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An Integrated Kansei Engineering and Genetic Algorithm Apporach for Modeling Oolong Tea Package Design

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Abstract

Penelitian ini dilatarbelakangi oleh belum optimalnya elemen desain kemasan teh oolong dalam merepresentasikan konsep yang diharapkan oleh konsumen. Permasalahan tersebut terlihat dari kelemahan pada aspek visual maupun informasi yang disajikan pada kemasan teh oolong. Berdasarkan hasil survey pada penelitian terdahulu, sebanyak 93% responden menyatakan perlunya dilakukan redesain pada elemen kemasan teh oolong. Metode yang digunakan pada penelitian ini adalah *Kansei Engineering*. Metode ini bertujuan untuk mengkaji hubungan antara respon emosional konsumen dengan atribut desain. Metode pendukung yang digunakan ialah Genetic Algoritma untuk memperoleh kombinasi elemen desain yang optimal. Data yang diperoleh dari 66 sampel kemasan, analisis morfologi, serta hasil kuesioner semantic differential 2, kemudian diolah menggunakan software *Visual Code Studio*. Hasil penelitian menunjukkan bahwa elemen desain kemasan mengarah pada dua konsep, yaitu ekslusif dan praktis. Konsep ekslusif memperoleh nilai 0,679 dengan material sebagai elemen utamaa, sedangkan konsep praktis memperoleh nilai 0,687 dengan volume sebagai elemen yang di prioritaskan.

Kata Kunci: Desain Kemasan; Elemen Kemasan; Genetic Algorithm; Kansei Engineering

Abstract

This study was motivated by the fact that the design elements of oolong tea packaging have not yet optimally represented the concepts expected by consumers. This issue is evident in the weaknesses of both the visual aspects and the information presented on oolong tea packaging. Based on the results of a survey conducted in a previous study, 93% of respondents stated that the design elements of oolong tea packaging need to be redesigned. The method used in this study is Kansei Engineering. This method aims to examine the relationship between consumers' emotional responses and design attributes. The supporting method used is the Genetic Algorithm to obtain the optimal combination of design elements. Data obtained from 66 packaging samples, morphological analysis, and the results of the Semantic Differential Scale 2 questionnaire were then processed using Visual Code Studio software. The results of the study indicate that packaging design elements align with two concepts: exclusive and practical. The exclusive concept received a score of 0.679, with material as the primary element, while the practical concept received a score of 0.687, with volume as the prioritized element.

Keywords: Packaging Design; Packaging Elements; Genetic Algorithm; Kansei Engineering.

1. Introduction

Design elements are one of the key aspects in creating effective designs. Design elements can represent the character, values, and identity of a product that the designer wishes to convey [1]. In a product, design elements play a role in shaping visual perception and influencing consumer interest in that product. This role is also evident in packaging, which utilizes design elements to convey information between the manufacturer and the consumer and to create an emotional connection with the consumer in order to enhance the product's competitiveness [2]. The Indonesian Food and Drug Administration (BPOM) requires that labels, as part of the packaging elements, contain complete and clear information, such as the brand name, ingredients, net content, and expiration date. This demonstrates that visual elements on packaging also influence consumers' purchasing decisions.

Packaging is a vital factor for a product. This is reflected in the sayings "packaging is king" and "packaging is a silent salesperson," which indicate that packaging serves as a promotional tool to attract consumer interest [3] [4] Packaging design elements focus not only on labels but also encompass various aspects such as typography, illustrations, color, materials, and others

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that contribute to building a product's visual identity [1]. Selecting appropriate design elements can enhance emotional appeal and strengthen brand perception. The elements and features within packaging play a significant role in creating a positive impact on consumers [6]. Oolong tea packaging is the subject of this study; previous research indicates that oolong tea packaging design still has several shortcomings, such as insufficient information, an unappealing appearance, and an inability to optimally represent the product's character and quality [7]. This is supported by survey results indicating that 93% of respondents stated the packaging needs to be redesigned. Therefore, this study will focus on developing oolong tea packaging designs aligned with consumer preferences.

The design process begins with establishing a packaging concept that serves as the foundation for design development and for building consumer emotional engagement [8]. Previous research yielded the concepts of "Exclusive" and "Practice" for oolong tea packaging using the K-Means method [7]. To establish a connection between consumers and packaging elements, the Kansei Engineering method is required in the product development process. The Kansei Engineering method translates consumers' psychological aspects regarding packaging design into more structured specifications for design elements [9]. Products designed based on consumer preferences using the Kansei Engineering approach have a higher potential for market success, as they effectively bridge emotional aspects with consumers' functional needs [10]. The Kansei approach is quantitatively based, enabling the transformation of consumers' subjective aspects into data that supports the packaging design process [11].

The application of Kansei Engineering is generally integrated with supporting methods to manage data and produce more effective and accurate decisions [12]. For example, research on blender product design was successfully conducted using Rough Sets and Fuzzy Quality Function Deployment [13]. Research on design elements conducted has been applied to the design of fried meatball packaging [14]. Research on the design concept for toasted bread packaging used the K-Means Genetic Algorithm method [15]. Based on previous Kansei Engineering research, basic statistical and computational methods were still used. These methods have not fully utilized artificial intelligence-based technology capable of processing data in a more complex manner. Therefore, the development of AI-based packaging is needed to produce more optimal analysis.

The GA method is used to predict packaging design elements because it is capable of generating optimal solutions from various possibilities through an efficient optimization process [16]. GA is more effective at finding comprehensive solutions, thereby helping to determine the most suitable product design in a short period of time [17]. The GA method in the process of determining packaging design elements is more time-efficient because it does not require repeated training, unlike neural network-based methods, which require a more complex training process that takes a long time [18]. Research conducted by [19] on the optimization of plaid fabric pattern design based on user preferences. The use of GA methods in the Kansei Engineering approach is still rarely found. One study integrating the Kansei Engineering approach, conducted by [20], utilized GA to incorporate elements of Jiangxi's red culture into watch design. The GA method was applied in this study as a continuation of previous research to visualize the concept of oolong tea packaging.

The output of this study is the alignment of the concepts of "Exclusive" and "Practical" with the visual elements of the oolong tea packaging, resulting in a more innovative 3D mockup in terms of materials, colors, shape, functionality, illustrations, and typography that align with consumer preferences. Furthermore, the resulting design is expected to optimally represent the product's character and quality while enhancing its visual appeal. Thus, this study not only produces alternative packaging designs but also serves as a reference for developing more effective and competitive packaging in the market.

2. Research Method

The data processing and analysis procedures in this study were carried out in a sequential and systematic manner from beginning to end. The visualization of the data analysis procedure in the form of a flowchart is presented in figure . An Integrated Kansei Engineering and Genetic Algorithm Approach for Modeling Oolong Tea Packaging Design.

2.1. Problem Identification

The problem identification stage is conducted to understand the initial conditions and the constraints present in the current oolong tea packaging design. The identified issues are related to the suboptimal performance of packaging design elements in representing the intended concept [5] [16]. Based on these conditions, an approach is needed to systematically connect consumers' emotional preferences with packaging design elements. Therefore, the Kansei Engineering method is used in this study to identify the relationship between emotional attributes (Kansei) and packaging design elements, in order to obtain design recommendations that better align with consumer needs and expectations [17].

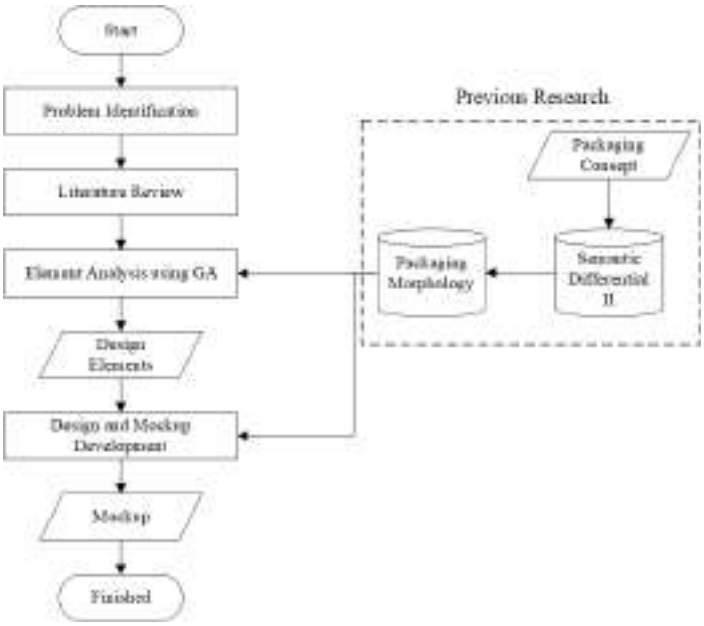


Figure 1. Research Flowchart

2.2. Literature Review

The literature review phase was conducted to gather various theories and previous research findings relevant to the design of oolong tea packaging. This literature review includes a discussion of the Kansei Engineering method and the Genetic Algorithm method from various sources, such as journals, books, and others. Through this literature review, it is hoped that the research will have a strong theoretical foundation, thereby ensuring that the design of oolong tea packaging elements is more focused and systematic.

2.3. Element Analysis

The analysis of oolong tea packaging design elements was conducted by examining 66 packaging samples obtained from a previous study. The number of samples collected is at least 20 to 25 samples [10]. These samples were then represented in the form of a morphological analysis that grouped various characteristics of packaging elements, such as shape, material, design style, and other attributes [18]. Subsequently, questionnaire data from 30 respondents in the previous study were processed together with the sample and morphological data using the Genetic Algorithm method to obtain optimal analysis results.

2.4. Mockup

Creating a 3D mockup is a crucial step in product development because it serves to visualize design elements in accordance with the packaging concept identified in previous research. This process begins with brainstorming using the mind mapping method so that ideas can be developed systematically and in a structured manner. Next, the resulting ideas are incorporated into a mood board as a reference for determining the overall packaging elements. After that, the design is implemented into a 3D mockup, starting with 2D design using Adobe Illustrator, followed by the 3D modeling process using Blender.

3. Result and Discussion

3.1. Problem Identification

Based on the findings, the design elements of oolong tea packaging including color, shape, and typography, have not fully represented the intended concept and are not yet aligned with consumer preferences. The results of the Semantic Differential questionnaire involving 30 respondents, indicate a score of 93 % for the oolong tea design [7]. Therefore, this study applies the Kansei Engineering approach to produce a design that better meets consumer needs.

3.2. Literature Review

During the literature review phase, the researcher collected various references from journals, books, and other scientific sources related to oolong tea packaging design, as well as Kansei Engineering and Genetic Algorithm methods. Based on the findings of this review, a number of relevant packaging design elements, such as color, shape, and typography, were identified and subsequently used as variables in the study. Additionally, the reviewed literature yielded Kansei word pairs used to represent consumers' emotional perceptions of packaging design. Packaging design samples were also collected from various reference sources for further analysis as alternatives in the evaluation process. The results of this stage served as the foundation for developing the questionnaire, Kansei Engineering modeling, and the design optimization process using Genetic Algorithm.

3.3. Element Analysis

3.3.1. Identification of Packaging Concepts and Elements

This study aims to build upon and refine the findings of previous research through further development of the design phase. The conceptual design process for oolong tea was conducted in the previous study using the K-Means Algorithm [7]. The results of the analysis yielded two concepts for oolong tea: "Exclusive" and "Practice." This stage uses a Genetic Algorithm-Backpropagation Neural Network method.These concepts serve as a reference for the next phase of this study, which involves analyzing the design elements of oolong tea packaging. The concept of "Exclusive," derived from previous research, is significant in creating a unique and high-value impression through the selection of appropriate visual and structural elements. The concept of "practice" in packaging design emphasizes user-friendliness and the effectiveness of the packaging in protecting and presenting the product to consumers [19]. Therefore, identifying packaging concepts and elements is a crucial step in this study to ensure that every design attribute developed can optimally represent the values of "Exclusive" and "Practice," resulting in oolong tea packaging that is not only visually appealing but also functional and aligned with consumer needs and perceptions.

3.3.2. Element Analysis using Genetic Algorithm

An analysis of packaging elements was conducted to examine the role of each attribute in shaping the packaging of oolong tea products. The results of the analysis of design elements in various packaging samples suitable for oolong tea products were obtained through a review of several digital platforms [20]. A total of 66 packaging samples were used in this study, which were obtained from a previous study. The sample selection process was based on the grouping of similar characteristics, such as shape, material, color, typography, layout, and other supporting aspects, as shown in Table 1.

Tabel 1. Sample

					
1 (A)	2 (B)	3 (C)	4 (D)	5 (E)	6 (F)
					
7 (G)	8 (H)	9 (I)	10 (J)	11 (K)	12 (L)
					
13 (M)	14 (N)	15 (O)	16 (P)	17 (Q)	18 (R)

19 (S)

20 (T)

21 (U)

22 (V)

23 (W)

24 (X)

25 (Y)

26 (Z)

27 (AA)

28 (AB)

29 (AC)

30 (AD)

31 (AE)

32 (AF)

33 (AG)

34 (AH)

35 (AI)

36 (AJ)

37 (AK)

38 (AL)

39 (AM)

40 (AN)

41 (AO)

42 (AP)

43 (AQ)

44 (AR)

45 (AS)

46 (AT)

47 (AU)

48 (AV)

49 (AW)

50 (AX)

51 (AY)

52 (AZ)

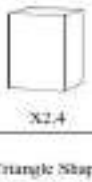
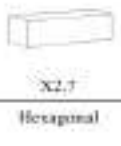
53 (BA)

54 (BB)

					
55 (BC)	56 (BD)	57 (BE)	58 (BF)	59 (BG)	60 (BH)
					
61 (BI)	62 (BJ)	63 (BK)	64 (BL)	65 (BM)	66 (BN)

A study of visual and structural elements was conducted on 66 samples of oolong tea packaging with the aim of identifying design characteristics and establishing guidelines for designing packaging that aligns with consumer preferences [21]. Based on the packaging samples shown in Table 2, a morphological analysis was conducted to examine the relevant design elements of each package. The results of this analysis were then presented in tabular form. The morphological data in Table 3 were classified into several more detailed categories according to the morphological characteristics of each sample. The determination of design elements in the morphological table was based on the results of discussions with 5 expert panelists [10]. The morphological analysis yielded 8 main factors, namely material (X1), shape (X2), lid (X3), features (X4), size (X5), design (X6), color (X7), and printing (X8).

Tabel 2. Morphology

Elemen	Type							
Material K. Sekunder (X1)	Ivory	Duples	Kraft | PE	Paperboard	Paperboard | Alu. Foil | PE	PET | PE	Alu. Foil | PE	Tinplate
	X1.1	X1.2	X1.3	X1.4	X1.5	X1.6	X1.7	X1.8
Bentuk (X2)	Rounded Edge Block	Cube	High Vertical Tuck	Slim Vertical Tuck	Standard	Mini Horizontal	Horizontal Sleeve	Built in Insert box
								
	X2.1	X2.2	X2.3	X2.4	X2.5	X2.6	X2.7	X2.8
	Custom Crease Line	Angled Top Box	Flat Bottom	Triangle Shape	Prismatik Trapezoidal	Pyramid Pack	Hexagonal	Custom Leaf Shape
								
	X2.9	X2.10	X2.11	X2.12	X2.13	X2.14	X2.15	X2.16
	Cylinder	Rounded edge canister	Standing Pouch	Four seal	Center Seal			
								
	X2.17	X2.18	X2.19	X2.20	X2.21			

Elemen	Type							
Sistem Tutup (X3)	Tuck Top + Auto lock	Straight Tuck End	Reverse Tuck End	Hinged Lid	Magnet Lid	Clamp Lock	Folding Flap	Sequential Panel Flap
								
	X3.1	X3.2	X3.3	X3.4	X3.5	X3.6	X3.7	X3.8
	Two Piece - Pendek	Two Piece - Sedang	Two Piece - Tinggi	Dome Lid	Screw Lid	Glue	Sealer	
								
	X3.9	X3.10	X3.11	X3.12	X3.13	X3.14	X3.15	
Material K. Primer (X4)	Tea Bag X4.1	Paper + TB X4.2	Alu. Foil X4.3	Tidak Ada X4.4				
Fitur Kemasan (X5)	Dispensing Hole - Oval	Dispensing Hole - Triangle	Dispensing Hole Square	Ziplock	Ziplock +Tear Notch	Ziplock + TN + Paper seal	Ziplock + Hanging Hole	Ziplock + Emboss
	X5.1	X5.2	X5.3	X5.4	X5.5	X5.6	X5.7	X5.8
	Ziplock + W. Square + Sp. + Pap. Seal	Window - Square	Window - Oval	Window - Pentagon	Window - Ornamental Shape	Window - Teapot Shape	Finishing Embos	Print Area
	X5.9	X5.10	X5.11	X5.12	X5.13	X5.14	X5.15	X5.16
	Hanging	Partisi / sekat	Paper Seal	Double Lock	No feature			
	X5.17	X5.18	X5.19	X5.20	X5.21			

Elemen	Type							
Ukuran (X6)	Kecil	Sedang	Besar					
	X6.1	X6.2	X6.3					
Desain (X7)	Minimalis	Simple	Elegan	Klasis/Vintage	Early Modern	Modern	Illustratif	Cheerful
	X7.1	X7.2	X7.3	X7.4	X7.5	X7.6	X7.7	X7.8
Warna (X8)	Komplementer	Cool Tone	Warm Tone	Neutral	Natural			
	X8.1	X8.2	X8.3	X8.4	X8.5			
Printing (X9)	Direct Printing	Label Sticker						
	X9.1	X9.2						

Tabel 3. Rank Coefficient

Exclusive		Practice
Atributte	Rank coefficient	Rank coefficient
Color	8	8
Material		4
Shape	6	6
Feature	1	7
Lid	3	5
Primary Materials	5	3
Design	2	2
Printing	9	9

The next step in determining the design elements is to analyze data from the Semantic Differential Scale 2 and morphological data. The Semantic Differential Scale 2 data was collected from 30 respondents who regularly consume oolong tea. A total of 30

respondents were selected using purposive sampling based on previous research [22], with the aim of evaluating the extent to which the packaging samples align with the concepts of exclusivity and practicality. A process of ranking design attributes grouped into eight factors was first conducted, as presented in Table 3.

The initial stage of data processing using the genetic algorithm method began with loading the necessary libraries, followed by entering morphological data and the results of the design concept evaluation questionnaire. The parameters used included a population size of 100, a mutation rate of 0.1, and 50 generations of iteration [23]. The selection of these parameters is based on ranges commonly used in Genetic Algorithm research to ensure stable optimization performance and to enable the research process to be reliably replicated in future studies. A population size of 100 was chosen to expand the solution search space and improve optimization quality, while a mutation rate of 0.1 was used to maintain solution diversity and prevent premature convergence during the optimization process. The number of iterations of 50 generations was retained because it had yielded consistent performance improvements; therefore, adding further generations was deemed to offer no significant benefit [2] The success of the genetic algorithm method is highly determined by the integration among the parameters used, with each parameter having a distinct role and influence [23]. The determination of parameters is based on commonly used ranges in Genetic Algorithm. The mutation rate is set to the range of 0.0001-0.1 to avoid premature convergence and maintain solution diversity [25]. In addition, a population size of 100 is used to improve optimization quality, as a larger population increases the solution search space. The results of the design elements based on the exclusive and practice concepts using the genetic algorithm method can be seen in Table 4 below.

Tabel 4. Rank Coefficient

Design Elements	Exclusive	Practice
Materials	Tinplate	Ivory
Shape	Cylinder	Cub
Lid	Two Piece-High	Magnet Lid
Primary Materials	Alu Foil	Paper and Tea Bag
Feature	Paper Seal	Paper Seal
Volume	Medium	Medium
Style Design	Elegant	Classic/ Vintage
Color	Warm Tone	Naturals
Printing	Direct Printing	Direct Printing

3.4. Mockup

The selected design elements were then used as the basis for creating a mockup of the oolong tea packaging. At this stage, careful planning was required to ensure that the visual outcome optimally represented the desired concept. Therefore, the mind mapping method was used to help organize and explore various ideas systematically. Through this process, the resulting ideas can develop in a more structured manner and foster creativity and originality in packaging design [26]. The systematically organized mind map of design elements is shown in Figure 2. Based on the mind mapping that has been created, the packaging design focuses on an exclusive and practical concept, distinguished by the nine main factors listed in Table 2. The exclusive concept utilizes tinplate material in a cylindrical shape. This shape conveys an elegant impression and reinforces the product's value in the eyes of consumers [27]. It is complemented by warm tones that evoke a sense of warmth, luxury, and visual comfort, thereby reinforcing the impression of exclusivity and creating a deeper emotional appeal for consumers. The use of serif typography combined with a structured layout creates an elegant and sophisticated look, while reinforcing the product's or brand's identity as premium [28]

Figure 2. Mind Mapping

The second concept is a practical design with a classic/vintage style that features a simple look yet retains timeless aesthetic appeal. The combination of natural colors in the classic/vintage design style conveys a warm, natural, and authentic feel [29]. In the next step, the results of the mind mapping are translated into a mood board as a visual representation of the ideas that have been formulated. This mood board combines elements of color, typography, shape, and other visual references to organize the elements more effectively [30]. This output helps clarify the visualization of the ideas while facilitating the development process for the oolong tea packaging design. A visualization of the mood board is shown in Figure 3.

(a) Mood Board Exclusive Concept (b) Mood Board Practice Concept

Figure 3. Mood Board Oolong Tea Packaging

After all the ideas were incorporated into the mood board, a 3D mockup of the oolong tea packaging was created using Blender software. As shown in Figures 4 and 5, the packaging has been visualized in 3D. In the exclusive concept, the combination of green and ivory creates a warm tone that conveys an elegant impression. This packaging also features a paper seal to hold the tea inside. Additionally, a visual element in the form of a photo of tea leaves was selected to evoke a sense of peace, naturalness, and calm, in line with the characteristics of oolong tea. As for the practical design featuring ivory-colored cube-shaped elements, it conveys a sense of simplicity, neatness, and functionality while still offering aesthetic appeal. Features a magnetic lid and a natural color scheme. According to [31], natural colors are favored by many people, as are illustrations of foliage, farmland, and mountains, which create a natural feel. The packaging also includes a paper seal and a tea bag to preserve product quality while making it easy to prepare. This, the design of the 3D mockup for oolong tea packaging using the Kansei Engineering approach successfully integrates emotional and functional aspects, resulting in a packaging design that is not only visually appealing but also aligns with consumer preferences. Consumer validation results indicate that the developed packaging design visualizations effectively convey the intended concept. A total of 96.7% of respondents agreed that the exclusive packaging mockup successfully reflected the concept of exclusivity, while 93.3% of respondents agreed that the practical packaging mockup aligned with the concept of practicality. These results indicate that the resulting packaging designs effectively met consumers' emotional perceptions and preferences regarding both developed design concepts.

(a) Mock Up 3D Exclusive Concept (b) Mood Board Practice Concept

Figure 4. Mock Up Oolong Tea Packaging

4. Conclusion

Based on the stages already completed regarding the development of oolong tea packaging elements. The results of this study utilized Kansei Engineering and Genetic Algorithms as supporting methods for processing packaging design element data. The packaging design elements generated by the Genetic Algorithm method were based on the rank coefficient values for exclusive and practical design concepts. The exclusive and practical concepts have distinct characteristics. In the exclusive concept, the design focuses on the use of tinplate material in a cylindrical shape, a two-piece high lid, and a primary material of aluminum foil combined with a paper seal, medium volume, an elegant design style, warm colors, and direct printing techniques. Meanwhile, in the practical concept, the design emphasizes ease of use with ivory material in a cube shape, a magnetic lid, and primary materials of paper and a tea bag, medium volume, a classic/vintage design style, natural colors, and direct printing techniques, resulting in packaging that is more functional and practical for consumers. The results of the questionnaire-based validation indicate that the developed packaging designs align with consumer preferences, with 96.7% of respondents agreeing with the mock-up visualization of the exclusive concept and 93.3% agreeing with the mock-up visualization of the practical concept.

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