

## **COST-BENEFIT ANALYSIS OF BIOCONVERSION NEUFCHATEL WHEY INTO RECTIFIED ETHANOL AND ORGANIC LIQUID FERTILIZER IN SEMI PILOT SCALE**

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### **Abstract**

*Aims of the study was to determine the cost-benefit analysis in neufchatel whey bioconversion into rectified ethanol and organic liquid fertilizer. Bioconversion whey into rectified ethanol and organic liquid fertilizer has shown great potential as a way to reduce the pollution resulting from cheese-making process. Semi pilot scale experiment was done to ferment 5 L neufchatel whey using 5% K. lactis at 33°C for 24 h in semi anaerobic plastic container without agitation and then distilled into 96.2% purity. Data collected and analyzed descriptively related to benefit cost ratio/BCR, net present value/NPV and internal rate returns/IRR. The result showed that semi pilot scale bioconversion of neufchatel whey resulting in 106.42 ml rectified ethanol and 4404.22 ml distillery residue. Economic benefit could achieved by the support of distillery residue sales as organic liquid fertilizer.*

**Key words:** cost-benefit analysis, neufchatel whey, rectified ethanol, organic liquid fertilizer, semi pilot scale.

### **INTRODUCTION**

By-product of cheese making as we called it whey are increasingly of concern to the cheese producers. To date, Indonesian small scale cheese producers dumped whey directly into the environment and causing pollution. Along with that, there are costs to incurred which became an additional burden for small scale cheese producers.

Whey could utilized into many products such as functional drink, whey protein concentrates, biopolyester and single cell protein (Siso, 1996; Singh and Singh, 2012; Shukla et al., 2013; Spalatelu, 2012; Koller et al., 2012) However, lack of knowledge and small capital owned by small scale cheese producers became one of constraints to do it. Appropriate technology that easy to apply such as bioconversion can be used to utilize whey into bioethanol (Siso, 1996; Guimaraes et al., 2010; Koller et al., 2012).

Neufchatel whey is one of whey that resulted from small-scale cheese producers in Indonesia and cannot utilized to date. Production of semi-

soft cheese from cow's milk that has been done by the producers will resulting Neufchatel whey (Fox et al., 2004). Utilization of Neufchatel whey through laboratory scale bioconversion inside sealed container (semi-anaerobic) with batch system for 24 hours incubation could produce bioethanol content of 1.79 to 1.94% (Roostita et al., 2010; Utama et al., 2011). Bioethanol produced could distilled into rectified ethanol which has 96.2% purity, and the distillery residue could applied as organic liquid fertilizer.

The feasibility of appropriate technology application that done in the laboratory has to be tested on a larger scale. Up-scaling into semi pilot scale and economic feasibility calculation should be considered.

Cost benefit analysis provides to determine the best way for Neufchatel whey utilization in small scale cheese producers. The emphasis lies on the evaluation of the profitability aspect that emphasizes the benefits of Neufchatel whey utilizations for cheese producers (Suharjito et al., 2003).

## MATERIALS AND METHODS

Whey taken from PT Yummy Food Utama, East Jakarta with the composition of 4.09% lactose, 2.39% fat, 0.75% protein, 0.089% ash, 0.015% fiber and 92.67% water. *Kluyveromyces lactis* from School of Life Science, Institute Technology of Bandung. Semi pilot scale experiment was done to ferment 5 L Neufchatel whey using 5% *K. lactis* at 33°C in semi anaerobic plastic container without agitation with 4 replications. Incubation was held for 24 h and then distilled into 96.2% purity (Utama et al., 2011).

The results of quantity and quality of ethanol and organic liquid fertilizer used as the design basis for the calculation of economic feasibility based on Net Present Value (NPV), Benefit Cost Ratio (BCR) and Internal Rate Return (IRR) (Suharjito et al., 2003).

Net Present Value (NPV), the current value of project or activity calculated by the formula:

$$NPV = \left( \sum_{t=1}^{t=n} \frac{Bt - Ct}{(1+i)^t} \right)$$

Benefit Cost Ratio (BCR), ratio of benefit and cost of the project or activity, calculated by the formula:

$$BCR = \frac{\left( \sum_{t=1}^{t=n} \frac{Bt}{(1+i)^t} \right)}{\left( \sum_{t=1}^{t=n} \frac{Ct}{(1+i)^t} \right)}$$

Internal Rate of Returns (IRR), the maximum interest that can be paid by the project or activity, calculated by the formula:

$$IRR = \left( \sum_{t=1}^{t=n} \frac{Bt - Ct}{(1+i)^t} \right) = 0$$

Ko = Initial Investment

Bt = Benefit

Ct = Cost

t = Year of the project

i = Discount rate

n = Period of the project

## RESULTS AND DISCUSSIONS

Semi pilot scale of bioconversion 5 L Neufchatel whey into ethanol showed that average rectified ethanol produced was 106.42 and 4404.22 ml distillery residues. Which mean, bioconversions 1L Neufchatel whey resulting in 21.284 ml rectified ethanol and 880.34 distillery residues. The results on Table 1 taken as basis for economic feasibilities calculation.

Table 1. Results of semi pilot scale experiments

Replication	Rectified Ethanol (ml)	Distillery Residues (ml)
1	116.42	4395.22
2	118.56	4442.11
3	89.88	4566.41
4	100.82	4507.25
<b>Average</b>	<b>106.42</b>	<b>4404.22</b>

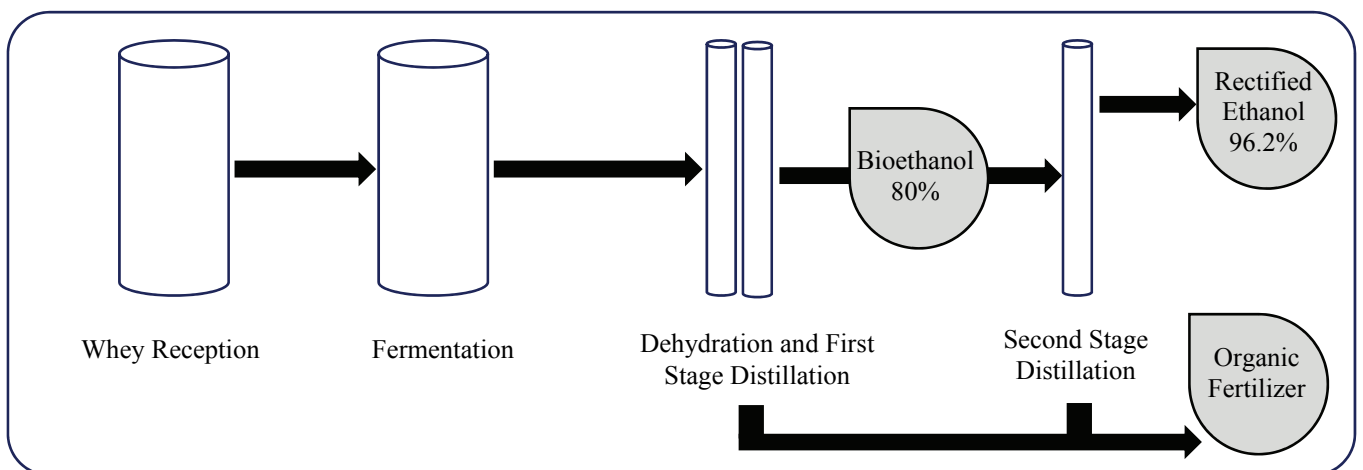


Figure 1. Flow chart of bioconversion whey into rectified ethanol

Table 2. Initial investments

Subject	Unit	Price (Euro)
Land Rent 5 m x 4 m	1 Unit	1000
Single Distilator 1500 L	1 Unit	345
Dehydrator and Distilator 1500 L	1 Unit	695
Fermentation Tank 1500 L	1 Unit	155
Fermentor Pump	1 Unit	235
pH meter	1 Unit	50
Alcoholmeter	2 Unit	80
Reception Tank	1 Unit	80
Piping	1 Pack	350
<b>Total</b>		<b>2990</b>

Table 3. Monthly costs

Subject	Unit	Price (Euro)
Salary	3 employee	240
Yeasts	1875 L	750
Electricity	100 kWh	10
LPG	200 Kg	25
Water	25 m <sup>3</sup>	5
<b>Total</b>		<b>1030</b>

Table 4. Monthly incomes

Subject	Unit	Price (Euro)
Rectified Ethanol (€0.5/L)	787.5 L	393.75
Organic Liquid Fertilizer (€1/U)	1650 U	1650.00
<b>Total</b>		<b>2043.75</b>

If small scale cheese producers able to produced 15kg Neufchatel cheese per day, it can assumed that approximately 1500 L Neufchatel whey per day will be discarded. In a month with the assumption of 25 production

days, there will be 37500 L Neufchatel whey that were not utilized.

Whey utilization for rectified ethanol and organic fertilizers can be done by some capital investment to build the installation. Scheme of whey utilization as shown in Figure 1, will need a number of investment such as distilator, dehydrator and fermentor as shown in Table 2. Initial investment of bioconversion Neufchatel whey into rectified ethanol and organic liquid fertilizer for 1500 L/d will spent €2990.

Beside the initial investment, operational costs that spent monthly need to calculated. Table 3, showed that €1030 needed as monthly costs which covered salary for 3 employee, yeasts, electricity, LPG for distillation and dehydration then also water.

Monthly operation will produce 787.5 L rectified ethanol and approximately 33000 L organic liquid fertilizer. As shown in Table 4, rectified ethanol will generate income €393.75 if the highest international price of rectified ethanol was €0.5/L (Ogbonna and Okoli, 2013). Beside that, organic liquid fertilizer will packed in 20L/Unit and per unit sold €1 which generate €1650. The organic liquid fertilizer generated from ethanol distillery residues with neufchatel whey as raw materials contains N of 0.1%, P of 0.067% and K of 0.135 (Utama et al., 2011). Bioconversions Neufchatel whey into rectified ethanol and organic liquid fertilizer will generate total monthly income of €2043.75.

Table 5. Net Present Value and Benefit Cost Ratio calculation for Scenario A

Year	Investment	Operational Cost (C)	Total	Benefit (B)	Discount Factor (DF) 15%	B * DF	C * DF
1	2990	12360	15350	0	0.78	0	11973
2		12360	12360	4725	0.76	3591	9393.6
3		12360	12360	4725	0.66	3118.5	8157.6
4		12360	12360	4725	0.57	2693.25	7045.2
5		12360	12360	4725	0.5	2362.5	6180
						11765.25	42749.4
Net Present Value = -30984.15							
Benefit Cost Ratio = 0.275							

Table 6. Net Present Value and Benefit Cost Ratio calculation for Scenario B

Year	Investment	Operational Cost (C)	Total	Benefit (B)	Discount Factor (DF) 15%	B * DF	C * DF
1	2990	12360	15350	0	0.78	0	11973
2		12360	12360	24525	0.76	18639	9393.6
3		12360	12360	24525	0.66	16186.5	8157.6
4		12360	12360	24525	0.57	13979.25	7045.2
5		12360	12360	24525	0.5	12262.5	6180
						61067.25	42749.4
Net Present Value = 18317.85							
Benefit Cost Ratio = 1.43							

Table 7. Internal Rate Returns calculation

Year	Investment	Operational Cost (C)	Total	Benefit (B)	B-C	DF 12%	NPV 12%	DF 15%	NPV 15%	DF 90%	NPV 90%
1	2990	12360	15350	0	-15350	0.893	-13707.55	0.87	-13354.5	0.526	-8074.1
2		12360	12360	24525	12165	0.797	9695.505	0.756	9196.74	0.277	3369.705
3		12360	12360	24525	12165	0.712	8661.48	0.658	8004.57	0.146	1776.09
4		12360	12360	24525	12165	0.636	7736.94	0.572	6958.38	0.077	936.705
5		12360	12360	24525	12165	0.567	6897.555	0.497	6046.005	0.04	486.6
							19283.93		16851.195		-1505
Internal Rate Returns = 84.24 %											

Feasibilities of the project shown by NPV, BCR and IRR results on Tables 5, 6 and 7.

Table 5 showed that the scenario A without organic liquid fertilizer sales, lead to loss and the project was not feasible which shown by the value of NPV < 0 and BCR value < 1 (Suharjito et al., 2003).

However scenario B with organic liquid fertilizer sales (Table 6 and 7), shown benefit and feasibility of the project which shown by the value of NPV €18317.85, BCR of 1.43 and IRR of 84.24%.

High income generated from organic liquid fertilizer increased the value of the project and the benefit-cost ratio, so that the IRR also increased into high percentage.

Bioconversions of Neufchatel whey into rectified ethanol and organic liquid fertilizer gave multi benefit to the communities.

Beside the economic benefit, this project could employ three workers from surrounding communities.

As the environmental benefit, there will be reduction of pollution load resulting from Neufchatel whey disposal.

## CONCLUSIONS

Semi pilot scale of bioconversion neufchatel whey resulting in 106.42 ml rectified ethanol and 4404.22 ml distillery residue.

The economic benefit will achieved with organic liquid fertilizer sales, with the NPV €18317.85, BCR of 1.43 and IRR of 84.24%.

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