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Development of Sago-based Analog Rice Using Kansei and Value Engineering

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ABSTRACT

This study used two product development methods: Kansei and value engineering. Kansei engineering was used to identify and translate consumer psychological impressions or feelings in the form of Kansei words to the design parameters, while value engineering was used to analyze the functional properties by considering cost, reliability, and performance. The consumers determined the priority attributes of analog rice products, namely a good taste, a fluffy and soft texture, as well as a bright color. Three alternative variations of the product development concept were formulated based on these priorities. The concept with the highest value was then concluded as an analog rice produced from 90% Sago flour and 10% MOCAF (Modified Cassava Flour) with a value of 1,131.

Keywords: Analog rice, Kansei engineering, product development, value engineering

INTRODUCTION

According to the World Health Organization (WHO), obesity is a condition characterized by an excessive increase in adipose tissue. It can also be defined as a systemic disease affecting white adipose tissue. Furthermore, obesity has become a global health problem because it can potentially lead to some non-communicable diseases, such as heart disorders, diabetes, hypertension, stroke, pulmonary emboli, cancers, osteoarthritis, gallbladder diseases, and respiratory abnormalities (Baboota et al., 2013; Mohamed, 2014; Gómez et al., 2021). In The Global Burden of Disease (1996), Muray and Lopez stated that the number of deaths caused by these conditions was predicted to increase by 77%, from 28.1 million in the year 1990 to

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49.7 million in the year 2020 (Baboota et al., 2013; Blümel et al., 2015; Salleh, 2018). Obesity and metabolic disorders could be influenced by several factors, including genetic and physiological differences, namely gender and age. They can also be influenced by the environment and habits, such as diet, stress, smoking, alcohol, and practice (Shabayek et al., 2022).

Obesity can be prevented using a good diet and healthy lifestyle, such as the regular consumption of functional foods of analog rice (Shao et al., 2017). Analog rice is a non-rice ingredient with high levels of carbohydrates, and it is often produced from carbohydrate-rich flour, such as cassava and corn flour, as well as starch (Park et al., 2021). It also has organoleptic, chemical, and aesthetic characteristics similar to other rice products (Banovic & Sveinsdottir, 2021). These foods have a low glycemic index; hence, the blood sugar was not increased significantly. The product can be used as an alternative to rice consumption. The analog rice product has the physical properties of rice and was made from various formulations of non-rice carbohydrate sources.

Sago is one of the sources of non-rice carbohydrates that can be recommended for its production. The Sago flour has a high carbohydrate content with a competitive yield and affordable price (Nururrahmah et al., 2018; Zhu, 2019; Du et al., 2020). It also has similar energy content to corn and rice, namely 353 kcal, 361 kcal, and 360 kcal per 100 grams, respectively. Sago is gluten-free and has a low glycemic index of 28 (Nururrahmah et al., 2018) compared to corn and rice, with 48 and 68, respectively. Sago starch contains 11.07% dietary fiber and 10.58 mg/100 g resistant starch (Wahjuningsih et al., 2020), which can be developed as a functional food due to its health beneficiary (Azkia et al., 2021). Consumption of dietary fiber can increase productivity activity, enhance the digestive system, increase short-chain fatty acid formulation (SCFA), as well as reduce the risk of cancer and diabetes Mellitus (Kaczmarczyk et al., 2012; Jha et al., 2017; Azkia et al., 2021). The resistant starch also helps to improve digestive health by reducing the number of pathogenic bacteria in the intestine (Azkia et al., 2021).

Analog rice is considered a valuable functional food that the community can consume. However, convincing people to consume the analog as a staple food substitute for rice was difficult. The taste of rice is considered the most delicious and easy to process with a relatively stable price. One of the ways that can be used to increase the consumption of these analog products is to produce them based on the consumer's needs in terms of good physical properties and affordable prices. Therefore, this study aims to identify the quality attributes of analog rice and determine the best alternative concept for developing its products based on consumer needs.

The Kansei engineering method is a new product development technology carried out by identifying the Kansei words, which describe or represent consumer feelings towards a product, service, and technology (Ushada, Amalia, et al., 2023; Ushada, Trapsilawati et al., 2023). The data obtained are then translated into a product design element (Jiang et al., 2021). The value engineering method can be used to analyze the minimum costs of analog rice. It is also a creative technique used to achieve the function of a product by applying the optimal cost and production system (Hidayat et al., 2021). The method is often used to determine the best functional balance between cost, reliability, and performance.

MATERIALS AND METHODS

Materials

The analog rice in this study was produced from the main ingredients of Sago flour collected from Sago tree starch. Additional ingredients that align with the identification of the product specifications were also used for the process. Furthermore, other additives used to develop the texture and aroma of analog rice include 2% Glycerol Mono Stearate (GMS), 1% Carboxy Methyl Cellulose (CMC), 5% palm oil, 1% salt, and 30% water. The type of Sago flour used was the local brand in the Yogyakarta Special Region, Indonesia.

Respondents

The population for the study was Indonesian society, with the inclusion criteria being people aged 18–60 years willing to fill out the questionnaire. Data was collected from the respondents using a questionnaire in the form of Google Forms. The sample size used in this study was determined with Cochran's formula because some populations were unknown (Seyyedamiri & Khosravani, 2020) (Equation 1).

$$n = \frac{z^2 pq}{e^2} \quad [1]$$

Where n is the minimum sample size, z is the confidence level (90%), p is the presumed proportions, q is 1-q, and e is the margin error (0,5). Based on the calculation results, the minimum sample size was 272 respondents. The validity and reliability of the questionnaire were assessed with a pilot test on 30 respondents.

Methods

This study combined two product development methods, namely Kansei and value engineering. Integration of the methods is presented in Figure 1.

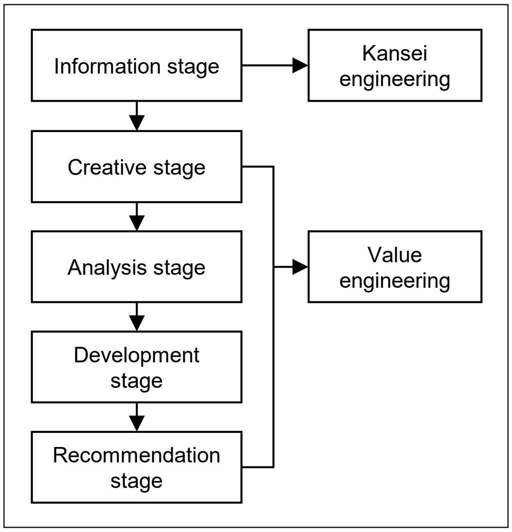

Figure 1. Integration method diagram

Information Stage. At this stage, data collection consists of primary and secondary data. The primary data were obtained through direct observation from the field and interviews with respondents using a preliminary questionnaire. Meanwhile, the secondary data were obtained from other sources related to the study object, and they were in the form of documents, files, literature, and company records.

Data processing was carried out with the following steps:

- Collecting consumers' voices based on Kansei's words about product attributes.
- Arranging a semantic differential questionnaire to measure the words obtained in numbers.
- Factor analysis of the questionnaire answers. The selected Kansei words had the highest utility value and served as the basis for product development attributes. In factor analysis, the Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO MSA) test and the Bartlett test were used to summarize or reduce Kansei words. The cut-off value of KMO MSA is between the range of 0.5 to 1 (Djaali et al., 2008).

Creative Stage. The factor analysis results were used to measure the level of consumer importance in the selected product attributes. Identifying their needs was also carried out to determine the product specification to be developed by giving multiple-choice questions to the respondents. Data was collected through interviews using a questionnaire, results of the development of information stage. Furthermore, the questionnaire was divided into two parts: (1) the level of consumers' importance and (2) the identification of needs. The measurement of the importance level was carried out using a Likert scale with five response points: 1 (very unimportant), 2 (unimportant), 3 (neutral), 4 (important), and 5 (very important). Table 1 indicates the questionnaire for consumer needs. The questionnaire consisted of 4 primary and 4 secondary attributes.

Table 1
Questionnaire for consumer needs

No.	Primary Attributes	Secondary Attributes
1	Texture	Fluffier
2	Texture	Mushy
3	Taste	Tasty
4	Color	Bright

Analysis Stage. The Function Analysis System Technique (FAST) diagram was used to develop several alternative ideas to fulfill the requirement based on the information obtained in the previous stage. Furthermore, the diagram consists of four functions, namely the main, derivative, and objective functions, as well as product specifications. The combination results of the attributes gave variations of the product concepts based on the modification design.

Development Stage. The development stage was carried out by determining the alternative variations of the product concepts and the attributes to be developed. Determination of the alternative concept variations was performed using the zero-level diagram. Subsequently, a prototype as the product sample was developed for each concept.

Recommendation Stage. Panelists' assessments were carried out on the concept variations, which were determined and had a prototype. The results were used to calculate the performance, cost, and value analysis. Determination of the best alternative concept was performed by looking for the highest value. The value engineering method is often used to obtain the best value in a project or process by defining the functions needed to achieve the target at the lowest cost with good quality and performance (Hidayat et al., 2021).

Statistical Analysis

Pearson Correlation and Cronbach's Alpha were carried out using SPSS 24 for Windows™ (IBM SPSS Inc., Chicago, IL, USA) to obtain the validity and reliability of Kansei word analysis. Factor analysis was also performed using the Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO MSA) and Bartlett tests to summarize or reduce the words. This step helped to focus on the attributes of analog rice development that were considered important by the respondents.

Sensory Analysis

Sensory testing was carried out with the hedonic test of acceptance to determine the level of acceptance or consumer preference for the prototype of analog rice products. A total of 32 untrained panelists recruited from the Faculty of Agricultural Technology, Universitas Gadjah Mada, were used for this process. The panelists consisted of 5 males and 27 females aged 20 to 25. They were instructed to evaluate three formulations based on sensory analysis: color, aroma, texture, and taste. The samples were prepared with three-digit random numbers in the containers as a code, and each sample was prepared with a different number. Panelists were asked to evaluate the rice analog samples for sensory parameters such as color, aroma, texture, and taste using the 7-point hedonic scale (Ong et al., 2022). The rating scale used is a score of 1 for the lowest and 7 for the highest: 1 (dislike very much), 2 (dislike moderately), 3 (dislike slightly), 4 (neither like nor dislike), 5 (like slightly), 6 (like moderately), and 7 (like very much).

RESULTS AND DISCUSSION

Socio-demographic of Participants

Among 297 respondents who completed the questionnaire, 69.5% were female, 45.5% were highly educated with bachelor's and postgraduate degrees, 75.9% were below 26 years old, and 24.1% had a high income. Table 2 shows the socio-demographic profile of the consumers. The results showed that the items were closely related, and the scales were unidimensional.

Table 2
Respondents' characteristics

Characteristics	*N*	%
Gender		
Male	67	30.5
Female	153	69.5
Age (years)		
Teenagers (18–25)	167	75.9
Adults (26–45)	37	16.8
Elderly (>46)	16	7.3
Education level		
Low education	120	54.5
High education	100	45.5
Income		
Low income	167	75.9
High income	53	24.1

Information Stage

Kansei words of analog rice were obtained by distributing interview questionnaires to thirty people, literature, and social media, such as Instagram, YouTube, and Twitter. A total of 57 words were collected and described in Table 3.

The Kansei words were then filtered or grouped by selecting words with close adjective and visual meanings to the study objects and subjectively selected. Hence, 27 were obtained. Subsequently, they were paired with antonyms and arranged in a semantic differential questionnaire. It was then distributed to 292 respondents to measure the psychological meaning of word pairs with analog rice. The semantic differential questionnaire is presented in Table 4.

The semantic differential questionnaire was carried out using a pilot test on thirty respondents, followed by a validity test. The results showed that there were 6 invalid

Table 3
Kansei words of analog rice

Kansei word	Kansei Word	Kansei Word	Kansei Word
Special	Certified	Strong scent	Destroyed
Healthy	Standardized	Easy stale	Clot
Diet	Quality	Expensive	Fine
Satisfied	Tasteless	Safe	Bright
Variety	Sweet	Easily obtained	Gentle
Delicious	Tasty	Steady	Bitter
Curious	Rough	Hygienic	Typical
Organic	Mushy	Cool	Oily
Interesting	Hard	Practical	Alternative
Halal	Sticky	Clear	Native
Unique	Springy	Affordable	Obesity
Trend	Cheap	Local	Diabetes
Simple	Fluffier	White	
Dry	Pera	Fragrant	
Functional	Watery	Durable	

questions because *r*-calculate < *r*-table. The details of the validity test are presented in Table 5. The number of pairs was reduced to 21 because 6 questions were invalid (27-6 = 21). Subsequently, a reliability analysis was carried out to assess the remaining words. The test results showed that the Cronbach Alpha value was 0,894, greater than 0,6. This finding indicates that the 21 pairs are reliable.

Kansei word pairs declared valid and reliable were analyzed using factor analysis. The KMO and Bartlett Test results were 0,864 with a significance of 0,000, indicating that the variables can be processed using the analysis method. The next step was to eliminate the pair of Kansei words that can represent each factor. Elimination was carried out to simplify the study attributes further, making it easier to carry out designs focusing on important variables. The factor analysis results are presented in Table 6; the highest value of component 1 was 'not-delicious-delicious.' The lowest value was 'not certified-certified.'

Table 4
Pair of Kansei word

Pair of Kansei Word	Pair of Kansei Word
Unhealthy – Healthy	Mushy – Solid
Not efficient – Efficient	Sticky – Dry
Normal – Unique	Clot - Not clumping
Disappointed – Satisfy	Watery - Rough
Not curious – Curious	Dull – Bright
Ancient – Trend	Unscented – Fragrant
Inorganic – Organic	Temporary – Durable
Alternative – Primary	Destroyed – Intact
Not certified – Certified	General – Typical
Tasteless – Tasty	Hard to get - Easy to get
Not delicious – Delicious	Unvariety – Variety
Pera – Fluffier	Rigid – Springly
Expensive – Affordable	Rude – Fine
Complicated – Simple	

Table 5
Invalid Kansei word

Kansei Word	*r*-calculate	*r*-table
Not curious – Curious	0,177	0,361
Ancient – Trend	0,337	0,361
Unvariety – Variety	0,277	0,361
Alternative – Primary	-0,013	0,361
Sticky – Dry	-0,006	0,361
Watery - Rought	0,347	0,361

Table 6
Factor analysis of analog rice product

Kansei Word	Component 1
Disappointed – satisfied	0,739
Inorganic – organic	0,670
Not certified – certified	0,657
"Pera" – fluffier	0,686
Not delicious – delicious	0,834
Mushy – solid	0,742
Unbright – bright	0,694

Creative Stage

The ranking or determination of the priority of consumer needs attributes based on information from 107 respondents was used to calculate the importance level and weight values (Table 7).

Based on the ranking of each attribute of consumer needs, the priority of the attributes desired by consumers is the attribute of goods taste, followed by attributes of fluffier, texture, bright color, and soft texture. The identification of consumer needs is carried out to find out the specifications of a product to be developed. The basis for determining the material formulation for the development of analog rice in this study is to form the color and taste of analog rice according to the needs of respondents. In addition, it also considers the price and nutritional content of the material for making an analog rice prototype.

Identification of consumer needs was performed to determine the specifications of the product to be developed. The results obtained from 66.4% of the 107 respondents served as a reference for producing prototypes of analog rice. From Table 8, the consumer needs white analog rice. Hence, a prototype was made from the combination of Sago and MOCAF.

Table 7
Importance level of analog rice attributes

Primary attribute	Secondary attribute	Level of importance	Weight	Rank
Texture	Fluffier	4.1869	0.2819	2
	Mushy	2.6449	0.1781	4
Flavor	Delicious	4.2991	0.2895	1
Color	Bright	3.7196	0.2505	3

Table 8
Specification of analog rice

Question	Development Alternatives	Percentage (%)
Favorite product color	White is made from the formulation of Sago and MOCAF (Modified Cassava Flour).	66.4%
	Orange is made from the formulation of Sago and corn flour.	13.1%
	Purple is made from the formulation of Sago and purple sweet potato.	21.5%

Analyze Stage

The formulation of creative product ideas for the development concept was performed by mapping out the required product functions. The analysis of the interrelationships between the functions was carried out using a FAST diagram to facilitate the preparation of the ideas. The FAST diagram of analog rice is presented in Figure 2.

Based on the FAST diagram image above, the scope of the problem and its solution have been described through the interrelationships between functions arranged in the diagram. The basic function, the scope of the problem to be solved, is analog rice. There is an objective function to complete the basic functions of analog rice, namely quality and aesthetic functions, to get a design that suits consumer needs.

The quality function consists of primary attributes of texture and taste, while the aesthetic function consists of primary attributes of color. The secondary function of fluffier and mushy can be fulfilled by determining the appropriate dough composition and the right

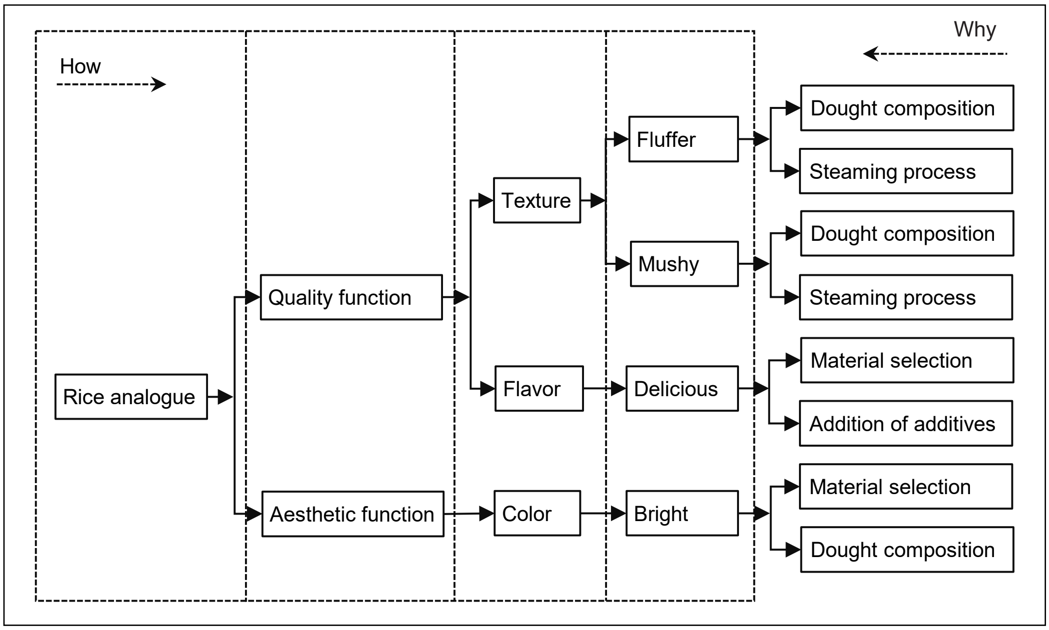

Figure 2. FAST diagram

steaming process, namely by paying attention to the time and temperature during steaming. The secondary function of good taste can be fulfilled by selecting the ingredients for making analog rice, paying attention to dough consumption, and adding additional ingredients to create a good taste from analog rice. Then, the secondary function of the bright color of analog rice can be fulfilled by determining the choice of materials to be used and paying attention to the appropriate dough composition.

Development Stage

In the development stage, the concept of analog rice consists of 3 variations of alternative concepts as 10%, 20%, and 30% additive composition (Figure 3).

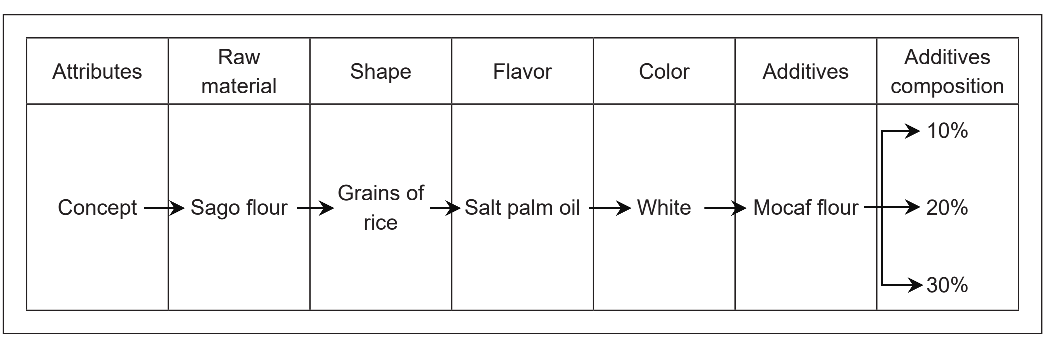

Figure 3. Zero level concept diagram

Based on the Zero Level Concept diagram, Sago flour is the raw material used to develop analog rice products. The expected attributes of analog rice form are similar to rice grains in general. The formulation of grains like rice in the dough is carried out by adding 2% GMS and 1.5% CMC, which function as an emulsifier or adhesive to the material, so that when the extrusion process is carried out, it makes the material stronger, not sticky, and crumbles. The taste attribute is the priority in the development of analog rice products. Consumers want good taste, so they add 1% salt and 5% palm oil.

Recommendation Stage

The alternative design concepts were assessed based on the questionnaire on the preference level of 32 panelists. The result was then used to obtain a score for the calculation of weight and performance. Attributes of the level of preference assessment include color, aroma, taste, and texture. The prototype of analog rice, which was developed based on the alternative concept variations, is presented in Table 9. The concepts were developed based on the varied composition of Sago flour and MOCAF.

In the analysis of product performance values using an evaluation matrix, the total weight of the attributes was obtained by dividing the score on each of them by the total score. Furthermore, the product performance was calculated by multiplying the total score by the weight of each attribute. The results of the performance calculation are presented in

Table 9
The prototype figure of the alternative concept variations

Concept	Prototype figure	Description
1		The analog rice was produced with 90% Sago flour and 10% MOCAF
2		The analog rice was produced with 80% Sago flour and 20% MOCAF
3		The analog rice was produced with 70% Sago flour and 30% MOCAF

Table 10. Table 10 indicates that the best performance is Concept 1, with a performance value 164,510.

This study selected the alternative concept with the highest value as the best alternative concept. The performance value in the formula above does not have units, while the costs have units, namely rupiah. Therefore, the performance needs to be converted into rupiah to calculate the value of each alternative. The formula used for the conversion can be obtained from Equation 2 (Hidayat et al., 2021):

$$Pn' = \frac{P_n C_0}{P_0} \qquad [2]$$

Where P_n' is converting alternative performance to rupiah, P_n is alternative performance n, P_0 is alternative average performance, and C_0 *is* the alternative average cost.

The results showed that the best concept in developing analog rice products can meet 70% of consumer needs. Based on the sensory tests, the attributes tested were adjusted to others generated from identifying consumer needs, namely taste, texture, color, and aroma. Furthermore, Table 11 shows that the panelist's assessment is in the moderately favorable range for alternative concept 1. Table 11 confirmed Table 10 that the best value is concept 1 of 1,131. The research concluded that the best material formulation is 90% Sago and 10% MOCAF.

Table 10
Performance of analog rice concept

Quality attributes	Color	Aroma	Texture	Flavor	Performance
Attribute weight (%)	24,424	23,695	25,884	25,997	
Concept 1	175	157	162	164	164,510
Concept 2	142	233	148	149	143,240
Concept 3	118	132	151	150	138,178

Table 11
Value of analog rice concept

Concept	Performance	Converted performance	Production cost	Value	Rank
1	31,101	31,101	27,501	1,131	1
2	27,080	27,080	28,101	0,964	2
3	26,123	26,123	28,701	0,910	3

CONCLUSION

The Sago-based analog rice was developed using Kansei and value engineering. The research results concluded the quality attributes of Sago-based analog rice as delicious, fluffier, and mushy texture, as well as bright color with the specification of white. Three alternative variations of the product development concept were formulated based on these priorities. The best alternative concept was produced from 90% Sago flour and 10% MOCAF (Modified Cassava Flour) with a value of 1,131.

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