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by Muh Akhsan Akib

Submission date: 14-Oct-2020 06:25AM (UTC+0700)
Submission ID: 1414412771
File name: 18._J._ATJ_Fermentation_of_whey_wastes.....pdf (1.97M)
Word count: 2936
Character count: 15734

Agrotech Journal
ATJ
Url: http://usnsj.com/index.php/ATJ
Email: editor.atj@usnsj.com

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AUTHORS INFO

Henny Setiawati
Muhammadiyah University of Parepare, South Sulawesi
hennys73@yahoo.co.id
+62813551414500

Muh. Akhsan Akib*
Muhammadiyah University of Parepare, South Sulawesi
akhsanbagus@yahoo.co.id
+62811343885978

*Corresponding Author

ARTICLE INFO

ISSN: 2548-5121
Vol. 2, No. 2, November 2017
URL:http://usnsj.com/index.php/ATJ/article/view/2.2,7-13

Abstract

Whey waste contains organic materials, particularly high complex proteins and amino acids in the form of suspended and dissolved solids, however the utilization of whey as a organic liquid fertilizer still has a less attention. Thus the Utilization of the whey waste through anaerobic process to be used as a organic liquid fertilizer is the purpose of the research. This research was conducted using factorial design with completely randomized design (CRD) which consists of two factors: the yeast concentration (without yeast; 0.25 and 0.50 g/500 ml of whey waste) and the fermentation time (0, 3, and 5 days). The variables measured were the content of organic C, C/N Ratio, and Total N, P_2O_5 and K_2O contents. The results showed that the fermented whey waste on the different fermentation time and yeast concentration had increased the organic C and C/N ratio, but decreased P_2O_5 and K_2O contents. The utilization of whey combined with solid or other liquid wastes gave a chance to produce a quality organic liquidfertilizer.

Keywords: fermentation, pucafu, tofu, yeast, waste.

A. Introduction

Industrial tofu waste consists of liquid and solid wastes. The tofu liquid waste is the biggest part of the tofu's waste and potentially contaminates the environment. Most of the liquid waste produced is derived from a viscous liquid separated from the tofu' solid at the stage of the coagulation and filtering process, called as whey (Husin, 2008).

Chemical compounds contained in whey waste are 40% - 60% of protein and amino acids in the form of suspended and dissolved solids, 25-50% of carbohydrate, 10% of fat (Said, 1999), 4.55% of iron, and 1.74% of phosphorus (Fatha 2007), as well as 0.24 mg/l Pb, 34.1 mg/l Ca, 0.12 mg L^{-1} Cu, and 0.59 mg L^{-1} Na (Lisnasari, 1995). The largest component of liquid waste of tofu is protein (Total N) of 226.06 to 434.78 mg L^{-1}. The presence of the organic compounds causes the liquid waste of tofu industry contains Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD) and TSS that are high (with the average of 3250, 6520, and 1500 mg L^{-1}, respectively) which is when these organic compounds are discharged into the waters without processing can cause pollution (Husin, 2008), due to the increase of total N in the waters.

The study of whey waste utilization has been carried out by Ahmia *et al* (2014) which found the utilization of whey as a raw material for biodiesel, Ridhuan (2016) and Subekti (2011) utilized that as raw material for biogas, and Sutiyani *et al*. (2013) used it as a raw material of Nata de Soya and soya, Rahayu *et al.* (2012) utilized the tofu liquid waste as a source of rural energy, and Handajani (2016) used it as a nutrient in the culture of *Microalgae Spirullina sp*. In addition, several methods were investigated to decrease the contamination level of whey waste, such as the methods of using the cow dung (Angraini *et al*., 2014), anaerobic digester (Indriyati and Susanto, 2012), fishing nets and bioball biofilters (Zahra *et al*., 2015), rotating biological contactor (Laili *et al*., 2014) to decrease BOD, COD and TSS levels of the whey waste.

Anaerobic respiration process (fermentation) is one of the biochemical processes that can be used to extract the organic compounds contained in waste with the help of microorganisms, which is also affected by several factors including: pH, time of operation, nutrient, temperature, and sugar content (Sari, 2009). Some researchers who have conducted the research of fermentation to know the mineral content of the material are Sapariantin *et al* (2010) which fermented the ethanol from cashew juice by *Z. mobilis* with the addition of urea, Santi (2008) studied the fermentation time, Siahan (2010) and Akib *et al* (2014) investigated the yeast concentration and fermentation time of *Leri* (rice water) waste.

Several information on the research results of whey waste utilizations have been reported, but the quantitative data about the quality of fermented whey waste for the organic liquid fertilizer (OLF) is remain unknown. Thus, the researchers have a big interest to conduct a research of whey waste with anaerobic processing for the organic liquid fertilizer "OLF PUCAFU".

B. Methodology

The research was conducted using factorial design with completely randomized design (CRD), which consisted of two factors: the concentration of yeast (0 g (control), 0.25 g and 0.50 g per 500 mL of whey waste) and fermentation time (0 day (control), 3 days and 5 days). The combination of these two factors resulted 9 treatment units.

The primary samples of fermented whey were taken in three points, that are in the bottom, middle and top of the fermentator container by using a pipette hose, 50 mL of the samples was taken then blended into a composite sample. The variables observed were: Organic C content, C/N ratio, Total N, P_2O_5 and K_2O contents. The results data of the laboratory test was shown in the figures.

C. Result and Discussion

Organic C (organic matter) is a part of solid or liquid medium which is a complex and dynamic system derived from the residues of the plant and animal contained in solid or liquid media that is constantly undergoing a shape change due to the impact of biological, Physics, and chemistry factors. Organic C is the percentage of fertility in solid and liquid media consisting of various C (carbon) bond (Irawan *et al*., 2016; Sipahutar *et al*., 2014; Nariratih *et al*., 2013).

The Organic C content of the fermented whey waste for 3 days with yeast concentration of 0.25 g per 500 ml of waste whey, showed an increase of Organic C content that was higher than other treatments. This might be caused by the better growth of microorganisms and there was no competition in the utilization of nutrition. Total population of microorganisms of whey waste was also very instrumental in the increase of Organic C of where microorganisms biomass was

also a part of the organic matter composed of carbohydrates, proteins and lipid (Purwitasari *et al*., 2004; Utomo and Shovitri, 2014).

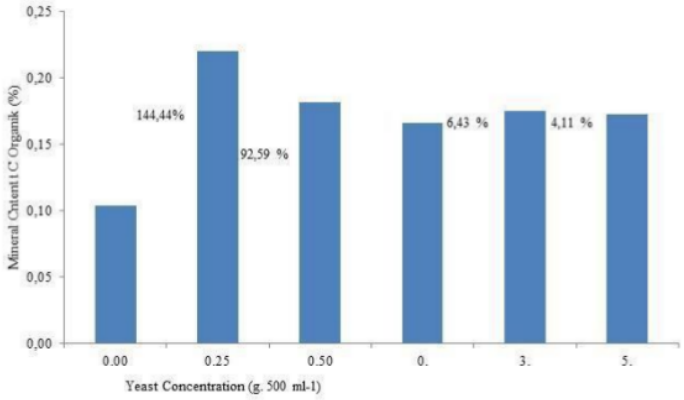

Figure 1. Organic C Content (%) of OLF PUCAFU on the treatment of the different fermentation time and yeast concentration (The data shown is the result of logarithmic interpolation).

The indicator of the quality and maturity level of fertilizer materials could be seen from the C/N ratio. Degradation processes occurred during the fermentation required an organic carbon (C) to meet the energy and growth, and nitrogen (N) to meet the protein as a cell metabolism-building substance (Ismayana *et al*., 2012).

A high increase of C/N ratio on the treatment of yeast concentration of 0.25 g per 500 ml of whey waste revealed that the decomposition process has not been finished. If the C/N ratio is too high (excess Carbon), the microbe will suffer N deficiency for protein synthesis so that decomposition slows down (Dewi and Treesnowati, 2012), however, the fertilizer material with a lower C/N ratio contained a lot of ammonia (NH_3) produced by ammonia oxidizing bacteria. These compounds could be further oxidized to be nitrite and nitrate which are readily taken by plants (Ismayana *et al.*, 2012).

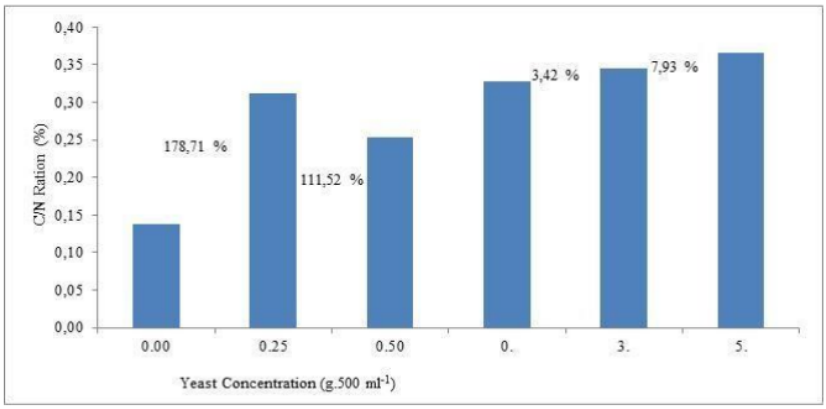

Figure 2. The C/N ratio of OLF PUCAFU on the treatment of the different fermentation time and yeast concentration (The data shown is the result of logarithmic interpolation).

N content in whey waste fermentation decreased after a few days in various yeast concentrations, the same result has also been reported by Makiyah (2013). The decrease indicated that the yeast as the microorganism required the nitrogen as the protein source for the process to reproduce itself.

Total N in a liquid fertilizer was influenced by the quality of the fermented substrate and the fermentation process. The addition of *Saccharomyces cerevisiae* in addition to help the degradation process of organic matter at the beginning of fermentation stage, also donated a number of single cell protein obtained in the extraction process of the solid substrate into a liquid substrate, which further used as the base material of the liquid fertilizer (Hidayati *et al*., 2011).

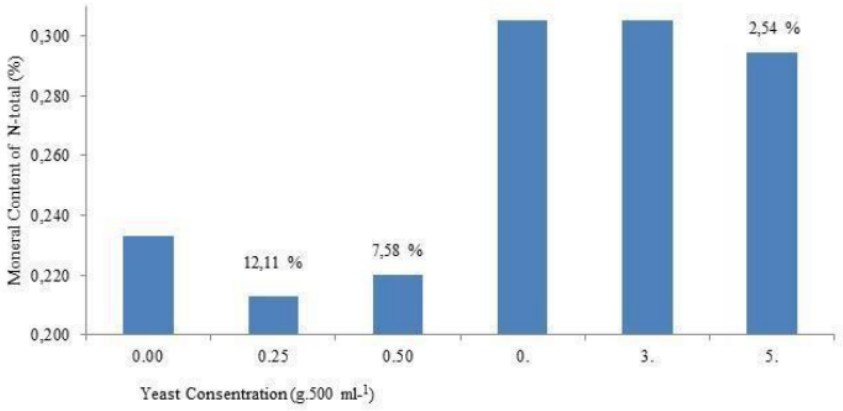

Figure 3. Total N Content (%) of OLF PUCAFU on the treatment of the different fermentation time and yeast concentration (The data shown is the result of logarithmic interpolation).

The breakdown of proteins into simpler compounds allows the compounds to be more degradable, either water-soluble or vaporized before use, particularly when the C/N ratio is too low will result in leading to the formation of ammonia gas, thus the nitrogen is easily lost into the atmosphere (Harada *et al.*, 1993). According to Sintha (2008), the reaction of fermentation process to fix the nitrogen (N) is follows:

$$\text{Protein} \xrightarrow{\textit{Proteinase}} \text{TP} + \text{NADP} + \text{NH3} + \text{energy}$$

$$2NH_3 + 3O_2 \xrightarrow{\textit{Nitrosomonas}} 2HNO_2 + 2H_2O + \text{energy}$$

$$2HNO_2 + 2O_2 \xrightarrow{\textit{Nitrobacter}} 2HNO_3 + 2H_2O + \text{energy}$$

The decrease of P_2O_5 content occurred in all treatments (Figure 4). Stofella and Kahn (2001) suggested that the P2O5 content was related to the N content in substrate, the greater the nitrogen content will increase the multiplication of phosphorus solubilizing microorganisms, so that the phosphorus content in liquid fertilizer also increased. The content of phosphorus in the substrate will be used by most microorganisms to build its cells. The mineralization process of phosphorus was occurred due to the phosphatase produced by most microorganisms.

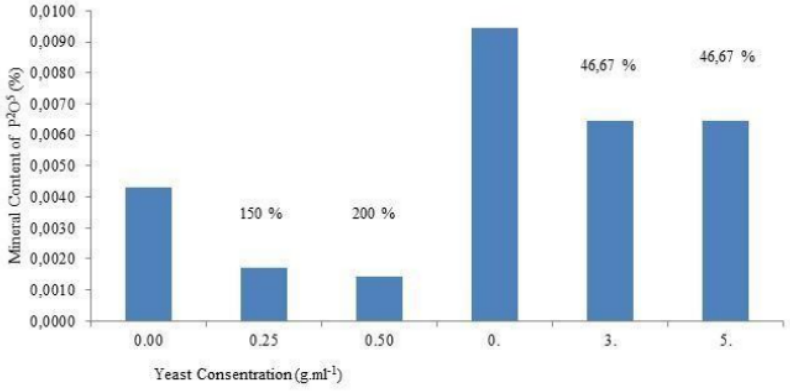

Figure 4 The content of P_2O_5 (%) of OLF PUCAFU on the treatment of the different fermentation time and yeast concentration (The data shown is the result of logarithmic interpolation).

One of the phosphorus bound in the form of P_2O_5 at the end of the decomposition process. Phosphorus is occurred in two forms namely inorganic and organic such as nucleic acids, phitin and lecithin. According to Yuli *et al.* (2011), the available sources of carbon and nitrogen

affected the fungus that could solubilize lecithin and nucleic acids as well as liberate phosphorus from insoluble phosphate complexes.

Similar results were also obtained by Lubis *t al.* (2014) who used palm oil mill effluent into the organic liquid fertilizer with the P_2O_5 content of 0.05%. According to Sitha (2008), the running metabolism to obtain the nutrient phosphorus is as follows:

ATP + glucose → ADP + glucose 6 phosphate

Glucose 6-phosphate + H_2O ↔ glucose + phosphate

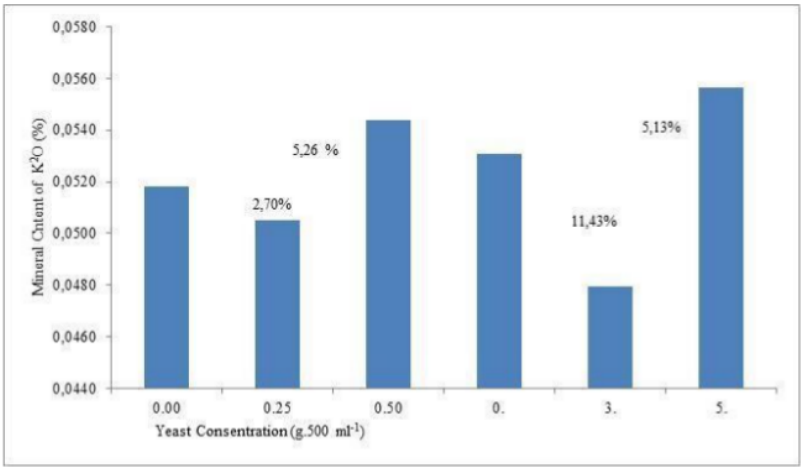

Figure 5. The average content of K_2O (%) of OLF PUCAFU on the treatment of the different fermentation time and yeast concentration (The data shown is the result of logarithmic interpolation).

Potassium (K_2O) is not contained in the protein. The element is not a direct element involved in the formation of organic matter where it only plays a role in helping the formation of protein and carbohydrates. Potassium is used by microorganisms in the substrate material as a catalyst. The presence of the fungus and its activity will greatly affect the increase of potassium content. Potassium is bonded and stored in the fungus cells. Therefore, when it is degraded then the potassium will become available again (Yuli *et al*., 2011).

D. Conclusion

Waste whey which is a residual waste of tofu production process has a chance to be used as organic liquid fertilizer. The results showed that the fermented whey waste on the different fermentation time and yeast concentration had increased the organic C and C/N ratio and decreased the content of Total N, P_2O_5, and K_2O.

E. Acknowledgment

The author would like to thanks to the Minister of Research, Technology and Higher Education of republic Indonesia (RISTEK DIKTI), which provided the research funds for the implementation of Competitive Research Grant Scheme.

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