MAKARA, TEKNOLOGI, VOL. 16, NO. 1, APRIL 2012: 63-67

PINEAPPLE LIQUID WASTE AS NATA DE PINA RAW MATERIAL

Agus Sutanto

Biologi Education Department, University of Muhammadiyah Metro, Metro Lampung 34111, Indonesia

E-mail: sutanto11@gmail.com

Abstract

This research aims to study the quantity, quality, ecological and economic feasibility of nata de pina production (NP) from pineapple liquid waste (PLW). The design of the study employs complete random design (CRD) with three treatments: PLW without nutrients addition (A), PLW nutrients addition (B), and PLW stored for six months with nutrients addition (C). The nata de pina's production factors measured were weight, thickness, fiber content, color, brightness, and residual waste. The highest weight was reached in treatment B (899 grams), followed by treatment A (616.4 grams), and C (477.8 grams). The thickness of NP of the height and low as in treatment B (1.58 cm) followed by treatment A (1.24 cm) and C (0.88 cm), respectively. The highest fiber content was found in treatment C (9.3%) followed by treatment B (7.6%) and A (6.9%), respectively. The fiber content, along with color quality and brightness fit with food standards. The production of NP may reduce the volume of the PLW from 46.2% to 89.1% (p = 0.001). Based on the standard value of biological oxygen demand (BOD), chemical oxygen demand (COD), total suspended solid (TSS) below to the required threshold except pH. The production of NP is economically feasible to 4.7 BC ratio. The overal manufacture of nata de pina from PLW produces better and feasible product ecologically and economically

Abstrak

Limbah Cair Nanas sebagai Bahan Baku Pembuatan Nata de Pina. Penelitian bertujuan mengkaji kuantitas. Kualitas, kelayakan ekologis dan ekonomis pembuatan nata de pina limbah cair nanas (LCN). Penelitian menggunakan rancangan acak lengkap (RAL) dengan 3 perlakuan yaitu (A) LCN tanpa penambahan nutrisi; (B) LCN dengan penambahan nutrisi dan (C) LCN penyimpanan 6 bulan dengan penambahan nutrisi. Produk nata meliputi berat, tebal, warna, kecerahan. Kandungan serat dan sisa limbah dianalisis dengan Anova. Analisis deskriptif untuk kelayakan ekologis dan ekonomi. Hasil penelitian terdapat perbedaan yang sangat nyata perlakuan fermentasi LCN. Ketebalan nata berturut-turut dari dari tinggi kerendah perlakuan B 1,58 cm A 1,24 cm, dan C 0,88 cm. Berat nata B 889 gr, A 616,4 gr, dan C 477, 8 gr. Kadar serat C 9,3%, B 7,6% dan A 6,9% dengan kualitas warna, kecerahan, dan serat, sesuai standar untuk makanan. Pembuatan nata de pina mengurangi volume LCN 46,2-89,1% (Sig. 0,001). Berdasarkan baku mutu limbah, *biological oxygen demand* (BOD), *chemical oxygen demand* (COD) dan *total suspended solid* (TSS) dibawah ambang batas yang dipersyaratkan kecuali pH. Secara ekonomi pembuatan nata de pina layak (BC ratio 4,7). Secara keseluruhan pembuatan nata de pina dari LCN menghasilkan nata yang baik serta layak secara ekologis dan ekonomis.

Keywords: bioremediation, Nata de pina, pineapple liquid waste (PLW)

1. Introduction

Pineapple industry produces not only main products such as pineapple, pineapple concentrate juice and sugar (clarified pineapple juice), but also delivers solid, liquid and gas wastes. These wastes are coming from certain phases of the processing unit which yield varied forms, characteristics, and waste qualities [1]. The liquid waste is generated from industrial activities: cleaning, separation process, and pineapple concentrate production. The various processing will deliver large number of pineapple waste between 5,000–7,000 m^3 [2]. The waste is rich in more or less 87% water, 10.54% carbohydrate, 1.7% fiber, 0.7% protein, 0.5% ashes, and 0.02% fat [3]. Based on the nutrient contents, PLW contains high carbohydrate and sugar. PLW can be utilized as substrate for the growth of nata's bacteria synthesizer. It contains 81.72% water; 20.87% rough fiber; 17.53%

carbohydrate; 4.41% protein and 13.65% reduction sugar [4]. The extract of the waste contains organic acids and minerals which may accelerate the growth of *Acetobacter xylinum* [5]. The pineapple pH level is around 3-4 and contains bromelain, a protease, that if discarded without treated first would cause soil damage, reduce the soil fertility, and responsible for the reduction of soil pH and cause soil and water organism protein damages [6].

Since pineapple wastes have not been widely managed, and could cause environmental problems, a breakthrough to reuse pineapple wastes is needed. One of them is utilizing pineapple wastewater as nata de pina product. This is to answer nata-making raw material shortages that currently rely heavily on the use of limited raw materials such as coconut water. Nata is a fermented product which is formed by *A. xylinum* [7]. This bacteria belongs to acetic acid bacteria type (*aceto;* acetate, *bacter;* bacteria) [8]. When the bacteria are planted into liquid medium containing sugar, they will produce acetic acid and a white layer floating on the liquid medium. The white layer is called nata [9].

A wastewater treatment technology that is environmentally friendly is one that use bacteria as potential decomposers; i.e. bioremediation. It is less expensive than applying chemical or physical substances [10]. Bioremediation is a biological technique that restore contaminated environment through a process that utilizes natural organisms in transforming organic substances to be nontoxic products [11]. The increased utilization of micro organisms as biotechnological agents are due to the fact that: (1) it is easy to be developed and controlled, (2) the substrate growth is relatively inexpensive, even to use agricultural waste, (3) it can produce nata making, the starter used in fermentation process is *A. xylinum* bacteria, planted in liquid media containing sugar that will produce acetic acid and floated white layer on the surface of the liquid media. The floated white layer is known as nata. It is white cell or bright grey, transparent and tough like kolang-kaling (raw sugar palm fruit). The nata will be fibrous in cold situation and rather fragile in hot situation [13]. The beginning signs of bacteria growth can be seen from the turbidity of the liquid media after fermention for 24 hours in room temperature. After 36–48 hours, a translucent thin layer begins to shaped on the surface of the media and the liquid becomes clear. The nata formation occurs due to the glucose uptake process from the media solution, sugar or medium which contain glucose by *A. xylinum* cells. Then, the glucose is joined with acid grease to form precursor in the cell membranes. The precursor is issued as excretion and together with polymerize enzyme the glucose into cellulose on the outside of the cell [14]. Cellulose is one of the natural polymers utilized. Yet, the bacterial cellulose produced by fermentation process uses bacteria known as one of the cellulose source. Cellulose is un-branch polymer of sugar connected through 1.4-beta-glikosidic bonds. The cellulose fiber has high physical strength, formed by coiled fibrils like spiral with opposite direction followed by one fuse [15].

In this study, the nata making was undertaken by using pineapple waste and additional sugar and urea. It is important to know that the essential components of nata's growth media are carbon and nitrogen which will provide nutrients to the growth of *A. xylinum*. Both substances potentially set up nutrient resources for *A. xylinum*, even though they are not optimal yet. Ten percent sucrose and glucose would produce the thickest nata compared to other sugar sources [16]. When it is compared between the use of glucose and sucrose, the use of glucose produces thicker nata, so glucose is the best carbon source for the formation of nata. The glucose can be obtained from any parts of pineapple including the waste generated during pineapple processing. If PLW can be used asmedium for *A. xylinum* bacteria's growth, it prove that undergoing PLW bioremediation is be economically advantageous.

2. Methods

The research employed experimental method with complete random design (CRD) with 3 treatments (t) and 5 replications (r). The treatments are: PLW without the addition of nutrients (A), PLW with nutrients addition (B), and PLW stored for six months with the addition of nutrients (C). Dependent variables measured were weight, thickness, fiber content, color, brightness and residual waste.

The material for nata making was the pineapple liquid waste from PT Great Green Pineapple (GPP) Lampung. The study was conducted at the microbiology laboratory of the Biology Department of State University of Malang from January to March 2010. The research procedures is as described in Figure 1.

The data was analyzed in quantitative descriptive. Weight, thickness, fiber content, and residual waste content residual data of PLW are analyzed using variance analysis. Color/brightness is analyzed descriptively. The economic analysis border economic profit (BEP) is calculated based on cost investment, fixed cost, outcome and profit and benefit cost ratio (BCR) [17]. The calculation refers to home industry scale which produces 100 liters per day. The ecological analysis is conducted by analyzing residual of nata waste, including the parameter to the waste of food industry: pH, BOD, COD, and TSS compared to the quality standard of pineapple liquid waste as with the State Ministry of Environment rules Number: 05 year 2007 date 8th of May 2007 [18].

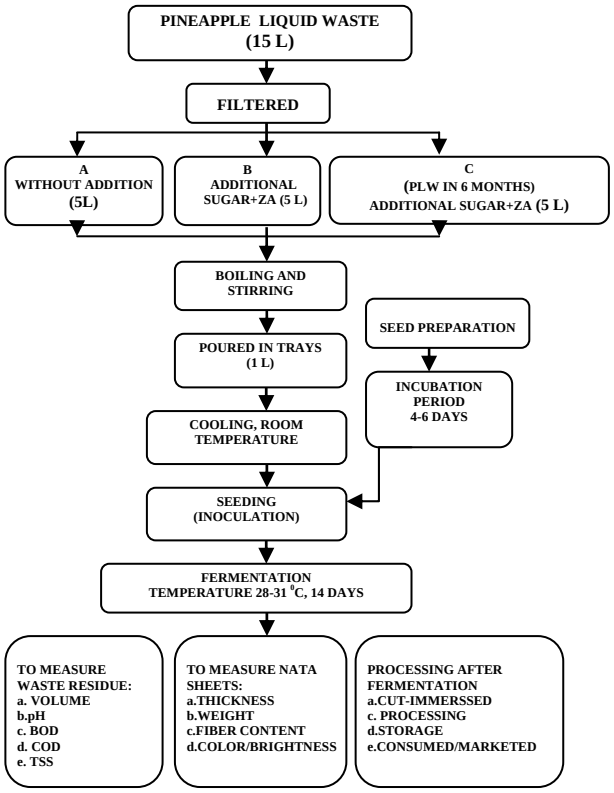

Figure 1. General Scheme of Nata Making (Adapted [19])

3. Results and Discussion

Quantity and Quality of Nata de Pina. The variables analyzed statistically were weight, thickness, fiber content, and residual waste. There are significant weight differences (p=0.01) with the weight reached in each treatment was as followed: treatment B 889 gram, A 616.4 gram, and C 477.8 gram. The nata thickness were 1.58 cm in treatment B, 1.24 cm in treatment A, and 0.88 cm in treatment C. The fiber content meets demand of INS (Industrial National Standard) or SNI (Standar Nasional Industri) [1]: 9.1%, 7.5%, and 6.9% from treatment C, B, and A respectively. with prerequisite standard of color and brightness. The reduction of waste content ranged from 46.2-89.1% which significantly can reduce the volume of industrial waste.

The enhancement of the weight results from the high glucose availability as carbon source since the formation of cellulose depends on *A. Xylinum*'s ability to use sugar in the medium as the carbon source. One of the important factors concerning fermentation is that carbon source is used in fermentation medium, whether it is easily metabolized or not by the microbe [16]. The researchers propose that the cellulose gel can not be created when there is no glucose or oxygen available in the medium. So, when the carbon source used by the *A. xylinum* has sufficient oxygen, the cellulose will be produced faster.

The nata de pina yielded from PLW showed the highest thickness and weight when it is added with sugar and ZA. The nutrients enrichment in the media allow bacteria abundant supply of the nutrient. In treatment C, even though PLW has been stored for 6 months, the nutrient content is enough to grow the bacteria and to produce more fiber. A treatment where there was no nutrient additional produce nata that is fairly well compared to the enriched PLW (B). The difference in weight is 272.6 gram compared to B medium and 138.6 gram compared to C medium. It shows that without adding nutrients, PLW can be used as the medium to grow *A. xylinum* well [20]. PLW used here fulfill two basic requirement to grow the bacteria: pH between 3-4 with more than 10% of monosaccharide [1]. The fiber content of the 3 treatments were higher than the minimum standard for fiber content in food (5%) by National Standard of Indonesia (NSI) [8]. Color and brightness respectively are white (A), gloomy (B), and brown (C). PLW without sugar and ZA addition are whiter and brighter. The more balance its pH the whiter the nata will be [21].

The quantity and quality of pineapple liquid waste (PLW) residue of nata de pina making. Table 2 shows the comparison of pH, Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Suspended Solid (TSS) of PLW before and after nata de pina production compared to the quality standard of the liquid waste of fruit processing as regulated by the State Ministry of Environment decree No. 05/2007 [15].

The values of the waste parameters, BOD, COD and TSS, as well as pH, declined after the nata de pina production. The decrease of the pH value is related to *A. xylinum* activity. If the bacteria are planted in thesugary liquid medium, they will produce acetic acid or acetate and further, produce floating white piece on the surface of the liquid media, known as nata [9]. The acid production decrease pH value. When compared with industrial waste standards quality, the components of the organic substances are lower that the threshold of the standards, while pH has not fulfilled the criteria.

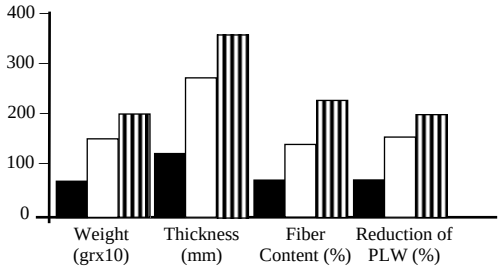

Figure 2. Weight, Thickness, Fiber Content and Reduction Percentage in Nata de Pina from One Litre of Pineapple Liquid Waster (PLW) through Three Treatments; A (■), B (□), and C (▥)

Table 2. Quantity and Quality of Pineapple Liquid Waster (PLW) Residue of Nata de Pina Making

Parameter	PW before treatment	PW after treatment	Quality Standard
pH	3-4	2.9	6-9
BOD (ppm)	217	196	75
COD (ppm)	184	64	150
TSS (ppm)	165	1.4	100

Therefore, the residual waste of nata needs to be treated in accordance with its quality standards. As seen in Figure 2 and Anova testing result, the nata de pina production reduces the volume of the industrial waste significantly ($p < 0.001$). The reduction ranges from 46.2-89.1%. This number shows that it can reduce the volume of industrial waste in significantly. The residual waste can even be used to make more nata whether as the starter or directly as the medium. It could produce 560 gram nata, in average, for every 700 mL the pineapple liquid waste. As a whole, nata de pina production using PLW can reduce PLW significantly. The standard quality of BOD, COD, and TSS are below the threshold. The process is called pineapple liquid waste bioremediation that is environmentally safe and friendly [22]. It is believed that bioremediation physiologically is the most effective and best way to overcome the dangerous contamination of chemical compounds [23].

The feasibility analysis in nata de pina production. Economically, 100 liters of pineapple liquid waste for the home industry scale is needed to reach a break even point; IDR. 1,342,991.81 and cost benefit ratio; 1.9% at the beginning investment cost and will be 4.7% of profit in each month; IDR. 2,359,575.00. This is a very prospective business opportunity. Moreover, if it is developed to industrial scale, it may decrease the production cost up to 65%. The industrial scale production will reduce the cost of fuel, sugar addition, syrup, etc, because industrial production of nata does not need media sterilization and acid neutralization [24]. It means that nata de pina making using PLW as raw material does not needs additional material in spite of regular regeneration of starter; *A. xylinum.*

Totally, the production of nata de pina from pineapple liquid waste has a good chance to be develop outside the laboratory. Economically, it may gives added value for PLW and opens job opportunities, especially for its industry and people who live in the vicinity. A starter can be added to produce nata de pina without additional nutrient. The nata production may yield standardized nata for PT. GGP to open another production of the company. Each year, PT GGP Lampung generates 5,000–6,000 m^3/day PLW. The use of PLW has solved raw material problem for nata production. Unfortunately, the ongoing supplies of pineapple generally encounter the seasonal pineapple problems and would cause 'seasonal' supply of PLW as raw material for nata production of the company that would lead to a problem to the continuity of the production. The regular input supplies is a must in the agribusiness management include the nata de pina's production [25]. In the other hand, [26] It is stated that nata de pina has very good strength since it provide micro fibrils which less than 10 nm length, straight like spider net. The strength of the net makes nata de pina composite nearly as strong as light steel while its density is much lower than light steel. nata de pina composite can be used in various applications such as in automobile industries, electronic, and constructions. Nata de pina composite is light, strong, cheap, easy to produce, is renewable resources and available in abundance in the area.

The principle application of reuse in waste management is to reduce the volume of the waste [27]. It can be seen from the volume decrease analysis of waste relate to waste quality and especially to the qualification of quality standard required [28]. In this case, che utilization of the PLW as raw material in nata de pina production will provide additional values for the company economically and even ecologically, so that the demand of green market can be fulfilled by PT. GGP Lampung as the third biggest pineapple producer in the world that exports to more than 55 countries [29].

4. Conclusion

Nata de pina's production using pineapple liquid waste (PLW) through the three treatments yield shows that treatment A (PLW without nutrient addition) produce nata that has good quality for consumption and industry. The production of nata reduces the volume of PLW significantly ($p = 0.001$). The reduction of PLW was between 46.2-89.1% which significantly reduce the waste volume. Meanwhile, the quality standard value of BOD, COD and TSS were below the threshold, except pH that needs to be treated. Economically, nata de pina home industry can gain 4,7 of B/C ratio. The production of nata de pina from PLW has economical and ecological benefit that meet the demand from green market for pineapple processing industry.

Acknowledgement

The authors would like to thank for the financial support from Hibah Penelitian Mahasiswa Program Doktor Tahun 2010 of Ministry of Education-Republic of Indonesia Through Directorate or Research and Community Service- University of Malang with contract no: 495/SP2H/PP/DP2M/2010.

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