Development of Frozen Food Packaging Design Based on Kansei Engineering

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Abstract. With increasing socioeconomic trends, frozen food is becoming more popular, making packaging crucial for attracting consumer interest. Brands like Cedea face the challenge of improving packaging designs to stay competitive. This study combines Kansei Engineering with the Term Frequency-Inverse Document Frequency (TF-IDF) method, Factor Analysis, and Conjoint Analysis. Kansei Engineering helps understand and incorporate consumer emotions and preferences into new product designs. Data is processed using TF-IDF, while Factor Analysis and Conjoint Analysis determine correlations between Kansei words and product attributes, as well as the levels of these attributes. A purposive sample of 100 respondents was used. The study identified 27 Kansei words. These words describe consumer emotions and preferences, aiding in designing more suitable packaging. These words are grouped into three selected design concepts: premium, simple-elegant, and illustration. Twenty-four product samples were created for the second evaluation, combining packaging material and shape, color palette, and visual design concepts. The results show that consumers prefer pillow bag packaging, warm color palettes, and premium designs.

Keywords: Conjoint Analysis, Consumer Preferences, Factor Analysis, Packaging Design, Kansei Engineering, Term Frequency–Inverse Document Frequency (TF-IDF)

1 Introduction

Frozen food has become a practical solution for today's dynamic lifestyle, leading some people to switch from fresh ingredients to frozen products [1]. Increasing demand is driving the expansion of the packaged food market in Indonesia. Attractive product packaging is crucial for capturing consumer attention and providing long-term benefits for companies [2], [3].

PT Citra Dimensi Arthali, the producer of Cedea, understands the importance of attractive packaging. Although Cedea is one of the best-selling brands, its packaging is unappealing and lacks variety. Improving packaging design can address these issues. This study uses Kansei Engineering, TF-IDF, Factor Analysis, and Conjoint Analysis to refine the packaging design of Cedea Salmon Ball to match consumer preferences better.

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2 Literature Review

2.1 Kansei Engineering

Kansei Engineering (KE) is a product design approach focusing on consumers' emotional needs by integrating physical design elements and emotional data. Developed by Mitsuo Nagamachi in the 1980s, KE combines affective psychology, mathematics, and engineering to measure and analyze human sensations [4],[5],[6]. The KE process includes three stages: Kansei research (collecting emotional responses), Kansei analysis (using analytical techniques), and product design based on the analysis [7]. KE uses modern technology to convert user perception into design parameters, helping designers meet consumer needs [8].

2.2 Semantic Differential

Semantic Differential (SD), introduced by Charles E. Osgood in the 1950s, is a method for measuring emotions or attitudes toward certain concepts using a five- or seven-point scale with opposing bipolar adjectives, such as good-bad or light-dark [9],[10]. SD helps connect Kansei words to design elements. A 5-point scale is preferred because it is easier for respondents to understand [11].

2.3 Term Frequency-Inverse Document Frequency (TF-IDF)

TF-IDF is a method for classifying text documents by measuring term frequency (TF) and inverse document frequency (IDF) [12]. The process includes text preprocessing, case folding, tokenization, stop-word removal, filtering, and stemming. The TF-IDF score is calculated by multiplying TF and IDF, with keywords identified by the highest scores [13], [14].

2.4 Factor Analysis

Factor analysis reduces related variables into a few key factors, with PCA as a standard method. Steps include determining variables, calculating the correlation matrix with Bartlett's Test and KMO (> 0.5), extracting factors using PCA, determining the number of factors based on eigenvalues (> 1), and rotating factors for more straightforward interpretation [15].

2.5 Conjoint Analysis

Conjoint analysis is a statistical method for assessing individual preferences for multi-attribute goods or services. Introduced in 1971, it helps understand consumer preferences for product design, pricing, and target market. This technique tests object feature priorities through individual responses and answers "what if" questions with a market

simulator [16],[17],[18]—quantitative data from conjoint analysis models customer preferences for various product features.

3 Methodology

3.1 Population and Sample

The study's population is DKI Jakarta residents, with a sample selected to represent this group [19]. Using purposive sampling, the sample includes consumers aged 17-64 who buy or consume frozen food at least once a month. The Slovin formula determines the sample size, ensuring adequate representation. With DKI Jakarta's 2022 population at 10,679,951 and a 10% error rate, the final sample size is 100 individuals.

3.2 Research Flow Diagram

The research sequence is presented in diagram form to facilitate understanding, as shown in Fig 1.

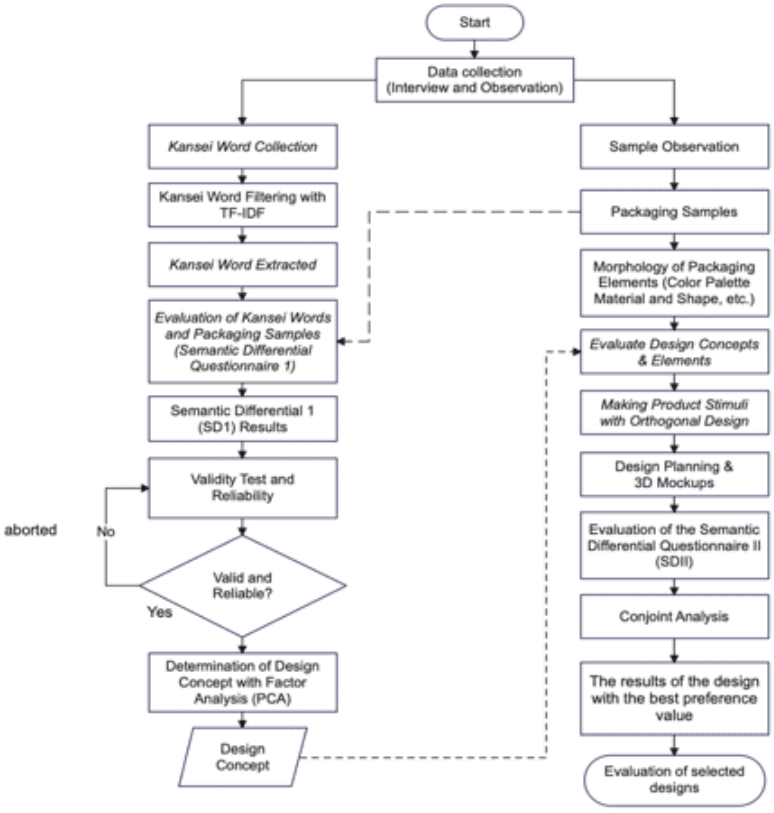


Fig. 1. Research flow diagram

4 Results and Discussion

4.1 Collection Of Packaging Samples

Sample collection involved gathering 20-25 samples of frozen food packaging from various sources, including market surveys, competitor products, and the Internet, to achieve a broader range of variations [20]. Out of the 40 packaging samples collected, selection was performed to ensure variation in design elements, and ultimately, 20 samples were chosen, as shown in Fig 2.

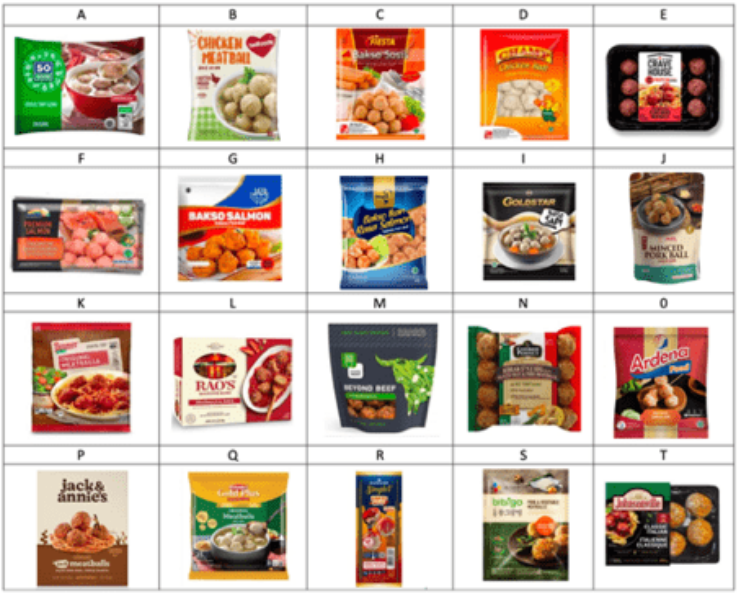


Fig. 2. Packaging samples

4.2 Kansei Word Collection

Kansei words (KW) were collected from interviews with 100 frozen food consumers, reflecting their impressions and expectations for Cedea Salmon Ball packaging. The survey used stimuli such as market packaging samples and current Cedea packaging to enhance consumer response to the product. Kansei words require specific stimuli to elicit customer feelings [21], which can be product samples [22].

4.3 Kansei Word Filtering

The collected KW had many errors and non-standard terms. Therefore, data cleaning was performed, including case folding, tokenization, filtering, normalization, and stemming. After pre-processing, TF-IDF was applied using Google Colaboratory. TF-IDF identified 501 terms and 27 KW as having the highest weights. These KW were paired

with their antonyms based on their high TF-IDF weights, indicating greater relevance [14].

4.4 Evaluation Of Kansei Words with Packaging Samples

From the 27 relevant KW aligned with consumer preferences, the next step is to create the first questionnaire (Semantic Differential I). This questionnaire is given to 100 respondents who are consumers of frozen food products. Respondents are asked to use a 7-point Semantic Differential scale. Positive KW are placed on the right side, while negative ones are on the left. A 7-point scale allows for more sensitive and specific evaluations [22].

4.5 Validity and Reliability Testing of the Semantic Differential I Questionnaire

The questionnaire data is valid if the KW reflects the desired product image. Validity testing compared the R-values of 27 KW to the R-table value (0.468) at a 5% significance level. Out of 20 packaging samples, 12 KW were invalid. Reliability testing, with a Cronbach's Alpha > 0.60, showed a value of 0.881 for 15 items, indicating the questionnaire's reliability and readiness for Factor Analysis.

4.6 Factor Analysis Evaluation

After validity tests, 15 KW are analyzed for packaging concepts. The KMO value of 0.619 and Bartlett's Test significance of 0.000 confirm data suitability. The MSA test shows that all 15 words have MSA values > 0.5. PCA identified four factors with eigenvalues > 1. After rotation, factor 1 has 4 variables, factor 2 has 4, factor 3 has 4, and factor 4 has 3. Table 1 shows the factor analysis results used as a design concept.

Table 1. Factor Analysis Grouping Results.

Factor	Variable
1	Resealable feature, product photo, informative, premium.
2	Practical, less color, elegant, simple design.
3	Illustration, window, easy to tear, easy to recognize.
4	Easy to store, easy to read, maintains product quality.

Factor one represents premium and factor two is simple and elegant, which is a third-factor illustration. The fourth factor is practical and protects the product. In factor 4, there needed to be a visual impression of the desired concept. Therefore, only three design concepts were created. Online interviews with ten respondents using Zoom and Google Meet focused on design, color, and materials. The results provide a clear picture of consumer preferences for design.

4.7 Identification of Packaging Elements (Packaging Morphology)

Field research, observation, literature review, and consumer perception are used to determine the product properties of the planned frozen food.

Material and Packaging Shapes. This study identifies two primary packaging materials from market research: plastic and cartons. Market research, which includes sales data, industry trends, consumer behavior, and competitor analysis, provides a comprehensive view and reduces bias compared to direct consumer interviews [23]. Market research helps identify trends, forecast changes, and offer competitive insights with time and cost efficiency. The analysis identified four packaging variations: paperboard, pillow bag, tray sealer, and standing pouch, as shown in Fig 3.

Fig. 3. Alternative materials and forms of frozen food packaging

Color Palette. In color theory, each color has unique characteristics, including hue (type of color), value (brightness level), and chrome (color intensity). Colors can be classified as cool or warm based on their hue [24]. Warm colors, like red, yellow, and orange, convey warmth and confidence. New packaging design color palettes were based on current frozen meatball product palettes. Figure 4 shows a color palette search using Adobe Color.

Fig. 4. Example of a color palette search

Out of 20 collected colors, they are divided into two palettes. The first palette contains warm colors, and the second palette includes a mix of warm and cool colors. The color

palettes generated from the twenty samples of cold food packaging currently available in the market are shown in Fig. 5

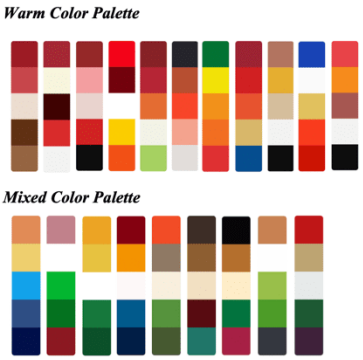


Fig. 5. Color palette frozen food on the market

Fig. 6 shows the color variations selected from the available color palette. For different frozen food packaging designs, two palettes of 20 colors each were chosen and divided into two groups. The first palette mainly consists of warm colors, while the second palette includes a mix of cool and warm colors.

(a) Warm Color Palette Variation (b) Mixed Color Palette Variation

Fig. 6. Variety of selected palette colors

4.8 Design Planning

The packaging design process involves expert panels and consumer input. The stages include concept determination, market research, material and shape selection, idea sketching, and choosing colors and typography through in-depth interviews. Design concept factors are considered when creating labels for frozen food packaging, resulting in alternative designs. Fig. 7 and 8 show the results of frozen food packaging designs using three design concepts: premium, illustrative, and simple-elegant. The established color palette was applied in these designs.

(a) Premium (b) Simple - Elegant (c) Illustration

Fig. 7. Color palette frozen food packaging label design 1

(a) Premium (b) Simple - Elegant (c) Illustration

Fig. 8. Color palette frozen food packaging label design 2

4.9 Creating Product Combinations (Stimuli) and 3D Mockups

Frozen food packaging design comprises three elements: packaging material and shape, color palette, and design concept. These factors are discussed in various stages. Each item is categorized into levels listed in Table 2.

Table 2. Frozen food product packaging design items and categories

No	Item	No	Categories	Code
1	Packaging Material & Shape	1	Paperboard	X11
		2	Pillow Bag	X12
		3	Tray Sealer	X13
		4	Standing Pouch	X14
2	Color Palette	1	Warm Color Pallete	X21
		2	Mixed Color Pallete	X22
3	Design Concept	1	Premium	X31
		2	Ilustration	X32
		3	Simple - Elegant	X33

Table 3 shows that the design of frozen food packaging consists of three items and nine categories. Stimuli are combinations of factors and levels analyzed using conjoint analysis. The first stage involves creating design alternatives using card and orthogonal design, resulting in 24 product sample combinations. Stimuli for design A to X.

Table 3. Combination of frozen food product packaging design

No	Card Id	Packaging Material & Shape	Color Palette	Design Concept
1	A	Tray Sealer	Warm Color Pallete	Ilustration
2	B	Pillow Bag	Warm Color Pallete	Ilustration
3	C	Tray Sealer	Mixed Color Pallete	Simple – Elegant
4	D	Paperboard	Mixed Color Pallete	Premium
5	E	Pillow Bag	Warm Color Pallete	Premium
6	F	Standing Pouch	Warm Color Pallete	Premium
7	G	Pillow Bag	Mixed Color Pallete	Ilustration
8	H	Paperboard	Mixed Color Pallete	Ilustration
9	I	Paperboard	Warm Color Pallete	Simple - Elegant

10	J	Standing Pouch	Mixed Color Pallete	Simple - Elegant
11	K	Paperboard	Warm Color Pallete	Premium
12	L	Tray Sealer	Mixed Color Pallete	Premium
13	M	Tray Sealer	Warm Color Pallete	Premium
14	N	Standing Pouch	Mixed Color Pallete	Premium
15	O	Pillow Bag	Mixed Color Pallete	Simple – Elegant
16	P	Tray Sealer	Warm Collor Pallete	Simple - Elegant
17	Q	Pillow Bag	Warm Color Pallete	Simple – Elegant
18	R	Tray Sealer	Mixed Color Pallete	Simple - Elegant
19	S	Standing Pouch	Mixed Color Pallete	Ilustration
20	T	Paperboard	Mixed Color Pallete	Simple – Elegant
21	U	Pillow Bag	Mixed Color Pallete	Premium
22	V	Standing Pouch	Warm Color Pallete	Ilustration
23	W	Paperboard	Warm Color Pallete	Ilustration
24	X	Standing Pouch	Warm Color Pallete	Simple - Elegant

Material, shape, color palette, and design concept are applied to the design alternatives. Fig 9 shows mockups from Orthogonal Design, used in the second questionnaire, to assess the design's alignment with customer preferences. Product mockups are also created to assist respondents.

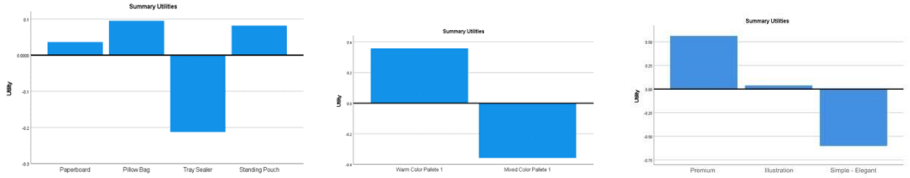
Fig. 9. Stimuli for packaging design A to X

4.10 Conjoint Analysis

The results of SD 2 are used for conjoint analysis to link design elements with KW, producing utility values that show respondent preferences. Negative values indicate less preferred elements, while positive values indicate more preferred ones. Pearson and Kendall correlations for KW are above 0.5, with values between 0.60 and 0.79 being strong and 0.80 to 1.0 being very strong. Pearson's correlation (0.829) and Kendall's Tau (0.599) demonstrate a significant and robust relationship between KW and product design, indicating that KW effectively predicts user preferences.

4.11 Evaluation of Selected Designs

Based on overall utility values, consumers prefer Pillow Bag packaging the most (0.95). Fig. 10 shows the utility of various packaging materials and shapes: Paperboard, Pillow Bag, Tray Sealer, and Standing Pouch. Pillow Bag has the highest utility, followed by Standing Pouch and Paperboard, while Tray Sealer is the least preferred. For colors, consumers like the warm color palette (0.358), with warm colors having a positive utility of about 0.3 and mixed colors having a negative utility of about -0.3. Regarding label design, consumers prefer premium designs (0.563), followed by neutral illustrative designs, while simple-elegant designs are the least preferred.



(a)Packaging Material & Shape. (b) Color Pallete (c)Design Concept

Fig. 10. Utility Graphics material, color palettes and design concepts

The results indicate that consumers prefer frozen food packaged in a Pillow Bag with a product photo design and a warm color palette. Based on this analysis, Design E was selected. Fig. 11 shows the chosen design.

Fig. 11. Selected Design Results (Design E)

The packaging design evaluation, conducted via an online questionnaire, revealed that 98% of 100 respondents believe the Cedea Salmon Ball packaging meets the expected design elements. There were 74% delighted, 24% satisfied, and 2% unsatisfied. The survey results show a strong positive response to the packaging development.

5 Conclusions

Based on the research findings, several conclusions can be drawn: The application of KE and TF-IDF successfully extracted 28 Kansei words for frozen food development, which were then reduced to the 15 most relevant words. Factor Analysis revealed three main design concepts: "Premium," "Simple-Elegant," and "Illustrative," which can guide packaging development. Conjoint Analysis showed that consumers preferred label designs with product photos and warm color palettes, while simple designs were the least preferred. A 100 frozen food consumers survey indicated that 98% felt the packaging development was appropriate, with 71% delighted. This suggests that well-designed packaging meets design expectations and positively impacts customer satisfaction and purchase likelihood. With 98% of respondents finding the packaging design appropriate and 71% very satisfied, it can be concluded that packaging is a critical factor in purchasing decisions. In conclusion, a comprehensive and consumer-oriented approach to packaging design can result in products that are more accepted by the market. Further research is needed to align designs with evolving consumer trends.

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