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CHARACTERISTICS OF NATA DE SOURSOP ON THE CONCENTRATION VARIATIONS OF LIME JUICE AND MUNG BEAN EXTRACT

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Abstract

Nata is one of the functional foods resulting from fermentation on the growth of *Acetobacter xylinum* as a source of probiotics for digestion and is beneficial for health. Soursop fruit as an innovation of nata substrate contains carbohydrates, protein, fat, calcium, phosphorus and vitamin C. The study aimed was to determine the characteristics (fiber content, reducing sugar and organoleptic quality) of nata de soursop on the variations of juice lime concentration and mung bean extract. This research method was an experiment with a Completely Randomized Design (CRD), two factors. The first factor : lime juice concentration of 1.2% and 2.8%. The second factor: mung bean extract concentration of 20% and 25%. The results of statistics showed ($p > 0.05$), (Asymp. sig) $0.199 > 0.05$ and mung bean extract $0.078 > 0.05$, so H0 was accepted that lime juice and mung bean extract were not significant on the fiber content and reducing sugar content of nata de soursop.It was concluded that the best characteristics of *nata* soursop were the fiber content, and the reducing sugar 4.51% and 12.7% respectively, as well the organoleptic quality of cloudy white color, chewy texture, quite sour aroma and good acceptability at the J2K1 (Lime juice 2.8% + mung bean extract 20%).

Keywords: Nata, Fiber, Reducing Sugar, Soursop, Mung Beans, Organoleptic

INTRODUCTION

Nata is a functional food fermented by the growth of *Acetobacter xylinum*, beneficial for health and serves as a source of probiotics that are good for digestion. Nata is formed through a fermentation process by acetic acid bacteria, *Acetobacter xylinum,* on the surface of liquids containing sugar, fruit juice (Ramadhan et al., 2019). *Acetobacter xylinum* also plays a role in converting sugar into cellulose during the fermentation process (Putri et al., 2021). Nata de coco is made by utilizing old coconut water as a raw material for making nata (Fitri et al., 2022). Several research results mention that materials can be used as nata substrates include coconut water (Fatimah, 2019), pineapple (Suseno, 2025), and jackfruit (Dea et al., 2023). The novelty of this research used soursop fruit as a substrate which has never been used as a nata substrate in the previous research.

Soursop fruit consists of 67.5% edible flesh, 20% skin, 8.5% seeds, and 4% pith and

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contains vitamin C (20 mg) (Wiradharma, 2021). , 81.16 g water, 66 calories, 1 g protein, 16.8 g carbohydrates, 3.3 g fiber, potassium (278 mg), calcium (14 mg), magnesium (21 mg), phosphorus (27 mg) / 100 grams (USDA, 2019). The carbohydrate content of soursop fruit is 16.8 g potential as a substrate for functional food ingredients. In Wiradharma's research (2021), soursop fruit is used as an ingredient for making puree, with a high antioxidant content. The novelty of this research used soursop fruit as a substrate in making nata fermentation which has never been used in previous nata research.

Lime (*Citrus aurantifolia*) contains 7-7.6% citric acid / 100 g of fruit (Lestari, 2018), 27 mg of vitamin C, 40 mg of calcium, 22 mg of phosphorus, 12.4 g of carbohydrates, 0.04 mg of vitamin B, 0.6 mg of iron, 0.1 g of fat, 37 g of calories, 0.08 g of protein, 86 g of water / 100 g (Yulianto et al., 2022). The high citric acid content can be used as a pH regulator in nata production. The low pH (acidic) in lime can help *Acetobacter xylinum* in the nata fermentation process. The study of Aini & Nur (2019), showed that the liquid tofu waste substrate with the addition of 1% lime had an effect of thickness, yield, water content, and fiber. During the fermentation process, the carbon source of palm sugar containing sucrose is very important for the metabolism of *Acetobacter xylinum* bacteria. Sucrose is converted into cellulose by bacteria, forming the chewy, fibrous structure of nata. According to Sunanto (Aprianto et al., 2024), palm sugar contains 368 calories, 95g carbohydrates, 75mg calcium, 35mg phosphorus, and 3mg iron per 100 grams, making it a good carbon source for bacteria in the nata fermentation process.

Mung beans are a food crop playing s an important role as a source of nutrition, containing 62.9 g of carbohydrates/100g, a source of protein and minerals (Pawana, 2020), 323 calories, 22.9 g of protein, 7.5 mg of iron, low fat (1-1.2%), and vitamin B1/100g (Sari et al. 2020). The research results of Ratnasari et al., (2021) showed that mung beans are an alternative food for degenerative diseases, increase immunity, facilitate digestion, are a source of vegetable protein, help maintain body weight, reduce the risk of diabetes. The nutritional content in mung beans can increase the nutritional value of nata. The research results of (Hidayat, 2020) showed that 25% mung bean extract nata de kersen in fiber content of 4.08%, chewy texture, yellowish white color, quite sour aroma, and very acceptable.

The study aimed was to determine the characteristics of nata de soursop (fiber content, reducing sugar, organoleptic quality) on the variations of lime juice concentrations and mung bean extract, as a functional food innovation based on the local fruits.

IMPLEMENTATION METHOD.

This research was conducted in September 2024 – March 2025 at the Industrial Microbiology Laboratory of the Faculty of Teacher Training and Education, Muhammadiyah University of Surakarta, fiber and reducing sugar content tests were conducted at the Nutrition Laboratory of the Faculty of Health Sciences, Muhammadiyah University of Surakarta, and organoleptic quality tests were conducted on the campus of Muhammadiyah University of Surakarta.

The tools in this research: 50 ml measuring cup, 500 ml beaker, thermometer, glass stirrer, pan, pH stick, digital scales, plastic, mask, gloves, scissors, spoon, basin, cloth, sieve, blender, stove,cutting board, knife, rubber, jar, plastic box, caliper, test tube, tissue, rubber band, label paper. Materials in this study were soursop fruit, palm sugar, lime, Acetobacter xylinum starter, mung beans, umbrella paper, mineral water, distilled water, 70% alcohol.

The experimental research method used a Completely Randomized Design (CRD) with a factorial pattern of 2 factors and 3 replications. The first factor :Lime juice 1.2% of the medium volume (3ml/250ml)/J1 and lime juice 2.8% of the medium volume (7ml/250 ml)/J2. The second factor : Mung bean extract 20% of the medium volume (50ml/250 ml)/K1 and Mung bean extract, 25% of the medium volume (62.5ml/250 ml)K2.

The equipment used in this study, 500 ml plastic container (box), chopping board, knife, measuring cup, Erlenmeyer flask, wooden stirrer, basin, with autoclave. The fermentation substrate was prepared by 100 grams of soursop fruit with 600 ml of water, then straining the mixture and placing the extract into a 500 ml plastic container (box).

For nata de soursop production fruit extract 250 ml/treatment + 25 g palm sugar (according to treatment), namely:J1K1 (1.2% lime juice + 20% mung bean extract), J1K2 (1.2% lime juice + 25% mung bean extract), J2K1 (2.8% lime juice + 20% mung bean extract), and J2K2 (2.8% lime juice + 25% mung bean extract) at a temperature of 60°C for 15 minutes, waited until warm, then added lime juice (pH regulator) according to the treatment until acidic (pH 4). Next, pour the nata de soursop into a 500 ml plastic container and add 30 ml/treatment of *Acetobacter xylinum* starter, shake gently so that the media was homogeneous, then cover it with umbrella paper and tie it with rubber, place it at a sterile room temperature and the surface was even. Fermented for 14 days and measuring the pH of nata de soursop before the fermentation process and after fermentation with a pH stick. After fermentation wash the nata de soursop thoroughly with running water, cut into small pieces, soak for 2 days (change the water every 24 hours), then wash again thoroughly, and boil to remove the sour smell.

Test the fiber content of nata de sourp using the gravimetric method. Weigh 1 g of nata (A), put it into an Erlenmeyer, add 1.25% H_2SO_4, then heat it on a hot plate for 1 hour. Next, add 3.25% NaOH and heat it again for 1 hour, then filter it (filter paper whose empty weight was known (B). The filter paper was cleaned with 1.25% H_2SO_4 3 times, put it in an oven at 105°C for 10 hours, cooled in a desiccator, then weighed (C). The filter paper and sediment are weighed, put into a petri dish whose empty weight is known (D) and put into an oven at 600°C for 5 hours, cooled in a desiccator, and weighed after reaching room temperature (E). The fiber content is calculated using the formula (Hidayat, 2020):

$$\frac{(C-D)(E-B)}{A} X\ 100\%$$

Description:
A = Sample weight (g)
B = Weight of empty filter paper (g)
C = Weight of filter paper + sediment (g)
D = Weight of empty glass (g)
E = Weight of cup + ash (g)

Nata reducing sugar test using the Nelson-Somogyi method. A 4g nata sample was added with 20 ml of 15% potassium iodide (KI) using a volumetric pipette, then titrated with thiosulfate solution. After adding 1% starch indicator, ensure that the indicator drop does not turn dark blue, and record the first titration volume (V1). Next, a blank test was made by replacing 25 ml with distilled water (L2) and the same procedure was repeated. After that, the titration volume of the blank test obtained (V2) was recorded. Finally, the reducing sugar content was calculated before the inversion process using the following formula (N. Sari, 2019):

$$\frac{AT = (V2 - V1) X\ 0{,}1\% = (AT\ X\ FP)}{W\ (100\%)}$$

Information :
AT = Table Number
V1 = Titration Volume of Sample 1
V2 = Titration Volume of Sample 2
FP = Dilution Factor
W = Sample Weight.

Organoleptic quality tests of nata de soursop include color, aroma, texture and acceptability of 25 panelists. Testing the thickness with a caliper on different nata and dividing the average as the result of the thickness of the nata de soursop. Yield test by measuring the total volume of nata de soursop media with a measuring cup (ml), measure the mass of nata divided by the volume of media before fermentation (%):

$$\text{Result} = \frac{massa\ nata\ (gram)}{volume\ media\ (ml)} x\ 100$$

Analysis of fiber and reducing sugar content of nata de soursop using quantitative descriptive method (Kruskal-Wallistest), while organoleptic quality of thickness and yield of nata de soursop using qualitative descriptive method (Microsoft Excel).

RESULTS AND DISCUSSION

Fiber Content

The highest fiber content of nata de soursop was 4.82% in the J1K2 treatment (1.2% lime juice + 25% mung bean extract) compared to the commercial nata fiber content (control) of 3.265%), while the lowest fiber content of nata de soursop was 4.51% in the J2K1 treatment (2.8% lime juice + 20% mung bean extract). The high fiber content of nata de soursop was due to the high fiber content of mung beans. According to the (Insania et al. 2024), dried mung beans contain 7.5g of dietary fiber./100g. The research results of Dea et al. (2021) stated that the addition of mung bean sprout extract in the fermentatio process of jackfruit flesh nata can increase the fiber content of nata.

The high fiber content of nata de soursop can also be influenced the duration of the fermentation process. Nata can be formed with a fermentation duration of around 7-10 days, if the nata fiber formed was longer then the fiber content of nata will increase. The research results of Majesty's (2015)using pineapple as the substrate produced a nata fiber content of 1.776% after 15 days of fermentation. The nitrogen source in the fermentation medium also influences the formation of nata fiber; the higher the nitrogen content, the higher the nata fiber content produced. The research study of (Hidayat, 2020) the pineapple as substrate and the addition of 25% mung bean extract produced nata de kersen fiber content of 4.08%.

Table 1. The Fiber Content, Reducing Sugar, Thickness and Yield of soursop nata

Treatment	Fiber Content (%)	Reducing Sugar Content (%)	Thickness (cm)	Yield (%)
J1K1	4.73	13,785	1.1*	31.2
J1K2	4.82**	14,415**	1.3	25.2*
J2K1	**4.51***	**12,770***	**3.5****	**33.2**
J2K2	4.63	13,915	2.1,	36.4**

Information :

J1K1 : Lime juice 1.2% + Mung bean extract 20%

J1K2 : Lime juice 1.2% + Mung bean extract 25%

J2K1 : Lime juice 2.8% + Mung bean extract 20%

J2K2 : Lime juice 2.8% + Mung bean extract 25%

** Highest fiber and reducing sugar content

* Lowest fiber and reducing sugar content

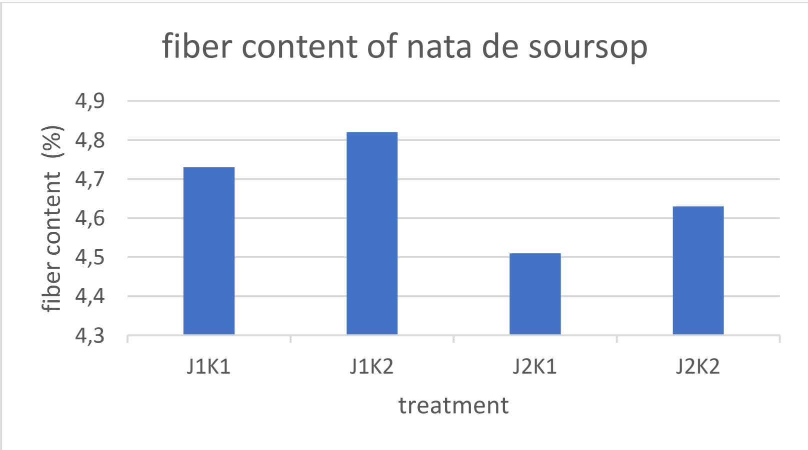

Figure 1. Resident of Village A

The results of the Kruskal-Wallis non-parametric statistical test showed that the fiber content of nata de soursop between treatments was not statistically significant ($p > 0.05$), (Asymp. sig) and 0.199 > 0.05, so H0 was accepted, this showed that the concentration of lime juice and mung bean extract was not different significantly on the fiber content of nata de soursop. The best fiber quality of nata de soursop was 4.51% in the J2K1 treatment (2.8% lime juice + 20% mung bean extract). In this study, the nata fiber content was slightly higher than the SNI standard (SNI 01-4317-1996,maximum nata fiber content 4.5%)

Reducing Sugar Content

The reducing sugar content of nata de soursop increased significantly in all treatments compared to the reducing sugar content of commercial/control nata of 1.845%. The highest reducing sugar content of nata de soursop was 14.415% in treatment J1K2 (1.2% lime juice + 25% mung bean extract).while the lowest reducing sugar content of nata de soursop was 12.770% in the J2K1 treatment (2.8% lime juice + 20% mung bean extract). The high reducing sugar content can be caused palm sugar containing calories 368, carbohydrates 95 mg, calcium 75 mg, phosphorus 35 mg, iron 3 mg, water 4% in 100g (Aprianto, 2024).The increase of the reducing sugar content of nata de soursop in all treatments with palm sugar showed the enzymatic activity of microorganisms during the fermentation process was able to break down complex sugars into simple sugars (reducing sugars), and most of them were used as substrates by bacteria. *Acetobacter xylinum*. The research results of Rohmah et al. (2022) showed the total sugar content of seaweed nata was 1.35-1.86%.with seaweed and palm sugar substrate as a source of nutrition. The increase in reducing sugar levels was an indicator of the success of the hydrolysis process of complex carbohydrates into simple sugars, which can be utilized as the primary nutrient source by *Acetobacter xylinum*. The citric acid in lime juice plays a crucial role in regulating the pH of the medium, thus creating an optimal environment for *Acetobacter xylinum* activity during the nata fermentation process. *Acetobacter xylinum* was active in the pH range of 3.0–7.0, but the optimum pH for nata formation was 4.0 (Hasanah et al., 2020).

The levels of reducing sugar between treatments showed a clear difference descriptively, the Kruskal-Wallis non-parametric statistical test showed that the difference was not statistically significant ($p > 0.05$). The output result (Asymp. sig) was 0.078 > 0.05, so H0 was accepted, meaning that the concentration of lime juice and mung bean extract was not difference significantly in reducing sugar levels of nata de soursop.

Thicknes of nata de soursop

The highest thickness of nata de soursop was 3.5 cm in the treatment J2K1 (Lime juice 2.8% + Mung bean extract 20%), while the lowest thickness of nata de soursop was 1.1 cm at J1K1 (Lime juice1.2% + Mung bean extract 20%).This showed that the thickness of nata de soursop was maximum in the J2K1 treatment, indicating the concentration of lime juice and mung bean extract had an effect on the thickness of nata de soursop.

The thickness of nata was influenced by the availability of nutritional sources needed by *Acetobacter xylinum* bacteria during the fermentation process,that was nitrogen sources, carbon sources and the optimal acidity level (pH) in the fermentation medium.The highest thickness of nata de soursop was 3.5 cm in the treatmentJ2K1 (2.8% lime juice + 20% mung bean extract) that produced optimal thickness. However, the concentration of 25% mung bean extract in the

J2K2 treatment (2.8% lime juice + 25% mung bean extract) did not produce a significant increase in the thickness of nata de soursop. This may be due to an imbalance of nutrients or a less than optimal fermentation process at that concentration. According to the research results of Romadhoni (2023), the optimal starter concentration of 30% can significantly increase the thickness of nata. Sugar is the main carbon source for *Acetobacter xylinum* in producing cellulose. The research results of Rohmah (2019) the Gracilaria sp. seaweed 4% and addition of palm sugar12.5% can produce the highest thickness nata of 6.75 mm. The nata thickness is also influenced by the nitrogen source; the availability of mung beans as a nitrogen source was less, which can cause the nata to become thicker. This was in line with research by Hidayat (2020) that the addition of low concentrations of mung bean extract can increase the thickness of nata de kersen, while the addition of high concentrations of mung bean extract can decrease the thickness of nata de kersen. This showed that the balance of mung bean extract concentration was very important in influencing the thickness of nata.

Soursop Nata yield

The highest yield of soursop nata was 36.4% in the J2K2 treatment (Lime juice2.8% + 25% mung bean extract), while the lowest nata de soursop yield was 25.2 at J1K2 (Lime juice1.2% + Mung bean extract 25%).This showed that the combination between lime juice and mung bean extract concentrations had a significant effect on nata yield. The availability of nutrients, especially nitrogen sources, wss very important to support the growth of *Acetobacter xylinum* bacteria and cellulose synthesis. Mung beans rich in protein and nitrogen, play a role in increasing bacterial growth and nata production, thus directly affecting the resulting nata yield. The research results of Suseno et al., (2025) added 50% mung bean sprout extract to get the highest nata yield of 29.62% so that the higher the addition of mung bean sprout extract, the higher the nata yield. This indicates that the use of organic nitrogen sources, such as mung bean extract, affects nata yield. Furthermore, the addition of lime juice as an acid source can lower the pH of the fermentation medium, thereby affecting the enzymatic activity of Acetobacter xylinum bacteria and accelerating the cellulose formation process.The research of Iryandi et al. (2014) found that the supplementing of lime juice in the nata de soya production process can increase the yield of 44.30%. The combination between the organic nitrogen sources and adjusting the pH of the fermentation medium can increase the nata yield. This was in line with research by Fitri et al. (2021) stating that the balance of nutrients (especially nitrogen sources) and environmental pH conditions were crucial for the success of the fermentation process and nata yield. An imbalance in either factor can reduce the nata yield, as seen in the low yield in treatment J1K2 (1.2% lime juice + 25% mung bean extract), with a nata yield of 25.2%.

Organoleptic Quality of Nata de Soursop

The organoleptic quality of nata de soursop (color, texture, aroma, and acceptability) was as follows:

Table 2. The Organoleptic Quality of Nata de Soursop

Treatment	Assessment aspects			
	Color	Texture	Aroma	Acceptance
J1K1	Cloudy white	Springy	Quite Sour	Quite Like
J1K2	Cloudy White	Springy	Quite Sour	Like
J2K1	Cloudy white	Springy	Quite Sour	Like
J2K2	Cloudy white	Springy	Quite Sour	Quite Like

Information :
J1K1 : Lime juice 1.2% + Mung bean extract 20%
J1K2 : Lime juice 1.2% + Mung bean extract 25%
J2K1 : Lime juice 2.8% + Mung bean extract 20%
J2K2 : Lime juice 2.8% + Mung bean extract 25%
** Highest fiber and reducing sugar content
* Lowest fiber and reducing sugar content

The color of nata de soursop was cloudy white in all treatments, J1K1 (1.2% lime juice + 20% mung bean extract), J1K2 (1.2% lime juice + 25% mung bean extract), J2K1 (2.8% lime juice + 20% mung bean extract), and J2K2 (2.8% lime juice + 25% mung bean extract), while the color of commercial nata/control was transparent white, the cloudy white color of nata de soursop was caused by the high concentration of mung bean extract affected the color of nata in the forming process the cellulose layer during fermentation. The research results of Fauziah & wahyuningsih's (2021) showed that the color of nata de cassava was yellowish white with the addition of mung bean sprouts as a nitrogen source. This was different from the control (commercial nata) used ZA (Zwavelzure Ammonia) as a nitrogen source. This supports that the use of plant-based ingredients such as mung beans can affect the color of the nata produced.

The texture of nata de soursop was chewy in all treatments J1K1 (1.2% lime juice + 20% mung bean extract), J1K2 (1.2% lime juice + 25% mung bean extract), J2K1 (2.8% lime juice + 20% mung bean extract), and J2K2 (2.8% lime juice + 25% mung bean extract), The addition of mung bean extract not only increased the fiber content, but also affected the nata texture. The fiber content of mung beans helps to increasing the elasticity of nata and maked it chewier. The research results of Fitri et al. (2021) showed that the addition of mung bean sprout extract can produce a very chewy nata texture as well. This showed that *Acetobacter xylinum* bacteria can grow optimally and form cellulose as well because of the nutrients from mung bean extract.

The aroma of nata de soursop was sour in treatments J1K1 (1.2% lime juice + 20% mung bean extract), J1K2 (1.2% lime juice + 25% mung bean extract), J2K1 (2.8% lime juice + 20% mung bean extract), and J2K2 (2.8% lime juice + 25% mung bean extract), this was a typical characteristic of nata. This sour aroma was produced from the activity of *Acetobacter xylinum* bacteria during the fermentation process producing the organic acids. The addition of mung bean extract did not provide a significant change in the aroma of nata de soursop, this indicated that this mung bean extract did not affect the aroma of nata nata de soursop. According to Hidayat (2020) the sour aroma of nata can be caused by the boiling factor that was not long enough, so that the sour aroma of nata had not completely disappeared.

The acceptance of nata de soursop was quite like and liked, and was acceptable to the panelists. The acceptance of nata de soursop was quite like in the treatments J1K1 (1.2% lime juice + 20% mung bean extract) and J2K2 (2.8% lime juice + 25% mung bean extract), and the acceptance of nata de soursop was like in the treatments J1K2 (1.2% lime juice + 25% mung bean extract), and J2K1 (2.8% lime juice + 20% mung bean extract). while in commercial nata (control) the acceptance was very like

CONCLUSION

The best characteristics of *nata* soursop were the fiber content, and the reducing sugar 4.51% and 12.7% respectively, as well the organoleptic quality were cloudy white color, chewy texture, non-sour aroma and like acceptability to treatmentJ2K1 (Lime juice 2.8% + mung bean extract 20%).

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