

## Conference Paper

# Development of Nata de Coco with Natural Dyes Using Value Engineering Method

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## Abstract

Nata de coco is a well-known food and consumed worldwide. Its general characteristics are white, packed with syrup, chewy texture, with the scent of coconut water. Nata de coco uses natural dyes has not received much attention. This research sought to develop natural dyes for nata de coco using value engineering method. The natural dyes were added into nata de coco using dehydration and rehydration techniques. Three natural dyes used were dragon fruit, strawberry, and bit. The development step generates nine alternatives products of nata de coco with natural dyes. The specs of chosen concept was cube, sweet, with dragon fruit dyes.

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**Keywords:** Dehydration-rehydration; dragon fruit; nata de coco; natural dyes; value engineering.

## INTRODUCTION

Nata de coco is well-known foodstuff, chewy, translucent, jelly-like produced by the fermentation of coconut water which gels through the production of microbial cellulose by *Acetobacter xylinum*. The structure of nata de coco is composed of coconut milk bio- cellulose fermented with acetic acid bacteria. Nata de coco is most commonly sweetened as a candy or dessert, and can accompany many things including pickles, drinks, ice-cream, puddings and fruit mixes.

Nata de coco consists of 67.7 % water, 0.2 % fat, 12 mg calcium, 5 mg iron, 2 mg phosphorus and small amounts of vitamin B1, protein and only 0.01 mg of riboflavin per 100g [3]. This product contains mainly water and cellulose (fiber) so is safe to be eaten by anyone. It's low in calories and can be considered an ideal addition to your diet if trying to lose or manage body weight. Because of the high fiber content, it's also good for digestion and has a cholesterol lowering effect. Indonesia yields coconuts at about

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3,166,666 tons in 2010 rose to 3,262,721 tons in 2014 According to Indonesia Minister of Agriculture (2015).

One important aspect in nata de coco that can be developed further is its color. Color is a component with the potential to attract consumers' desire through the sense of sight.

Some nata de coco producers still use artificial coloring to enhance their product appeal. The use of artificial coloring in food products has some shortcomings such as the dose of use and the type of dyes used needs strict supervision. We can see some cases of food poisoning caused by food additives, artificial coloring. The addition of natural dyes on nata de coco products in the market is considered as a safe and environmentally friendly.

The use of natural dyes for nata de coco products on the market seems not developed seriously. Such conditions favor researchers to develop products nata de coco with natural dyes using the value engineering method.

## Research Objectives

This research aims 1) To identify quality attributes of nata de coco with natural dyes based on consumer preferences. 2) To develop product alternatives of nata de coco with natural dyes. 3) To determine the performance and value of nata de coco with natural dyes.

## MATERIAL and METHODS

### Research Material

Materials used were nata de coco size of 1x1x1 cm as the main ingredient and a natural colorant. Nata de coco was purchased from local producer in bulk form, plain, and not packed in containers. The dyes used were natural dyes derived from fruits.

This study intended to develop products nata de coco with natural dyes using value engineering method that includes five stages: information, creativity, analysis, development, and recommendations. Natural dyes were added using the techniques of dehydration and rehydration. Temperature used in the dehydration process was 50 °C for 150 minutes, and the rehydration process used a temperature of 70 °C for 30 minutes. Natural dyes used were red dragon fruit, strawberries, and beet. Variations in

the concentration of natural dyes were 0.5%, 1%, 1.5% with a mixture of sugar solution 15%.

## Research Procedure

### Information Stage

The significance of this information stage is to obtain information and knowledge of product as much as possible at the time of collecting information. The most common way is by using a questionnaire distributed to customers.

Quality attributes were developed in the form of primary and secondary attributes of nata de coco products obtained from data collection at the stage of observation. Quality attributes were organized into questionnaire. The questions on the questionnaire indicate the level of importance of quality attributes using likert scale. Likert scale used to measure attitudes, opinions and perceptions person or a group of social phenomenon to obtain quantitative data [2].

The questionnaire was distributed to 100 respondents who have consumed nata de coco via online. Furthermore, the data was analyzed to obtain priority product attributes. To determine the validity of the questionnaire and then tested the validity and reliability.

Validity and reliability test performed using SPSS software ver. 17. Validity test conducted to test the validity of a statement-questionnaire in achieving its goals. Reliability tests performed to determine the distribution of responses. This stage is necessary to determine the order of priority the development of quality attributes resulted from the average ranking of the quality attributes by questionnaire respondents in the first stage.

$$\text{Average score} = \frac{\text{Total score}}{\text{Number of respondent}}$$

### Creativity Stage

Stage of creativity is a stage to raise the idea of the concept of development. The development concept is based on the description of the needs and desires of consumers to the products to be studied. At this stage of creativity is the determination of priorities the development of quality attributes.

Based on every attribute of a priority then be made to the question of a number of alternative products with variations in specifications. Then a new product was

designed by considering various aspects, such as technical and market aspects. These questions are a continuation of the first questionnaire.

Advanced questionnaire that has been equipped with the elaboration of specific questions of priority primary attribute deployed up to 97 respondents. The number of respondents was used because the population of consumer products are not identified [5]. Identification of creativity is based on the needs and desires of consumers, the calculation is based on the percentage of respondents preferred alternative.

### Analysis Stage

This stage serves to analyze and select the results of testing that have been done to define the concepts of product development nata de coco that have been designed. In the analysis phase is the mapping function of FAST (Function Analysis System Technique).

### Development Stage

This stage is a further step of the analysis phase. FAST diagrams that have been made at this stage of the analysis is then used as a reference for developing the product nata de coco with natural dyes so obtained some alternative concepts of nata de coco with natural dyes. Alternatives that have been selected from the previous stage development program were then made up into a full proposal. In this development phase, the concept of product to be made is poured into the Zero Level Concept diagram. Concepts that have been determined and then made a prototype or a product sample with a dehydration-rehydration technique.

The dehydration process is the first process to produce nata de coco with the addition of natural colors. The temperature used for the dehydration process is 50 °C. Temperature is selected as the optimal temperature in the dehydration [4]. Manufacture of natural dyes is done in the traditional way. The dye sourced from natural ingredients based on the needs and desires of consumers. To simplify the process of making the color on the dye carrier material, the material is cleaned and then reduced in size. The material is then dissolved using water with varying concentrations of 0.5%, 1% and 1.5%. Nata de coco which has been subjected to the process of dehydration and then boiled to withdraw water into nata de coco. The process is called rehydration. The collected data is then used to calculate the index level of rehydration nata de coco by the formula:

$$\text{Rehydration Index} = \frac{(BA - BSP) - (BA - BSR)}{BA}$$

Where:

- BSR = Weight after rehydration
- BSP = Weight after dehydration
- BA = Initial weight

## Different Phase

Data obtained from the study, then tested for significant difference from average to determine whether the three functions of the treatment given to the rehydration process for each natural dyes have a significant difference or not. The mean difference in testing was done by the method of statistical analysis using SPSS software. There are two possible decisions on ANOVA, i.e. accept or reject  $H_0$ . When the decision to accept  $H_0$ , concluded there was no significant difference among the treatments. When rejecting  $H_0$ , concluded there are significant differences among the treatments. If it turns out the decision rejecting  $H_0$  (because the number of treatment more than two), we then want to know which treatment that shows the difference.

## Recommendation Stage

At this stage, the sensory test was conducted for various characteristics of the product concept based on quality attributes nata de coco that have been developed. Testing was conducted on a product that has been developed in comparison to similar products already on the market. In this study the sensory test using 40 panelists who consumed nata de coco (based on the minimum requirement of normal distribution).

The sensory test results are then used to determine the value. Value of the concept of the product is obtained by comparing the performance of each product concept to production costs. The formula used to calculate the value of each concept is as follows [6]:

$$\text{Value} = \frac{\text{Performance}}{\text{Cost}}$$

## Proximate Test

Proximate test was also performed in this study to determine the nutritional content of the base in the concept development of nata de coco products that have been selected.

Proximate test performed in the laboratory of food and nutrition, PAU, University of Gadjah Mada. The nutrient content of the material being tested include moisture, fat, ash, protein, carbohydrates, and fiber.

## RESULTS and DISCUSSION

### Information

Preliminary questionnaire contains questions about the attributes that are used as a reference for product development nata de coco. Quality attributes are determined from the results of in-depth interview. Questionnaires distributed using the technique of "nonprobability purposive sampling" to 100 respondents, of which a minimum requirement for a sample of unknown population with a 95% confidence level (5% significance level) is 97 respondents to make it easier then rounded to 100 respondents. Respondents used were those who consumed nata de coco and reside in the Yogyakarta area.

The questionnaire was tested to determine the validity and reliability of the questionnaire. Statistical test by calculating the correlation of each statement with a total score using the formula product moment correlation. A question as valid and able to represent the purpose of distributing questionnaires when the value of  $R$  arithmetic  $>$   $R$  table value. Reliability testing performed on a valid point statement using Cronbach Alpha [1]. One of the questions is declared reliable if the data has a value of  $R$  arithmetic  $>$   $R$  table value. Validity and reliability of the questionnaire is shown in Table 1.

Questionnaires were distributed to 100 respondents online, where the minimum requirement for a sample of unknown population with a 95% confidence level (5% significance level) is 97 respondents to make it easier then rounded to 100 respondents. Respondents used were those people who consumed nata de coco and their residence in the area of Yogyakarta. The mean primary attribute is obtained through the sum total value of the secondary attribute of each primary attribute divided by the total respondents in the primary attribute. Then it can be obtained by order of priority of the highest quality attributes, namely natural dye, flavor, price, type of color, quality color, texture, and aroma (Table 2). The percentage of the relative importance (Table 3) obtained by dividing the relative importance of each attribute primary total relative importance of the primary attributes to obtain the percentage of relative importance. Of the seven primary attributes indicate that the rate of interest of between 3-4 is important to do development, but this study chose to take the top three priorities with

TABLE 1: Questionnaire Validity and Reliability.

Prime Attribute	Secondary Attribute	Notes
Natural dyes	Derived from fruit	Valid and reliable
	Derived from vegetable/leaf	Valid and reliable
	Derived from herb	Valid and reliable
Color types	Bright	Valid and reliable
	Dark	Valid and reliable
Color quality	Bound in nata de coco	Valid and reliable
	In solution only	Valid and reliable
Flavor	Sweet	Valid and reliable
	Suitable natural dyes	Valid and reliable
Aroma	Coconut	Valid and reliable
	Suitable natural dyes	Valid and reliable
Texture	Chewy	Valid and reliable
	Soft	Valid and reliable
Price	Affordable	Valid and reliable
	according to the quality	Valid and reliable

TABLE 2: Priority of Product Quality Attributes.

Primary Attribute	Total Score	Average Score	Priority Rank
Natural dyes	1186	3.953	1
Flavor	788	3.940	2
Price	785	3.920	3
Color type	746	3.730	4
Color quality	739	3.695	5
Texture	722	3.610	6
Aroma	689	3.445	7

consideration for the specific products developed. The top three priorities are natural dyes, flavors, and price. On the technical review, the price aspect is that regardless of the product components. The price attribute is a quality attribute that comes from the outside of the product so that the chosen priority natural dye, flavor, and color type.

TABLE 3: Relative Percentage interests and Product Quality Attributes.

No	Primary Attribute	Relative Interest	Percentage of Relative Interest (%)
1	Natural dyes	3.953	15.03
2	Flavor	3.940	14.98
3	Price	3.920	14.90
4	Color type	3.730	14.18
5	Color quality	3.695	14.05
6	Texture	3.610	13.72
7	Aroma	3.445	13.10
Total		26.293	100.00

### Creativity

From a sample of 100 respondents, 42% of respondents chose red for product development nata de coco with natural dyes. Consumers who prefer red dye from natural dyes dragon fruit is 38% of the total sample with added sweetener of sugar by 57%. Then the main alternative is the development of nata de coco red and additional sweetener to sugar.

### Analysis

Specifications desired by consumers have been known at the stage of creativity. The corresponding relationships between product specifications are prepared in diagram FAST (Function Analysis System Technique). FAST mapping function is based on a hierarchy of functions where high-level functions are on the left while the lower level functions are on the right. Stages begin with identifying how basic functions can be defined or implemented. The answer of this question is put on the right basic functions, then do the same question of the new functionality in order to get other new functionalities answered that function. This question continues to be done to obtain a number of functions that can reflect the problem.

Scope of the issues contained in the FAST diagram nata de coco with natural dyes (Figure 1). The scope of this problem is resolved as well as the core component for limiting the discussion of the problems encountered. The right side of the scope of the problem is the function of FAST in which the function is the basic function of the product development function is the function of quality and price. The quality function



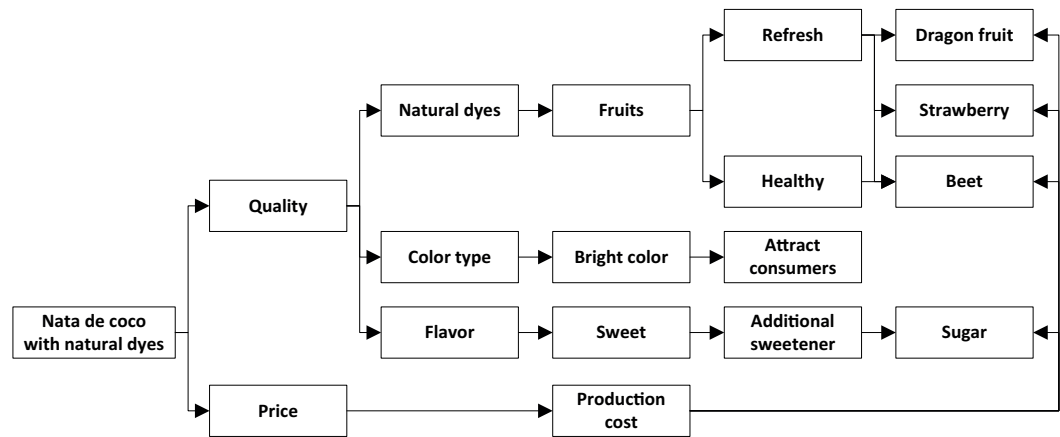


Figure 1: Product FAST Nata de coco with Natural Dyes.

is an influential factor of the product itself, while the price of an influence function that is outside of the product. On the quality function can be divided into three basic functions or settlement that is natural dyes, the kind of color, and flavor. While the price function is specified to the cost of production.

## Development

Zero Level Concept diagram in Figure 2 shows that the raw material used is nata de coco as a main component used in the research object. Aspects of the selected shape are nata de coco to the shape of a cube measuring 1x1x1 cm. The sense of being one of the specifications of the concept of development of nata de coco is due to these components is one of the three main development priorities nata de coco with natural dyes. The flavors were selected to be developed that is sweet; the sugar is used as a source of sweetness. In the specification aspect of staining nata de coco use additional materials such as natural dyes with specific color is red. The red color extracted from red-pigmented fruits including dragon fruit, strawberries, and fruit bits. All the specifications of the concept of product development nata de coco is based on quality attributes that consumers want, so we get nine concepts that can be developed into a new product alternatives.

## Recommendation

Tests of significance index rehydration showed that the dragon fruit with strawberries there are real differences between the dragon fruit with fruit bits there is a real difference, and the strawberries with fruit bits there is no real difference, while in treatment

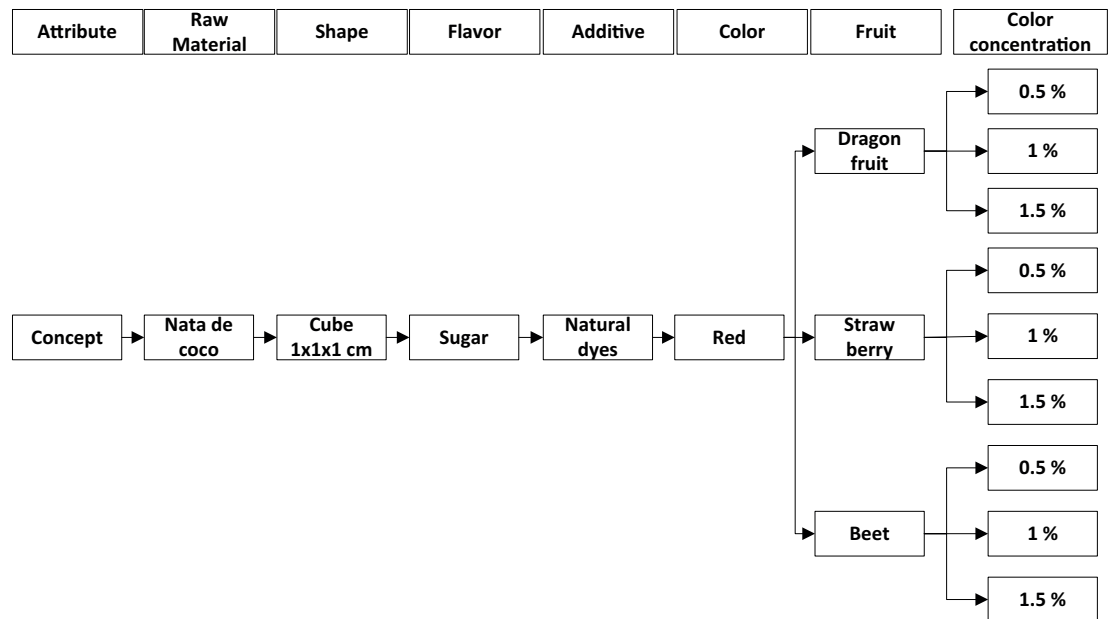


Figure 2: Zero Level Products Concept Nata de coco with Natural Dyes.

concentration, the concentration of 0,5% to 1% there are no real differences between the concentration of 0.5% to 1.5% there is a real difference, and the concentration of 1% to 1.5% there is a real difference.

Calculation of the total value of the sensory test nata de coco products with five parameters are: color, shape, aroma, texture, and flavor. It was concluded that the product nata de coco concepts 2 with a total value of 762 of the most preferred by consumers than products nata de coco other.

The percentage weighting of attributes in the form of a percentage which is to color (22.10%), the form (18.62%), aroma (18.51%), texture (20.06%), and taste (20.71%). Color has the highest interest rate of the sensory test results followed by flavors, textures, shapes, and scents.

Rated performances of the concept (Table 4) are as follows: concept-1 (107.563), the concept-2 (152.7646), concept-3 (140.3346), concept-4 (149.0837), concept-5 (142.6874), concept-6 (138.9472), concept-7 (92.4981), the concept-8 (91.8851), and concept-9 (87.7705). Sequentially from the order of the highest value to the low performance of the concept of 2, 4 concept, the concept of 5, 3 concept, the concept of 6, a concept first, the concept of 7, 8 concept, and the concept 9. Concept 2 is a concept that has the highest performance values but values higher product performance may not necessarily have the value (value) is better anyway because the value of a product is also influenced by the costs of production are used.

Concept 2 is nata de coco cube 1x1x1 cm size, taste sweet, red, using natural dyes dragon fruit with a concentration of 1%. The composition of the raw material that is 100 grams of nata de coco, 1 gram of dragon fruit dissolved in 100 ml of water, and 12 grams of sugar dissolved in 100 ml of water is a concept that has the highest value (value) of 0.0238. That is, the value equal to 0.0238 for every 100 grams of product can be achieved at a cost of Rp. 6415 that has the performance value of 152.7646. The resulting value of the selected concept is less than 1 which means the product development process does not incur cost savings but additional costs, but it is a proclamation because in the process of developing additional technological factors, these factors increase the selling value of the product. In addition, the cost of which used a laboratory scale development costs. If the concept is elected there will be mass produced cost savings.

The test results indicate that the proximate nutrient nata de coco concept 2 has a water content of 93.8%, ash 0.039%, 0.0185% fat, protein 0.145%, and 0.755% crude fiber. When compared with the content of water in nata de coco has not added any material or do not have a process of dehydration rehydration moisture content of 80% have much difference. The difference between the water content of nata de coco products using natural dyes with the addition of nata de coco plain showed that the dehydration-rehydration technique is applied to the development of nata de coco succeed.

Rehydration index of different test results show that there is a real difference between a dragon fruit with strawberries and the dragon fruit with fruit bits, while the strawberries with fruit bits there is no real difference.

In the treatment of concentration, there was no significant difference between the concentration of 0.5% to 1%. However, there is a significant difference between a concentration of 0.5% to 1.5% and the concentration of 1% to 1.5%.

Calculation of the total value of the sensory test nata de coco products with five parameters: color, shape, aroma, texture and taste can be concluded that the product nata de coco concept-2 is the most preferred by consumers than any other nata de coco products with a total value of 762. Percentage of attribute weights are for color (22.10%), the form (18.62%), aroma (18.51%), texture (20.06%), and taste (20.71%). Color has the highest interest rate of the sensory test results followed by flavors, textures, shapes, and scents.

Rated performances of all the concepts are as follows: concept-1 (107.563), the concept-2 (152.7646), concept-3 (140.3346), concept-4 (149.0837), concept-5

TABLE 4: Calculated Value of Each Concepts.

Product	Production Cost (Rp/100 gr)	Product Performance	Value
Concep-1	6407.5	1075630	0.0168
Concep-2	6415.0	1527646	0.0238
Concep-3	6422.5	1403331	0.0219
Concep-4	6412.5	1490837	0.0232
Concep-5	6425.0	1426874	0.0222
Concep-6	6437.5	1389472	0.0216
Concep-7	6407.5	924981	0.0144
Concep-8	6415.0	918851	0.0143
Concep-9	6422.5	877705	0.0137

TABLE 5: Concept-2 Nutrient of Nata de coco with Sugar 15%.

Nutrient	Percentage (%)
Water	93.8
Ash	0.0395
Fat	0.0185
Protein	0.145
Crude fiber	0.755

(142.6874), the concept-6 (138.9472), concept-7 (92.4981), the concept-8 (91.8851), and concept-9 (87.7705).

When the value of the performance are sorted from highest value to lowest value is as follows: concept-2, concept-4 concept-5, concept-3, concept-6, concept-1, concept-7, concept-8, and concept-9,

Concept-2 has the highest performance values but values higher product performance may not necessarily have the value (value) is better, because the value of a product is also influenced by the cost of production.

Concept-2 is the concept of nata de coco products which have a size of 1x1x1 cm cube shape, taste sweet, red, using natural dyes of dragon fruit with a concentration of 1%.

The composition of the raw material that is 100 grams of nata de coco, 1 gram of dragon fruit dissolved in 100 ml of water, and 12 grams of sugar dissolved in 100 ml of water is a concept that has the highest value (value) of 0.0238.



**Figure 3:** Concept-2 Nata de coco with natural dyes from the dragon fruit concentration of 1%.

This means that the value of 0.0238 for every 100 grams of product can be achieved with an estimated cost of Rp 6415 that has the performance value of 152.7646.

The resulting value of the selected concept is less than 1 which means the product development process does not incur cost savings but additional costs, but it is a proclamation because in the process of developing additional technological factors, these factors increase the selling value of the product. Costs incurred a laboratory scale development costs, if the concept of elected would be mass produced certainly needs to be cultivated in order to save production costs.

Proximate nutrient test results show that nata de coco concept-2 has a water content of 93.8%, ash 0.039%, 0.0185% fat, protein 0.145%, and 0.755% crude fiber (Table 5). When compared with the content of water in nata de coco has not added any material or do not have a process of dehydration rehydration moisture content of 80% have much difference. The difference between the water content of nata de coco products using natural dyes with the addition of nata de coco plain showed that the dehydration-rehydration technique for the development of nata de coco is successful.

## CONCLUSION

Stages quality attribute information obtained according to preference to be prioritized in the development of technical products, namely: quality attributes natural dye, flavor, and color type. Alternative product development nata de coco with natural dyes obtained 9 concept, selected concept is a concept-2 (nata de coco with dragon fruit colorant 1% - Figure 3) with a value of 152.7646 and value performance products at 0.0238 with a production cost of Rp. 6415/100 grams. That is, the value equal to 0.0238 for every 100 grams of product can be achieved at a cost of Rp. 6415 that has the performance value of 152.7646.

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