Development of Sago Analog Rice with The Addition of Glucomannan Flour Using Value Engineering Method

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Abstract

Analog rice is an imitation of rice made with non-rice ingredients such as tubers and cereals as an alternative healthy food. However, the existence of analog rice has not been fully known and accepted by the public due to a lack of knowledge. The physical characteristics of analog rice do not resemble paddy rice and still have several attributes that interfere with consumer acceptance. Adding glucomannan to make analog rice is expected to improve product attributes. This study aims to determine the priority of product development attributes and produce analog rice with the best concept through high value. The method used in this product development is value engineering, which has five steps: information, creativity, analysis, development, and recommendation steps. The best concept for analogs is rice made from sago with an additional composition of 0.07 gram glucomannan flour and 7 ml pandan essence oil. Sago analog rice with 0.07 grams of glucomannan and 7 ml pandan essence oil has 83.74% carbohydrate, 3.02% fat, 4.53% protein, 8.15% water content, and 0.55% ash content.

Keywords: *glucomannan, product development, rice analog, value engineering*

1. INTRODUCTION

Indonesia is the third country in the world's most significant domestic rice consumption in 2016 – 2020, after China and India. The data support that 90% of Indonesians consume paddy rice as a staple food, with a percentage of 7.48% of the total world rice domestic market (Pusat Data dan Sistem Informasi Pertanian, 2021). The behaviour of the Indonesian people to make rice the leading staple food is feared to affect food security in the future. Therefore, there is a need for food alternatives to rice that still provide satiety and high nutrition in order to anticipate the crisis, provide alternative local food, and reduce people's dependence on paddy rice (Handajani et al., 2020).

Analog rice is an imitation of rice made from 50-98% ingredients containing starch or its derivatives, 2-45% ingredients that can enrich analog rice, and 0.1-10% hydrocolloids (Damat et al., 2020). Analog rice has a carbohydrate content that is not different from paddy rice, a lower glycemic index (GI) and provides a more prolonged feeling of satiety. Consumption of local food substitutes for paddy rice has indeed begun to develop. However, there are still obstacles, such as a lack of nutritional knowledge of the community, a lack of psychological readiness to replace staple foods, and the limited availability of food that meets people's tastes (Novrini, 2020). You can make analog rice using either granulation or extrusion. The essential difference between these two methods is in the gelatinization stage of the ingredients and the moulding stage, which will affect the product's final shape (Pudjihastuti et al., 2019). The extrusion method has advantages over the granulation method: it can produce with a larger capacity, and the process of flowing, mixing, kneading, heating, and forming occurs at the same time so that the rice produced has similar characteristics to paddy rice (Budi et al., 2013).

The selection of raw materials in making analog rice can affect the characteristics of the rice produced. For consumers, physical appearance is the first thing to be assessed in food products (Novitasari et al., 2017). Analog rice still has several attributes that interfere with consumer acceptance. Choosing the right ingredients can overcome these problems. One of the main ingredients for making analog rice is sago, a food commodity with a high starch content and complex carbohydrates that cause satiety longer (Hariyanto et al., 2017). Adding ingredients like pandan essence oil and glucomannan flour is one of the new alternatives to improve attributes considered disturbing by consumers, especially the aroma and taste attributes.

Previous research on analog rice development has been carried out using sweet potato and taro flour (Srihari et al., 2016), breadfruit sorghum flour (Rasyid et al., 2016), mocaf and cornstarch (Yuwono and Zulfiah, 2015), white corn (Noviasari, 2013), white coconut yam (Adicandra and Estiasih, 2016), and sago flour (Septiani, 2021). However, these studies were only limited to variations in constituent ingredients, not including identification of consumer acceptance before and after product development. Based on the existing problems, it is necessary to develop analog rice by identifying the community's needs before producing the best concept. Product development uses the value engineering method, which is a method that is able to measure the value of a product with regard to quality, performance, and reliability at an acceptable price and is able to eliminate aspects that have no value (Iswahyuni, 2020). The company chose this method to develop a specific new product that the market has not yet fully recognized.

2. MATERIAL AND METHODS

2.1 Materials

The ingredients used are sago flour (65%), mocaf flour (7%), Glycerol Monostearate (1.5%), Carboxy Methyl Cellulose (1%), salt (0.1%), cooking palm oil (1.8%), water (22%), pandan essence oil (1.5%), and glucomannan flour (0-0.1%).

2.2 Tools

Tools for producing analog rice include a digital balance, stand mixer, basin, stove, steaming pot, white cloth, trays, spatula, extruder, and cabinet dryer.

2.3 Research stage

This research uses the value engineering method with several combinations of tests at each stage. This method consists of 5 stages: information, creative, analysis, development, and recommendation.

2.3.1 Information stage

At this stage, we conducted initial observations and identified analog rice quality attributes. We made these observations to gather information about analog rice through the Internet or market surveys. In addition, we observed the making of analog rice through trial and error. We will use the results of these observations as a reference and consideration in production.

After enlisting the expertise of five academic professionals, we assessed the Content Validity Ratio (CVR) to gauge the questionnaire's content validity prior to its distribution among participants. We integrated attributes that successfully cleared the CVR evaluation into an initial questionnaire to assess their perceived significance. This questionnaire employed a Likert scale that ranged from 1 (indicating very unimportant) to 5 (signifying very important). The individuals chosen to respond to the questionnaire encompassed the general public aged between 18 and 65 years, all of whom had prior experience with analog rice consumption. Upon gathering responses from 30 participants, the attributes of the questionnaire underwent rigorous testing for validity and reliability by utilizing IBM SPSS Statistics 26 software. If we confirm that all attributes possess validity and reliability, we will distribute the questionnaire to a larger cohort of no fewer than 100 respondents. This expanded distribution will occur with a high level of confidence at 95% and a significance level set at 5%. This statistical approach adheres to the established minimum sample size requirement of 97, as stipulated by Sugiyono in 2019.

After identifying five academic experts, we conducted a Content Validity Ratio (CVR) test to measure the content validity of the questionnaire before distributing it to respondents. After passing the CVR test, we will place the attributes into a preliminary questionnaire about the importance level. This questionnaire will utilize a Likert scale ranging from 1 (very unimportant) to 5 (very important). The questionnaire respondents were the general public aged 18 - 65 years who had consumed analog rice. After getting 30 respondents, the questionnaire attributes were tested for validity and reliability using IBM SPSS Statistic 26 software. Upon confirming the validity and reliability of all attributes, we distributed the questionnaire to a minimum of 100 respondents with a confidence level of 95% and a significance level of 5%, effectively fulfilling the minimum sample requirement of 97 (Sugiyono, 2019).

2.3.2 Creative stage

At this stage, we will determine the level of importance of the product by utilizing the formula for assessing importance and assigning weights to prioritize the development of product attributes.

$$Level\ of\ importance\ attributes = \frac{Score\ level\ per\ attribute}{Number\ of\ respondents} \quad (1)$$

$$Weighted\ importance\ level = \frac{Level\ of\ importance\ per\ attribute}{Total\ importance\ level} \quad (2)$$

2.3.3 Analysis stage

We generated Function Analysis and System Technique (FAST) diagrams for raw and cooked rice during this stage. A FAST diagram represents the technical functions of the product through graphical means, structured by a hierarchy of primary and secondary functions. The primary function elucidates the fundamental technical attributes of the product, whereas secondary functions expound upon the collection of advanced attributes inherent to the product (Julien and Barradas, 2017).

2.3.4 Development stage

We determined alternative product concepts by formulating a zero-level concept using the attributes identified earlier. We then conducted prototyping of analog rice products, introducing variations in the formulation of additional ingredients while keeping the production process unchanged.

2.3.5 Recommendation stage

This stage begins with product testing using the organoleptic test, specifically the hedonic test (level of preference), with 33 untrained panellists. The number of panellists follows SNI 01-2346-2006 related to the organoleptic test, which uses a minimum of 30 untrained panellists in one test (Badan Standardisasi Nasional, 2006). This test uses a questionnaire form with a scale of liking levels of 1 (immensely dislike) to 7 (very like). In this study, we will test the parameters of liking for the colour, texture, aroma, and shape of raw analog rice and the taste, colour, texture, and aroma of cooked analog rice.

We calculated each product concept's performance, cost, and value upon testing. The higher the performance value for each concept, the more the concept is favoured by the panellists.

$$Performance = \sum(total\ score\ x\ attribute\ weight) \quad (3)$$

We can calculate the attribute weights for each factor using the formula.

$$Attribute\ weight = \frac{Score\ of\ each\ factor}{Total\ score\ for\ each\ factor} \quad (4)$$

The next step is to determine production costs, especially raw material costs. This research does not consider the cost of equipment, rent, and labour because all concepts are considered the same. The primary step is calculating the best concept based on the highest value.

$$Value = \frac{Performance}{Cost} \quad (5)$$

Performance and cost values did not have the same units. Therefore, before determining the value of each concept, it is necessary to convert the performance needs into rupiah units to calculate the value of each alternative. We obtain the average alternative by averaging the performance of multiple alternatives and the average cost of several alternative costs. You can calculate the IDR value of each alternative performance using the following equation (Hidayat et al., 2021).

$$Pn' = \frac{Pn\ x\ Co}{Po} \quad (6)$$

Pn' is converting alternative performance to rupiah, Pn is alternative performance n, Co is the alternative average cost, Po is alternative average performance.

After obtaining the value for each concept, you can determine the best product concept by selecting the one with the highest value.

3. RESULTS AND DISCUSSION

3.1 Information stage

We identified attributes for raw rice and cooked analog rice by conducting a literature study of previous research, performing a Content Validity Ratio (CVR) test, and assessing validity and reliability. The resulting attributes, presented in Table 1, will be utilized in preparing the level of importance questionnaire.

Table 1. Identification of Product Attributes

Primary attributes	Secondary attributes	Reference
Raw analog rice		
Shape	Slender and oval; uniform size	(Mardiah et al., 2016) & (Nafiah et al., 2015)
Texture	Strong and not easily broken	(Novitasari et al., 2017)
Colour	Pure white; evenly coloured	(Novitasari et al., 2017)
Aroma	Unscented (neutral)	(Nurjaya and Maulida, 2018)
Cooked analog rice		
Taste	Neutral flavor	(Mardiah et al., 2016)
Texture	Soft and fluffy	(Novitasari et al., 2017)
Colour	Bright white, evenly coloured	(Hasan et al., 2022)
Aroma	Unscented (neutral)	(Rizkiabdillah, 2017)

Previous research according to the reference list in the table is only limited to identifying attributes based on consumer voices. However, there is no advanced stage to realize these attributes in product development. So that in this study, information related to relevant attributes is needed in order to develop products in the form of prototypes according to consumer desires. Research (Septiani, 2021) also uses the value engineering method in developing analog rice but is only limited to cooked rice, while this research is reviewed from 2 sides of raw and cooked rice.

3.2 Creative stage

We utilized the predetermined primary attributes to craft a level-importance questionnaire. Each attribute has a percentage weight level of importance. The importance weight value is obtained from the calculation of formula (2) by dividing the level of importance per attribute by the total importance level. This score is obtained from a recap of the questionnaire respondent's assessment which will be calculated by the researcher. The importance weight value is employed to prioritize the attributes for development. Table 2 presents the attribute weight percentages.

Table 2. Weighted Importance Level Raw Rice and Cooked Rice

Primary attributes	Weighted importance level
Raw analog rice	
Texture	26.99%
Aroma	25.87%
Colour	24.13%
Shape	23.01%
Cooked analog rice	
Taste	26.84%
Texture	25.85%
Aroma	24.87%
Colour	22.44%

Not all attributes desired by consumers into consideration in product development because there are cost constraints, it will only be prioritized on the top 2 attributes. Based on Table 2, development priorities focused on texture and aroma for uncooked rice and flavor and texture for cooked rice. These results are quite in accordance with (Novitasari et al., 2017) which states that the attributes that consumers consider in development of rice analog are fluffy texture, fragrant aroma, good taste, and economical price. In the study (Nurjaya and Maulida, 2018) also mentioned that the attribute that most determines the level of consumer preference for rice is the aroma variable. Aroma is considered important as a distinctive point of rice and increases consumer interest in buying. In research (Pratiwi and Rosyid, 2022) states that the strategy for developing rice attributes is to focus on the attributes of fullness, color, cleanliness, durability, price, and ease of obtaining products. This shows that the results of this study are not much different from previous studies regarding what rice attributes are considered important by consumers.

In raw rice, the texture attribute is expected to have firm grains, not sticking together, and not crumbling easily, so a binder additive is needed, namely Carboxy Methyl Cellulose (CMC) (Hidayat et al., 2013). In cooked rice, the expected texture attributes are soft and fluffy, so it uses a sago starch base material that contains high amylopectin (73%) and low amylose (27%) (Rahmawati et al., 2019). Texture is enhanced using additional ingredients, namely mocaf flour and glucomannan. Glucomannan has the ability to expand, gel, thicken, absorb, and bind water so that the texture and rheological properties of food products can be improved (Amrozi, 2018). Furthermore, the taste and aroma attributes that consumers want are neutral. Basically, analog rice made from sago flour and mocaf has a taste and aroma that is quite disturbing due to the influence of the ingredients themselves. The musty smell and taste comes from flour and processed products from tubers (Cahyani, 2018) Therefore, additional ingredients are needed in making analog rice that can cover the annoying taste and aroma. The material chosen is flavor in the form of pandan essence oil. According to (Habullah et al., 2019), it turns out that aromatic rice and fragrant rice flavor are more in demand by consumers. Flavors with aromas such as pandan leaves are ingredients that are often added in making rice by Indonesians so it is hoped that these aromas can be well received by consumers.

3.3 Analysis stage

At this stage, we create Function Analysis and System Technique (FAST) diagrams for raw and cooked rice attributes. We had previously categorized the primary attributes into essential functions. The FAST diagram of raw analog rice is presented in Figure 1 and FAST diagram of cooked analog rice is presented in Figure 2.

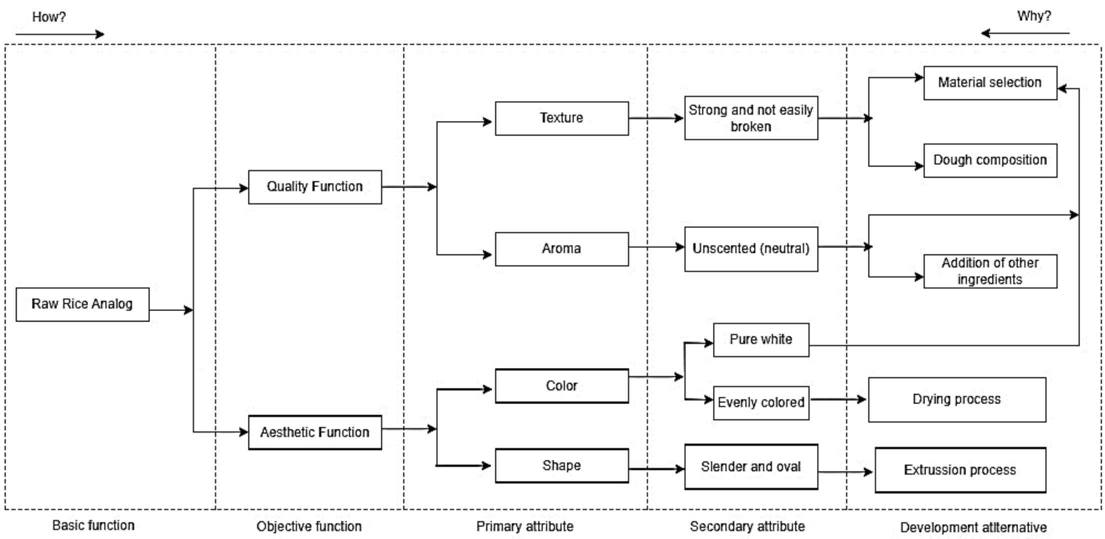

Figure 1. FAST diagram of raw analog rice

We focus analog rice attribute development on texture and aroma, which fall under the quality function. Achieving the desired texture, characterized by solid grains not prone to crumble, will involve ingredient selection and appropriate dough composition. Additionally, obtaining a neutral and unobtrusive aroma function will entail ingredient selection and adding other components.

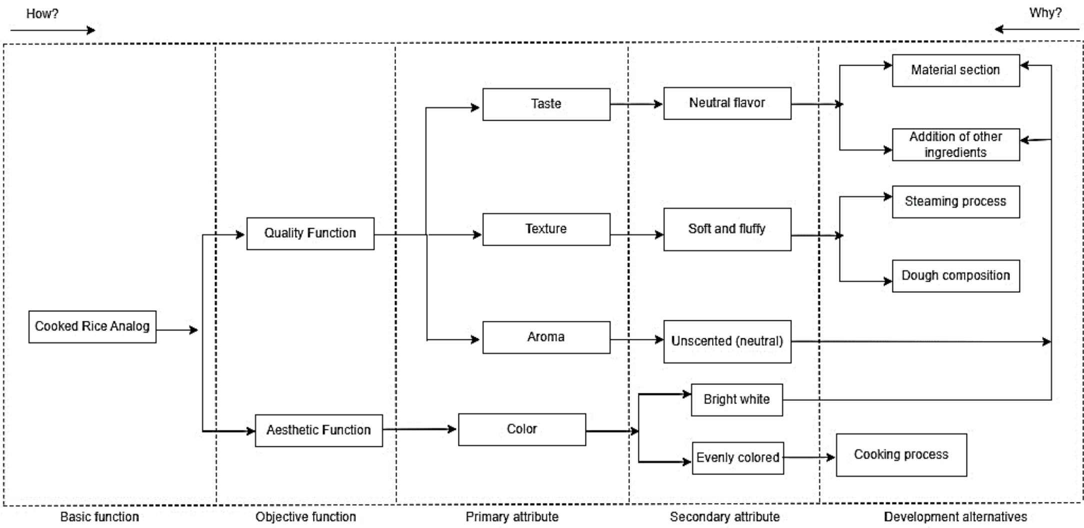

Figure 2. FAST diagram of cooked analog rice

The quality function consisting of flavour, texture, and aroma attributes is the top priority in producing neutral cooked rice with no distracting flavours and aromas. It is tasty and fluffy in terms of texture.

3.4 Development stage

We determined alternative concepts for the product by employing the Zero Level Concept diagram. In making analog rice, the variation in the formulation is the addition of glucomannan flour and pandan essence oil flavour. Other main ingredients used are the same, which are sago flour, mocaf, and supporting ingredients such as Glycerol Monostearate (GMS), Carboxy Methyl Cellulose (CMC), salt, water, and palm cooking oil. In the development stage, the concept of analog rice consists of 4 variations of alternative concepts (Figure 3).

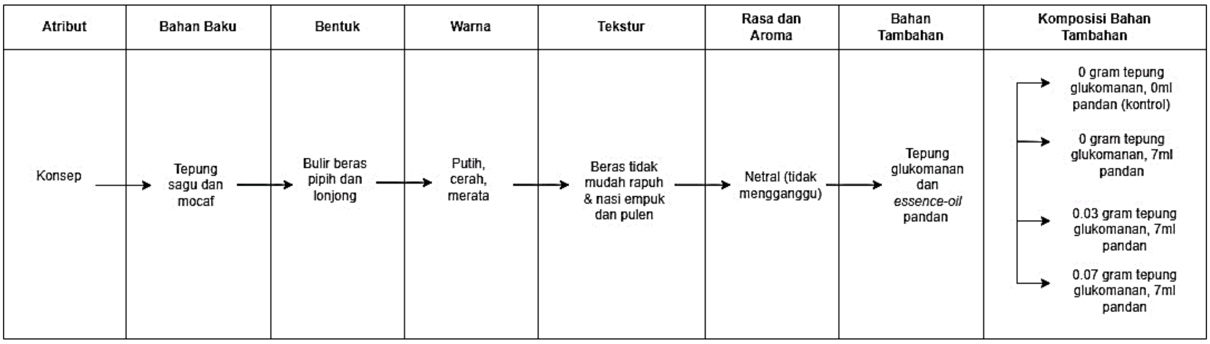

Figure 3. Zero-level concept diagram of analog rice

Flour glucomannan can be added as thickeners, chewers, stabilizers, and texture formers in food products (Guna et al., 2020). Using porang flour derived from glucomannan has found widespread application, including its use as an additive in producing artificial rice. This incorporation offers the advantage of reducing blood cholesterol levels and the risk of diabetes (Setyono et al., 2021). In addition, adding pandan essence oil flavouring to the analog rice dough aims to cover the annoying taste and aroma. Analog rice has a disturbing taste due to its constituent ingredients. A musty aroma and taste have become a characteristic of flour and processed products derived from tubers (Cahyani, 2018). Picture and explanations of each analog rice concept can be seen in Table 3.

Table 3. Alternative raw rice and cooked rice analog concepts

Concept	Picture	Description
1		Control formulation (no glucomannan flour and pandan essence oil added)
2		Formulation with 7 ml pandan essence oil and no glucomannan flour added.
3		The formulation added 7 ml pandan essence oil and 0.03 grams of glucomannan flour (0.01%).
4		The formulation added 7 ml pandan essence oil and 0.07 grams of glucomannan flour (0.02%).

3.5 Recommendation stage

The organoleptic test assessed the products developed at the previous stage. The test samples consist of four raw analog rice samples and four cooked rice samples. The researcher will use the scores obtained from the organoleptic test to calculate the performance of each concept, so as to identify the concept with the highest score. Panelists assessment of the total score and average per attribute on each sample can be seen in Tables 4 and 5.

Table 4. Organoleptic score of raw analog rice

Attributes	Score	Concept 1 (Non Glucomannan + Non Pandan)	Concept 2 (Non glucomannan + Pandan 7 ml)	Concept 3 (Glucomannan 0.03 grams + Pandan 7 ml)	Concept 4 (Glucomannan 0.07 grams + Pandan 7 ml)
Texture	Total	143	152	158	166
	Average	4.3	4.6	4.7	5.0
Aroma	Total	135	156	159	162
	Average	4.1	4.7	4.8	4.9
Color	Total	158	167	164	172
	Average	4.7	5.1	4.9	5.2
Shape	Total	150	157	170	173
	Average	4.5	4.7	5.1	5.2

In the four attributes of raw analog rice, the highest value is concept 4 with the formulation of adding glucomannan 0.07 grams and pandan 7 ml.

Table 5. Organoleptic score of cooked analog rice

Attributes	Score	Concept 1 (Non Glucomannan + Non Pandan)	Concept 2 (Non glucomannan + Pandan 7 ml)	Concept 3 (Glucomannan 0.03 grams + Pandan 7 ml)	Concept 4 (Glucomannan 0.07 grams + Pandan 7 ml)
Taste	Total	135	141	139	156
	Average	4.1	4.2	4.2	4.7
Texture	Total	131	125	137	166
	Average	3.9	3.7	4.1	5.0
Aroma	Total	123	146	142	147
	Average	3.7	4.4	4.3	4.4
Color	Total	140	146	137	156
	Average	4.2	4.4	4.1	4.7

In the attributes of taste, texture, and color of cooked analog rice, the highest value is concept 4 with the formulation of adding glucomannan 0.07 grams and pandan 7 ml. As for the aroma attribute, the highest scores are concept 2 and concept 4. The diagram below provides an overview of the total scores for each attribute across the samples (Figure 4 and 5).

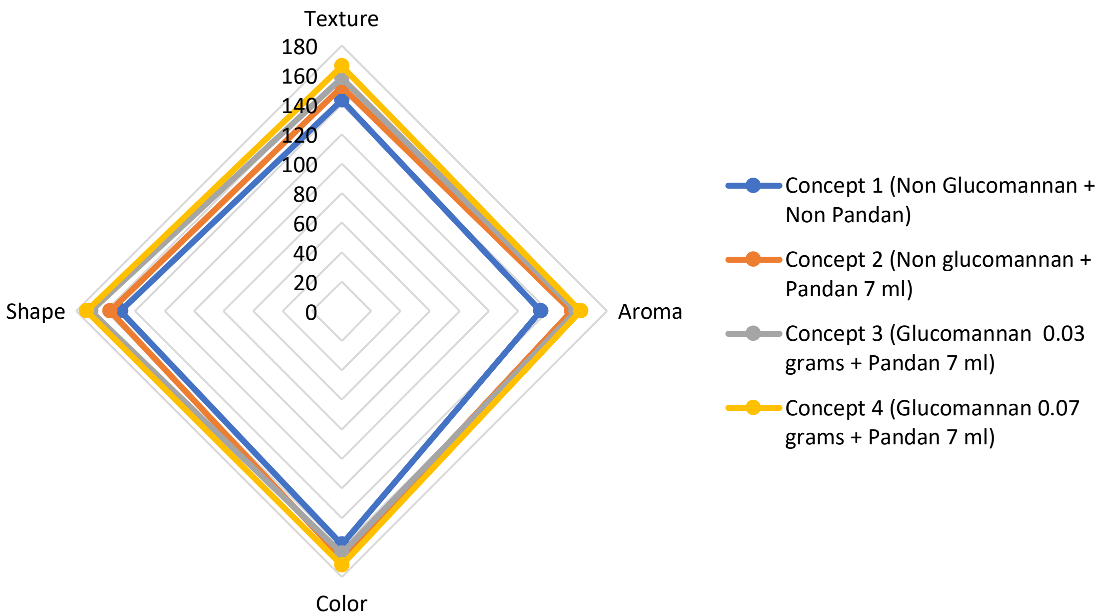

Figure 4. Radar chart of raw analog rice

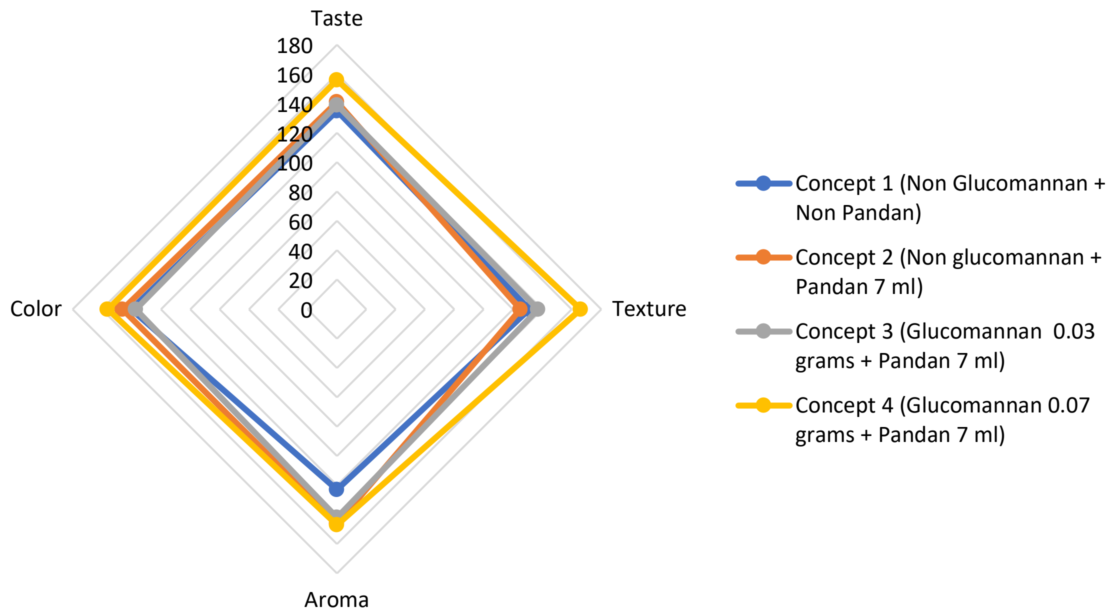

Figure 5. Radar chart of cooked analog rice

The formulation in concept 4, with the addition of 0.07 grams of glucomannan flour and 7 ml pandan essence oil, is preferred by most panellists compared to other concepts, characterized by the distribution of data shown in the diagram above. Value engineering employs performance and cost considerations to discover the optimal concept. The cost used here in this research covers materials only and does not include other costs. The performance calculation can be seen in Table 6, the cost calculation can be seen in Table 7, and result of performance score conversion to rupiah units can be seen in Table 8.

Table 6. Performance Score Analog Rice

	Concept 1	Concept 2	Concept 3	Concept 4
Raw Analog Rice Performance	147.673	158.141	162.869	163.386
Cooked Analog Rice Performance	132.337	139.561	138.734	156.251

Table 7. Cost Analog Rice (per 500 grams)

	Concept 1	Concept 2	Concept 3	Concept 4
Cost (for 500 grams of analog rice)	Rp20373	Rp23189	Rp23228	Rp23282

Table 8. Result of Performance Score Conversion to Rupiah Units

Raw Analog Rice				
Concept	Pn	Co	Po	Pn'
1	146.763	Rp22518	159.472	Rp20723.44
2	158.141	Rp22518	159.472	Rp22330.05
3	162.869	Rp22518	159.472	Rp22997.66
4	163.386	Rp22518	159.472	Rp23776.68
Cooked Analog Rice				
Concept	Pn	Co	Po	Pn'
1	132.337	Rp22518	141.72	Rp21026.97
2	139.561	Rp22518	141.72	Rp22174.79
3	138.734	Rp22518	141.72	Rp22043.39
4	156.251	Rp22518	141.72	Rp24826.66

Table 9. Value Calculation Results for Each Concept of Raw Analog Rice and Cooked Analog Rice

Raw Analog Rice				
Concept	Performance	Cost	Value	Ranking
1	20723.44	20373	1.01	2
2	22330.05	23189	0.96	4
3	22997.66	23228	0.99	3
4	23776.68	23282	1.02	1
Cooked Analog Rice				
Concept	Performance	Cost	Value	Ranking
1	21026.97	20373	1.03	2
2	22174.79	23189	0.95	3
3	22043.39	23228	0.94	4
4	24826.66	23282	1.06	1

Table 9 shows that raw analog rice and cooked analog rice concept 4 have the highest value compared to other concepts. Adding ingredients such as pandan essence oil of 7 ml and glucomannan flour of 0.07 grams to analog rice dough is more accepted by consumers because it improves the product's texture, taste, and aroma.

The panelists found the rice's texture firmer and less crumbly than the other samples. Adding glucomannan could enhance the texture of the cooked rice, making it more fluff and chewiness. Panellists with pandan fragrance can detect the aroma of cooked analog rice and rice because of the effect of pandan essence oil that makes the aroma on the ingredients covered.

Table 10. Chemical Content of Analog Rice

	Best concept analog rice	Paddy rice
Moisture content (%)	8.15	12
Ash content (%)	0.55	0.8
Fat content (%)	3.025	1.7
Protein Content (%)	4.545	8.4
Total carbohydrate (%)	83.74	77.1

Based on Table 10, analog rice's moisture content is lower than paddy rice, following the quality requirements for rice moisture content in SNI 6128: 2015, which is a maximum of 14% (Badan Standardisasi Nasional, 2015). The low moisture content is due to the raw material's low amylose content, which results in high water absorption (Kaemba et al., 2017).

The low protein content in analog rice is due to the lower protein content of sago flour than other ingredients. In 100 grams of sago flour, there are only 0.3 grams of protein content. In addition, the heating and extrusion process in making analog rice can also cause protein damage (Loebis et al., 2017). Hence, the protein content in analog rice is relatively low.

The fat content of analog rice is higher than rice because the manufacturing process uses several fat-containing raw materials such as palm oil and pandan essence oil. According to (Loebis et al., 2017), adding oil ingredients manufactures analog rice's largest source of fat.

This analog rice's most significant chemical content is carbohydrates at 88.277% because the raw materials used are sago and mocaf. Analog rice, which uses high carbohydrate ingredients in large quantities, will also produce analog rice with high carbohydrates. The heating factor of analog rice can also cause this high carbohydrate. The heating process can cause gelatinized starch to form and interact with other components such as protein and fat. This interaction can reduce the amount of fat and protein and increase the carbohydrate content (Finirsa et al., 2022).

4. CONCLUSIONS

Based on identifying the importance of attributes to consumers, product development priorities with the highest to lowest values are texture, aroma, colour, and shape for raw analog rice and taste, texture, aroma, and colour for cooked analog rice. The concept of raw rice and cooked analog rice with the highest value is concept 4, with the addition of 7 ml pandan essence oil and 0.07 gram glucomannan flour.

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