Product development of corn rice using value engineering method

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Abstract. National maize production is 19,612,435 tons. Corn has the main nutritional content in the form of starch (72-73%), simple sugar levels which include: glucose, fructose, and sucrose ranging from 1-3%, protein 8-11%. For health purposes, corn rice can be used as an alternative food to rice, because it contains a low glycemic index when compared to rice and potatoes. Considering many benefits of corn which has the potential as a functional food and to make it easier for people to enjoy functional foods made of corn, it is necessary to innovate instant corn rice products, especially for people with diabetics. The method used in this study is the value engineering method because this method is suitable for making a quality product using minimum costs. The stages in the value engineering method are the information, creative, analysis, development, and recommendation stages. The purpose of this research is to find the best alternative for the development of instant corn rice. The results of this study indicate that there are four attributes in the development of instant Madura corn rice, i.e price (0.286), texture (0.263), packaging (0.253), and net (0.196) which results in 90 alternative designs. Alternative one is the best alternative with a value of 1,093. Where the best alternative is instant corn rice that consumers want is instant corn rice with slightly coarse texture (30 mesh), using plastic packaging, net of 300 grams, and the price is IDR 7000 - IDR 8000.

1. Introduction
Corn (Zea mays L.) is a plant that is still consumed by Indonesians as a staple food or as a mixture of rice. The national maize production is 19,612,435 tons, with the highest producers being East Java, Central Java, and South Sulawesi [1]. As a food source, corn has the main nutritional content in the form of starch (72-73%), simple sugar levels which include: glucose, fructose, and sucrose ranging from 1-3%, protein 8-11% [2]. In terms of health, corn rice can be used as an alternative food to replace rice, because corn rice contains a lower glycemic index than rice [3]. Another advantage of corn is that it is a dietary fiber with a low glycemic index (GI) of around 50 - 90, with these advantages that corn can be processed into functional food products [4]. Based on the table of IG values from Harvard Medical School, every 150 grams of plain white rice has a glycemic index value of 72. Meanwhile, with the same portion size, the GI value of potatoes is 82 and corn is 48. The glycemic index is called high if it is above 70, moderate if it is in the range of 56-69, and low if it is
below 55. Judging from the above figures, it can be concluded that corn is a staple food that has the lowest GI value among the three.

According to 2015 data from the Endocrinology Association, the number of people with diabetes mellitus in Indonesia has reached 9.1 million people. Indonesia is said to have shifted from the 7th to the top 5 among the countries with the highest number of diabetes mellitus sufferers in the world. According to the Ministry of Health's 2018 Basic Health Research data, Jakarta Capital Special Region (DKI Jakarta) Province has the highest prevalence of diabetes sufferers, namely 3.4%, followed by the Special Region of Yogyakarta (DIY) (3.1%), East Java (3.1%) [5]. The three regions have the highest prevalence. Seeing the many benefits of corn that has the potential as a functional food and to make it easier for people to enjoy functional foods made from corn, it is necessary to innovate instant corn rice products for diabetics using the Value Engineering (VE) method. The VE can be defined as a creative effort to achieve a goal by optimizing the costs and performance of a system [6]. The VE method is a complex system method designed to determine a goal to develop several alternative means of achieving the previously made goals [7]. The VE is a method used to obtain a very efficient alternative option with the smallest cost and aims to obtain a certain performance [8]. The VE is a systematic approach to several techniques used to identify and analyze the function or usefulness of a product [9]. This VE method has proven to be successful because in practice this method not only provides cost savings but also improves functionality thereby ensuring its effectiveness and efficiency and obtaining high benefits. The value engineering method is widely used in product development research, among others; in the development of dodol packaging products [10], palm oil refinery [11], crispy peperek products [9], and the development of calcium [12]. The purpose of this research is to find the best alternative for the development of instant corn rice.

2. Methods
The method used in this research is the value engineering method because this method is very well used in making a quality product using minimum costs [8-11]. The stages in the value engineering method are information, creative, analysis, development, and recommendation stages [9-11, 13].

3. Results and discussion

3.1. Information stage
The results of the identification of raw materials for making instant Madura corn rice obtained at the information stage are local Madura corn that has been dried and has undergone a milling process. The following is a map of the production process presented in the form of a flowchart diagram [1].

Determination of the attributes of consumer interest in making instant Madura corn rice was carried out by distributing questionnaires to 100 respondents. There are four attributes given and explained by the researcher to the respondent, i.e. the attributes of packaging, texture, net weight, and price. The attribute that has the highest weight according to consumer desires is the price attribute. The weight of the price attribute is 0.286, the texture attribute value is 0.264, the packaging attribute value is 0.253, the net weight attribute value is 0.196. This is the same as the statement that there are four attributes in product development, i.e. taste, size, packaging, and net weight [9], attributes color, aroma, taste, and crunch [12], attributes taste, packaging, net weight [10], attributes of taste, and price [14].

In the alternative design above, five attributes can be developed by selecting items from each attribute. For example, developing an alternative product design for instant Madura corn rice, which consists of: (1) Granule size: 60 mesh, (2) Price: IDR. 5999-IDR. 6999, (3) Packaging: Aluminum Foil, and (4) Net Weight: 400g. Based on the choices for each of the attributes listed in Table 1, the development of alternative designs is (3 x 5 x 2 x 3) = 90 alternative designs. Design alternatives are carried out by analyzing each attribute because there are too many alternative designs to be offered to respondents, so it is necessary to calculate each attribute [11]. The search for design alternatives is carried out by analyzing each alternative to produce a sequence and comparative weight for each item.
Figure 1. Operation process chart of instant Madura corn rice.

3.2. Analysis stage
At the analysis stage, several analyzes were carried out including weighting analysis, performance analysis, alternative selection analysis, and cost analysis.

3.2.1. Weighting analysis
Weighting analysis is carried out to determine the weight of each of the available alternatives. Weights are obtained from the results of distributing questionnaires and recalculated using the following formula [11]:

\[
\text{Weight} = \frac{\text{Score of each factor}}{\text{Total score for each factor}}
\]  

Based on the results of the recapitulation of the 100 questionnaires that have been distributed, the scores and weights of each alternative are obtained. The scores and weights of each alternative can be seen in Table 1 to Table 4.
### Table 1. Alternative weight analysis of price attributes.

| Attribute   | Alternative         | Code | Questionnaire |
|-------------|---------------------|------|---------------|
|             | IDR. 5000 - IDR. 6000 | A1   | 394           | 0.224         |
|             | IDR. 6000 - IDR. 7000 | A2   | 398           | 0.226         |
|             | IDR. 7000 - IDR. 8000 | A3   | 438           | 0.249         |
|             | IDR. 8000 - IDR. 9000 | A4   | 310           | 0.176         |
|             | IDR. 9000 - IDR. 10.000 | A4   | 222           | 0.126         |

### Table 2. Alternative weight analysis of packaging.

| Attribute   | Alternative              | Code | Questionnaire |
|-------------|--------------------------|------|---------------|
|             | Plastic                  | B1   | 451           | 0.53          |
|             | Aluminium Foil           | B2   | 400           | 0.47          |

### Table 3. Alternative weight analysis of texture.

| Attribute   | Alternative             | Code | Questionnaire |
|-------------|-------------------------|------|---------------|
|             | Fine (60 mesh)          | C1   | 213           | 0.213         |
|             | Slightly Coarse (30 mesh) | C2   | 442           | 0.442         |
|             | Coarse (10 mesh)        | C3   | 346           | 0.346         |

### Table 4. Alternative weight analysis of product’s netto.

| Attribute   | Alternative  | Code | Questionnaire |
|-------------|--------------|------|---------------|
|             | 200 gr       | D1   | 266           | 0.245         |
|             | 300 gr       | D2   | 422           | 0.388         |
|             | 400 gr       | D3   | 402           | 0.369         |

### 3.2.2. Performance analysis

The performance value is obtained from the results of distributing questionnaires and recalculated using the following formula [11]:

\[
\text{Performance value} = \text{Score} \times \text{Weight of interest}
\]  

### Table 5. Alternative performance recapitulation.

| No | Price (A)  | Packaging (B) | Texture (C) | Netto (D) |
|----|------------|---------------|-------------|-----------|
| 1  | 88.103     | 239.015       | 45.324      | 64.914    |
| 2  | 89.902     | 188.015       | 195.169     | 163.370   |
| 3  | 108.879    | 119.597       | 148.261     | 148.261   |
| 4  | 54.541     |               |             |           |
| 5  | 27.971     |               |             |           |

### 3.2.3. Alternative selection analysis

Alternative selection analysis is conducted to select several alternative combinations that have the highest performance value to obtain the best alternative combinations according to consumers.
Based on the results of the alternative calculations listed in Table 6, the five best alternative combinations were obtained. Five alternative combinations were selected with the highest to lowest performance values, namely, the first alternative with code A3B1C2D2 with a total performance value of 706.442, the second alternative with code A3B1C2D3 with a total performance value of 691.323, the third alternative with code A2B1C2D2 with a total performance value of 687.463, the fourth alternative is code A1B1C2D2 with a total performance value of 685.665 and the last or fifth alternative is code A2B1C3D3 with a total performance value of 672.344.

### 3.2.4. Cost analysis

The cost calculation is done to find out the details of the costs required in making instant Madura corn rice. Details of alternatives and selected designs can be seen in Table 8.

#### Table 7. Alternative of instant Madura corn rice products.

| Attribute      | Cost (IDR) | Alternative 1 | Alternative 2 | Alternative 3 | Alternative 4 | Alternative 5 |
|----------------|------------|---------------|---------------|---------------|---------------|---------------|
| Price          | -          | -             | -             | -             | -             | -             |
| Packaging      | 440        | 440           | 440           | 440           | 440           | 440           |
| Texture        | -          | -             | -             | -             | -             | -             |
| Netto          | 2,289      | 3,051.5       | 2,289         | 2,289         | 2,289         | 3,051.5       |
| Gas            | 250        | 250           | 250           | 250           | 250           | 250           |
| Labor          | 1,730      | 1,730         | 1,730         | 1,730         | 1,730         | 1,730         |
| Total          | 4,709      | 5,471.5       | 4,709         | 4,709         | 5,471.5       | 5,471.5       |

Table 7 shows the calculation of the cost of making instant Madura corn rice. The total cost that must be spent on each alternative from alternative 1 to alternative 5 is IDR 4,709; 5,471.5; 4,709; 4,709; and 5,471.5.
3.3. Development stage

The development stage was carried out by the analysis process of determining the value to determine the value of each alternative of instant Madura corn rice products. The value can be calculated with the following equation [15]:

\[ V = \frac{P}{C} \] (3)

For performance, there is no unit, while the cost uses IDR units. Therefore, performance needs to be converted into rupiah units to calculate the value of each alternative. The conversion is done by determining the quantity \( n \) which determines the IDR value for each performance so that the following equation is obtained:

\[ Pn' = n \times Pn \] (4)

At value using the assumption of an average alternative with a value of 1, then:

\[ V_0 = 1 \]

\[ V_0 = \frac{P_0'}{C_0} = \frac{n \times P_0}{C_0} = 1 \] (5)

The average alternative is obtained from the average performance of several alternatives and the average cost of several alternative costs. Thus, the IDR value of each alternative performance can be obtained with the following equation:

\[ Pn' = \frac{P_n \times C_0}{P_0} \] (6)

Based on the equation that has been obtained above, then it will be possible to calculate the value of each selected alternative by comparing the performance with the cost of alternative 1 to alternative 5.

Table 8. Performance and cost of each alternative.

| No | Alternative | Performance | Cost (IDR) |
|----|-------------|-------------|------------|
| 1  | 1           | 706.442     | 4,709.0    |
| 2  | 2           | 691.323     | 5,471.5    |
| 3  | 3           | 687.463     | 4,709.0    |
| 4  | 4           | 685.665     | 4,709.0    |
| 5  | 5           | 672.344     | 5,471.5    |

Based on Table 8, it can be seen that the alternative that has the highest value is alternative 1 with a performance value of 706.442 with slightly coarse texture (30 mesh), using plastic packaging, net of 300 grams, and the price is IDR 7000 - IDR 8000. Slightly coarse texture (30 mesh) because it corresponds to the content of Madura corn, which has a fairly high amylose content of 37.75% [16]. This is by the research that maize rice with a low amylose content has a faster cooking time and is fluffier [17]. Polypropylene (PP) plastic packaging that is thicker (0.1 mm) has lower water vapor permeability so that the water vapor transmission rate for changes in the moisture content of instant Madura corn rice can be resisted compared to thin PP plastic packaging (0.03 mm). This is in line with the research the thicker the packaging for the same type of packaging, the lower the permeability to water vapour [18]. Net of 300 grams because it corresponds to the amount of daily human consumption [19]. The price is IDR 7,000 - IDR 8,000 because the Madura corn rice segmentation is the Madura community. The following is the alternative average calculation to make it easier to calculate the value of each alternative.

Based on Table 9, after the performance value is converted into IDR units, it is found that the alternative that has the highest value is the first alternative with a value of 1.093 while the alternative with the lowest value is the fifth alternative with a value of 0.895. The values of 1.093, 1.063, and 1.61 need to be developed because the values are above number one. This is by the research that if the value is more than the number, development is necessary [20, 21]. A minimum of 50% of the total value must be developed [22].
Table 9. Value of each alternative using conversion.

| Alternative | Performance | Cost (IDR) | Performance Conversion (IDR) | Value | Ranking |
|-------------|-------------|------------|------------------------------|-------|---------|
| Vo          | 688.648     | 5014       | 5014                         |       |         |
| 1           | 706.442     | 4709       | 5143.557                     | 1.093 | 1       |
| 2           | 691.323     | 5471.5     | 5033.477                     | 0.920 | 4       |
| 3           | 687.463     | 4709       | 5005.373                     | 1.063 | 2       |
| 4           | 685.665     | 4709       | 4992.281                     | 1.061 | 3       |
| 5           | 672.344     | 5471.5     | 4895.292                     | 0.895 | 5       |

3.4. Recommendation stage

Based on the analysis that has been done previously, it was found that alternative 1 is the best alternative according to consumer requirements with a value of 1.093. Where the alternative of instant Madura corn rice that consumers want is instant Madura corn rice with slightly coarse texture (30 mesh), using plastic packaging, net of 300 grams, and the price is IDR 7,000 - IDR 8,000.

4. Conclusions

The results of this study indicate that there are four attributes in the development of instant Madura corn rice, namely price (0.286), texture (0.263), packaging (0.253), and net (0.196) which results in 90 alternative designs. After analyzing the alternative selection, five best alternatives were selected and alternative 1 instant Madura corn rice with slightly coarse texture (30 mesh), using plastic packaging, net 300 grams, and the price of IDR 7,000 - IDR 8,000 is the best alternative with a value of 1.093. The next research is the analysis of the shelf life of corn rice.

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