratio 1,4.

Based of potential analysis in Table 1, total score in the result of feasibility analysis (48, 45 and 44 were the total score of yogurt, kefir and liquid fertilizer respectively) could be categorized in low potential level (36 – 49). Compare to others, yogurt product has the highest total score of 48 tends to high potential product to be produced in this factory. This means that yogurt product has the highest priority compare to kefir and liquid fertilizer product.

These results of study could provide more reliable informations to stakeholders. Regarding to these informations of product choices and processes, the best environmental performance could be reached by cheese factory.

## CONCLUSION

In this factory, waste from cheese making process was liquid material such as whey waste from the clumping process, whey from the shaping process, and salt water from salting process. The waste content of BOD, COD, TSS and oil and fat higher than limitation of the government regulation standard. Continuing process of liquid waste from this cheese making process is strongly required to prevent an environmental damage. There were 3 alternatives products could be produced from whey such as yogurt, kefir and liquid fertilizer. Yogurt product has the highest priority to be produced in this cheese factory.

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