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Submission date: 19-Nov-2018 03:38PM (UTC+0800)
Submission ID: 1041791795
File name: Full_Paper_GDIC_Tengku_Nurainun.pdf (500.86K)
Word count: 2917
Character count: 14451

The Economic Potential Analysis of Nata de Pina Production Using Pineapple Skin Waste to Develop Product Variants of Pineapple Food Industry in Riau Province

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***Abstract*— Sustainable development is an important issue that must be considered in an industrial business. Companies have been encouraged to include environmental aspects in making their strategic decisions and production activities by creating and implementing innovations to convert wastes into added value products. Riau province is one of the regions in Indonesia that produce pineapple fruits on a large scale. This research focused on developing product variants of pineapple food industry which is based on utilizing pineapple skin as raw material of making a new variant nata de pina. There were two studies in this research, the experimental design of nata de pina using taguchi method and economic potential analysis of developing this new product in Riau by implementing full costing method. The analysis concluded that sugar and vinegar contributed significantly to the process. The result showed that this product is economically potential to be developed with competitive selling price at IDR 1,612 per kg compared with nata de coco that has selling price at IDR 2,000 per kg.**

Keywords—experimental design; food industry; full costing; pineapple skin waste; taguchi

I. INTRODUCTION

Pineapple is one of the most popular tropical fruits in the world that is consumed as fresh food and processed food. Pineapple production in Riau Province for 2015 was 74,389 tons [14]. Kualu Nenas Village is one of pineapple commodity center in Riau Province that distributes the commodities as fresh fruits and processed food. This area has developed into a food industry that produces a variety of typical processed ingredients such as pineapple chips, jam, or dried pineapple.

Pineapple industry produces liquid, solid, and gas wastes. Based on observation in Kualu Nenas showed that pineapple skin are discarded around the factory. If this behavior lasts for a long time will potentially damage the soil condition, reduce the soil fertility, and cause the reduction of soil PH [10]. Currently, many food industries have realized about the importance of having a green management and committed to the environment sustainable. Pineapple food industry has opportunity to increase the profit by utilizing pineapple skin waste into an added value product that is nata de pina. But, in Riau, this new product is not popular. The communities prefer to consume nata de coco that is made by the fermentation of coconut water. Many literatures have dealt that nata de pina is acceptable and feasible to be consumed [3]. But, those researches have not considered about the more preferable taste of the consumers.

TABLE I. PRODUCTION OF PINEAPPLE IN RIAU PROVINCE

Regency/City	Production (ton)
1. Kuantan Singingi	35
2. Indragiri Hulu	8,511
3. Indragiri Hilir	9,982
4. Pelalawan	113
5. Siak	8,507
6. Kampar	8,482
7. Rokan Hulu	84
8. Bengkalis	2,470
9. Rokan Hilir	454
10. Kepulauan Meranti	56
11. Pekanbaru	8
12. Dumai	35,687
Total	**74,389**

As a new product, nata de pina needs to be examined whether it meets the market tastes so the market is willing to substitutes the available current products with the new product. Experimental design is a method to improve the quality of product that leads to making product that is acceptable to consumer expectations.

This research applied full costing method to calculate the production costs and finally estimates the competitive selling price of nata de pina that will make this product preferable than the current available products.

II. METHODOLOGY

A. Variables

There are some variables involved in this research which reflect the consumer's consideration in deciding to buy a food product. The variables are shown in Table. II.

TABLE II. VARIABLE OF PRODUCT

Variable	Description
Taste	The ability of a product to create a taste that suits the expectations of consumers
Size	A dimension of a product to become larger, either wide, elongated or thickened
Color	The color of product that influences the consumer's interest
Fiber Composition	How much and thick the fiber is included in the process
Fermentation Time Length	The length of process to produce a product that meets consumer quality standards and expectations
Expiry	Product life and expiry level when stored in a particular place
Water Dose	An ideal dose of water
Room Temperature	The ideal temperature for creating products that meet quality standards, consumer expectations and processing time

B. Experimental Design

Experimental design is widely used in industry to examine processes systematically or product variables that can affect product quality. After identifying the condition of a product and product components that can affect product quality, the next step is to make an effort to directly improve the product's manufacturing, quality and performance. This research employed experimental design by using taguchi method to formulate the best combination of product composition. The experimental design procedures are:

1. Conducted the first organoleptic test by distributing 25 questionnaires to the half-trained panelists. The selection of panelists is based on processes that require expertise. For the response, 30 questionnaires were distributed to the untrained panelists.
2. The first organoleptic test results are used to determine the scores that have been given by consumers to each response.
3. Get the basic recipes in making nata de pina.
4. Determine the factors that influence taste responses and other criteria.
5. Pre-experiment in accordance with influential factors and to get the upper and lower limits of the level usage. From this pre-experiment it can be seen the number of levels of each influential factor. So the purpose of pre-experiment implementation is to find out the levels of factors that have not been recognized by the level.
6. From the number of factors and number of levels, each factor will be adjusted to the existing orthogoral array. The result of this orrhogonal array selection is the number of experiments that must be done.
7. Do an experiment.
8. The second organoleptic test is conducted which aims to get the consumer's assessment of the taste and the ability to expand the experimental results. This test was carried out by distributing 30 questionnaires for observational response criteria with half-trained panelists and 30 questionnaires for taste response with untrained panelists.
9. Processing data obtained from the second organoleptic test with SNR, mean and ANOVA calculations to determine the optimal composition and process.
10. Making nata de pina in accordance with the design results.
11. Conducted a third organoleptic test by distributing questionnaires to compare consumer ratings of the initial nata de pina and design results for the response to taste and other observational criteria and to find out the number of consumers who liked the initial data and who liked the results of the proposed design. The questionnaire for this test was 30 pieces for each.
12. Conduct analysis of the data obtained by conducting a two sample t test and comparative analysis.

C. Full Costing Method

The cost of Production of nata de pina was calculated to determine the selling price of the product. Full costing is a method that involves all components of production costs as an element of basic price, which includes raw material costs, labor costs, machine depreciation costs, and factory overhead costs.

III. RESULT AND ANALYSIS

A. Pre-experiment which affects the characteristics of nata

The initial stage in the Taguchi method is determining the factors that influence the product. Factors that influence the taste and characteristics of a product in this study include the following:

1. Composition of sugar
2. Composition of vinegar
3. Composition of ZA (urea)
4. Starter dose (bacteria nata)
5. Boiling temperature
6. Temperature of fermentation
7. Time length of fermentation
8. Composition in the tray
9. Ratio of pineapple skin juice to water
10. Measurement of nata PH
11. Time duration of making nata starter
12. Time duration of of boiling nata sheet
13. Repetitions of boiling process

The result of these pre-experiment are shown in Table III.

The next step is to create an orthogonal array. Orthogonal array aims to shorten the experiments so that the experiment can be done without performing a process repeatedly. The orthogonal used in this experiment is L16, means that amount of experiments is 16 and consider 13 factors at 2 level.

TABLE III. THE RESULT OF PRE-EXPERIMENT

Factors	Best Composition
Composition of sugar	30/gr
Composition of vinegar	100/ml
Composition of ZA (urea)	40/gr
Starter dose (bacteria nata)	150/ml
Boiling temperature	100 ℃
Temperature of fermentation	27 – 32 ℃
Time length of fermentation	7 – 10 days
Composition in the tray	400 – 600 ml
Ratio of pineapple skin juice to water	1 : 2 or 1 : 3
Measurement of nata PH	2 – 4
Time duration of making nata starter	4 – 7 days
Time duration of boiling nata sheet	5 – 10 minutes
Repetitions of boiling process	3 – 4 times

TABLE IV. ORTHOGONAL ARRAY

L16	A	B	C	D	E	F	G	H	I	J	K	L	M
1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	1	1	1	1	1	2	2	2	2	2	2	2	2
3	1	1	2	2	2	1	1	1	1	2	2	2	2
4	1	1	2	2	2	2	2	2	2	1	1	1	1
5	1	2	1	2	2	1	1	2	2	1	1	2	2
6	1	2	1	2	2	2	2	1	1	2	2	1	1
7	1	2	2	1	1	1	1	2	2	2	2	1	1
8	1	2	2	1	1	2	2	1	1	1	1	2	2
9	2	1	1	1	2	1	2	1	2	1	2	1	2
10	2	1	1	1	2	2	1	2	1	2	1	2	1
11	2	1	2	2	1	1	2	1	2	2	1	2	1
12	2	1	2	2	1	2	1	2	1	1	2	1	2
13	2	2	1	2	1	1	2	2	1	1	2	2	1
14	2	2	1	2	1	2	1	1	2	2	1	1	2
15	2	2	2	1	2	1	2	2	1	2	1	1	2
16	2	2	2	1	2	2	1	1	2	1	2	2	1

B. *Output Interpretation of Taguchi Design*

The estimated output of the coefficient for the S/N ratio was that the model parameters have no effect on the experiments which is the p-value is greater than the significant value. But the output in Fig.1 shows that the p-value was below the significant value with the lowest value 0.159 so the null hypothesis was rejected. It means that the model parameters significantly effect on the experiments.

Fig. 1. Estimated Model Coefficients for SN ratios

Taguchi Analysis: 1, 2, 3, 4, 5, 6, 7, ... versus A, B, C, D, E, F, G, ...
Linear Model Analysis: SN ratios versus A, B, C, D, E, F, G, H, I, J, K, L, M

Estimated Model Coefficients for SN ratios

Term	Coef	SE Coef	T	P
Constant	2.08860	0.04277	48.829	0.013
A 1	-0.16803	0.04277	-3.928	0.159
B 1	-0.16803	0.04277	-3.928	0.159
C 1	-0.16803	0.04277	-3.928	0.159
D 1	-0.16803	0.04277	-3.928	0.159
E 1	-0.16803	0.04277	-3.928	0.159
F 1	-0.16803	0.04277	-3.928	0.159
G 1	-0.16803	0.04277	-3.928	0.159
H 1	-0.16803	0.04277	-3.928	0.159
I 1	-0.16803	0.04277	-3.928	0.159
J 1	-0.16803	0.04277	-3.928	0.159
K 1	-0.15781	0.04277	-3.689	0.169
L 1	-0.16803	0.04277	-3.928	0.159
M 1	-0.16803	0.04277	-3.928	0.159
A*B 1 1	0.04277	0.04277	1.000	0.500

S = 0.1711 R-Sq = 99.5% R-Sq(adj) = 92.5%

The consecutive decisions using ANOVA for the S/N ratio is shown in the Fig. 2.

Fig. 2. Analysis of Variance for SN ratios

Analysis of Variance for SN ratios

Source	DF	Seq SS	Adj SS	Adj MS	F	P
A	1	0.45174	0.45174	0.45174	15.43	0.159
B	1	0.45174	0.45174	0.45174	15.43	0.159
C	1	0.45174	0.45174	0.45174	15.43	0.159
D	1	0.45174	0.45174	0.45174	15.43	0.159
E	1	0.45174	0.45174	0.45174	15.43	0.159
F	1	0.45174	0.45174	0.45174	15.43	0.159
G	1	0.45174	0.45174	0.45174	15.43	0.159
H	1	0.45174	0.45174	0.45174	15.43	0.159
I	1	0.45174	0.45174	0.45174	15.43	0.159
J	1	0.45174	0.45174	0.45174	15.43	0.159
K	1	0.39848	0.39848	0.39848	13.61	0.169
L	1	0.45174	0.45174	0.45174	15.43	0.159
M	1	0.45174	0.45174	0.45174	15.43	0.159
A*B	1	0.02927	0.02927	0.02927	1.00	0.500
Residual Error	1	0.02927	0.02927	0.02927		
Total	15	5.87786				

Based on these results, we can conclude that the parameters have a very significant value on the response.

The influencing factor level and level usage in the suggested experiment is showed in Fig 3. The largest value was 2.257 so to obtain strong characteristic of nata then the best composition for each factor refers to the level 2.

Fig. 3. Response Table for SN ratios

Response Table for Signal to Noise Ratios
Larger is better

Level	A	B	C	D	E	F	G	H	I	J
1	1.921	1.921	1.921	1.921	1.921	1.921	1.921	1.921	1.921	1.921
2	2.257	2.257	2.257	2.257	2.257	2.257	2.257	2.257	2.257	2.257
Delta	0.336	0.336	0.336	0.336	0.336	0.336	0.336	0.336	0.336	0.336
Rank	8.5	8.5	3.5	8.5	8.5	8.5	3.5	8.5	8.5	8.5

Level	K	L	M
1	1.931	1.921	1.921
2	2.246	2.257	2.257
Delta	0.316	0.336	0.336
Rank	13	1.5	1.5

Response Table for Means

Level	A	B	C	D	E	F	G	H	I	J
1	1.462	1.462	1.462	1.462	1.462	1.462	1.462	1.462	1.462	1.462
2	1.538	1.538	1.538	1.538	1.538	1.538	1.538	1.538	1.538	1.538
Delta	0.077	0.077	0.077	0.077	0.077	0.077	0.077	0.077	0.077	0.077
Rank	9.5	9.5	9.5	3	9.5	3	9.5	3	9.5	3

Level	K	L	M
1	1.462	1.462	1.462
2	1.538	1.538	1.538
Delta	0.077	0.077	0.077
Rank	3	9.5	9.5

C. *The Economic Analysis*

Availability of raw materials is highly important in a production process. There are five pineapple food industries in Kualu Nenas Village that process an average of 150 kg of pineapple per day. Each industry produces 25% of wastes every day in various form and 15% of them are skin wastes. Based on survey and calculation, the quantity of pineapple skin waste were estimated about 22.5 kg per industry, so the total estimation of pineapple skin waste that can be supplied are 112.5 kg per day. Since every kilogram of pineapple skin waste yields 2 liters of juice so the total quantities of pineapple skin juice are 225 liters. If the success rate estimation is 80%, it will produce 210 kg nata per day.

The production cost calculation consists of raw material costs, labor costs, and factory overhead costs.

1. Raw material cost

Nowadays, pineapple skin wastes are considered no more than an industrial waste so there is no economic value created from that waste. After utilizing this waste, it is estimated that the economic value will increase at least IDR 50 per kg. So the raw material cost under this assumption can be predicted as below.

TABLE V. RAW MATERIAL COST ESTIMATION

Number of working days	25	Days/month
Production capacities	210	Kg/day
Raw material quantities	112.5	Kg/day
Price estimation of raw material	50	IDR/kg
Total	**140,625**	**IDR/month**

2. Labor cost

The production of nata needs at least 2 workers to reach the target of production. The calculation of labor cost is described in Table VI.

TABLE VI. LABOR COST ESTIMATION

Working hours per day	8	Hours/day
Number of working days	25	Days/month
Number of workers	2	Persons
Labor cost	6,000	IDR/hour
Total	**2,400,000**	**IDR/month**

3. Factory overhead cost

The estimation of overhead cost (IDR/month) can be seen in Table VII.

TABLE VII. OVERHEAD COST ESTIMATION

Building rent payable	500,000
Transportation	65,000
Utilities payable	150,000
Gas fuel (170 Kg/month)	190,000
Materials	310,750
Equipment rent payable	1,889,000
Total	**3,104,750**

The total production cost was calculated as the total cost needed in a month, as below.

TABLE VIII. PRODUCTION COST

Raw material cost	140,625
Labor cost	2,400,000
Overhead cost	3,104,750
Total Cost	**5,645,375**

The calculation of production capacity per month is:

PC per month = PC per day x number of working days

= 210 Kg/day x 25 days

= 5250 Kg

$$\text{COGS} = \frac{\text{TC per month}}{\text{PC per month}}$$

$$\text{COGS} = \frac{5{,}645{,}375}{5250}$$

COGS = 1075 IDR/kg

If the products are expected to sell at 50% profit of the production cost, then the product must be offered at price IDR 1,612 per kg. This price is lower than nata de coco that has selling price about IDR 2,000 per kg.

IV. CONCLUSION

Pineapple skin as a by-product of pineapple-based food processing industry is very potential to be developed as a new business in Kualu Nenas Village. Especially for the current pineapple food industry, they could directly use the skin waste that coming from their production without supplying the raw materials from others. This would increase the estimated profit that has been calculated in the end of this study.

Entrepreneurs who are interested in developing this business are strongly advised to refer to the best composition of ingredients for making nata as a result of this study in Table II. The analysis concluded that sugar and vinegar contributed significantly to the process so the composition of these materials should be the main consideration in processing nata de pina.

Based on the selling price estimation that is compared with nata de coco, this research showed that nata de pina economically potential to be developed as a new variant of nata. The profit might to increase if the nata de pina is

produced in industrial scale production. It will be supported by the ease of obtaining very large quantities of raw materials available in Riau province.

It is possible for future research to develop product variants that have a selling value using materials derived from food-produced waste. This supports the sustainable development principles to create an environmentally friendly industry.

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