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Integration of conjoint analysis and QFD for new product development in manufacturing small and medium enterprises (case study: a food company)

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Abstract. Basically, small and medium enterprises (SMEs) in Indonesia are weak in innovating product development in accordance with customer's needs, making it difficult for SMEs to penetrate the market. This paper discusses the application of integration between Conjoint Analysis and QFD in the development of a new product from SME. The research was conducted at a medium-sized company, which produces a variety of "dimsum" frozen food products. Finally, the integration of the two provides a double benefit in the research and development stage of the manufacturing SME so that a new product that is developed can really be realized. The final design results obtained two new product segments according to its target market, namely for the economic and premium segments.
Keywords: Integration, Conjoint Analysis, QFD, New Product Development, SME.

1. Introduction

The frozen food market in Indonesia is growing, for example in 2014 amounting to USD 421.8 million and becoming USD 434.3 million in the next year, and is predicted to continue to increase in the coming years [1]. It shows that frozen food products are increasingly in demand by the Indonesian people. Even in its development, there are currently many SMEs that produce frozen food products. According to the Association of Food and Beverage Entrepreneurs (Gapmmi), in Indonesia the number of SMEs that produce frozen food reaches 10% of the total national food processing SMEs [2].

Similar to SMEs in general, which has weaknesses for the following things; product development innovations including packaging design, marketing strategies, and distribution systems. However, frozen food production SMEs have difficulties with raw materials and their production processes so that a good quality management system is needed, starting from the preparation of raw materials to the processing and adequate food technology.

Along with the challenges mentioned above, innovation becomes a vital aspect in strengthening the competitiveness of food processing SMEs, especially frozen food production. The success of an innovation is largely determined whether an idea or a solution or a product offered must already have early adopters or consumers. Refer to Kosasih et.al. [3], discussing innovation is not just "what and how to design a product," but furthermore it related with "let's hear the voice of the customers"[4].

Therefore, this paper discusses how to integrate conjoint analysis and quality function deployment (QFD) in the development of a new product for frozen food production SMEs. The integration of both can offer more comprehensive product development so that it can penetrate a wider market. Conjoint analysis is an experimental approach to measure consumer preferences for an object (product, service, or idea) [5], [6], [7]. This analysis is based on how consumers evaluate the value of objects (real or hypothetical) by combining each different value from each attribute [7], [8]. Meanwhile, QFD is a quality management that focuses on consumers and product development methodologies that are tangible [9]. According to Jikar et.al. [10], QFD is the process of capturing and translating what consumers need into remedial actions involving many parties from the company, including; research and development, engineering and manufacturing, marketing/sales, and services.

2. Methods

2.1. Conjoint Analysis Approach

Conjoint Analysis was first developed by psychological expert Luce and statistician Tukey in 1964 in the field of mathematical psychology [5]. Since the mid-1970s, this method has attracted many researchers' attention as one method that is able to clearly describe the way consumers make decisions in the process of selecting products or services that have multi-attributes [11]. Then in the 1980s, conjoint analysis was widely applied to the industrial field. In the 1990s, the use of conjoint analysis was increasingly widespread in various fields of science [5], [11].

This research was conducted at a medium-sized company, which produces a variety of "dimsum" frozen food products. The initial step in this study began by discussing in depth with the management company regarding the market share of their products as well as their marketing mix strategy. In the next stage, the preliminary questionnaire was made to collect data in the form of what attributes were considered important/priority according to consumer preferences, and other supporting questions. Questionnaires that were made before the deployment were tested trial and error first.

Then fractional factorial design is used to stimulate and generate several profile combinations from a set of attributes with their respective levels arranged to describe the features of a product being developed, or called the full-profile method approach (as seen in Fig 1). An assessment uses Likert scale from value 1 to value 5. Value 1 indicates a preference for "dislike" and a value of 5 indicates a preference for "very like". According to the target consumers, the survey respondents who had consumed a "dimsum" frozen food product. The survey results obtained were then calculated the relative importance and the utility value using conjoint analysis. The final profile combination is determined based on the most positive utility value of a level in certain attribute.

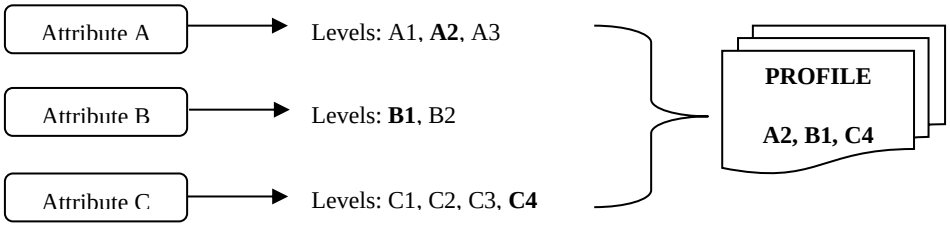


Figure 1. Relationships between attributes, attribute levels, and the profile [6],[7]

Conjoint analysis has metric or non-metric dependent variables (*Y*) and has several non-metric independent variables (X_1, X_2, X_3, ..., X_n), where the relationship between the variables can be expressed by the following formula [7], [12]:

$$Y = \sum_{i=1}^{n} X_i \quad (1)$$

Mathematical equation that can express the basic model of conjoint analysis is as follows:

$$\mu(x) = \sum_{i=1}^{m} \sum_{j=1}^{k} a_{ij} x_{ij} + \varepsilon_{ij} \quad (2)$$

Where; $\mu(x)$ = total utility of an alternative or stimuli, a_{ij} = utility of the i^{th} attribute (i = 1,2, ..., m) and j^{th} level (j = 1,2, ..., k), k = numbers of level of each attribute , m = numbers of attribute, x_{ij} = dummy variable of the i^{th} attribute and j^{th} level (value 1 if j^{th} level of i^{th} attribute occurs and 0 if it does not occur), ε_{ij} = value of stochastic or constant error.
The importance of an attribute that is I_i is defined in the range of part-worth which can be formulated as follows:

$$I_i = \{\max(a_{ij}) - \min(a_{ij})\}, \text{ for every i} \quad (3)$$

Normalizing the importance level of each attribute to ensure its relative importance with other attributes, can be expressed with the following equation:

$$W_i = \frac{I_i}{\sum_{i=1}^{m} I_i} \quad (4)$$

Where; W_i = relative importance weights for each attribute, I_i = range of importance values for each attribute.

2.2. *QFD Application for the Food Industry*
In final step, the product concept would be further developed using the QFD method to plan and design the manufacturing process up to the packaging design to meet consumer needs. Yoji Akao and Katsuyo Ishihara introduced and developed quality function deployment (QFD) from 1965 to 1967, and defined QFD as a method for developing design quality that leads to customer satisfaction and translating customer desires into design targets and critical quality assurance that can be used during development of production or service [13]. In 1972 QFD was first applied by Mitshubishi Heavy Industries Limited in Kobe Shipyard, Japan, and then in the late 1970s, the detailed QFD concept was further developed by Toyota which was then widely applied to the manufacturing industry in the world [14].

Generally, the QFD method consists of four phases of the planning and development matrix known as the four phase model or clausing model [15], [16], namely; a) Product planning matrix (house of quality); b) Design deployment matrix (part deployment); c) Manufacturing planning matrix (process planning); d) Production planning matrix (production operations planning). Refer to Benner, et.al. [16], Hofmeister [17] states that the application of QFD in the food industry has two paths in the product development process based on the needs or voices of customers. These two lines are the packaging deployment path and the food deployment path, each path contains four stages as shown in Figure 2. This method is used because it will be more difficult to integrate the four phase model for food products compared to mechanical products in the industry which are arranged from several components to end products. This case is different for food products where raw materials show a lot of interaction with each other [16].

3. Results and Discussion

From the results of the preliminary questionnaire with 214 respondents (see Table 1), it found that there are seven attributes of a "dimsum" frozen food product that were consumers' preferences in choosing the product when ordered from the highest priority level, among others; a) number of contents, b) attractive physical appearance or form, c) flavor, d) opener of packaging, e) packaging form, f) packaging material, and g) form of container. All of these attributes are considered in further product development. Each attribute is developed at a level based on survey results and in-depth discussions with customers, as shown in Table 2.

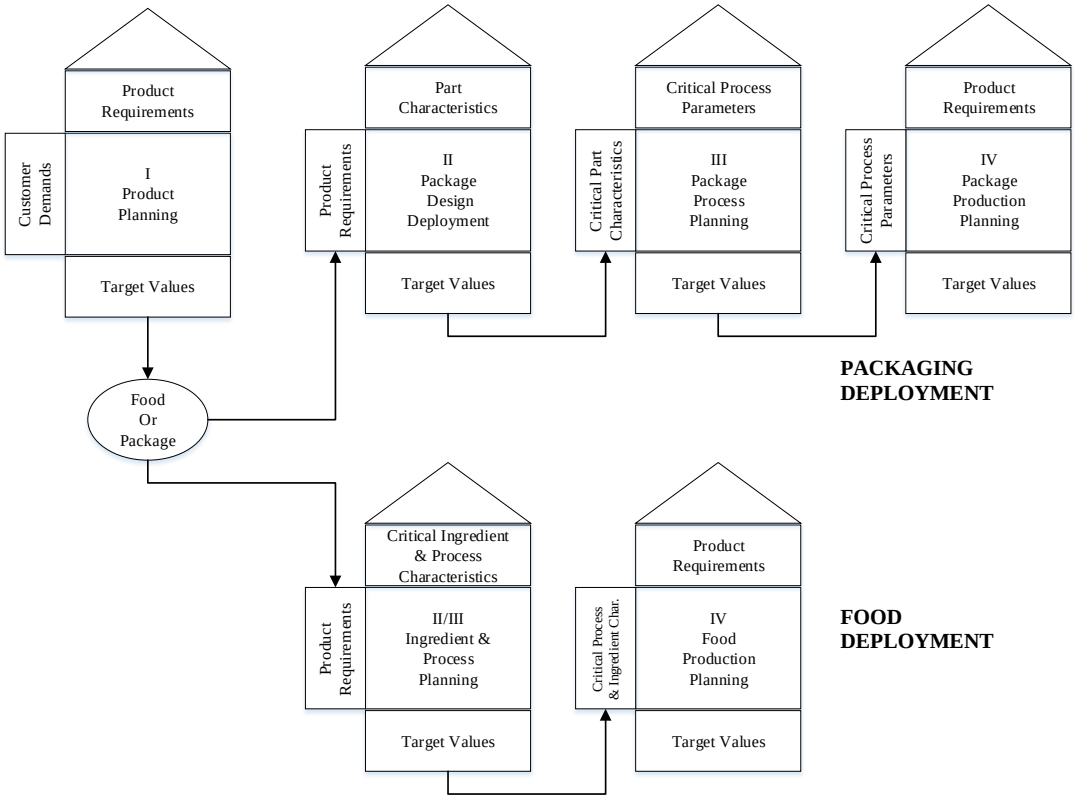


Figure 2. A scheme of QFD for the food industry [17]

Table 1. Demographic characteristics of respondents

No.	Variables	Description	Total (N = 214)	
			Respondents	Percentage
1	Gender	Male	127	59.35%
		Female	87	40.65%
2	Age	15-19 y.o.	8	3.74%
		20-29 y.o.	166	77.57%
		30-39 y.o.	24	11.21%
		Equal and greater than 40 y.o.	16	7.48%
3	Occupation	Student	109	50.93%
		Private employee	67	31.31%
		Entrepreneur	12	5.61%
		Housewife	14	6.54%
		Others: bureaucrat, doctor, teacher, artist, personal trainer, chef, travel guide, bartender, unemployment	12	5.61%
4	Expenditure per month	IDR 1.000.000,- to IDR 5.000.000,-	95	44.39%
		IDR 5.000.001,- to IDR 10.000.000,-	69	32.24%
		IDR 10.000.001,- to IDR 15.000.000,-	34	15.89%
		Greater than IDR 15.000.000,-	15	7.01%
5	Region	North Jakarta	54	25.23%
		West Jakarta	44	20.56%
		South Jakarta	23	10.75%
		Central Jakarta	16	7.48%
		East Jakarta	22	10.28%
		Tangerang	25	11.68%
		Bekasi	11	5.14%
		Others	19	8.90%

Table 2. Attributes and its levels

No	Attributes	Description of Attributes	Levels of Attributes
1	Flavor	Variety of stuffing	Salted egg Meat
2	Physical form	Form of outer appearance	Plain motif Tied motif
3	Amount of contents	the amount of contents in the packaging	8 pcs 12 pcs
4	Packaging form	Physical outer appearance of the packaging	Bright full color cover Dark full color cover Partially transparent
5	Packaging material	Type of packaging material	Plastic Cardboard or paper
6	Opener of packaging	Mechanism and instructions for opening the packaging	Tear mark Scissors line mark
7	Container form	Design of the container in the packaging	With partition Without partition Without container

If the result of the combination is too much, the respondents can be difficult in giving judgment. Therefore, Fractional Factorial Design is used to present and stimulate sixteen profiles of all possible combinations. Then 100 of the 214 respondents were selected as potential early consumers, who would conduct an assessment of all existing profiles. All survey results were tested by Pearson's R correlation. It was found that there were three respondents with Pearson's R value below 0.707 so that the data were not used for further data processing in order to obtain a more accurate the results of utility value and relative importance, as shown in Table 3 and Table 4 respectively.

In this study, "Pao" frozen food products were developed based on market segmentation. Simply stated respondents with expenses below 5 million rupiah per month are categorized as lower class buyers, where 52 respondents and the majority are students. Meanwhile, respondents with expenditure above 5 million rupiah per month are categorized as middle class buyers, where as many as 48 respondents and the majority are employees or entrepreneurs. The products are further divided into two segments, namely economic segment and premium segment. The two segments have different importance levels to the attributes of the product, as seen in detail in Table 4. From the utility of each attribute level, it can be seen that different segments produce different profile combinations as shown in Table 5.

Table 3. Average of part-worth utility for economic and premium segments

Attribute	Levels of Attribute	Economic segment		Premium segment	
		Estimated Utility	Std. Error	Estimated Utility	Std. Error
Flavor	Meat	-0.092	0.063	0.029	0.082
	Salted egg	0.092	0.063	-0.029	0.082
Physical form	Tied Motif	-0.030	0.063	-0.003	0.082
	Plain Motif	0.030	0.063	0.003	0.082
Amount of contents	8 pcs	-0.087	0.063	-0.226	0.082
	12 pcs	0.087	0.063	0.226	0.082
Packaging form	Bright full color cover	0.010	0.084	-0.028	0.110
	Dark full color cover	-0.105	0.099	0.145	0.129
	Partially transparent	0.095	0.099	-0.116	0.129
Packaging Material	Cardboard or paper	0.115	0.063	0.316	0.082
	Plastic	-0.115	0.063	-0.316	0.082
Opener of packaging	Tear mark	0.015	0.063	0.004	0.082
	Scissors line mark	-0.015	0.063	-0.004	0.082
Container form	With partition	0.333	0.084	0.493	0.110
	Without partition	-0.044	0.099	-0.167	0.129
	Without container	-0.289	0.099	-0.326	0.129
	(Constant)	3.252	0.070	3.004	0.091

Table 4. Importance level of each attribute for each segment

Attribute	Importance Level	
	Premium segment	**Economic segment**
Flavor	13.857 %	9.339 %
Physical form	10.012 %	8.218 %
Amount of contents	9.612 %	16.465 %
Packaging form	20.798 %	14.867 %
Packaging material	11.659 %	18.751 %
Opener of packaging	7.384 %	6.685 %
Container form	26.677 %	25.675 %

Table 5. Combined profile results for each segment

Attribute	Economic segment	Premium segment
Flavor	Salted egg	Meat
Physical form	Plain motif	Plain motif
Amount of contents	12 pcs	12 pcs
Packaging form	Partially transparent	Dark full color cover
Packaging material	Cardboard or paper	Cardboard or paper
Opener of packaging	Tear mark	Tear mark
Container form	With partition	With partition

QFD Integration Design

The results of HOQ design obtained eight technical responses related to consumer needs, including; composition of raw materials, ease of forming the motif, amount of contents in the packaging, the features displayed on packaging, type of packaging used, effort to open the packaging, type of container, size of pao. The importance of each technical response for each segment for details can be seen in Figure 3.

There are ten manufacturing processes that are designed from the development of the food deployment matrix as shown in Figure 4. This process is divided into 2 parts namely “baozi” and its stuffing. The process of making “baozi” considers the following factors; a) the composition of dough or the amount of each raw material used. In this case related to raw materials such as flour, sugar, water, yeast, and several other ingredients; b) Stirring time is related to the duration of kneading all raw materials so that they are evenly mixed. In this case the duration used must not be too long or too fast so that the dough gets time to ferment and expand; c) The type of mold is related to the type of motif produced by the machine. In this case only has 2 types of molds namely, plain and flower motifs; d) The size set on the machine is the size of pao to be printed according to its design specifications; e) Texture related to how a product is felt, such as tender, tough, smooth, creamy, etc.; f) Duration of fermentation is related to how much the dough can expand, where the duration of this process must be in accordance with the composition of the product because if it is not suitable for example too little duration will cause the dough to not expand properly. Conversely, if it takes too long, the texture will become rough and have many holes because the mixture will expand too much causing too much wind in the mixture; g) Heat treatment is related to how to cook the dough, which is used by the oven to steam with the duration of time and temperature that must be considered. The duration will increase with the weight of the dough. The temperature used must be optimal, it should not be too hot or not hot enough.

The manufacturing of product stuffing considers the following factors; a) its composition is directly related to the type of raw material used, wherein the composition of salted egg stuffing consists of salted egg yolk, water sugar, milk, and several other ingredients. Meanwhile, the composition of meat stuffing consists of chicken meat, sugar, salt, and several other ingredients; b) The processing starts from the preparation of raw materials to be processed to become finished products. In salted egg stuffing (economic segment product), the main ingredients are mixed then ground and then steamed. After steaming then add some ingredients and mashed and then steamed again. In meat stuffing (premium segment product), raw chicken meat is seasoned then the meat is grilled. After that, it is ground and then spread a "char-siew" sauce and stirs until blended; c) Heat treatment is related to the

process for cooking the product. As mentioned earlier in salted egg stuffing, the mixture is cooked by steaming. In meat stuffing, meat is cooked by roasting.

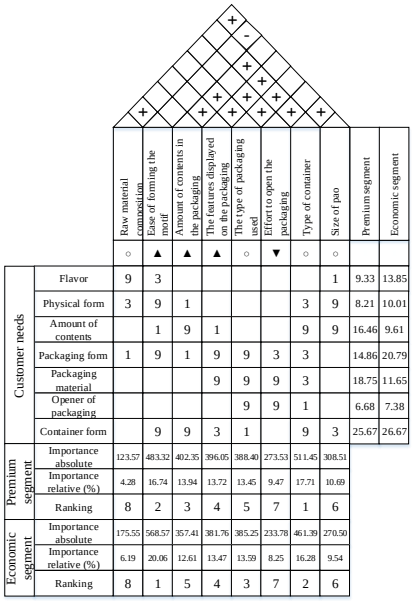
Besides, the results of the development of the packaging deployment matrix (see Figure 5) identify the six characteristics of this product packaging to meet customer's requirement, among others; a) The container size determines how much pao can be filled onto the container; b) The color of packaging serves to attract customers to buy the product; c) Information and product descriptions are related to the presentation of product composition and nutritional value; d) Carton used is food grade type which tends to be used to pack food. This material is also easier to decompose so it does not pollute our environment; e) The packaging is given a tear mark so that it is possible to open it easily; f) Container with partition that can separate each item so that those do not come into contact with each other.

Then it is planned to be more detailed in developing packaging using the packaging manufacturing deployment matrix (see Figure 6), among others; a) The dimension of packaging is 23 cm x 27 cm x 8 cm; b) The dark color is used as the background of packaging; c) Display product descriptions that aim to provide information about how the product will look; d) Carton used is food grade type; e) a tear mark to make it easier for consumers to open the packaging; f) Containers with 12 partitions according to most interested people from the results of this study.

Figure 7.a illustrates the final design of a new product for each segment developed using the integration of conjoint analysis and QFD methods. Figure 7.b shows an overview of the packaging from various points of view.

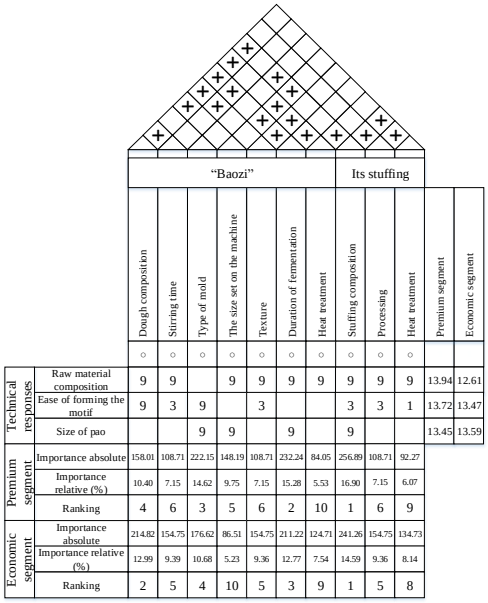
4. Conclusion

The integration of these two methods makes it possible to plan and develop structured products according to consumer preferences. The QFD used in this study was specifically developed for the food industry so it is appropriate to be applied to food processing SMEs, especially “dimsum” frozen foods. In this study, two new product segments are developed in accordance with the target market, namely for the economic segment and the premium segment. The final specifications of new products obtained are plain motifs, two flavor variants (salted eggs and meat), packaging size 27 cm x 23 cm x 8 cm, dark color, displaying product images on the packaging, food grade cardboard type, there is tear mark, and last it has twelve partitions on the container.



		Raw material composition	Ease of forming the motif	Amount of contents in the packaging	The features displayed on the packaging	The type of packaging used	Effort to open the packaging	Type of container	Size of pao	Premium segment	Economic segment
		○	▲	▲	▲	○	▼	○	○		
Customer needs	Flavor	9	3						1	9.33	13.85
	Physical form	3	9	1				3	9	8.21	10.01
	Amount of contents		1	9	1			9	9	16.46	9.61
	Packaging form	1	9	1	9	9	3	3		14.86	20.79
	Packaging material				9	9	9	3		18.75	11.65
	Opener of packaging					9	9	1		6.68	7.38
	Container form		9	9	3	1		9	3	25.67	26.67
Premium segment	Importance absolute	123.57	483.32	402.35	396.05	388.40	273.53	511.45	308.51		
	Importance relative (%)	4.28	16.74	13.94	13.72	13.45	9.47	17.71	10.69		
	Ranking	8	2	3	4	5	7	1	6		
Economic segment	Importance absolute	175.55	568.57	357.41	381.76	385.25	233.78	461.39	270.50		
	Importance relative (%)	6.19	20.06	12.61	13.47	13.59	8.25	16.28	9.54		
	Ranking	8	1	5	4	3	7	2	6		

Figure 3. Design of HOQ



		“Baozi”							Its stuffing				
		Dough composition	Stirring time	Type of mold	The size set on the machine	Texture	Duration of fermentation	Heat treatment	Stuffing composition	Processing	Heat treatment	Premium segment	Economic segment
		○	○	○	○	○	○	○	○	○	○		
Technical responses	Raw material composition	9	9		9	9	9	9	9	9	9	13.94	12.61
	Ease of forming the motif	9	3	9		3			3	3	1	13.72	13.47
	Size of pao			9	9		9		9			13.45	13.59
Premium segment	Importance absolute	158.01	108.71	222.15	148.19	108.71	232.24	84.05	256.89	108.71	92.27		
	Importance relative (%)	10.40	7.15	14.62	9.75	7.15	15.28	5.53	16.90	7.15	6.07		
	Ranking	4	6	3	5	6	2	10	1	6	9		
Economic segment	Importance absolute	214.82	154.75	176.62	86.51	154.75	211.22	124.71	241.26	154.75	134.73		
	Importance relative (%)	12.99	9.39	10.68	5.23	9.36	12.77	7.54	14.59	9.36	8.14		
	Ranking	2	5	4	10	5	3	9	1	5	8		

Figure 4. Food deployment matrix

		Container size	Packaging color	Product information and descriptions	Cardboard or carton	The packaging can be opened with a few slices	Container with partition	Premium segment	Economic segment
		○	○	▲	○	○	○		
Technical responses	Amount of contents in the packaging	9		3	1		9	13.94	12.61
	The features displayed on the packaging	1	9	9		9		13.72	13.47
	The type of packaging used	1	1	3	9	9		13.45	13.59
	Effort to open the packaging	3	3	3	9	9	1	9.47	8.25
	Type of container	9		3			9	17.71	16.28
Premium segment	Importance absolute	340.23	165.34	287.19	220.22	329.76	294.23		
	Importance relative (%)	20.79	10.10	17.54	13.45	20.14	17.98		
	Ranking	1	6	4	5	2	3		
Economic segment	Importance absolute	311.82	159.6	273.42	209.17	317.79	268.26		
	Importance relative (%)	20.25	10.36	17.75	13.58	20.64	17.42		
	Ranking	2	6	3	5	1	4		

Figure 5. Packaging design deployment matrix

		23 cm x 27 cm x 8 cm	Dark color	Display an overview of the product	Food grade cardboard type	Give a tear mark	12 partitions in the container	Premium segment	Economic segment
		○	○	○	○	○	○		
Part Characteristics	Container size	9					9	20.79	20.25
	Packaging color		9	1	3			10.1	10.36
	Product information and descriptions		3	9		3	9	17.54	17.75
	Cardboard or carton	1	3	3	9			13.45	13.58
	The packaging can be opened with a few slices					9		20.14	20.64
	Container with partition	9					9	17.98	17.42
Premium segment	Importance absolute	362.38	183.87	208.31	151.35	233.88	506.79		
	Importance relative (%)	20.01	11.17	12.65	9.19	14.20	30.78		
	Ranking	2	5	4	6	3	1		
Economic segment	Importance absolute	352.61	187.23	210.85	153.3	239.01	498.78		
	Importance relative (%)	21.48	11.40	12.84	9.34	14.56	30.38		
	Ranking	2	5	4	6	3	1		

Figure 6. Packaging manufacturing planning matrix

(a) (b)

Figure 7. Final design results: (a) new products for each segment, (b) packaging for each segment

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