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JOINT COST ALLOCATION OF CHEESE-MAKING WASTES BIOCONVERSIONS INTO ETHANOL AND ORGANIC LIQUID FERTILIZER

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Abstract

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Aims of this study was to determine the joint cost allocation in bioconversion of cheese-making wastes into ethanol and organic liquid fertilizer. Whey from cheese-making wastes, combined with napa cabbage wastes, has shown great potential for bioconversion into ethanol and organic liquid fertilizer as way to reduce the pollution load. Semi pilot scale experiment was done to fermented cheese whey and napa cabbage wastes, using the consortium of *Candida lambica* and *Prototecha zopfii* with the addition of 10% molasses at low temperature (17-21°C) for 72 hours in semi-anaerobic condition and resulting ethanol up to 11.06%. Economic feasibility was determined by calculating the joint cost allocation with the approach of market price method and the break even point (BEP). The results showed that bioconversion of cheese whey and napa cabbage waste saves waste disposal costs, the financial benefits increases to US$ 3 816.96 per month, reduces variable cost of the main product to 14.73% and attains the breakeven point in 3.53 months.

Key words: cheese whey; ethanol; joint; cost analysis; organic; liquid fertilizer

Introduction

The development of cheese industry in the world makes global cheese whey production as cheese-making wastes continues to increase. Cheese industries produce 270-450 liters of whey cheese from cheese production of 30-50 kg every day (Desiyantri et al., 2013). At the local cheese producer, the amount of cheese whey produced in a quite large quantity. The Cooperative of South Bandung Farmers/Koperasi Peternak Bandung Selatan (KPBS) is one of the cheese producers in West Java – Indonesia which resulted cheese whey around 3000-6000 liters per week (Hidayat, 2016).

The utilization of cheese whey has been widely applied in various ways such as waste-to-product approach. Some common ways such as physical and biological treatment. Physically, cheese whey can be processed by ultrafiltration and dehydrated into the whey protein concentrates (Siso, 1996). The biological processes through bioconversion is a popular method mainly performed in utilizing lactose to produce derivative products such as biopolyester and Single Cell Protein (Spalatelu, 2012; Koller et al., 2012). In addition to the waste-to-product approach, recycling cheese whey can be pursued through the concept of waste-to-energy which is solution for the increasing amount of waste and the depletion of energy resources (Forsyth, 2006). Aerobic bioconversion of cheese whey can produce methane (Sauve, 2013). Besides methane, other energy sources that can be produced is ethanol (Guimaraes et al., 2010; Utama et al., 2016).

Ethanol with the highest purity can be obtained by distillation. However, the distillation still leaves some residual

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distillery that can be problems. In other hand, amino acids, peptides, polysaccharides, minerals and vitamins that remains in the rest of the distillation process are the potentials that can be exploited (Stemwedel, 2009). Some of the refining industry take the advantage of the destillery residue for organic fertilizer. But the quality of the destillery residue still can not meet the technical requirements, so making it less worthy of merchantability (Utama et al., 2017).

Bioconversion of cheese whey and napa cabbage waste to produce ethanol and utilization of the distillery residues as organic liquid fertilizer shows high attention on the settlement of environmental problems through the approach of waste-to-energy and waste-to-product. Therefore, the feasibility of appropriate technology application has to be tested on a larger scale and up-scaling into semi pilot scale and economic feasibility calculation has been considered (Utama et al., 2015). Consideration of the economic pillar is needed, especially related to the development of the environmental issues completion concept for sustainable development.

Materials and Methods

Cheese whey is taken from KPBS with the composition of 3.16% lactose, 0.40% fat, 2.20% protein, and 93.66% water. Napa cabbage waste is taken from Pangalengan Traditional Market Bandung with the composition of 3.65% fat, 2.76% protein, 1.81% fiber and 85.38% water. Ethanol production was done using *Candida lambica* and *Prototecha zopfii* as consortium starter that inoculated into the wastes and combined with the addition of 10% molasses and incubated at low temperature for 72 hours (Utama, et al., 2017). The results of the quantity and quality measurement of ethanol, as well as the distillery residue tested as an organic fertilizer, are used as the basis design for the calculation of economic feasibility. Economic feasibility determined by calculating the joint cost allocation with the approach of market price method and the break even point (BEP) (Mulyadi, 2010; Wahyuni, 2012).

Joint cost allocation

– ***Cost classification***, data such as raw materials, labor, sales and others are classified

– ***Joint process determination*** (Split Off), calculate the production cost before the split-off in the joint production process.

– ***Market Price Method***:

Hypothetical Market Price =

$$= \text{Market Price after Process} - \text{Additional Cost} \tag{1}$$

Relative Hypothetical Market Price =

$$= \frac{\text{Prod.Hyp.Mark.Price} \times \text{Prod.Capacity}}{\text{Total Hyp.Mark.Price} \times \text{Prod.Capacity}} \times 100 \tag{2}$$

Joint Cost Allocation =

$$= \text{Relative Hypo.Market Price} \times \text{Total Production Cost} \tag{3}$$

Contribution Margin

$$\text{Contribution Margin} = \text{Price per unit} - \text{Variable cost} \tag{4}$$

$$\text{Contribution Margin Ratio} = \frac{\text{Contribution Margin}}{\text{Price per unit}} \tag{5}$$

Break Event Point (BEP)

$$\text{BEP (US\$)} = \frac{\text{Fixed Cost}}{\text{Contribution Margin}} \tag{6}$$

$$\text{BEP (Product Units)} = \frac{\text{BEP (US\$)}}{\text{Price per unit}} \tag{7}$$

$$\text{BEP (Month)} = \frac{\text{BEP (US\$)}}{\text{Unit Produced} \times \text{Price per unit}} \tag{8}$$

Results and Discussions

The cheese whey bioconversion into ethanol needs to be taken into economic feasibility that can be considered for a sustainable production. Table 1 is shown for utilizing 24 000 L of cheese whey per month required investment of US$12 781.56 with the production cost per month of US$ 2 180.80 (Table 2). The investment will support the production process to produce 2 688 L of ethanol with total income up to US$ 8 117.76 per month. The results also were able to save on cheese whey disposal costs for business as usual of US$

Table 1
Investment for small scale cheese whey utilization with the capacity of 6000 L cheese whey per week or equal to 24000 L cheese whey per month

Investment	Volume	Unit	Price (US$)	Total (US$)
Land and Building	200	m^2	37.79	7 558.58
Chopper and Mixer	1	unit	377.93	377.93
Destilator and Dehidrator 1000 L	1	unit	2 267.57	2 267.57
Single Destilator 1000 L	1	unit	755.86	755.86
Fermentor Tank 1000 L	6	unit	151.17	907.03
Fermentor Pump	2	unit	340.14	680.27
pH Meter	3	unit	37.79	113.38
Alcohol Meter	3	unit	15.12	45.35
Container Tank	1	unit	75.59	75.59
Total				12 781.56

0.076-0.113 per L, which means saving up to US$ 1 814.06 – 2 721.09 per month when there was no income from wastes utilization (Hidayat, 2016). Considering that the production process should be run to produce multi-products, then the join cost allocation conducted.

The cheese production processes with a capacity of 24 000 liters per month produces 4 045 kg of cheese, 2 688 liters of ethanol and 12 216 liters residual distillation which can be packed into 2 433 units of liquid organic fertilizer.

Table 2
Variable cost for ethanol production (per month)

Cost	Volume	Unit	Price (US$)	Total (US$)
Yeast Starter	720	L	1.13	816.33
Electricity	480	kWh	0.049	23.58
Liquid Petroleum Gas	288	Kg	0.378	108.84
Water	100	m^3	0.076	7.56
Manpower (25 d)	4	Per-son	75.59	302.34
Other Equipment	1	Pack	188.96	188.96
Zeolith	1	Pack	7.558	7.56
Molasses	2 400	L	0.302	725.62
Total				2 180.80

The shared production of combined total production cost per month can reached US$ 19,130.50 consisting of US$ 14 298.00 for 4 045 kg of cheese, US$ 4 832.50 for the production of 2.688 liters of ethanol and 2 443 units of organic liquid fertilizer in the 5 liters packaging (Table 3).

Table 3
Production cost of cheese whey utilization and liquid organic fertilizer packaging

Total of Production Cost			
Cheese Production (Wijaya and Saputro, 2004)			US$ 14 298.00
Ethanol Production			US$ 2 180.80
Total			US$ 16 478.80
Additional Cost for Ethanol and Liquid Organic Fertilizer Packaging			
Ethanol	2 688 unit	× US$ 0.3 =	US$ 812.7
Fertilizer	2 443 unit	× US$ 0.76 =	US$ 1 839
Total			US$ 2 651.70
Total			**US$ 19 130.50**

The revenue with the hypothetical price shows the contribution of each product from the total incomes of US$ 26 456.61 (Table 4). Cheese product shows the contribution to 63.60% with the incomes of US$ 16 827.20, while ethanol with US$ 5 940.48 (22.45% contributions) and liquid organic fertilizer with US$ 3 688.93 (13.94% contributions). The contribution percentage was the basis for the joint allocation costs towards the total cost of production which was US$ 12,167.57 for the cheese, US$ 4 295.50 for ethanol and US$ 2 667.43 for liquid organic fertilizer. However, if the fertilizer couldn't be sold because of its characteristics cannot meet the technical requirements for liquid organic fertilizer, so the ethanol can be sold directly without the packaging then recalculation of the joint cost allocation was needed (Table 5).

Table 4
Joint cost allocation of cheese whey bioconversion into ethanol and distillery residue utilization for liquid organic fertilizer

No.	Subject	Cheese	Ethanol	Liquid Organic Fertilizer
1.	Price per unit (US$)	4.16	3.02	2.29
2.	Cost per unit after split off (US$)		0.81	0.78
3.	Hypothetical market price (US$)	4.16	2.21	1.51
4.	Production capacity (unit)	4 045	2 688	2 443.00
5.	Hyp. mark. price × Prod. capacity (US$)	16 827.20	5 940.48	31 688.93
6.	Relative hypothetical market price (%)	63.60	22.45	13.94
7.	Joint cost allocation (US$)	12 167.57	4 295.50	2 667.43

Table 5
Joint cost allocation of whey cheese bioconversion into ethanol

No.	Subject	Cheese	Ethanol
1.	Price per unit (US$)	4.16	3.02
2.	Cost per unit after split-off (US$)		0.81
3.	Hypothetical market price (US$)	4.16	2.21
4.	Production capacity (unit)	4045.00	2688.00
5.	Hypothetical market price × Prod. capacity (US$)	16 827.20	5940.48
6.	Relative hypothetical market price (%)	73.91	26.09
7.	Joint cost allocation (US$)	12 179.48	4 299.32

The joint cost allocation can be used as the basis for determining the cost of goods sold with full costing approach (Pitriani, 2015; Mujab, 2015). Consideration of the production units generated by joint cost allocation resulted in the calculation of the variable cost for cheese as main product so it can be used as basis to recalculate the cost of goods sold (Table 6).

The calculation of the distillery residue utilization as liquid organic fertilizer showed that the number of the

Table 6
Variable cost, contribution margin and contribution margin ratio calculation with joint cost analysis

	Cheese	Cheese		Ethanol		Fertilizer	
	Initial (US$)	* (US$)	** (US$)	* (US$)	** (US$)	* (US$)	** (US$)
Joint cost allocation	–	12 167.57	12 179.48	4295.50	4299.32	2667.43	–
Variable cost	3.52	3.01	3.01	1.60	1.60	1.09	–
Contribution margin	0.64	1.15	1.15	1.42	1.42	1.20	–
Contribution margin ratio	0.15	0.28	0.28	0.47	0.47	0.52	–

* with organic liquid fertilizer
** without organic liquid fertilizer

same production unit variable cost of cheese production that can be reduced up to 14.73%, from US$ 3.53 to US$ 3.01. Recalculation by not inserting the organic liquid fertilizer as component of income showed an increase in the joint allocation costs of main commodities of cheese and ethanol as by-products. However, this resulted non-significant change for the variable cost which is not affected the contribution margin of 1.15 for cheese and 1.42 for ethanol with the contribution margin ratio of 0.28 for cheese and 0.47 for ethanol. The benefit of cheese whey bioconversions into ethanol calculated from the value of contribution margin that was US$ 3 816.96 per month. Analysis of joint cost allocation along to the production of by-products allows the calculation of the absorption of production costs evenly to obtain the lower cost of production (Pitriani, 2015).

The relationship between investment, costs, sales and production volume until the company reaches condition where no loss or gain calculated by breakeven point (BEP) analysis (Wijayanti, 2013). Wijaya and Saputro (2004) said that the total investment needed for the small scale cheese production was US$ 142 827.51, so that the total investment with the utilization for ethanol of US$ 12 781.56 was US$ 155 609.07. The whole investment and production cost of cheese and cheese whey utilization into ethanol reach the breakeven point in less than 4 months (Table 7). The production scheme runs to produce breakeven in 9 001.01 liters of ethanol production, or equivalent to US$ 27 183.32 of income from ethanol sales, that can be achieved at 3.35 month in the production of ethanol.

Table 7
Break-even point (BEP) analysis of bioconversion cheese whey into ethanol

Type of Product	BEP (US$)	BEP (unit)	BEP (month)
Cheese	510 098.30	122 619.80	30.31
Ethanol	27 183.32	9 001.01	3.35

Conclusions

Utilization of cheese-making wastes through bioconversions with napa cabbage wastes addition resulting in cost savings of wastes disposal, provide the financial benefits up to US$ 3 816.96 per month, decreased the variable cost of the main product until 14.73 % with the breakeven point in 3.53 months.

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