Optimizing the Formula of *Nata De Citrullus* By the Use Of Response Surface Methodology

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ABSTRACT.
Currently, food products such as Nata are no longer consumed by the public. Initially, the nata that was widely circulated on the market was nata made from coconut water, known as Nata de Coco, but now there has been a lot of research on making nata using ingredients other than coconut water, for example pineapple, palm juice and corn. Based on this, researchers are interested in conducting research on making nata from rejected watermelons. Watermelon has the characteristics of containing water content, fiber content and high sugar content so that it fulfills the requirements as a growing medium for *Acetobacter xylinum* bacteria. Researchers are interested in conducting research on optimizing the formulation of *Nata De Citrullus* (rejected watermelon) using the response surface method. This response surface method will help optimize formulations with several variables expressed in response units. The aim of this research is to produce the best *Nata De Citrullus* formulation. The three factors studied at this stage are the amount of carbon (sugar) with a lower limit of 40 gr and an upper limit of 80 gr, the amount of nitrogen (bean sprout juice) with a lower limit of 150 ml and an upper limit of 250 ml and the starter volume of *Acetobacter xylinum* with a lower limit of 75 ml. and the upper limit is 125 ml. It can be concluded that the optimal treatment for producing the highest quality *Nata De Citrullus* is to use sugar at a concentration of 60.00, with a lower limit of 26.36 and an upper limit of 93.64. Similarly, for bean sprout juice, the recommended concentration is 200.00, with a lower limit of 115.91 and an upper limit of 284.09. Lastly, for starters, a concentration of 100.01 is advised, with a lower limit of 57.96 and an upper limit of 142.
Keywords: Watermelon, Nata, Response Surface Methodology.

1. Introduction

Watermelon (*Citrullus vulgaris*) is an annual plant from the *Cucurbitaceae* family that grows throughout Indonesia. Harvested watermelons range in size from huge (≥2 kg), medium-sized (±2 kg), and small (≤ 2 kg). These small-sized watermelons are known as rejected watermelons; they are typically underutilized and sold at low prices. An available option for processing discarded watermelon is its conversion into *Nata De Citrullus* . The term "Nata" originates from Spanish and refers to a cream-like substance produced through the fermentation process by the microbe *Acetobacter xylinum*. This fermentation results in the formation of a gel on the surface of a sugar-containing solution. Introducing *Acetobacter xylinum* bacteria to the fermentation process decreases the likelihood of spoilage bacteria contamination and expedites the production of Nata [1]. *Nata De Citrullus* is a viable choice

due to its extended shelf life and ease of conversion into processed food components particularly bakery products, soup, instant noodles, pasta, composite flour, as an enrichment of functional materials, and natural coloring ingredients [2].

Multiple studies have demonstrated that *Nata De Citrullus* derived from discarded watermelon fits the nutritional standards for nata as specified by SNI [3]. Fermentation time and starter concentration affect nata results [4]. In addition, physical quality with diverse starter sources and fermentation duration did not affect Nata De Whey and Nata De Coco results [5].

Response Surface Methodology (RSM) measures the correlation between a response variable and a group of input variables (Khuri and Mukhopadhyay, 2010). Using RSM, Salinas and Puppo (2015) optimized the nutritional content of bread based on calcium carbonate and inulin and optimized pumpkin flour production to boost antioxidant activity. This led researchers to apply the response surface method (RSM) to optimize variable results. Nwabueze (2010) highlighted that RSM is better for identifying factors and finding multivariable optimal processes. This suggests that the RSM method is highly appropriate for developing a formulation to produce *Nata De Citrullus* using discarded watermelon. There are currently no published/limited published/ study findings about using RSM in the production of *Nata De Citrullus*. This study used RSM to optimize *Nata De Citrullus* production for yield.

2. Material and Methods

The ingredients used in this study comprised of discarded watermelon, granulated sugar, water, bean sprouts, acetic acid, Nata starter, specifically *Acetobacter xylinum*, H2SO4, NaOH, KsO4 10%, alcohol, petroleum ether, and distilled water. The equipment used to conduct this study encompassed fermentation trays, measuring cups, basins, filter cloths, pans, stoves, stirrers, newsprint, rubber bands, blenders, scales, Nata cutting knives, rulers, Erlenmeyer flasks, filter paper, and an oven. The three variables examined in this phase include the quantity of carbon (sugar), which must fall within the range of 40 gr to 80 gr; the amount of nitrogen (bean sprout juice), which must range from 150 ml to 250 ml, and the initial volume of *Acetobacter xylinum*, which must be between 75 ml and 125 ml. This experiment uses X1 for carbon (sugar), X2 for nitrogen (bean sprout juice), and X3 for starting volume with yield response. The acquired data was evaluated utilizing the Design Expert 10.0 program. Verification is performed to confirm if the optimal response value obtained from the Design Expert 10.0 calculation matches the value obtained in the research investigation. The verification analysis was conducted thrice. All treatments consisted of 20 reference formulations where each process followed an experimental design.

Yield

After 7 days of fermentation, the nata was extracted and measured, including its thickness and weight.

3. Results and Discussion

The analysis of the *Nata De Citrullus* response is based on the conditions of each treatment point. The recommended model and data are used to compare the actual conditions with the model predictions for the response. The quadratic model is specifically used for this analysis. The actual and predicted yield value curves can be seen in Figure 1, which provides a

clearer representation of the response. Outliers exist in the data points that are significantly outside the regression line due to substantial disparities between the actual and expected response values, resulting in deviations. The observed and predicted yield values may not be identical for each treatment, but the model accurately represents the real situation. This is evidenced by the high R-squared value, which approaches one.

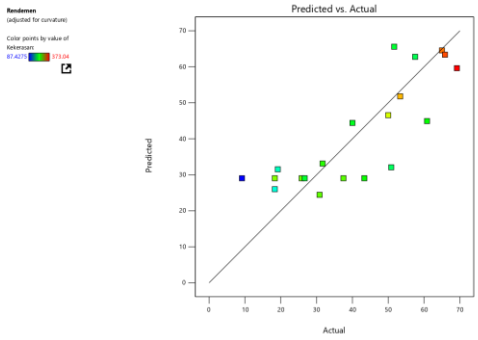

Figure 1. Actual and predicted response value curves

Yield Response Analysis with the Influence of Sugar and Bean sprout Juice.

The yield results, which are affected by sugar components and bean sprout juice, are visualised through contour and three-dimensional plots. The contour conditions display yield values ranging from 30-60%, exhibiting variations in colour. A larger colour yield value will result in a red area or a situation with a low influence factor on bean sprout juice with low sugar, as depicted in Figure 2.

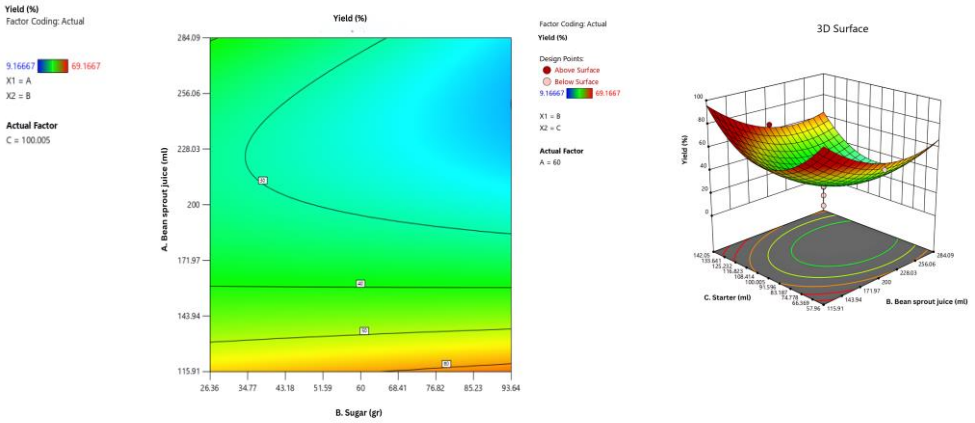

Figure 2. Contour and three-dimensional plot of the influence of sugar and bean sprout juice

The three-dimensional condition of the resulting response is parabolic, with the quadratic equation utilised being a power of two. The area depicted in red represents the effects of a high yield response under process circumstances of low sugar volume and low bean sprout juice. The MAE approach requires much less extraction time, but produces significantly more yield, and increasing the solvent volume ratio can speed up the extraction process [6].

Yield Response Analysis with the Effect of Sugar and Starter

The contour plot of the yield response findings, driven by sugar and starting variables, indicates that the contour line spans a range of 40-80%. The red area represents the best yield outcomes, which are influenced by the low starting factor. Conversely, the blue area represents the lowest yield results (Figure 3). The response value in the extraction process can be

significantly affected by the conditions, such as the choice of starter and sugar. Increasing the amounts of starter and sugar can lead to a decrease in the yield value [6].

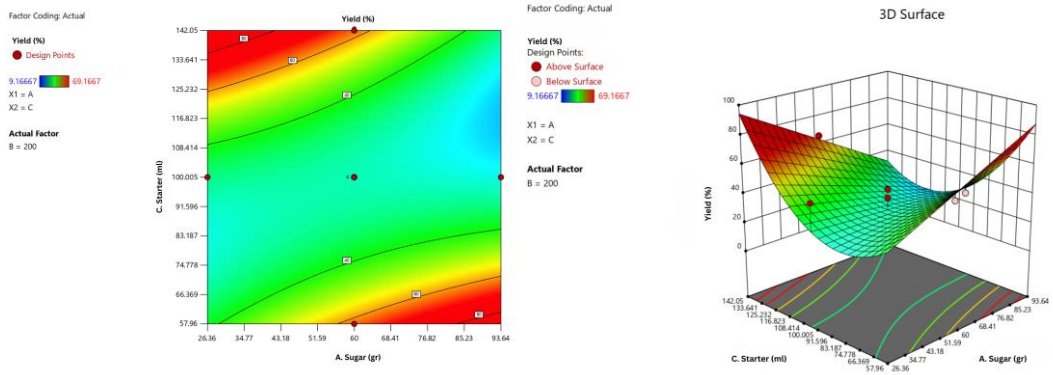

Figure 3. Contour and three-dimensional plots of the influence of sugar and starter

Analysis of Yield Response with the Influence of bean sprout juice and Starter

The contour plot illustrates the yield response, which is affected by the sprout juice and starter. The contour line spans a range of 40-80%. The red area represents the highest yield outcomes, which are influenced by a low starter. Conversely, the blue area represents the lowest yield results (Figure 4). The response value of the extraction process can be significantly influenced by the conditions involving the use of appropriate bean sprout juice and starter. This is because an increase in the factors of sprout juice and starter can lead to a drop in the yield value [6].

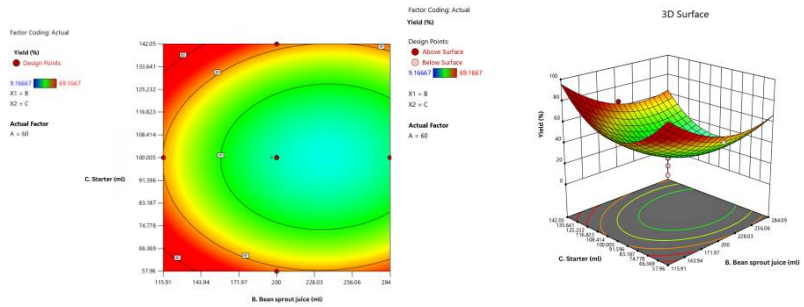

Figure 4. Contour and three-dimensional plot of the influence of sprout juice and starter

Optimization of *Nata De Citrullus* Yield

The optimization approach employs a design expert application to achieve the desired result. Optimization is performed once a mathematical model of the response has been obtained. The goal of optimization is to minimize the necessary or operational effort and optimize the desired outcomes (Nurmiah et al., 2013). The level of desirability shown for the yield response analysis is presented more fully in Table 1.

Table 1. Recommended desire level values

No	Sugar (Gram)	Bean Sprout Juic	Starter (ml)	Yield (%)	Desirability (%)	Annotation

		e (ml)				
	60	200	100	25.83	0.68	Selected

According to Engelen et al. (2015), a desirability value near to one suggests that the ideal optimisation technique is appropriate for the intended response variable. A desirability value or desirability level approaching 1 signifies the appropriateness of the optimal optimisation method in relation to the intended response variable (Engelen et al., 2015). The chosen process conditions, which have a high level of attractiveness, indicate that the expected yield will be approximately 43.3%. The suggested recommended quantities, with rounded figures, are 60 grammes of sugar, 200 millilitres of bean sprout juice, and 100 millilitres of starter.

Verification of Optimum Yield of *Nata De Citrullus*

A yield of 25.83% was achieved from the validation findings based on the suggested parameters. The validation findings are either the average of two run results or duplicate data. The final validation value of 29.014% deviates significantly from the expected yield. Compared to the expected value, the yield value of the actual test findings is lower. More thorough validation outcomes are shown in Table 2.

Table 2: Validation results for optimal yield

Response	Predicted Value	Actual results	95% PI low	95% PI High	Std deviation
Yield (%)	29.014	25.83	-2.47	60.55	13.53

The validation result remains within the range of the 95% prediction interval (PI) low and 95% PI high, as determined by comparing the verification data with the application's predictions. The prediction interval (PI) is a statistical range that represents the anticipated value of the next response, assuming the same conditions, as described by Engelen et al. (2015). The response value obtained by combining specified parameters and the response within the range of prediction intervals indicates that the model is applicable and the response is improving (Hepi et al., 2021).

4. Conclusions

Based on the presented results, it can be concluded that the optimal treatment for producing the highest quality *Nata De Citrullus* is to use sugar at a concentration of 60.00, with a lower limit of 26.36 and an upper limit of 93.64. Similarly, for bean sprout juice, the recommended concentration is 200.00, with a lower limit of 115.91 and an upper limit of 284.09. Lastly, for starters, a concentration of 100.01 is advised, with a lower limit of 57.96 and an upper limit of 142.

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References

[1] Marlinda and R. Hartati, "Optimalisasi Karakteristik Nata De Banana Skin Melalui Perubahan Konsentrasi Acetobacter Xylinum," *J. Optim.*, vol. 5, no. 2, pp. 52–59, 2019.

[2] A. K. Dhiman, K. D. Sharma, and S. Attri, "Functional constituents and processing of pumpkin: A review," *J. Food Sci. Technol.*, vol. 46, no. 5, pp. 411–417, 2009.

[3] Ezi Angraini, Elida, Anni Faridah, and Sari Mustika, "Pkm Pembinaan Pengolahan Nata De Citrullus Dan Olahan Lainnya Dari Semangka Afkir Bagi Petani Semangka Di Nagari Kapelgam Kec. Bayang, Kab. Pesisir Selatan," *J. Community Serv.*, vol. 2, no. 2, pp. 109–114, 2020, doi: 10.56670/jcs.v2i2.40.

[4] K. Nurtjahtja, "The The Effect of Acetobacter xylinum Starter in Waste Liquid Pineapple Peel on the Properties of Nata de Pina," *Int. J. Ecophysiol.*, vol. 2, no. 02, pp. 86–91, 2020, doi: 10.32734/ijoep.v2i02.4364.

[5] Asmaul Khusna, A. U. Prastujati, S. Setiadevi, and M. Ilham Hilal, "Comparison of Physicochemical Quality between Nata De Whey and Nata De Coco," *Sch. J. Agric. Vet. Sci.*, vol. 8, no. 4, pp. 51–54, 2021, doi: 10.36347/sjavs.2021.v08i04.002.

[6] N. Guo, F. Gong, Z. Chi, J. Sheng, and J. Li, "Enhanced inulinase production in solid state fermentation by a mutant of the marine yeast Pichia guilliermondii using surface response methodology and inulin hydrolysis," *J. Ind. Microbiol. Biotechnol.*, vol. 36, no. 4, pp. 499–507, 2009, doi: 10.1007/s10295-008-0519-2.