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Development of a New Sesame Product using QFD and DOE methods: A Case Study of Sesame Product in Yazd

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ABSTRACT

The aim of the study is to identify customer's needs for new sesame products, converting requirements into product and process qualitative characteristics, and improving the new product quality. Based on morphological approach and point of views of the manufacturers of sesame products and customers(384 persons), new ideas were extracted and between them a chocolate sesame product was selected. By coducting a survey of consumer expectations(382 sample) taste of new product was examined and translated into technical specifications. The paper considers the implementation of the Quality Function Deployment (QFD) and DOE in BAH(Booz, Allen and Hamilton) framework for the development of new food products. It also aims to meet the challenge of satisfying customer's inconstant demands and, in turn, to make the business thrive. The results show that main quality features for final product are in good taste, no bitter-taste and be Fresh. Satisfying these requirements are relative to parameters such as sesame variety, chocolate melting point, control of cooking time and oven temperature.

INTRODUCTION

New product development (NPD) is an approach adopted to create competitive advantages and successful opportunities in today's global food markets (Costa and Jongen, 2006). Nowadays; everything is affected by major changes in markets and economic conditions as well as rapid advances in technologies. Therefore, companies try to do their best to develop new products for all markets specially high-tech markets (Ayağ, 2014). There has been a renewed demand for customized solutions, high quality, fast delivery, sound environmental performance, and low cost. So, it is clear that, to face these challenges and to ensure survival and constant success, companies must highlight the importance of producing new and improved products, (Huang, 2013).

In this process, there are basically certain main methods and techniques, and the information needed to push the project forward from one stage to another is gathered in each stage (Cauchick Miguel, 2005). As a few examples of those methods, one can refer to quality function deployment (QFD), functional analysis, failure mode and effect analysis (FMEA), and morphological chart analysis (Huang, 2013).

In the literature, new product development is described as the transformation of a market opportunity into a product available for sale. The pleasing result of this process is the commercialization of the product within a logical time duration (Griffin and Hauser, 1996), Good fulfillment of customer's needs and wants by a developed product is the most important factor for successful NPD performance (Cooper and Kleinschmidt 2007; Henard and Szymanski, 2001).

Although some studies have suggested that it is necessary to integrate 'the voice of the consumer' to NPD and emphasized that there must be external communication between consumers and companies, consumer information must be not only acquired but also disseminated and applied within the company. In this regard, internal communication must be paid attention too (Jacobsen *et al*., 2014).

Two significant drivers of product performance are listed below according to previous researches:

– An effective NPD process model
– Appropriate metrics to measure the quality of the NPD process (Huang, 2013).

A lot of efforts were made to take QFD and DOE data by concentrating on the above factors. This paper suggests that the design of experiments (DOE) combines with QFD to reduce the negative effects of human experiences. DOE is used to recognize and compare the effects of the quality characteristics on the process (Sheng *et al*., 2002). In addition; the aim of DOE is to determine the design variables which can significantly affect the response values. This aim is very important, particularly when new products or processes are developed (Jeang, 2015). This issue affects more and more industrial fields, including production of foodstuffs.

Searching for new and better products and the achieved development in this regard can introduce the market with goods which best suit the consumer's preferences and exhibit characteristics widely accepted by them. A wide range of customers with different requirements and preferences of the market of food industry, which clearly defines and determines the basis of both product design and manufacturing process (Kowalska et al., 2015). According to issues raised, and the importance of new product development in success of companies, this study aims at identify customer's needs for new products and improving the new product quality In iran- Yazd Sesame Product industry.

1. RESEARCH LITERATURE

The present study was conducted by taking some insight from the essential data in the literature mainly about NPD, QFD in the food industry, and corporation of DOE into QFD.

1.1 New Product Development (NPD)

The New Product Development model has been studied widely over the past two decades (Başog et al., 2012). In common understanding, attempts are often directed toward designing, producing, and commercializing products of great novelty. Any change in a recipe, new technology, production lines, or extension of the existing ones may cause the product to be considered as a novel (Halagarda, 2008). In the PDMA handbook, NPD is clearly defined as "the complete process of strategy, organization, concept generation, product and marketing plan creation and evaluation, and commercialization of a new product'' (Başog et al., 2012).

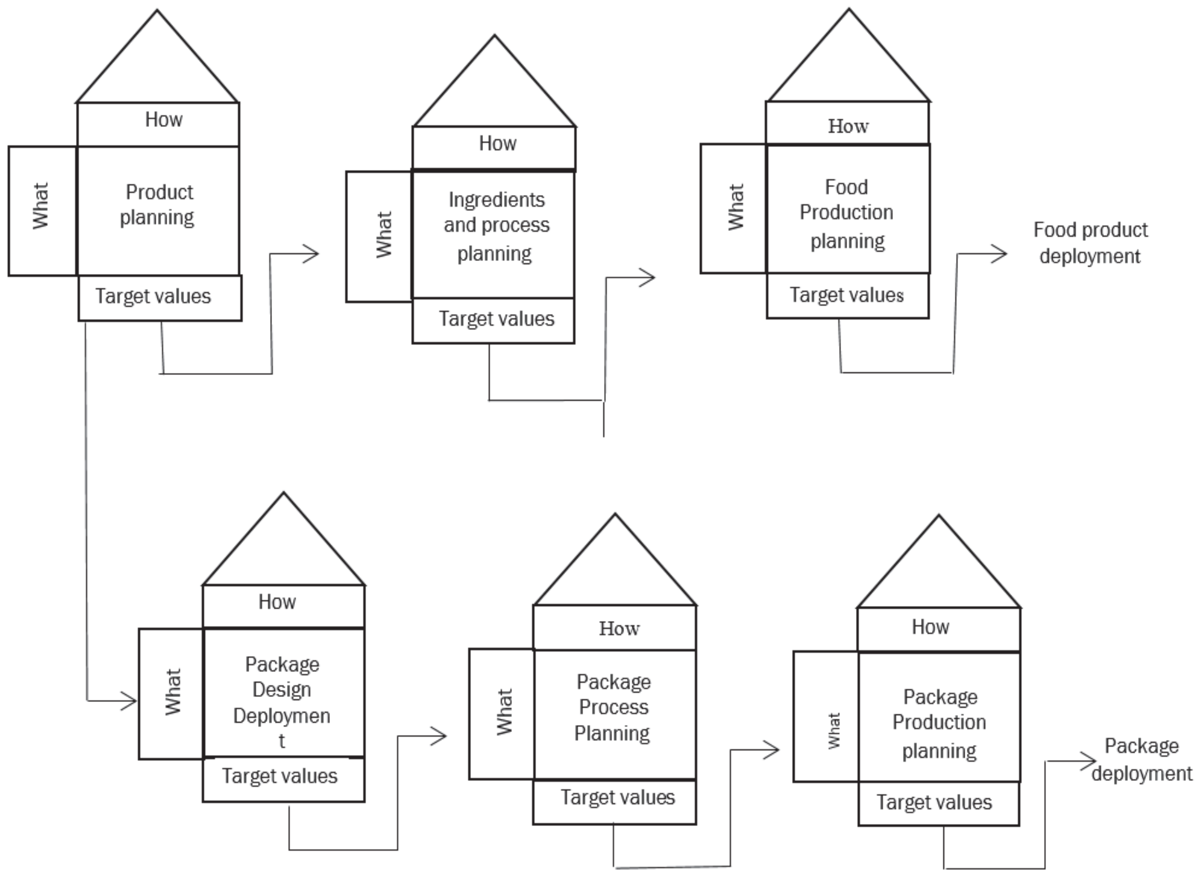
In this context, the QFD methodology is designed to keep away from developing a new product that has no success in the market and to reduce the costs of development. This paper proposes a method to help companies both develop new products and improve the existing products by a series of innovations to make through some related steps, starting from the process of idea generation and ending in launching the product into the market (Ionica and Leba, 2015).

We applied the QFD method which, as stated by Chan and Wu (2002), is a method of transforming the "customer's voice" into "product technical characteristics". It is to be combined with NPD because the most important requirement for a successful NPD is defined as "Meet the needs of potential customers" (Ionica and Leba, 2015).

1.2 QFD in the food industry

The food industry is a great divided market in which both manufacturers and retailers must be able to meet the changing needs of consumers (Haq and Boddu, 2014). According to Hofmeister (1991), the quality function deployment method has been utilized in the food industry since 1987. At the beginning of the nineteenth century, all articles were published on the benefits that the QFD method could offer, especially in the field of consumer-oriented food product development. The first matrix, namely the House of Quality, is the central point. There are very few articles to explain experiences of how QFD has been used in actual products.

Figure 1 QFD Food Industry Roadmap



Source: Benner et al., 2003.

This agrees with the conclusions of other authors. Costa et al. (2001) came to the conclusion that the most relevant information has only been published as scientific working papers, theses and reports. Thus, the public has not been allowed to use this information (Benner et al., 2003). Since the base of designing and manufacturing a new or modified food product is an examination of the customer's preferences, The QFD method can be used as a cross-functional planning tool which ensures that the voice of the customer is systematically heard all through the stages of designing and making the product (Kowalska et al., 2015).

Hofmeister (1991) named QFD "The Food Industry Roadmap" in which two alternative roads are defined for spreading the voice of the customer through the product development process (Fig. 1). The two roads are the packaging deployment road and the food deployment road. On the food deployment road, phases II and III are combined because both the ingredients and the manufacturing process determine the characteristics of the end product in the food industry (Hofmeister, 1991).

1.3 Framework of the integration of DOE into QFD

QFD and DOE have their exclusive roles, but with the same goals; they are formed by customer's satisfaction and driven by a minimum social loss to find ways to decrease the mass loss in order to improve the design quality and produce the products that respond to the customer's preference. They consider and ensure the quality design for the product from different levels and aspects. So, a combination of QFD and DOE for the product design and the quality control will help to promote the product design and the development and manufacturing process so as to enhance the product quality (Ma, 2013).

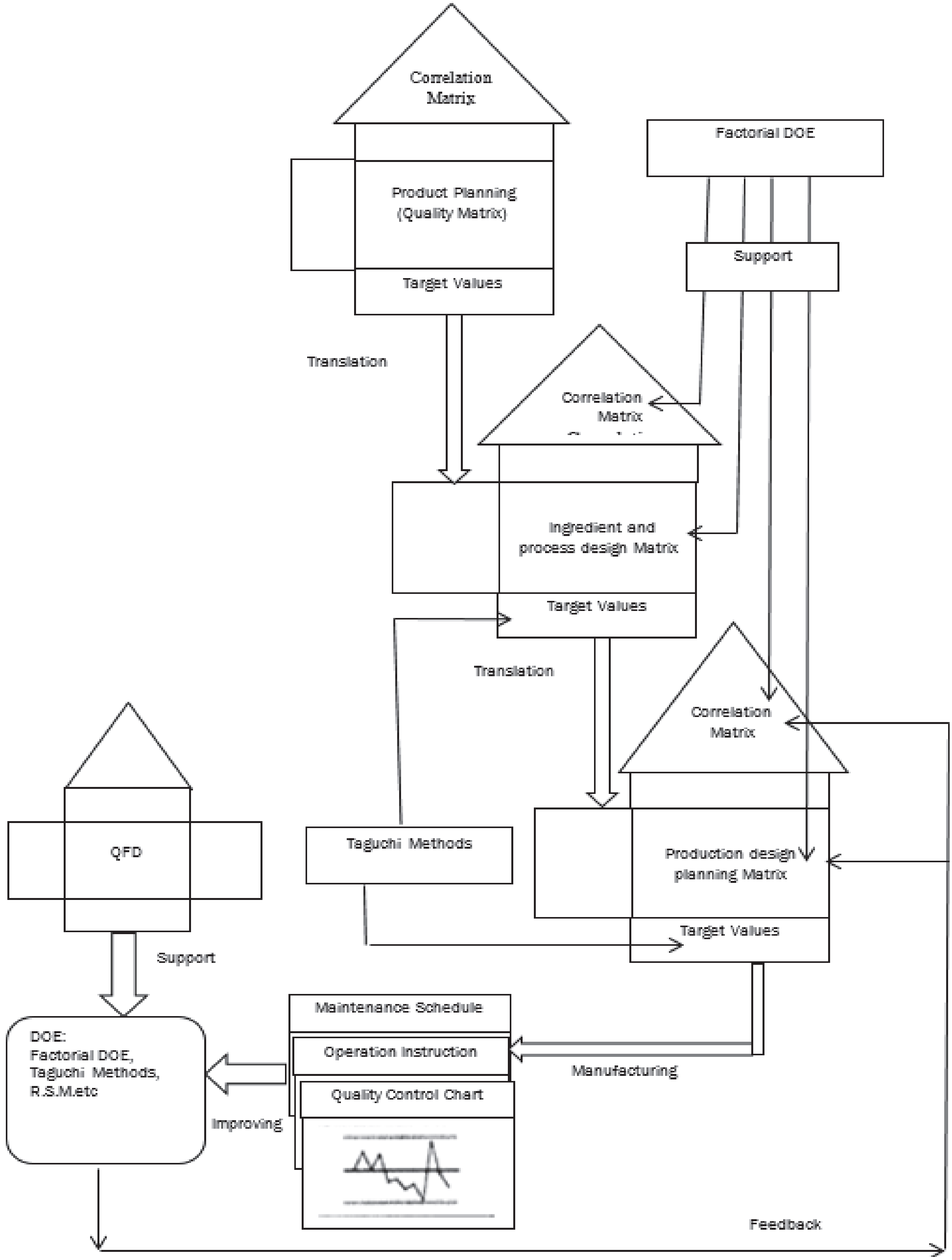
In the present study, based on QFD in food industry map (Figure 2) and the integration of DOE and QFD approaches Sheng et al. (2002), the framework for integration of DOE and QFD in the food industry is taken into consideration according to Figure 2.

In this framework, according to Hofmeister's perspective second and third QFD matrix is integrated and taken into account as Ingredients and process planning ". Also in conformity with QFD Food Industry Roadmap, Figure 2 shows a framework of combining DOE and QFD on the basis of a three-phase model.

A description is presented below for this framework: a) Use of DOE has not been defined for all relationships, correlations, and targets, b) In setting the targets, it is always worth mentioning that the team should emphasize not only the customer's satisfaction but also the market tolerances. DOE support for QFD may happen not in the design process alone; in the production process, the design obtained by using QFD will not always produce the best product.

Based on the feedback from the production DOE, QFD can adapt its elements and reproduce the output.

Figure 2. The integration framework of QFD/DOE in the food industry



2. CASE STUDY

Yazd province is the core of sesame production in Iran and the history of this product in this area was nearly 200 years ago. At present 154 production units and corporations in the production of sesame products are active. Also taking into account the successful record of sesame products production in this state, high quality and the suitable price are the increasing demand for these products. Generally, the different products of sesame are Tahini, roasted sesame seeds, sesame oil, Tahini with Cacao chocolate, Tahini with milk chocolate, Tahini with Coffee chocolate, sesame pudding and sesame bars.

3. RESEARCH METHODS

New product development is one of the most critical tasks in the business process. Every company develops new products to increase sales, profits, and competitiveness; however, NPD is a complex process and is linked to substantial risks. The objective of NPD is to search for possible products for the target markets. So, scientific research has proposed several different models (see for example Mahajan and Wind, 1992; Booz 1982; Clark and Fujimoto 1991; Maritan, 2015). In the other words New product development is critical to long-term profitability or even to the survival of firms in a variety of industries (Hsieh and Chen, 2006). According to the framework proposed by Booz, Allen and Hamilton (1982), NPD can be divided into seven phases, including a) new product strategy phase, b) idea generation phase, c) screening and evaluation phase, d) business analysis phase, e) design and development phase, f) testing phase, and g) commercialization phase. In the NPD process, decision makers have to screen new-product ideas according to a number of criteria. Subsequently, they recommend the ideas to R&D engineers, marketers, and sales managers at every stage of development.

The study was conducted in three stages. In the first stage, the target market and the new idea were identified, and the basic concepts of the study and the feasibility of the process were investigated. In the second stage, the voice of customers was taken and put in the first QFD, and the other matrices were formed. In the final stage, the DOE method was implemented. The development process is presented in Fig. 3, and more details are given in the following section.

4. RESULTS AND DISCUSSION

Here is a step-by-step account of how DOE can help QFD throughout the different phases of an NPD process.

4.1 Step 1: New product strategy phase

It links the NPD process to the company objectives and puts a focus on idea/concept generation and guidelines for establishing screening criteria. The company objective is to produce a new product for children. The target market is made up of the children in the city of Yazd, aged between 5 to 10 years.

4.2 Stage 2: Idea generation phase

The study uses morphology analysis (MA) at this step. The basic procedure of MA as stated by Yoon and Park (2007) is as follows. First, the fundamental functions of the subject are defined. At this step, the features of the subject are broken down into several attributes. The next step is to list all possible levels at which each attribute can manifest itself. Third, all combinations that can produce unique sets of levels are investigated. The number of combinations can be calculated by multiplying the number of levels of each attribute by those of the other attributes. The fourth step is an attempt to find practical instances for each combination. The final step is to eliminate infeasible combinations and list the remaining combinations in the order of importance. In the present case study, the team of authors created an initial morphology matrix (Table 1) and interviewed experts about a new idea. The team chose seven new ideas including a) Tahini ice cream, b) sesame snack, c) chocolate sesame, d) flavored roasted sesame seeds (for example, flavored with pepper, etc.), e) flavored Tahini (using sour fruits like cherry, etc.), f) a combination of nuts and Tahini, and g) cookies with Tahini or Tahini Halva core.

Table 1. Morphology matrix of sesame products

Functional		*Structural*								
Product	Serving	Consistency	Taste						Color	Size
			Spice	Nut	Fruit	Vegetable	Extra			
Tahini	Breakfast	Solid	Peppery	Peanut	Pineapple	Garlic	Honey		Dark	20 gr
Halva	Lunch	Concentrated	Curry	Walnut	Strawberry	An onion	Candy		Bright	50 gr
Tahini + Halva	Supper	Diluted	Salty	Pistachio	Peach	Cabbage	Rosewater		Beige	100 gr
Halva + sesame seeds	Dinner	Liquid	Cinnamon	Almond	Orange	Spinach	Cheesy		Bright yellow	200 gr
Tahini + sesame seeds			Zafarani	Hazelnut	Pomegranate	Tarragon	Pizza		Yellow	500 gr
			Cumin	Cacao	Apricots	Chamomile			Brown	1 kg
			Sumac		Banana	Mint				2 kg
			Nigella sativa seeds		Raisins	Coriander				5 kg
			Ginger		Grapes	Basil				
			Marjoram		Figs	Fenugreek				
			Thyme		Cherry	Torre				
					Watermelon	Parsley				
					Talebi	Radishes				
					Sour orange	Bell peppers				
					Raspberry	Mushrooms				
					Coconut	Satureja				
					Apple	Tomato				
					Kiwi	Cucumbers				
					Pear	Celery				
					Lemon					

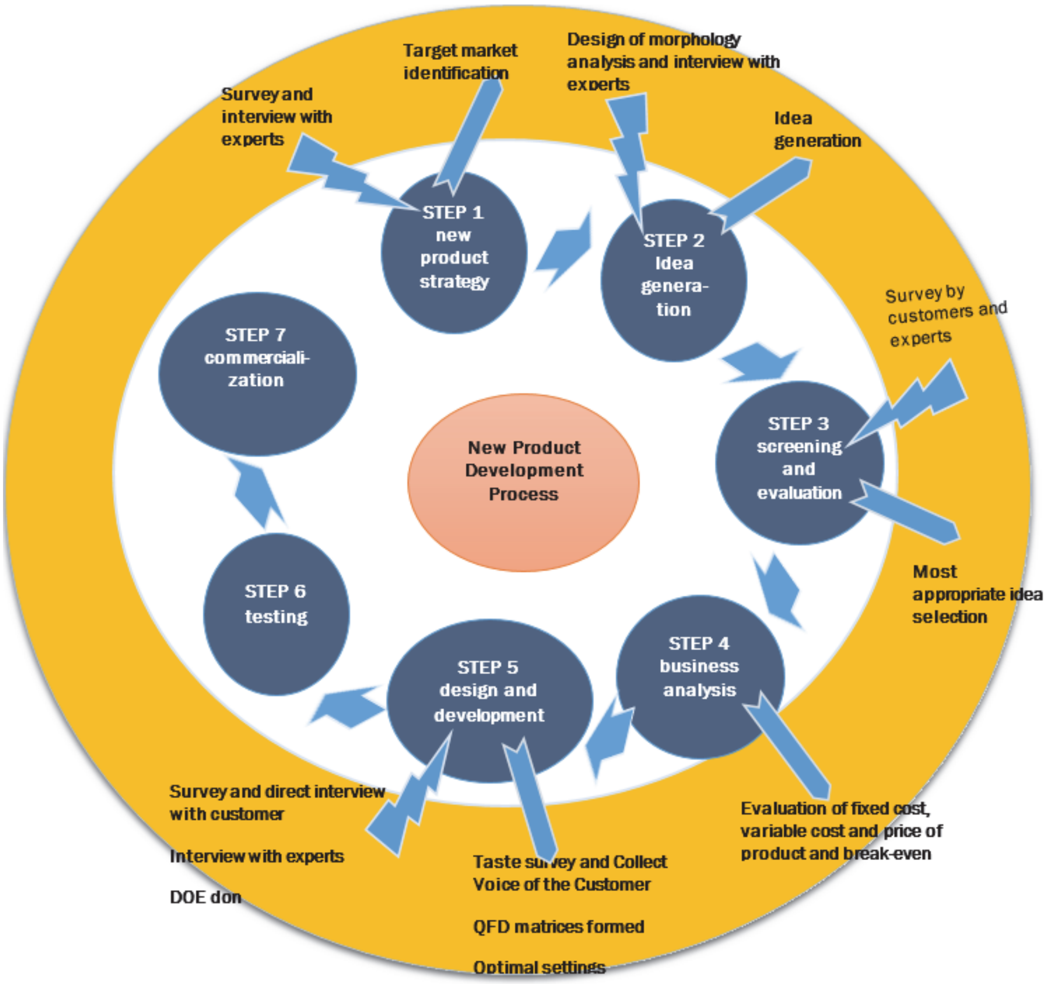
4.3 Step 3: Screening and evaluation phase

A survey was performed with 384 respondents in the city of Yazd. It was intended to measure the tendency of consumers for seven new ideas. At the end, chocolate sesame proved to be a high priority for the consumers. Different combinations of chocolate sesame were produced using a trial and error method. The best combinations are shown in Table 2.

Table 2. Selected combinations for the taste poll

Number of combinations / Combinations	1	2	3
Sesame (%)	66	66	66
Chocolate	White	Cacao	Coffee
Chocolate + Coconut paste + Emulsifier (%)	34	34	34

Figure 3. Process of the new product development



A test was conducted on the taste of customers. As many as 382 respondents aged between 5 and 10 took part in the survey and expressed their opinions about a product combined with white chocolate. The product, indeed, turned out to be a high priority for those children. The voice of customers in a case study such as this actually regarded the quality improvement of a white chocolate sesame product. Along with a taste survey of the customer's voice and its significance, QFD data were collected in the first matrix.

4.4 Step 4: Business analysis phase

Break-even analysis is a tool commonly used by industrial marketers. It is utilized for a wide variety of purposes in virtually all types of decision making. In our study, break-even analysis was used for this phase. Fixed cost, variable cost and price of the product were evaluated, and the break-even point was calculated.

Fixed cost = 250000000 (Rial), variable cost=1600 (Rial), price = 2000 (Rial)

Quantity = 625000

The result indicates that a firm can reach a profit after producing 625000 units of the products.

4.5 Step 5: Design and development phase

QFD is a method for structured product planning and development that enables a development team to specify the consumer's demands and needs and to evaluate the proposed product systematically in order to determine its impact on meeting these needs. The QFD method consists of the construction of one or more matrices. Also, DOE is employed to determine the effect of variables on the process.

According to Kowalska et al. (2015) research The main input of QFD is the data on the customer's requirements generally extracted from direct interviews and surveys. Lui et al. (2016) in their research collected the needs of customers through surveys and questionnaire, Also Jia et al. (2016) explains in his research that customers' needs and voice can be achieved through the user surveys or online-interviews to focus groups.

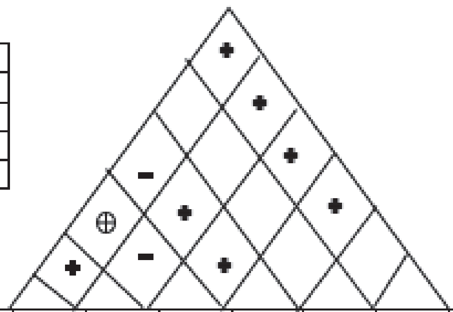
Therefore, based on Kowalska et al. (2015), Jia et al. (2016) and Lui et al (2016) studies, the material of this study was collected by questionnaires and direct interviews in which the respondents determined their preferences and evaluated the suggested parameters with regard to the quality of chocolate sesame. Also, the respondents in taste surveys of the products in addition to the product test table 2.

Commented on the quality, appearance and stability of the whole on the basis of 1-10 and also expressed their wants and also highlighted the importance of each of these demands. In the next stage, according to the roadmap (food deployment), HOQ and two next matrices were completed. For this purpose, the results of a brainstorming session were used as a way of group exploration of new ideas to solve problems. During the study session, the participants were free to raise any number of custom solutions, then evaluate all of the proposals, and make their selections. Figures 4, 5, and 6 present the diagrams of matrices

Figure 4. The House of Quality for chocolate sesame (Phase I) showing the customer's demand, the product requirements and the relationship matrix

Correlations	
Strong●	+9
Medium○ +3	
Weak +1	Δ

Relationships	
Strong positive	⊕
Positive	✚
Negative	▬
Strong negative	⦸



	Technical parameters / Customer requirements	Sesame	Paste Coconut	White chocolate	Emulsifier	Template	Time of mix	Important to customers
Quality Characteristics	Be tonic	●	○	○				6
	Good taste	●	●	●			○	10
	Pleasant smell	○	●	●				6
	No bitter-taste	●	△	△				8
Appearance characteristics	Natural color	○	○	●				5
	Be Smooth surface			○		○		4
	Be Appropriate size					●		4
	Be patterned					●		5
	Be soft	○	△	○	○		●	6
Reliability characteristics	No corrosion				○			6
	Good adhesion				●			6
	Be Fresh	○	△	○				7
	Be Good shelf life	○	○	●	●		△	5
Target value		66%	8%	25%	1%	……	(15-20)min	78
Weight		303	213	311	135	93	89	1144
Normalized weight		26	19	27	12	8	8	100

Figure 5. Ingredient and process planning matrix for chocolate sesame

			Chocolate process				*Coconut process*			*Sesame process*				*Emulsifier Process*
Technical parameters	Target value	Weight	Chocolate melting point	Control of chocolate melting tank temperature	Control of melting time	Control of conditions of raw materials	No space between two millstones	Speed rotation of millstone	Control of conditions of raw materials	Sesame variety	Control of conditions of raw materials	Control of oven temperature	Control of cooking time	Control of Emulsifier temperature
Sesame	66%	26								☐	☐	☐	☐	
Paste coconut	8%	19					☐	☐	☐					
White chocolate	25%	27	☐	☐	☐ ☐	☐	☐							
Emulsifier	1%	12												☐
	Target value		37-40°C	40-45°C	60min	24°C	1-1.5 mm	40-45	24°C	---	24°C	500-700°C	16-20h	60-70°C
	Weight		288	96	96	96	69	207	69	279	93	93	279	126
	Normalized weight		16.1	5.4	5.4	5.4	3.9	11.5	3.9	15.5	5.2	5.2	15.5	7

Figure 6. Production planning matrix for chocolate sesame

		FMEA				Needs of planning									
		Occurrence	Severity	Detectability	Risk priority Number	Action to prevent failure	Methods to avoid errors	Review instructions quality control unit	Increasing the number of quality control staff	Training of quality control's stuff	Qualitative improvement of equipment's quality control unit	Measurement system analysis (MSA)	Preparation of control charts	Careful selection of raw material suppliers	Increasing the amount of product sampling
Chocolate process	Chocolate melting point	3	3	2	18			☐	☐	☐	☐			☐	☐
	Control of chocolate melting tank temperature	2	3	1	6	☐ ☐ ☐	☐ ☐ ☐	☐ ☐ ☐	☐ ☐ ☐	☐ ☐ ☐	☐ ☐ ☐	☐ ☐ ☐	☐		☐
	Control of melting time	3	1	3	9	☐	☐	☐	☐	☐	☐	☐	☐		☐
	Control of conditions of raw materials	2	2	2	8	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Coconut process	Control of conditions of raw materials	2	2	1	4	☐	☐	☐	☐	☐	☐	☐			☐
	The filter of millstone	3	2	1	6	☐		☐	☐	☐	☐	☐	☐		☐
	Speed rotation of millstone	2	2	2	8	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Sesame process	Sesame variety	2	3	3	18			☐	☐	☐	☐			☐	☐
	Control of conditions of raw materials	2	2	2	8	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	Control of oven temperature	3	2	2	12	☐	☐	☐	☐	☐	☐	☐	☐		☐
	Control of cooking time	3	3	3	27	☐	☐	☐	☐		☐	☐	☐		☐

Cooking time, sesame variety, and chocolate melting point are the most important features (i.e. their risk priority is high). So, they were chosen as DOE design parameters.

4.6 Taguchi method of experimental design (TMED)

Taguchi method was developed by Genechi Taguchi (1950) in Japan in the 1950s. It promoted statistical techniques of quality evaluation from an engineering perspective (Tanco*et al.*, 2009). Taguchi method was originally recommended to improve the quality of products by applying statistical and engineering concepts. This approach is based on two fundamental concepts. The first one is that quality losses must be considered as deviations from the goals, not as conformities with arbitrary specifications. The second concept is that, to obtain high system quality levels economically, quality must be worked into the product (Mamourian*et al.*, 2016). The following case study is carried out by implementing a ten-step procedure based on Taguchi's parameter design methodology. The study illustrates an application of TMED to develop a new chocolate sesame product. The quality of this product is measured by "Peroxide". There are ten steps in a systematic approach to the use of Taguchi's parameter design methodology (Antony *et al*., 2006). The steps are as follows:

- Determining the nature of the problem and setting the objective(s) of the experiment: The amount of peroxide must be measured (<= 3). Hence, in this study, the following objectives were set by the team:
- . Which of the design parameters affects variability in "peroxide"?
- . What is the optimal condition to achieve the desired performance for "peroxide"?
- Selection of quality criterion: For the present case study, "peroxide" is the quality criterion which is critical to customers.
- Selection of design parameters: Prior to a thorough QFD session, four design parameters are identified.
- Classification of design parameters into control, noise and/or signal factors: In this case study, all the design parameters were classified as control factors.
- Determining the levels of design parameters and their ranges for the experiment:As a part of the initial investigation and to minimize costs associated with the study, it was decided to study each design parameter at two levels.
- Interaction of interests of the team: Interaction occurs when the effect of one design parameter on the quality characteristic of a product is different at different levels of another design parameter. For example, the sesame variety is heavily influenced by its cook time. Then there is an interaction between these two parameters.

For this study, the team investigates an interaction. Table 3 presents the list of four design parameters (control factors) along with their ranges chosen for the experiment.

Table 3. Factors and their levels

Factors	Level 1	level 2
Sesame variety (A}	Larry	Sudanese
Sesame cook time (B)	3h	4h
Interaction (A*B)	---	---
Chocolate melting point (C)	37 c	40 c

- Choosing an appropriate orthogonal array (OA) for the experiment: The selection of an OA depends on the degrees of freedom associated with the interaction effects, design resolution, objectives of the experiment and, of course, cost and time constraints. The degree of freedom is 4 with regard to the three main parameters of designing and one interactive effect. The most suitable OA to meet this requirement is an 8-trial experiment (L8 OA). That is shown in Table 4.

Table 4. L_8 orthogonal array (levels of four different factors and obtained results)

Experiment number							Peroxide		
	A	B	C	A	B	C	RUN		
							Replicate 1	Replicate 2	Replicate 3
1	1	1	1	Larry	3h	37	2.7	2.8	2.65
2	1	1	2	Larry	3h	40	2.9	2.9	2.80
3	1	2	1	Larry	4h	37	2.3	2.5	2.45
4	1	2	2	Larry	4h	40	1.8	2.0	2.10
5	2	1	1	Sudanese	3h	37	2.0	2.3	2.50
6	2	1	2	Sudanese	3h	40	2.5	2.7	2.70
7	2	2	1	Sudanese	4h	37	1.0	1.5	1.30
8	2	2	2	Sudanese	4h	40	1.7	1.7	1.50

- Conduct experiments:Conduct the experiment based on the pre-prepared experimental layout showing all the experimental trial conditions.
- Perform a statistical analysis: The analysis was carried out using Minitab software (Minitab version 16.0). The first step was to compute the signal-to-noise ratio (SNR) corresponding to each experimental trial condition. SNR is a measure of robustness. The higher the SNR, the greater the performance. The SNR for Smaller is better quality characteristic is calculated using the equation provided in Roy (2001). Table 5 presents the computed SNR values for all the eight experimental trials. Then, determine the best design parameter settings, predict the optimal condition, and establish a confidence interval for the predicted response or quality characteristic (see Tables 6 and 7). Also, the plot of the main effects for SNR is shown in Figure 7. This plot is most useful when there are several designs or process parameters to be studied.

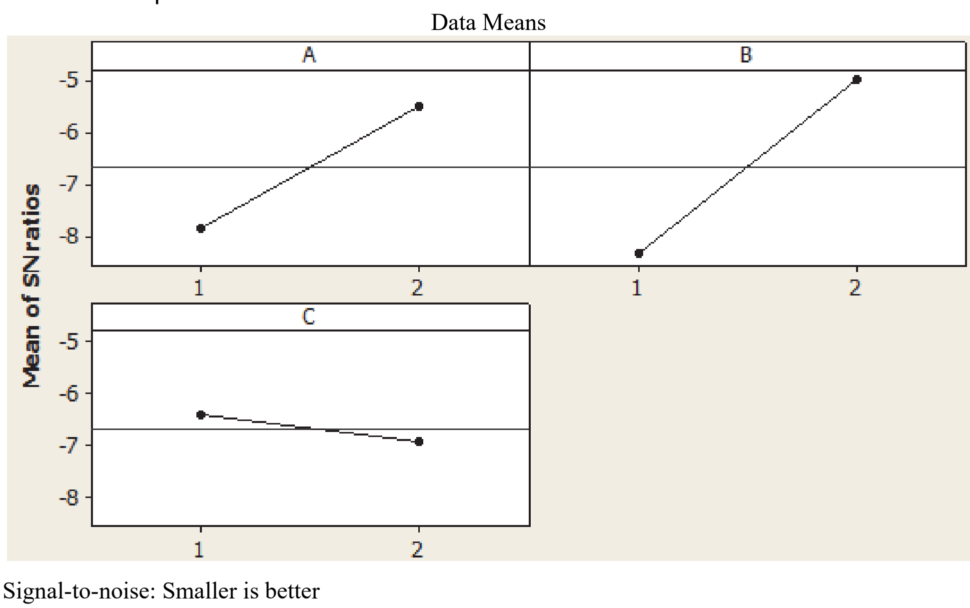
Table 5. Results of mean and SNR

Experiment number	A	B	C	Peroxide			Mean	S/R ratio
				RUN				
				Replicate 1	Replicate 2	Replicate 3		
1	Larry	3h	37	2.7	2.8	2.65	2.71667	-8.68301
2	Larry	3h	40	2.9	2.9	2.80	2.86667	-9.14872
3	Larry	4h	37	2.3	2.5	2.45	2.41667	-7.66970
4	Larry	4h	40	1.8	2.0	2.10	1.96667	-5.89205
5	Sudanese	3h	37	2.0	2.3	2.50	2.26667	-7.14330
6	Sudanese	3h	40	2.5	2.7	2.70	2.63333	-8.41568
7	Sudanese	4h	37	1.0	1.5	1.30	1.26667	-2.16606
8	Sudanese	4h	40	1.7	1.7	1.50	1.63333	-4.27594

Table 6. Average effect response for signal-to-noise ratios

Factor	A	B	C
Level 1	-7.848	-8.348	-6.416
Level 2	-5.500	-5.001	-6.933
Delta	2.348	3.347	0.518
Rank	2	1	3

Figure 7. Main effects plot for SN ratios



Given that the response variable has the feature "The less, the better", so, according to Table 6 and Fig. 7, factors A and B have a better performance on the second level, and factor C is optimized on the first level. In other words, the use of chocolate with a melting point of 37 ° C and Sudanese sesame baked in the oven for four hours shows a lower peroxide value (i.e. the S / N ratio is greater). Thus, the optimal condition is A2B2C1.

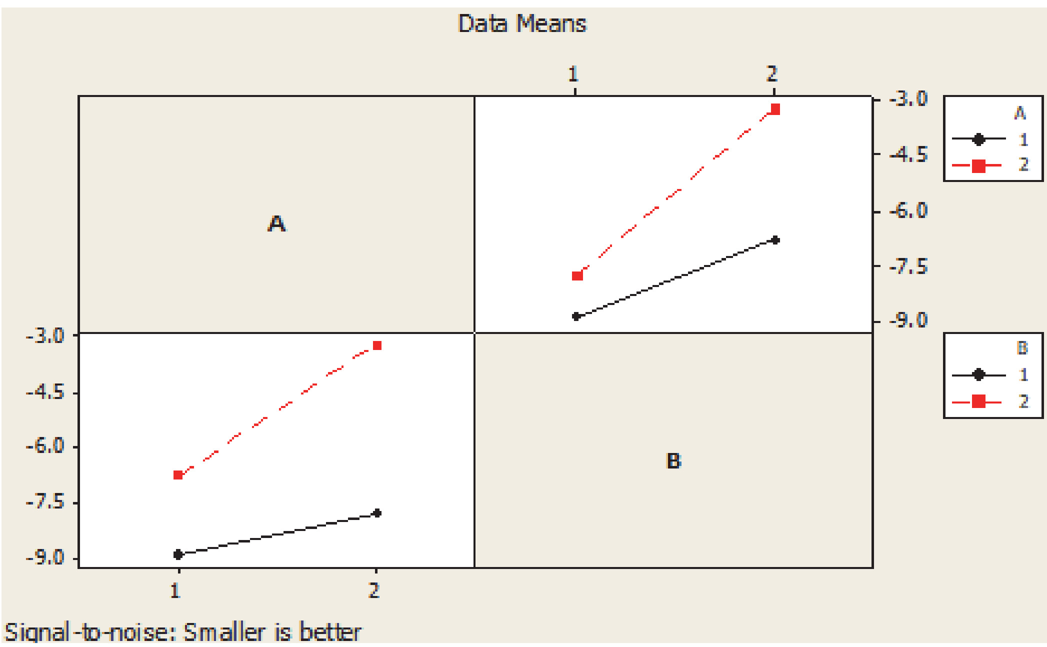
Table 7. Pooled ANOVA analysis of signal-to-noise ratios

Factors	DF	Sum of squares	Variance	F	Percent (%)
Sesame variety (A)	1	11.0274	11.0274	9.345	23.96
Sesame cook time (B)	1	22.4013	22.4013	18.984	51.65
Interaction (A*B)	1	2.9367	2.9367	2.489	4.27
Chocolate melting point (C)	(1)	(0.5358)	Pooled		0
All others/error	4	4.7238	1.18		20.12
Total	7	52.816			100.00

Also, the contribution of the ratio of each factor in the table of the Analysis of Variance for SN ratios shows the effectiveness of that factor. With regard to the percentages in Table 7, cooking time of sesame and sesame variety have significant effects on the results, so they were taken into account for the quality improvement. The less effective factor C (i.e. melting point of chocolate), due to its low share of participation and in order to correct the degree of error freedom, is integrated with the error.

According to Fig. 8, there is a poor interaction between the cook time and the variety of sesame. This implies that the effect of sesame variety on SNR is different at different cook times.

Figure 8. Interaction plot for SN ratios



– Performing a confirmatory experiment and implementing the results

A confirmatory experiment is performed to verify the optimal settings of the design parameters and to see whether or not the optimal condition derived from the experiment actually leads to an improvement in the product quality. If the results from the confirmatory experiment are conclusive, a specific action on the product or process must be taken for making improvements. On the other hand, if unsatisfactory results are obtained, further investigation of the problem may be required. As for the present study, an experiment was conducted with about three times, and the results were acceptable each time.

4.7 Step 6 and step 7: testing and commercialization phases

It is necessary to do advertising and financing in order to implement the two-step process for development of the new product development. In addition, for market testing and commercialization of the product, it is needed by the company to spend time and invest funds. Since the aim of this study is to achieve a basic layout of the new product, the two mentioned steps are vested in the company so that the necessary investment will be made on the plan after completion of the study.

CONCLUSION

The qualitative methods of creating new products have been progressing a lot for several years. Nowadays, rules of creativity are better codified and less chaotic than before, thanks to well-structured phases. In this article, we have described a process which systematically integrates QFD with DOE and makes effective and systematic technical innovations possible for new products. It is clear that this integration is both possible and necessary. Historically, separation of QFD and DOE has had disadvantages; products or services developed according to the customer's needs are not robust, and even if robust, they do not meet the customer's needs (Sheng *et al*., 2002).

Using QFD and DOE methods, an analysis of the data showed that there does exist a chance of producing a food product. This was confirmed in this study; it was shown that chocolate sesame, as a type of sesame product, can meet the demands of consumers, and, at the same time, meet the requirements of nutritionists and technologists.

The analysis also showed that the major parameters that account for the quality of the finished chocolate sesame and are preferred by consumers are the cook time and the variety of the sesame product. This means that consumers need a product which is characterized by a natural color, nutritious ness, a good taste, a pleasant smell, a good shelf life, no bitter taste, being patterned, softness, no corrosion, good adhesion, and freshness. Also the results showed that cooking time, sesame variety, and chocolate melting point are the most important processes, thus so much attention to these factors and controlling sesame baking time and chocolate melting point, the product will provide higher quality.

The optimal settings are those which provide the best performance based on the data obtained from the experiment. For the present case study, we need to choose the best settings of critical design parameters obtained from the plots of main effects and interaction effects. Based on these plots, the optimal settings are determined as:

a. Sesame variety = Sudanese

b. Sesame cook time = 4hours

c. Melting point of chocolate = 37°C

So the use of chocolate with a melting point of 37 ° C and Sudanese sesame baked in the oven for four hours will provide the product higher quality and lower peroxide that based on the optimal settings of above design parameters, peroxide is close to the desired performance of 1.54.

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