Feasibility Analysis of Cassava and Glucose Syrup as Alternatives Raw Materials for Industrial Nata (Case Study at CV. Agrindo Suprafood, Yogyakarta)

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Abstract

CV Agrindo Suprafood as one of the largest suppliers of nata de coco in Yogyakarta is only able to meet 40% of market demand due to the limitations of coconut water. An alternative strategy to tackle this problem is by looking for coconut water substitute as raw material for the production of nata. The purpose of this study was to analyze the potential of cassava and glucose syrup as raw material alternative of nata and its feasibility on an industrial scale .

Formulation of nata is performed on a pilot plant scale with cassava and glucose syrup as raw material. Cassava glucose and glucose syrup were separately used as a growth medium of Acetobacter xylinum for the production of nata. The physical, chemical, and sensory evaluation as well as technical and financial feasibility analysis were conducted on the nata product.

The best formula for production of nata de cassava and nata de glucose was obtained by a combination of glucose, glucose syrup, coconut water, ZA,vinegar, and acetic acid. Based on the analysis, it was concluded that both of nata production were industrially-feasible in terms of both technical and financial analysis. However, based on the financial analysis, nata de glucose was more prospective than nata de cassava.

Keywords: *Cassava, feasibility, glucose syrup, nata, scale-up*

1. INTRODUCTION

Nowadays, the processed food in Indonesia is increasingly diverse. Raw materials in the form of staple food or previously considered as residual waste can be processed into a product that can be consumed and has a high selling value. One of the food products which currently processed from residual waste is the product from coconut water or commonly called as nata de coco. Nata de coco is one of the products which is processed through fermentation of coconut water using starter bacteria *Acetobacter xylinum*(Sutarminingsih, 2004).

Many industries use coconut water as fresh beverages and their processed products which cause its limited availability. This makes the coconut water-based manufacturers to look for alternative strategies in order to continue its industrial activities. One of the coconut water-based industriesthatis quite prominent and becomes a supplier of raw materials for several national large scale plants in Indonesia is CV. Agrindo Suprafood. Established in 2003 at Bantul, Yogyakarta, CV. Agrindo Suprafood has a production capacity of approximately 400 tons/ month which requires about 400,000 liters of fresh coconut water every month. Currently, the company is only able to meet 40% (4 tons/day) of the total market demand of 10 tons/day due to the limitations in the availability of coconut water as raw materials. Therefore, it is necessary to findan alternative raw material as an addition to the coconut water. In general, a simple carbohydrate compounds can be used as a carbon source in nata production, including maltose, sucrose, lactose, glucose, fructose, and mannose. The glucose were produced by hydrolysis of starch, so it can be used as an energy source for the nata producing bacteria.

This study is a preliminary study to assess utilization of glucose syrup and cassava as a substrate for the growth of *A. xylinum* in the fermentation process for the production of nata. The use of these materials is to reduce the company's dependency on coconut water. If the glucose in the glucose syrup and cassava can be used by *A. xylinum* to convert glucose into extracellular cellulose and form a network of long microfibrils in the liquid fermentation, the the formula containing glucose syrup and cassava is potential to be bacterial growth media which will be converted into a nata.

The assessment of nata production in a large scale and its commercialization to become a nata industry were conducted in form of technical and financial analysis (Syarif, 2011). The purpose of this study was determining the best medium formula (sugar, ZA, and vinegar) based on cassava and glucose syrup for the growth of *A. xylinum* in nata production, identifying the physical, chemical, and organoleptic tests of nata product at pilot plant scale, knowing the characteristics of the product resulted from the scale up process, and determining the feasibility of nata industry through technical and financial aspects.

2. METHODS

2.1 Materials

The main raw materials used in this study are glucose syrup and cassava. Glucose syrup is directly used, while cassava is converted first into glucose. Additional materials used in this research are coconut water, sucrose, ZA (ammonium sulfate), and CH_3COOH (acetic acid).

2.2 Equipments

The equipments used consist of two groups. The first group is a tool for pilot plant scale consisting of 500 ml pot, stove, trays 500 ml, measuring cup 100 ml, glass beaker, pipettes, and stirrer . The second group is a tool for industrial scale consisting of 120 L pot, stove, trays 1.5 L, measuring cups 2 L, stirrers, rack fermenter, and bucket 20 and 150 L.

2.3 Research sequences

Research sequences to determine the potential of glucose syrup and cassava as an alternative raw material for nata productionin industrial scale are as follows :

2.3.1 Formulation of nata production was conducted in a pilot plant scale with preliminary studies include analysis of reducing sugar content, pH, and variations in factors affecting the growth of *A. xylinum*.

2.3.2 Physical, chemical, and organoleptic tests include elasticity, thickness, pH, crude fiber, water content, ash, minerals, flavor, color, aroma, and texture. The tests were conducted to determine whether the product formula has meetthe standards of nata product and determine consumer preferences towards product nata. The testing was performed by comparing both of nata product with nata de coco produced by CV. Agrindo Suprafood. The testing attribute based on SNI 01-4317-1996 about packaged nata.

2.3.3 At the stage of scale-up, formulation of the pilot plant is transformed into an industrial scale using CV. Agrindo Suprafood facilities, which the volume of 500 ml to 120 liters.

2.3.4 Technical and financial feasibility analysis were performed after the scale-up process. The technical feasibility analysis includes production process technology, production capacity, machinery and equipment, and labor. Investment feasibility analysis include the Net Present Value (NPV), Internal Rate of Return (IRR), and Benefit Cost Ratio (BCR) while the analysis of business includes Break Even Point (BEP) and payback period (PBP).

3. RESULTS AND DISCUSSION

3.1 The Potential of Glucose Syrup and Cassava (Pilot Plant)

Determination of formulation media of glucose syrup and cassava to be a nata was conducted at the pilot plant stage using boiling medium and a tray with a capacity of 500 ml. Glucose syrup is a mixture of glucose, maltose, dextrin, and water (Gaman, 1992).

Glucose syrup was clear and viscous liquid, has a shelf life longer than coconut water. The color of glucose syrup (translucent white) also tends to be one of the advantages to get the original color of nata, which is white. Another potential of glucose syrup is widely available atchemicals stores and bakeries. This glucose syrup can be used directly in the production process of nata. While cassava must undergo enzymatic hydrolysis to glucose before the glucose can be used as a medium for bacterial growth to form nata. To survive, *A. xylinum* requires a medium with reduced sugar content of 4-6 % (Pambayun, 2002). To obtain cassava glucose with appropriate levels of reducing sugars, the amount of water to dissolve 1 kg of grated cassava were varied. A comparison of cassava : water = 1:5 added by 0.5 ml each of α- and β-amylase gave a reduced sugar of 4.89% which is the best level for growing *A. xylinum*.

3.2 Formulation of Nata Production

Formulation for making nata was initiatedin a pilot plant scale. At this laboratory scale, the production process is conducted using 500 ml tray as a fermentation place of nata product. Based on the experiment, the best media formulations for making nata de glucose was composed of 60% of glucose syrup solution,40% of coconut water, 2% of ZA, and 0.75% of acetic acid. Glucose syrup solution was obtained by dilution of glucose syrup 4%, then added by2% of ZA and 0.75% of acetic acid, and 10% of bacterial starter. In the other hand, the best formulation for nata de cassava production was obtained by the composition as follow: glucose 100%, sucrose 1%, ZA 0.3%, and vinegar 1%. Optimization to find the best formula was based on a standard thickness of nata produced by CV. Agrindo Suprafood, ranging from 1 to 1.3 cm.

Observation of the fermentation medium is conducted periodically every 24 hours until the nata is formed in desired thickness, i.e 1-1.3 cm. In the fermentation process, *A. xylinum* converts glucose into cellulosa, a thick membrane on the surface of fermenting liquids. The cellulose formed a submicroscopic fibrils are then bound irregularly to form gelatinised membrane that can trap large quantities of water, called the pellicle nata. Cellulose formed like threads on the medium was then form a network that thickened continuously into a layer of cellulose (Rahayu, 2003). The thickness of nata during the fermentation process is presented in Fig.1.

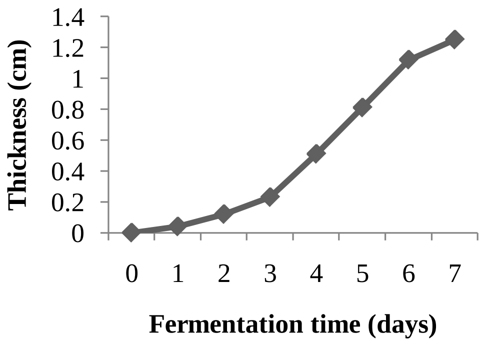

Figure 1. The Development of Nata Thickness During 7 days

On 7th day, the thickness of nata de glucose had reached 1.25 cm. The thickness is in compliance with nata thickness preferred by consumers, the fermentation time of 7 days as the longest fermentation of nata de coco.

In nata de cassava processing, cassava was enzymatically hydrolyzed to break down the starchs (polysaccharide) into into simple sugars (monosaccharides) using amylase enzyme. With cassava glucose media, nata production using formula of 0.5 ml of each α- and β-amylase, sucrose 10 g , and Za 3 g. After 7 days fermentation, a maximum nata thickness of 1.3 cm is obtained. On 7th day, almost all of reduced sugar in the medium are overhauled by *A. xylinum* into cellulose as a floating white layer called nata layer.

Another parameters that indicates the success of nata production is elasticity and color. If the carbon and nitrogen sources is not appropriate, it can affect the texture or elasticity of the resulting nata (Pambayun, 2002). The results of nata elasticity and color tests as physical properties were presented in Table 1.

Table 1. Physical Properties of Nata Product

Physical Properties	Nata de Coco	Nata de Glucose	Nata de Cassava
Texture	25.28 N	31.61 N	32.46 N
Color	L: 37.93 a : -2.62 b : 0.06	L: 42,12 a : -3.01 b : 0.81	L: 29,01 a : -1.55 b : 0.45

Table 1 showed that the texture of both nata de cassava and nata de glucose was more chewy than nata de coco. Texture test using UTM tools shows that compression force to destroy nata de cassava (32.46 N) and nata de glucose (31.61 N) were higher than that to destroy nata de coco (29.28 N). In terms of appearance, the color of nata de glucose was brighter than that of nata de coco, while the color of nata de cassava was more muddy. However, the muddy color of nata was overcomed by pressing the nata prior to the boiling process to release its contained water. Although nata de cassava has a somewhat muddy color, but it has a longer shelf life than the others. The chemical composition of the nata product were presented in Table 2.

Table 2. Chemical Composition of Nata Product

Chemical Properties	Nata de Coco	Nata de Glucose	Nata de Cassava
Water (%)	97.83	95.28	97.27
Ash (%)	0.30	0.26	0.27
Crude Fiber (%)	1.63	2.26	2.31

Crude fiber contained in nata de glucose (2.26%) and nata de cassava (2.31%) were much higher than that of nata de coco (1.63%). These circumstances are such positive influences on the health issues. Gaman (1992) stated that the composition of the foods that contain lots of fiber will slow down the absorption rate of glucose and fat from the small intestine and thereby reduces the risk of diabetes and vascular diseases. Based on this fact, cassava and glucose syrup have potentials to be used as raw material for making nata because the crude fiber contentof both materials were higher than that of nata de coco. The relationship of crude fiber and elasticity or texture is straightlyproportional, the more crude fiber in a product, the acceptable force value of these products are bigger due to the product has more an instense bond (Sudarmadji, 1984).

During fermentation process, *A. xylinum* produces byproducts such as acetic acid. Thisacetic acid was produced from glucose, ethyl alcohol, and propyl alcohol.*A. Xylinum* has ability to oxidize acetate to CO_2 and H_2O. In the metabolism process, synthesis of glucose by enzymes occurs and produces gluconic acid so that the media becomes more acid (Rahayu, 2003). Changes in pH during nata fermentation was shown in Fig.2. The drop in pH level was directly proportional to the increasingof nata thickness andwas appeared in the exponential phase which characterized by increasing activity of bacteria to form nata.

The organoleptic test of this research was conducted based on SNI 01-4317-1996 about packaged nata, covering organoleptic attributes of nata product include smell, taste, color, and texture. The results of organoleptic test showed that the color of nata de glucose was better than that of nata de coco and nata de cassava. Consumers prefer a brighter colors, tended green and yellow nata resemble of nata de glucose color.

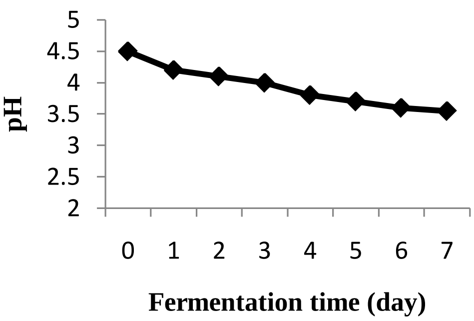

Figure 2. Graph of pH Change During Nata Fermentation

Products flavor was represented by the product acidity, where the flavor of nata de glucose preferred by consumers has a pH of 3.55 after the fermentation process. Nata de cassava has a pH of 3.1 at the end of the fermentation process, which means more acidic than nata de glucose . The results of the texture analysis showed that consumers preferred a compact and chewy nata texture. This texture was appropriate with texture test results of nata de cassava and nata de glucose, which were 32.46 and 31.61 N, respectively.

Based on the organoleptic test, consumers prefer nata de glucose compared to nata de cassava and nata de coco. Thus, glucose syrup as raw material for making nata de glucose has the potential to become a substitute product of nata. It was also supported by the continuous availability of glucose syrup as raw materials. While the flavor and taste of nata de cassava was almost similar with nata de coco.

3.3 Scale-up Process

3.3.1 Process Control Factors

Scale-up process was performed at CV Agrindo Suprafood from 500 ml of pilot plant scale to 120 l of industrial scale. Control factors in the production of nata de glucose waspH, in which the optimum growth of *A. Xylinum* to form of a thick and firm nata was 4-6 (Rahayu, 2003). *A.Xylinum* was mesophylicbacteria with an optimum temperature growth of 28-31°C (Pambayun, 2002). The starters added to the medium were 10 % of the total medium, while the boiling temperature in a pilot plant process was 115°C.

3.3.2 Dimensional Analysis and Production Processes

One of the principles in the scale -up process is to determine the dimensional group which gives the process characteristicby which the dimensional group must be maintained during the scale conversion process (Mithani, 1990). There is no difference on equipment neededbetween laboratory and industrial scale, except that the volume/size is enlarged. CV Agrindo Suprafood using 120 l capacity of pots and furnaces to replace astove for nata production. Dimensional analysis of nata production is presented in Table 3.

The chances of failure in thescale-up process on an industrial that utilize microbes, including nata industry, was high. Rahman (1989)showed that in a large scale, the fermentation using liquid medium is easily contaminated and thus require a lot of manpower and time to sterilize and keep the fermentation process remain steril. To keep the fermentation process remains steril, the fermentation rack has covered with clear plastic, trays used for the fermentation process are also sterilized by washing them using water and drying sunshine.

Table 3. Dimensional Analysis on Scale-up Process of Nata Production

Variables	Pilot Scale	Industry Scale
Medium	500 ml	100 l
Glucose Syrup	12 ml	2.400 ml
Water	288 ml	57,600 ml
Coconut Water	200 ml	40,000 ml
ZA	6 gram	1,320 gram
Acetic Acid	3.8 ml	750 ml
Starter	50 ml	150 ml

By considering several factors during the scale-up process, there is no difference between pilot plant and industrial scale in the pH of the medium during the fermentation process, as presented in Fig.3.

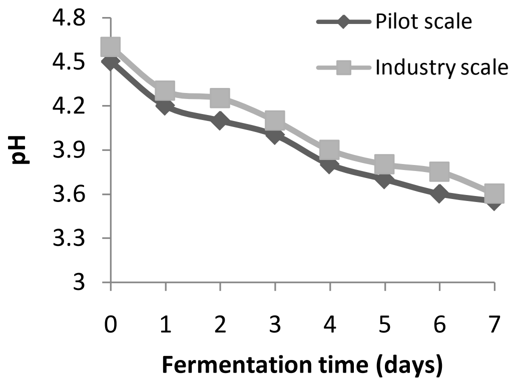

Figure 3. Graph of pH Change During the Fermentation Process in the Pilot and Industry Scale

Likewise, there was no difference of nata thickness between the pilot plant scale and industrial scale (Fig.4).

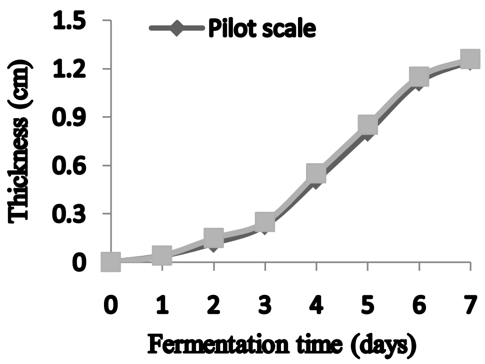

Figure 4. Graph of Nata Thickness During the Fermentation Process in the Pilot Plant and Industrial Scale

Table 4. The Physical and Chemical Composition of Nata in Pilot Plant and Industrial Scale

Composition	Pilot Scale	Industrial Scale
Water (%)	95.28	95.98
Ash (%)	0.26	0.28
Fiber (%)	2.26	2.30
Texture (N)	31.61	35.45
Color	L : 42,12 a : -3,01 b : 0,81	L : 38,94 a : -2,98 b : 0,92

The physical and chemical test result of nata in scale up process were presented in Table 4. There was no significant differences in moisture content and ash between nata de glucose and nata de coco. However, crude fiber and texture of nata de cassava and nata de glucose were higher than that of nata de coco,while the color of nata de cassava was most muddy than others.

3.4 Technical Feasibility Analysis

Technical feasibility analysis assesses all activities related to the production to produce a product that will be sold into the market. Itincludes industry location, raw materials, process technology, and machines and tools requirement. The fact that support cassava as an alternative option media for making nata, including relatively high carbohydrate content (32-35%). Cassava production in Indonesia is very abundant (4^{th} largest in the world after Nigeria, Brazil, and Thailand), and very cheap.

Based on the equipment analysis to produce nata, to meet the nata production target of 3.4 tons/day, CV. Agrindo Suprafood requires 7 pieces of furnace, each furnaceis used to heat pot with capacity of 100 kg of nata or 120 liters of medium, 1 stirrer for each pot, 1 volumetric flask and 1 filter for each furnace, 23.800 trays to meet the fermentation for 7 days, 278 fermentor racks with each rack can be used to set 600 trays, 159 storage drums with a nata capacity of 500 kg per drum and 50 pieces of washing bucket with capacity of 50 kg/bucket. The labor required to produce nata was 14 peoples. .

3.5 Financial Feasibility Analysis

Initial investment costs consist of machinery and equipmentsprocurement cost necessary for the production process. The total investment cost to start up a business of nata de glucose and nata de cassava were Rp 344,986,967,- and Rp 315,196,000,- respectively, while the operating costs for the production of nata de glucose and nata de cassava were Rp 1,464,476,640,- and Rp 1,375,695,000,- respectively .

Payback Period (PBP) for nata de glucose can be achieved within 1.47 years (1 year, 5 months, and 20 days),while that for nata de cassava can be achieved within 1 year and 18 days. Thus, the production of cassava and glucose syrup-based nata were feasible, with assumptionthat monthly sales target is reached. Break event point (BEP) calculation of nata de glucose was 2,374.77 units or Rp 3,799,636,- while nata de cassava was 662, 177 kg or Rp 1,059,483,200,-.

Nata industrial business was eligible if NPV value is positive and its vice versa. Based on NPV analysis, NPV value of nata de glucose and nata de cassava were Rp 499,627,201.56 and Rp 1,282,690,697.59,- respectively. Positive value of NPV indicates that nata industrial plan was eligible.

IRR value showed a great ability of cash flow to restore their capital, while the obligations that must be met called the Minimum Attractive Rate of Return (MARR). An investment plan will be feasible/profitable if IRR $\geq$ MARR. MARR have determined subjectively by CV. Agrindo Suprafood was 12%. IRR value for both nata de glucose and nata de cassava were greater than MARR, ie 77 and 50%, respectively. Thus, the investment for nata industry was feasible.

Benefit cost ratio (BCR) emphasis to the ratio between benefits aspect that would be obtained with costs and losses aspect in the presence of such investation (Giatman, 2007). An investment plan is feasible if BCR value>1. Based on BCR calculations, BCR value of nata de glucose and nata de cassava were 1.14 and 1.18 (greater than 1), respectively, thus the nata industrial plan was feasible.

CONCLUSIONS

Glucose syrup and cassava have a potential value as a substitute material for nata industry, where cassava is first converted into glucose through enzymatic hydrolysis.

Nata de glucose and nata de cassava have texture and fiber content higher than that of nata de coco, but the appearance of nata de cassava was most muddy.

Scale-up process of both nata de glucose and nata de cassava showed no significant difference between the pilot plant and industrial scale.

Technical and financial feasibility analysis showed that both nata de glucose and nata de cassava were feasible.

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