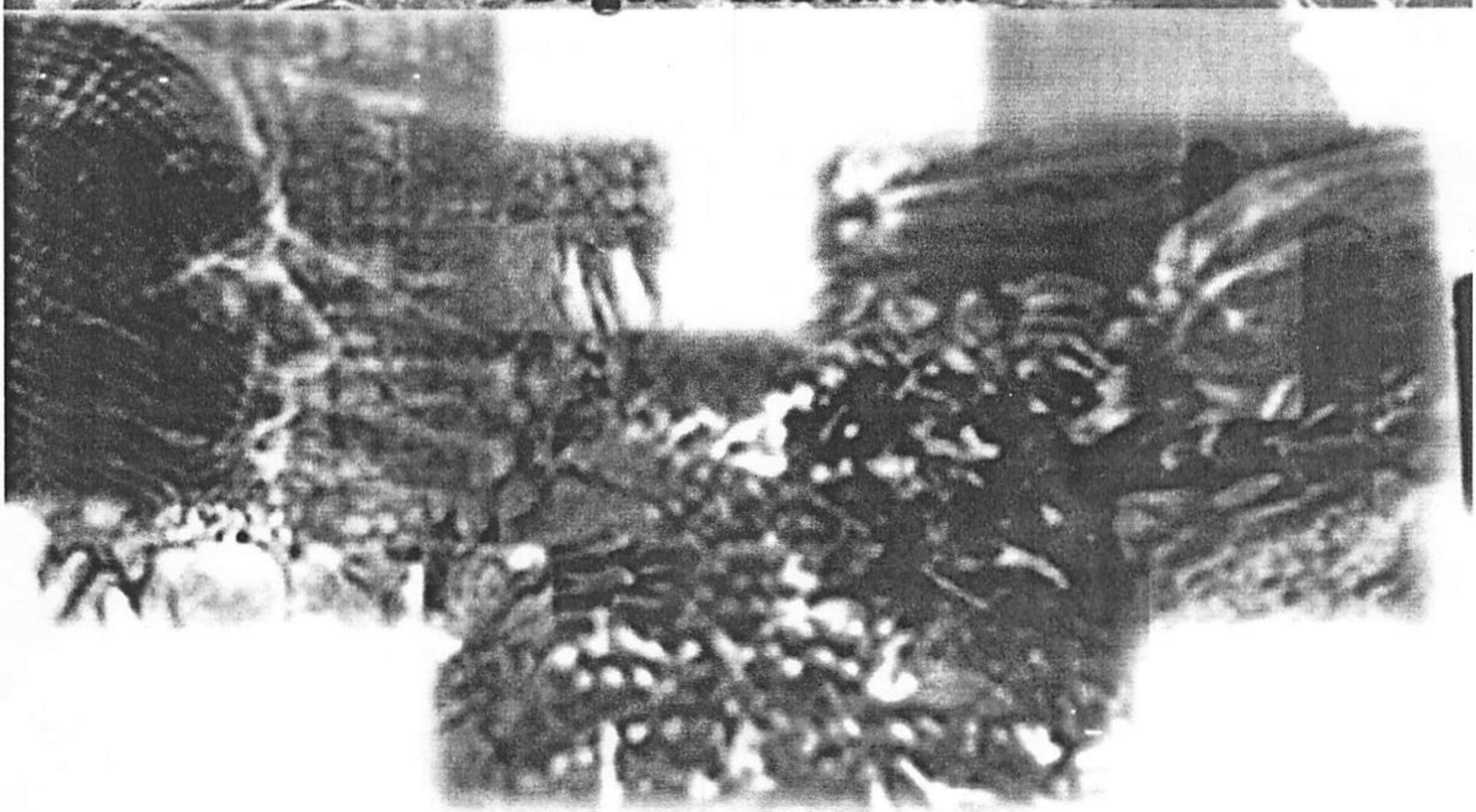
# PROCEEDINGS

## 2nd International Conference on Adaptive and Intelligent Agroindustry (ICAIA)

**September 16 - 17, 2013**

**IPB International Convention Center**
**Bogor - Indonesia**



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Department of Agroindustrial Technology

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Organized by :

1. Departement of Agroindustrial Technology, Faculty of Agricultural Engineering and Technology Bogor Agricultural University
2. George Mason University, Fairfax, Virginia, USA
3. Indonesian Agroindustry Association (AGRIN)

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# WELCOMING ADDRESS

**Prof. Dr. Ir. Nastiti Siswi Indrasti**
Head of Agroindustrial Technology Department
Faculty of Agricultural Engineering and Technology
Bogor Agricultural University
**On**
**Second International Conference on Adaptive and Intelligence Agroindustry (2nd ICAIA)**
Bogor, September, 16 – 17, 2013

Assalamu'alaikum Warohmatullahi Wabarokatuh
In the name of Allah, the beneficent and the merciful,

Distinguish Guest, Ladies and Gentlemen
Let me first thank you all for accepting the invitation to participate in this 2nd International Conference on Adaptive and Intelligence Agroindustry (ICAIA). In particular I would like to thank Rector of IPB (Institut Pertanian Bogor/Bogor Agricultural University) Prof. Herry Suhardiyanto for supporting this event as part of the series academic event in celebrating the 50th Anniversary of Bogor Agricultural University.

In fact, the idea of organizing this conference was the continuation of the International Workshop on Computational Intelligence and Supercomputing Technology for Adaptive Agroindustry held by the Department of Agroindustrial Technology, Bogor Agricultural University last year.

Professor Kenneth A De Jong from George Mason University, US has successfully conducted joint international research with some staff from the Department of Agroindustrial Technology and Department of Computer Science, Bogor Agricultural University. The research aims to develop an integrated and intelligent system (namely SMART-TIN©) for the design of adaptive agroindustrial system in order to achieve a sustainable agroindustry that can mitigate global climate change and at the same time secure food, water, energy and natural medicine supply.

We are certainly proud to have been able to assemble this event in IPB, Bogor. The range of participants and audience at this conference is precisely something I would like to stress. The main goal of the conference is to provide an effective forum for distinguished speakers, academicians, professional and practitioners coming from universities, research institutions, government agencies and industries to share or exchange their ideas, experience and recent progress in Adaptive and Intelligent Agroindustry.

Distinguish Guest, Ladies and Gentlement,
Global climate change is the most challenging problems for us today and in the near future. This global change in our climate can lead to the shortage of the food, water, bioenergy and natural medicine that will affect the quality of human life. Many studies indicate that the threat of food, water, bioenergy and natural medicine crisis due to global climate change still worries our society. This problem can be solved by the development of agroindustry, i.e. an interrelated value chain entities from farming, to agro-processing industry and then to the end-customers. In fact, the design of agroindustry is complex and involves many factors and large data bases and more importantly, needs a good intelligence to process data and information to good decisions. Therefore, the way to design and manage agroindustry should be improved in order to meet the design objectives.

Agroindustries consume quite significant amount of energy on one side, on the other side they generate sizable amount of industrial wastes and its utilization as a captive energy resource is a kind of potential. Based on our study, a plywood industry with the production capacity of 200.000 $m^3$/year could generate 32 percentage of solid waste. If this amount of waste used as an energy alternative, it may result on the saving of 131.037.768.597 rupiah per month. Similar to plywood industry, sugarcane industry with the production capacity of 480 ton per hour could generate 154 ton per hour of waste (bagasse) and this amount of waste contribute to the saving of energy consuming by 19.250 Kwh. Recent study we conducted, indicated that cassava starch industry may contribute to a significant amount of waste. It has also potential usage as an energy resource. Based on our study the conversion of its waste into energy will contribute to the saving of energy usage of 4100 liter biogas per ton material.

The three industries mentioned is only examples of how potential the role of agroindustrial waste as an alternative resource in replacing the conventional energy resource as its presence will be significantly reduced. The new, incremental energy contributions that can be obtained from waste biomass will depend on future government policies, on the rates of fossils fuel depletion, and on extrinsic and intrinsic economic factors, as well as the availability of specific residues in areas where they can be collected and utilized. All of these factors should be in detail examined to evaluate the development of the industrial waste contribution. Hope this conference will also discuss this issue in more detail as it is an important matter for all of us. We should no more think just how to produce high value product but it is also necessarily important how to keep our live in good quality by understanding following old saying..." only when the last tree has been cut, only when the last fish has been angled, and only when the last river has been polluted, then we realized that we could not eat money".

I do not to take up any more of your time with these opening remarks. Let me simply thank you once again for sharing your thoughts with us. Here's wishing every success for the conference. May Allah bless all of us.

Thank you for your kind attention,
Wassalamu'alaikum Warohmatullahi Wabarokatuh

# AGENDA of

# 2nd International Conference on Adaptive and Intelligent Agroindustry (ICAIA)

| Time | Activities | Room |
|---|---|---|
| **Day 1 (16 September 2013)** | | |
| 08.00 – 09.00 (60') | Registration | |
| 09.00 – 10.00 (60') | Opening Ceremony<br>• Welcoming Address: Prof. NastitiSiswiIndrasti (Head of Dept TIN, Fateta, IPB)<br>• Conference Opening: Prof. HerrySuhardiyanto(Rector of IPB)<br>o ABET Certification announcement and short ceremony<br>o Launching International Double Degree Master Program in Innovation and Technopreneurship in Cooperation with University of Adelaide, Australia<br>o Soft-launching Master in *Logistik Agroindustri* (Agroindustrial Logistics) | Ballroom |
| 10.00 – 10.45 (45') | Opening Speeches:<br>Prof. IrawadiJamaran (Agroindustry Guru, IPB: 25')<br>Prof. Eriyatno (Industrial and System Engineering, IPB: 20') | Ballroom |
| Session 1 | | |
| 10.45 – 11.15 (30') | Keynote Speech Dr. YandraArkeman (IPB) | Ballroom |
| 11.15 – 12.00 (45') | Keynote Speech Prof. Kenneth De Jong (George Mason University, USA) | Ballroom |
| 12.00 – 13.30 (90') | Lunch Break | |
| Session 2 | | |
| 13.30 – 15.15 (105') | Moderator: Prof. EndangGumbiraSa'id (IPB)<br>Invited Speakers (1-4) (4 x 20 minutes)<br>Discussion (25 minutes)<br>Tentative Schedule: Prof. Kim Bryceson (Australia), Prof. SyamsulMa'arif (IPB), Prof. KudangBoro Seminar (IPB), Prof. HaruhiroFujita (Japan) | Ballroom |
| 15.15 – 15.45 (30') | Break | |
| 15.45 – 17.30 (105') | Moderator: Prof. Marimin (IPB)<br>Invited Speakers (5-8) (4 x 20 minutes)<br>Discussion (25 minutes)<br>Tentative Schedule: Dr. Gajendran (UK), Prof. Noel Lindsay (University of Adelaide), Dr. KuncoroHartoWidodo (UGM), Prof. UtomoSarjonoPutro (ITB) | Ballroom |
| Day 2 (17 September 2013) | | |
| 08.00 – 08.30 (30') | Registration | |
| 08.30 – 10.15 (105') | Moderator: Prof. KudangBoro Seminar (IPB)<br>Invited Speakers (9-12) (4 x 20 minutes)<br>Discussion (25 minutes)<br>Prof. Egum (IPB), Prof. Marimin (IPB), Dr. AgusBuono (IPB), Dr. HeruSukoco (IPB) | |
| 10.15 – 10.30 (15') | Coffee Break | |
| 10.30 – 12.30 (120') | Parallel Session 1<br>Moderator: Prof. Fujita<br>(7 paper @ 15 minutes)<br>Discussion (15 minutes)<br><br>Parallel Session 2<br>Moderator: Prof. Ono Suparno<br>(7 paper @ 15 minutes)<br>Discussion (15 minutes)<br><br>Parallel Session<br>Moderator: Prof. Suprihatin<br>(7 paper @ 15 minutes)<br>Discussion (15 minutes) | |

| | | |
|---|---|---|
| 12.30 – 13.30 (60') | Lunch Break | |
| 13.30 – 15.00 (90') | Open Discussion (Open Forum) with Prof. Kenneth De Jong<br>Topic: Foundations and Applications of Genetic/Evolutionary Algorithms | Ballroom |
| 15.00 – 15.30 (30') | Conference Closing | Ballroom |
| 15.30 – 17.00 (90') | Indonesian Agroindustry Association (AGRIN) National Congress<br>(PIC: Prof. Suprihatin) | Ballroom |
| 17.00 – 17.45 (45') | Refreshment and Closing of AGRIN National Congress | Ballroom |

## CONTENT LIST

# Study on Effect ofxTemperatureIncrease on the Productivity of Methanefrom POME Fermentation

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## ABSTRACT

Indonesia as a biggest palm oil producer country in the world is also producing is also producing palm oil mill effluent (POME). In 2011, palm oil factories in Indonesia produced 68,697,300 tons POME. POME is a hazardous liquid waste for environment, but with proper processing POME will be a potential energy source. The research objective of this study were to determine the effect of temperature rise on the production of methane gas in the POME fermentation. The POME and sludge mixture then was fermented at different temperatures according to the treatment at room temperature, 45°C, and 55°C. Observation parameters were biogas volume and composition of biogas($CH_4$, $CO_2$, and $N_2$). The results showed that: (1) The temperature increase of POME fermentations from 30°C to 55°C can increase the speed COD removal, productivity methane, and methane gas concentration; (2) POME's fermentation at temperatures 55°C, temperature 45°C, and 30°C could produce methane productivity as much as 0,28 $m^3$; 0,25 $m^3$, and 0,20 $m^3$ respectively for each kg COD removal; (3) POME's fermentation at temperature 55°C, 45°C, and 30°C could produce biogas with methane contents of 65.44%, 62.57% and 59.55% respectively.

**Keywords:** POME, fermentation temperature, methane, biogas

## 1. INTRODUCTION

As the largest crude palm oil (CPO) producing country in the world, Indonesia produced more than 22,899,100 tons of CPO in 2011 [1]. The extraction of CPO requires large quantities of water for steam sterilization of the palm fruit bunches and clarifying the extracted oil. Palm oil mill (POM) requires a large amount of water for its operation and discharge considerable quantities of liquid waste, called palm oil mill effluent (POME). For each tonne of crude palm oil (CPO) produced, about 0.9-1.5 $m^3$ POME is generated [2] or about 2.5-3.0 tonnes of POME is discharged per tonne of CPO produced [3].

POME is the effluent from the final stage of palm oil production in the mill. It is a colloidal suspension containing 95-96% water, 0.6-0.7% oil and 4-5% total solids including 2-4% suspended solids [4]. The biological oxygen demand (BOD), chemical oxygen demand (COD), oil and grease, total solids and suspended solids of POME ranges from 23,500 to 29,300 mg/L; 49,000 to 63,600 mg/L; 8,370 mg/L, 26,500 to 45,400 mg/L and 17,100 to 35,900 mg/L, respectively [2].

In general, overall POME parameters are above the threshold quality standards established by the Government of Indonesia [5], thus POME is classified as environmental pollutants [6]. POME with average chemical oxygen demand (COD) and biochemical oxygen demand (BOD) of 70,000 and 30,000 mg/L, respectively, can cause serious environmental hazards if discharged untreated [7].

In Indonesia, the most common POME treatment is open ponding system. More than 90% of palm oil mills use ponding systems solely due to their low costs. Nonetheless, these methods for treatment of POME have several disadvantages such as long hydraulic retention time (HRT), bad odor, large areas of lands or digester are required and difficult in collecting and utilizing the methane generated, which causes a detrimental greenhouse effect to the environment [8]. Methane is a greenhouse gas (GHG) with global warming potential of 20-30 times more powerful than carbon dioxide [9].

On the other hand, methane is a flamable gas with high potential to be utilized as the source of renewable energy. The research objective of this study were to determine the effect oftemperature riseon the production ofmethanegasin thefermentationPOME. The expected benefit obtained from this study was to know the best temperature regime for the conversion of POME to biogas, in the effort to capture the methane for the production of electrical energy.

## 2. MATERIALS AND METHODS

The experiments were conducted in three anaerobic bioreactors of "*Bench Scale Advance Methane Fermentation Model AR-50L-3*" with the capacity of 50L each, with stirrer and automatic temperature control. During the fermentation, produced gas was measured continuously using gas flowmeter of "*Wet Gas Meter; Model W-NK 0.58*". POME and sludge were obtained from PTPN VII Bekri unit, Central Lampung, Indonesia.

The level of the temperatures studied were 27-28°C (room temperature), 45+/- 3°C and 55+/- 3°C. The stirring speed of 100 rpm was used at the temperatures of 45°C and 55°C. On the other hand, bioreactors with manual stirring was used for the treatment conducted at room temperature. Stirring was done three times a day, with stirring time of five minutes each.

This study was initiated by doing characterization of the samples which included POME, sludge and the mixtures of them with the ratio of 80% of POME and 20% of sludge. The mixturex of POME and sludge were then fermented at different temperatures accordingly. The experiments were terminated when the COD value of effluent was less than 10,000 mg/L. The flow diagram of study is illustrated in Figure 1.

The parameters being observed during fermentation were biogas productionand composition of biogas ($CH_4$, $CO_2$, and$N_2$). Biogas production was measured using gas flow meter (WK-NK-0.5B, Shinagawa Corporation, Japan). Composition of gas was analyzed using gas chromatography (Shimadzu GC 2014 plus) with thermal conductivity detector (TCD) and shin-carbon column with 4 meter length. Biogas production and temperature were measured every day. The gas composition were measured every seven days.

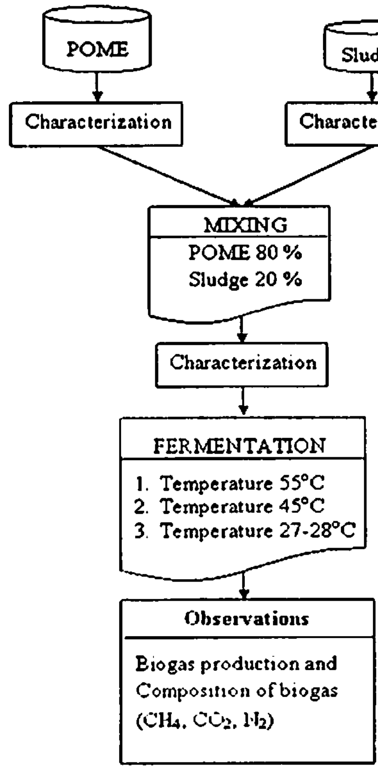


**Figure 1.** Flow Diagram of Fermentation Process of POME into Biogas

## 3. RESULTS AND DISCUSSION

### 3.1. Characterization of POME and Sludge

Characterization of POME and sludge which is used for the study are presented in Table1. It is seen that LCPK Shave a parameter whose value exceeds the threshol dto be dumped into public waters and potential as environmental pollutants (MENKLH RI, 1995).

**Table1.**Characterization of POME and Sludge

| Parameter | POME | *Sludge* | POME 80% &*Sludge*20% |
|---|---|---|---|
| Temperature($^{0}$C) | 50 – 70 | 26 - 27 | 26 - 27 |
| pH | 5,63 - 5,64 | 8,15 – 8,35 | 6,07 – 6,29 |
| COD (MG/L) | 41.250 - 52.000 | 19.500 - 28.750 | 43.375 – 51.000 |
| TSS (MG/L) | 46.174 - 55.328 | 21.448 - 54.540 | 40.851 - 44.336 |
| VSS (MG/L) | 12.324 - 20.720 | 6.751 - 9.850 | 19.572 - 24.950 |
| Color | Milk Chocolate | Dark black | Dark Brown |
| Odor | Typical(Not Smelling Rotten) | Foul smelling Sting | Foul smelling Sting |

### 3.2. Pattern of Biogas Production

Figure 2 shows the daily biogas production from fermentation temperatures of 55°C, 45°C and 27-28°C during the study period. The lag phase of biogas production at room temperature (27-28°C) was 151 days, at the temperature of 45°C was 25 days, and at the temperature of 55°C, the active microorganisms directly producing biogas without any lag phase. This indicated that the active microorganisms represented the group of thermophilic anaerobic microorganisms such as *Methanosarcina, Methanococcus, Methanobacterium*, and *Methanobacillus* [10].

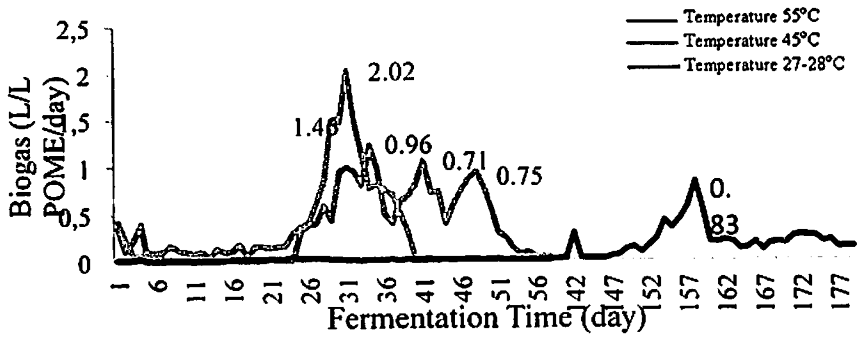


**Figure 2 :** The Biogas Production Pattern from POME at Different Fermentation Temperatures

### 3.3. The speed of COD removal

Increase in temperature from 30°C to 55°C in POME fermentation to increase the speed of COD removal of 0.43%/day to 2.07%/day, as in Figure3. At the temperaturs of 55°C fermentation of POME only took 42 days to reduce COD by 86.86%, namely from 43,375 mg/L to 5,700 mg/L. At the temperature of 45°C, POME fermentation took longer than 57 days to reduce COD by 84.31% or from 51,000 mg/L to 8,000 mg/L. While at room temperature (27-28°C) POME fermentation took much longer than 196 days to reduce COD by 57.25%, namely from 51,000 mg/L to 21,800 mg COD/L. The above results seem to be in line with the results of Choorit and Wisarnwan (2007) who reported that the fermentation time of POME at thermophilic temperatures was four times faster than that of the fermentation at mesophilic temperatures.

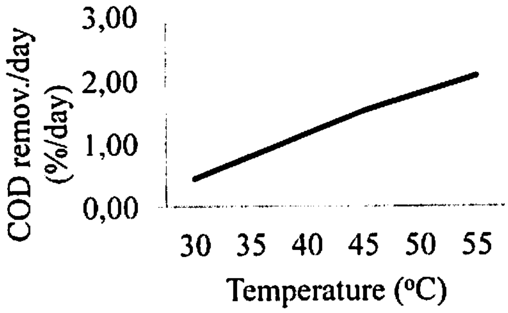


**Figure 3 :** Effect of Temperature Increased at COD removal Rate on POME Fermentation

### 3.4. Methane Productivity

Research results showing the production of methane from POME at different temperatures can be seen in Figure 4. POME fermentation at 55°C produced more methane than that of conducted at 45°C and 30°C. Fermentation at 55°C. 45°C. and 30°C produced methane as much as 0.28 L; 0.25 L, and 0.20 L respectively for each g of COD removal. On the other hand, stoichiometric estimation of each g of COD would produce 0.35 L methane gas. The lower value of biogas production in this study might be due to imperfect methanogenesis process resulting in many formation of $CO_2$.

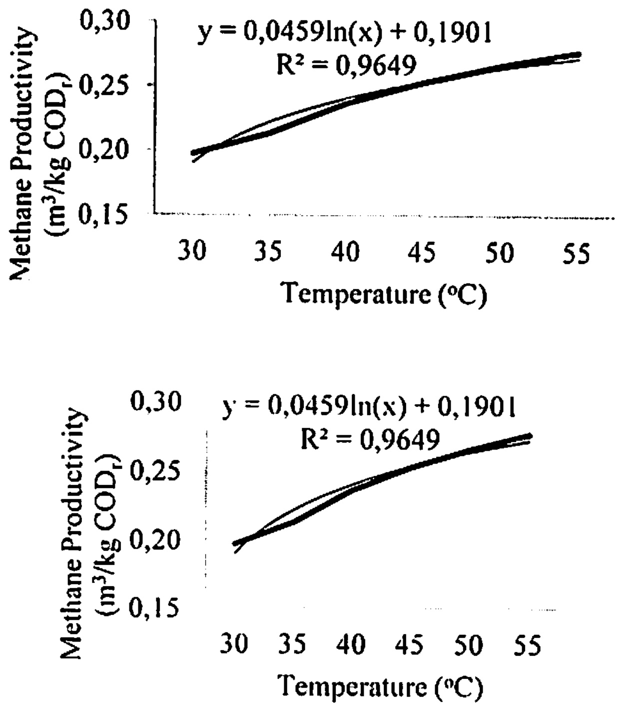


Figure 4. Effect of Increased Temperature on Methane Productivity Improvement on POME Fermentation

### 3.5. Methane Concentration

Fermentation temperature of 55°C produced biogas with a methane content higher than that of fermentation at 45°C and 30°C (Figure 5). Meanwhile, fermentation temperature at 55°C produces biogas with lesser impurity ($CO_2$ and $N_2$) than that of the fermentations conducted a t 45°C and 30°C. In producing biogas as fuel, especially for electrical energy, it is very important to remove carbon dioxide, which may increase biogas quality and higher heating energy point [11].

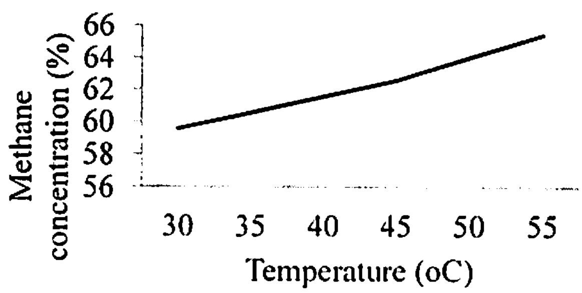


**Figure 5 :** Effect of Increased Temperature on the Concentration of Methane Gas in the POME Fermentation

## 4. CONCLUSIONS

(1) The temperature increase of POME fermentations from 30°C to 55°C can increase the speed COD removal, productivity methane, and methane gas concentration.
(2) POME fermentations at 55°C,45°C, and 30°C produced methane as much as 0.28 m³; 0.25 m³; and 0.20 m³. respectively. for each kg COD removal.
(3) POME fermentation at 55°C, 45°C, 30°C produced biogas with methane contents of 65.44%. 62.57% and 59.15% respectively.

## ACKNOWLEDGEMENTS

The authors thank the Directorate General of Higher Education of Ministry of Education and Culture The Republic of Indonesia for the financial support for this study through Pemprinas scheme of MP3EI 2012. Thanks also go to all leaders of the companies of the 13 POM's in Lampung Province. and the Board of Directors and Chairmen of PTPN V. Agro-Industrial Technology Department Fateta IPB. Faculty of Agriculture. UNILA. and Analytical Laboratories of POLINELA for the provision of the data. information and discussion.

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