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Food Product Design According to the Market Taste

Master of Science Thesis

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ABSTRACT

Food product development has always been a cause concern for the active companies in the food industry. Rapid technological advance provides food companies the ability to introduce a variety of new products to the market. However, the big concern is about the success rate of what is introduced as a new product to the market. Many methods, in product development, have been utilized by different food companies, while just a few concentrated on food products. Owing different characteristics from other industrial products raises the need to a bright guideline of improvement for food products. Studying different development procedures in this thesis, a method is proposed with the specialty in development of foods. The method uses the market research outcome to design an optimized product.

Key Words: Food Development, Food Product Development, Food Quality, Food Design, Food Marketing, Product Development Methodology, Food Optimization, Product Optimization, Sensorial Analysis

ACKNOWLEDGEMENTS

To all ones in support…

Contents

1 INTRODUCTION

This chapter introduces the background of the thesis and the reasons of interest. Further, the problem area is discussed to elucidate the case under study. This will be followed by purpose, method and delimitation of the master thesis.

1.1 Background

Product development as a part of business strategy has always been at the heart of the food industry. In the last century because of the rapid technological changes many new foods has been introduced to the market. To direct the product development the marketers started to cooperate with the recipe developers. R&D department and Marketing department were configured to speed up the development process. (Earle, 1997) Since then, a wide range of product development factors has been influential in product success and failure. (Stewart-Knox, et al., 2003) An example is a gap between two departments that resulted in product failure in many cases. While scientists were concerning about new processes and technologies without considering consumers' needs, marketers were looking for only the market needs neglecting the technical possibilities. (Earle, 1997)

Introducing a unique and superior product, recognizing consumer wants and preferences, having effective communication between product development team personnel, taking the advantage of top management support, and effective product marketing and launch were the effective factors in success of a product during the late 1970s according to Calatone and Cooper. (Stewart-Knox, et al., 2003) However, in the later1990s, using cross-functional teams was found much effective on product prosperity. It is of the essence to have communication between the different team members, particularly between technical and marketing personnel. An original product idea, in addition to a comprehensive market research and careful planning at the concept stage of product development as the result of such interdisciplinary team could potentially prevent problems arising elsewhere in the product development process. (Stewart-Knox, et al., 2003)

The food product development process has been difficult to define and model. (Rudolph, 1995) Nevertheless, different approaches try to make recommendations on how to modify the existing food products or how to define new food products to satisfy consumers' liking perceived through information collected by the marketers. (Trijp, et al., 2007) To find a proper procedure in food product development it is important to understand the meaning of quality from the view of the market. Different definitions of food quality could be made while asking people consumer by consumer. (Moskowitz, 1995) A simple outline of a consumer research method is composed of factors and parameters in general. The factors originate in product characteristics like formulation and package that stimulate the five senses resulting in unconscious cognitive processes. The parameters include the values, beliefs, expectations and mood of individual. Having any change in parameters will result in a different response even if the same combination of factors exists. Where individuals are exposed to specific stimuli in several sessions, the results could be different in subsequent sessions from before. (Oliveira, 2003) That is, depending upon the product and situation the use of the word "quality" may differ by the same consumer.

Notwithstanding the fact that people are not able to define what exactly quality means or what aspects represent quality, they have an internal indicator of quality. Despite the variation in the definition of quality, a consistency in people behavior is interesting. Consumers acknowledge that quality surpass the individual aspects of a product e.g. flavor, texture and appearance while applying it to the entire product. (Moskowitz, 1995) To have a product entirely acceptable from the market view, intrinsic and extrinsic attributes should be taken into consideration. Intrinsic attributes represent the characteristics of food e.g. flavor and texture satisfying the human feelings such as taste, smell and touch. On the other hand, extrinsic attributes deal with the characteristics like contents described on the package or advertisement as cognitive factors of pleasantness meeting the human feelings such as eyesight and hearing. (Ikeda, et al., 2004) Accordingly, in design of a food product two major steps are to be taken: food design and package design.

Many companies lack a new product guide to help managing the process. Just a few companies situate their product development process on literature-based models. (Rudolph, 1995) Furthermore, the conventional methodologies and tools used for industrial products are not functioning the same way once facing food products. Quality Function Deployment (QFD) that is a famous tool in product development is a good example in this way. Many QFD applications have not gone much beyond making a House of Quality matrix (Oliveira, 2003). While using the tool the concentration is mostly on the factors and relationships amongst rather than any outcome about the final product.

Therefore, in this master thesis, different methods are studied to draw out a practical way to design a food according to the information prepared by the marketing department. On account of the fact that all different methodologies applied for food optimization believe in the existence of an ideal product even if most of them agree that it may differ between consumer segments, (Trijp, et al., 2007) a process to seek the optimum product is designed.

1.2 Problem Area

First, it was in a dairy company in Iran the problem was faced. To design a specific product it was the chef suggesting a recipe with the hope of being successful in the market. Many products failed with such trial and error system. R&D department then started to make some sensorial analysis to develop the products. However, the result of such experiment was not useful since there was no direction in their final suggestion. As an illustration, the result of a survey asking about the sweetness of a product from customers just showed if the product is good or bad in that specific characteristic while not addressing to what extent. Moreover, the way to make the improvement and the direction to move towards was unknown. How to change the primary suggested formula to satisfy the customer opinion was not evident in that way. Therefore, the question came to mind how to define a well-structured procedure for food product development while satisfying the customer taste.

1.3 Purpose

The purpose of this master thesis is to define a practical methodology in food product development to design a food conforming to the taste of market.

1.4 Method

A main method to conduct this research would be literature study using credible references. Moreover, some information has been captured through different interviews with the experts.

1.5 Research Questions

To fulfill the purpose, this research aims to answer the below questions:

- Which method is suitable to be utilized in design of a food product?
- How the marketing research outcome could be used in a food design?
- How a food product could be designed to satisfy the market taste?

1.6 Delimitations

The idea about this project first came to mind while visiting a company in Iran. It was supposed initially to make this research in collaboration with the company and implement it successively. Many meetings and discussions were taken place before and after the thesis commencement. After months of research and study, the presented results were appreciated in the company. Unfortunately, because of many bureaucratic problems, no deal was made to perform the research outcome. The thesis, therefore, is an academic paper, even though there is a great potential for a practical experiment. Furthermore, different locations of university, living place of supervisor and the site of performing research were to somewhat problematic in this thesis. While Chalmers University is located in Sweden and the supervisor was in Italy, the research was made in Iran.

2 FRAME OF REFERENCE

This part contains the theories being utilized in this research. The chapter covers key concepts such as Sensorial Analysis, Design of Experiments and Response Surface Methodology.

2.1 DOE

Experimental design methods are used to improve process performance or obtain a robust process intensive to external noises. The objectives of the experiment could be determining the most influential variables on the response, setting the influential variables so that the response is near the nominal requirements, setting the influential variables so that variability in the response is small, or setting the influential variables so that the effects of the uncontrollable variable are small. Different steps should be taken in the procedure of designing an experiment:

- Recognition of the problem
- Choice of factors and levels
- Selection of the response variables
- Choice of experimental design
- Performing the experiment
- Data analysis
- Conclusions and recommendations

Having several factors of interest in an experiment, a factorial design is used in which the factors are varied together. In other words, in a factorial experiment, all possible combinations of the levels of the factors are investigated in each replicate. The 2^k factorial design that is a factorial design with k factors is one of the most important and basis of many other useful designs. An example in using the 2^3 design is illustrated in table 1 showing different required combinations of all three factors. (Montgomery, 2005)

Table 1: Signs for effects in the 2^3 design (Montgomery, 2005)

Treatment Combination	**Fractional Effect**							
	I	A	B	AB	C	AC	BC	ABC
(1)	+	-	-	+	-	+	+	-
A	+	+	-	-	-	-	+	+
B	+	-	+	-	-	+	-	+
Ab	+	+	+	+	-	-	-	-
C	+	-	-	+	+	-	-	+
Ac	+	+	-	-	+	+	-	-
Bc	+	-	+	-	+	-	+	-
Abc	+	+	+	+	+	+	+	+

To analyze the factorial experiments the experimenter should respectively

- Estimate the factor effects
- Form preliminary model
- Test for significance of factor effects
- Analyze residuals
- Refine model, if necessary
- Interpret results

To run all of the observation in 2^k factorial design under homogeneous conditions is sometimes impossible. To eliminate any unwanted variation, blocking as a perfect technique is often employed. The 2^{k-p} fractional factorial design is a result of turning a 2^k design into a $\frac{1}{2p}$ fraction using blocking and confounding techniques where confounding is a technique causing certain interactions to be indistinguishable. Table 2 illustrates blocking in a 2^3 design. (Montgomery, 2005)

Table 2: Blocking in a 2^3 design (Montgomery, 2005)

Run	**Fractional Effect**							
	I	A	B	C	AB	AC	BC	ABC
A	+	+	-	-	-	-	+	+
B	+	-	+	-	-	+	-	+
C	+	-	-	+	+	-	-	+
Abc	+	+	+	+	+	+	+	+
Ab	+	+	+	-	+	-	-	-
Ac	+	+	-	+	-	+	-	-
Bc	+	-	+	+	-	-	+	-
(1)	+	-	-	-	+	+	+	-

2.2 RSM

Response surface methodology is a way to model and analyze the problem, using a collection of mathematical and statistical techniques with the aim of optimizing the response. The objective of RSM is to determine the optimum operating conditions for the system. A response surface is usually depicted graphically as seen in figure 1. A counter plot in figure 1 contains lines of constant response.

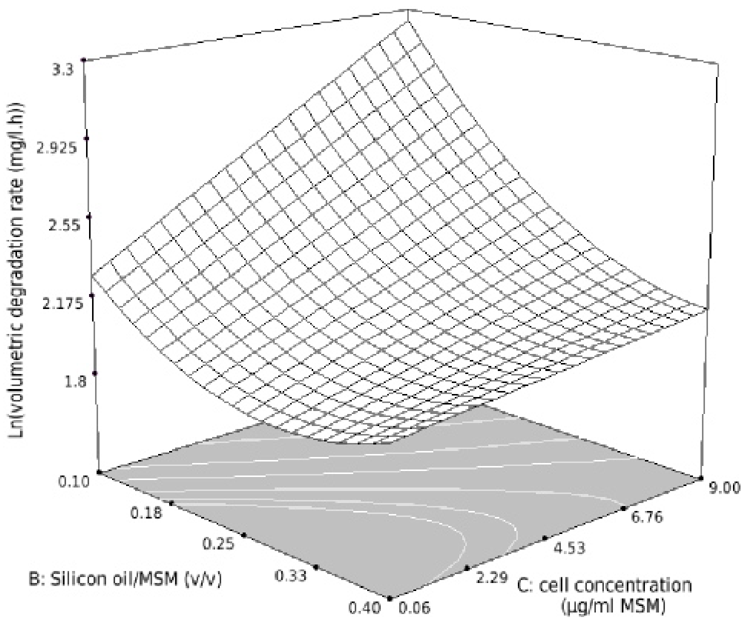

Figure 1: A three dimensional response surface

The first step in RSM is finding a suitable approximation for the functional relationship existing between y (response) and set of independent variables. Being well modeled by a linear function, the approximating function as a first-order model would be:

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_k x_k + \epsilon \quad \textbf{(1)}$$

Where ϵ represents the experimental error observed in the response y.

Having a curvature in the system, a polynomial of higher degree like a second-order model would be suitable:

$$y = \beta_0 + \sum_{i=1}^{k} \beta_i x_i + \sum_{i=1}^{k} \beta_{ii}\, x_i^2 + \sum_{i<} \sum_j \beta_{ij} x_i\, x_j + \epsilon \quad \textbf{(2)}$$

It is almost improbable to have a polynomial model as an approximation of a true functional relationship over the entire space of the independent variables; however, for a small region it functions properly.

RSM is a sequential procedure since the working point on the response surface is usually far from the optimum, making us to move along a path of improvement toward the region of the optimum, employing a first order model. Once finding the region of the optimum, a more complicated model like a second-order one is suitable to be analyzed to locate the optimum.

By proper choice of an experimental design, fitting and analyzing response surface is considerably facilitated. The most popular design used for fitting a second-order model is the central composite design (CCD). (Montgomery, 2009) A CCD with k factors generally consists of 2^k factorial runs, $2k$ axial runs, and about 3 to 5 center points. (Montgomery, 2005) Figure 2 shows the CCD for k=2 and k=3 factors.

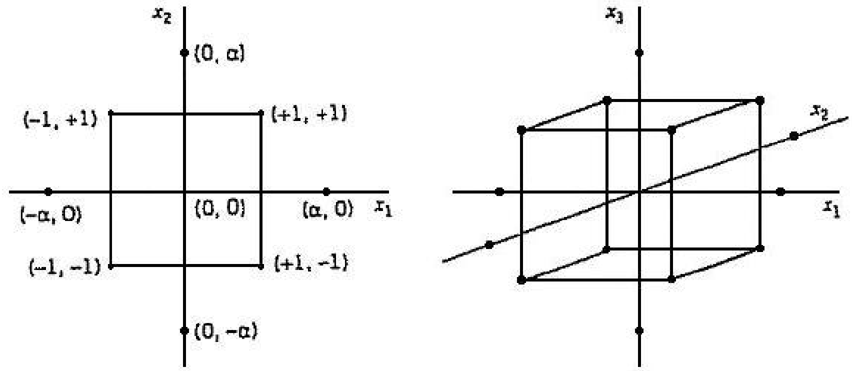

Figure 2: Central Composite Design for k=2 and k=3 factors (Montgomery, 2005)

While design of CCD, two parameters, the distance α of the axial runs from the design center and the number of center points n_c, are of the essence to be taken in to consideration. Center runs are to provide reasonably stable variance of the predicted response. Appendix 1 shows the appropriate value of α and n_c for different amount of k. To eliminate nuisance factors it is often necessary to consider blocking while using a response surface design. The spherical CCD, the Box-Behnken design and face-centered CCD are the other possible designs to be chosen to take a proper strategy. (Montgomery, 2009)

2.3 Sensorial Analysis

"Sensory analysis is a method, which uses human senses - the sense of sight, hearing, smell, taste, and touch - as instruments of measurements. In other words, differences between products, the intensity of a quality, or the degree of preference for a product, are measured by the senses." (Bech, et al., 1994) "This tool is utilized to provide complete information on product differences, product perception, and on how preferences are related to product perception and to ingredient and process variables." (Koeferli, et al., 1998)

The basic aim of sensory analysis is to supply information for the decision-making process that means the decisions about a product's sensory attributes, appearance, smell, taste, and consistency in food industry. The risk of introducing a new product and maintaining the existing ones would be kept down with the aid of sensory analysis. (Bech, et al., 1994)

Three different targets can be followed by using sensory analysis: differentiating between two products, providing a detailed description of the product's attributes, and finding the consumer preference named respectively: Discriminative analyses, Descriptive analyses, and Affective test. According to ISO13299-2003" a sensory profile is a description of the sensory properties of a sample, comprising the sensory attributes in the order of perception, and with assignment of an intensity value for each attribute."

To establish a sensory profile various steps should be taken:

1. Establishing a sensory facility like area
2. Selecting products showing the range of attributes
3. Training the assessors
4. Attributes selection
5. Selecting the scales of intensity
6. Training the assessors to use the selected attributes and scales
7. Conducting the test
8. Reporting the results (ISO13299-2003)

3 RESEARCH METHOD

This chapter introduces the method employed in this master thesis. The research strategy is described first, followed by the sections illustrating the ways to collect data and research design. This chapter concludes in a discussion about validity, reliability and generalization in this thesis.

3.1 Research Strategy

Goddard and Melville (2007) identified different types of research as: Experimental, Creative, Descriptive, Ex Post Facto, Action, Historical, and Expository Research. Creative research is a research to develop new theories, procedures and inventions. Both practical and theoretical researches are included in this type of research. While practical creative research focuses on design of physical objects and development of real world processes, theoretical creative research is about innovation in models, theorems and algorithms. (Goddard, et al., 2007)

As the first step, the aim of doing this master thesis was defined. A theoretical creative research was made thereafter to draw out a methodology in food product development as the purpose of this project. Literature review through credible journals and reference books is the major approach to conduct this research. Almost every literature has been interpreted rationally to a stepwise procedure. Furthermore, some information has been captured through different interviews with the experts. That is, managers and specialists in marketing and R&D departments of the company were questioned through semi-structured interviews. Some questions could be found as samples in appendix 2. The next step was thinking, reasoning, comparison between different concepts and judgment, leading to observe the drawbacks and take the advantages of every studied method. The methodology design is the final step in this thesis. However, it is recommended to make a practical experiment to test the proposed methodology as a continued research.

According to Shields (2003) when there is a need to measure something, quantitative research methods are utilized; on the other hand, when it is needed to describe and investigate a question thoroughly, qualitative methods are employed. Qualitative data such as interviews' outcome and subjective analysis deal with the qualitative dimension of this thesis. However, the need to precise measurement and statistical data analysis shows the quantitative aspect regarding this project.

3.2 Data Collection

Both primary and secondary data comprise the collected data. Semi-structured interviews are the main sources of primary data; however, the main source of secondary data is literature study.

3.3 Research Design

A researcher may tackle a problem in the form of induction or deduction. While induction proceeds from particulars e.g. observations, measurements, and data to generalities e.g. governing rules, laws, and theories as a reasoning progression, deduction moves in the opposite direction. Induction is the natural human learning style to infer principles, whereas deduction is the natural human teaching style to deduce consequences. (Felder, et al., 1988) This thesis work is built to a large extent on a deductive reasoning since the consequences of using scientific theories are taken the advantage of to make the desired final result.

3.4 Validity, Reliability and Generalization in the Thesis

Reliability means the degree of consistency between two measures of the same thing (Merhens, 1987); in other words, to what extent a methodology of investigation might give the same results under the same conditions at different occasions. (Bell, 1993) It is important to notice that reliability is not measurable; however, it should be estimated.

On the other hand, "Validity is the best available approximation to the truth or falsity of a given inference, proposition or conclusion." (Cook, et al., 1979) That is, to what extent we are right. From the other point of view, validity is the degree of accomplishing the purpose (Worthen, et al., 1993)

In this thesis, to reach an objective, with a worldwide use, a procedure is proposed with the knowledge-based steps. Literature study was the main source in defining every step. Efforts have been made to increase the validity through utilizing valid sources. On the other hand, although testing the same products using identical market segment in different times might result in totally dissimilar final products as the outcomes of the procedure, it is not a proof to bring the process reliability under question. In this case, in spite of the apparent difference between outcomes, both are the optimum products according to the market taste. The reason to have different results in different times might be the changing attitude of people during time.

4 EMPIRICAL STUDY

This chapter represents the empirical study conducted in this master thesis. Through many articles different procedures and methodologies, some of them specifically designed for food products development while the others intended to a product development in general, have been studied. The main aspect was to find the rationality of every step and the coherence amongst all. Almost every literature has been interpreted rationally to a stepwise procedure. Amongst them, five ones have been found as the most appropriate methods for product development in the food industry: QFD, Conjoint Analysis, Kansei Engineering, Food Kansei and CA/KE. The criteria to evaluate and select the methods encompass different aspects like: number of articles using a specific method, logicality of process, and credibility. Every methodology is defined systematically; however, as a preliminary step, a case study in a dairy company in Iran as the incentive of the entire project is taken a look briefly.

4.1 Case Study

As a product development project in an Iranian company, it was decided to introduce a new kind of sauce, called African sauce, to the market. Being simultaneous with the World Cup competitions in South Africa, the marketing department suggestion was accepted by the top management as a great idea to take the lead of the sauce market. Therefore, a prototype was made by R&D department. A sensorial experiment was implemented comparing the prototype called product 1 in table 3 with a specific sauce from Spain with Ybarra label on it called product 2 in the same table. This Spanish sauce was prepared from a supermarket in Barcelona with a taste stimulating African taste to the mind of marketing staffs.

Table 3: The sensorial result of African sauce

Attribute	Product 1	Product 2
Flavor	2.9	3.5
Color	3.0	3.7
Mouth-feel	2.9	3.5
Spiciness	3.0	3.7
Density	2.8	4.2
Overall Liking	3.1	3.9
Mean	2.9	3.7

Having the results of sensorial experiment in table 3, the department announced the conclusion:

- Comparing the means of two products the prototype is rejected as an appropriate one to the market.
- The Spanish sauce is selected as an appropriate product to the market.

- Except overall liking, all attributes of the prototype are rejected while the Spanish sauce is accepted in all.

4.2 QFD

Quality function deployment (QFD) is a method to have a more effectively communication between product development team members using a complex set of data. It is a structured approach for product development that could be applied for food products as well. However, it is a complicated task since the cooperation of different departments is needed. (Viaene, et al., 1999) The house of quality containing the most critical information about the relationship between company and customers and the competitive position of company in the market is the most focused part of QFD. To generate the house of quality matrix the customer demands, often called the WHATs, are determined in the first step. That is, by qualitative market search voice of the customer is obtained to construct the house of quality. The importance rating of customer demands are asked to set the priorities for the product development process. On the other side of the house, the customer perception about the company's product compared to the competitors' products is placed. (Benner, et al., 2002)

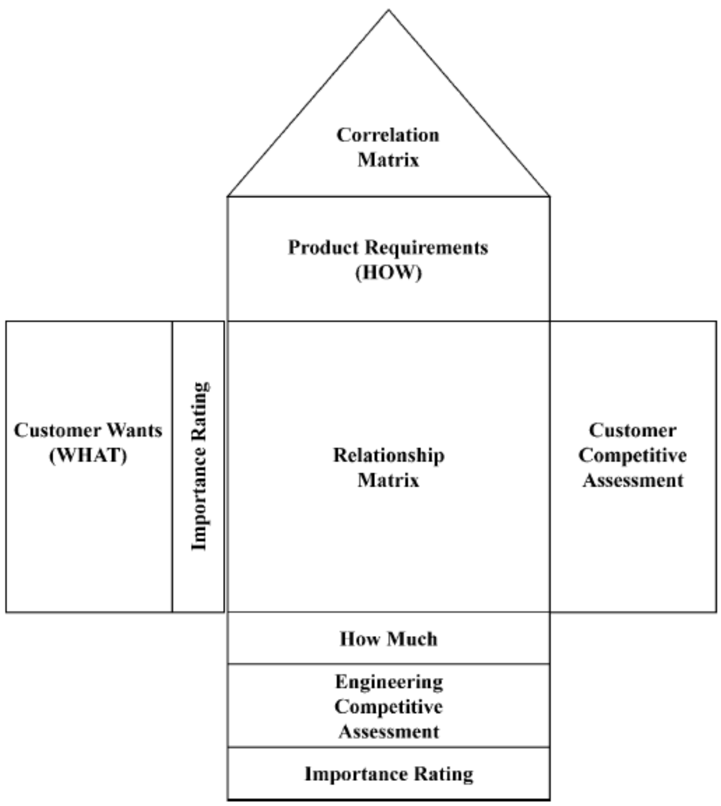

Figure 3: The House of Quality (Benner, et al., 2002)

On the upper side, in product requirement section, the end-product's technical characteristics related to the customer's requirements often called HOWs are listed. (Costa, et al., 2001) In the center part, the relationships between WHATs and HOWs are illustrated. On the top, as the roof of the house of quality, the correlations between HOWs are depicted to find out where trade-off decisions should be made. In the top bottom, the measurements or targets for HOWs are determined. These targets, that should be measurable as much as possible, address how good the company has to be to satisfy the customer. (Benner, et al., 2002) In the next room, in the bottom, a technical competitive assessment of the end-product's characteristics is depicted. That is, for each product characteristic a comparison between the company's and the competitors' performance level is done. The technical importance rating as the last room indicates the relative importance of each end-product characteristic in satisfying consumer requirements. (Costa, et al., 2001)

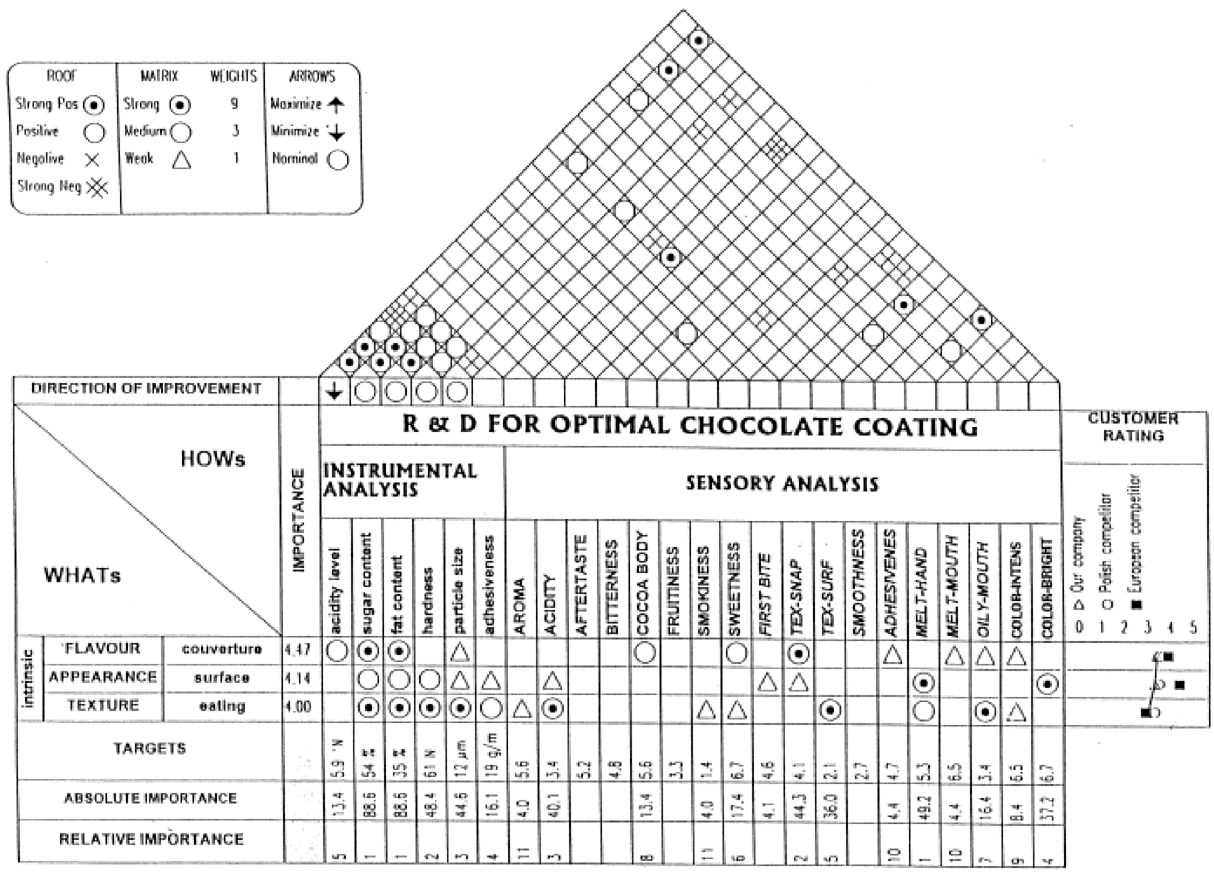

Figure 4: House of Quality for couverture chocolate (Viaene, et al., 1999)

An experiment on couverture chocolate, using QFD, was made by Viaene and Januszewska in 1999. A market survey was conducted to identify the consumers' needs through a set of questions. As a result, three sensory aspects (flavor, appearance and texture) were selected as WHATs. Four different products varying in characteristics such as different levels of cocoa butter, sugar content and cocoa bean origin were selected from the market. Now, it was the time to find out the most acceptable product from the market view. Therefore, a consumer panel was made to evaluate the overall impression of these four products. The scores were based on a 9-point scale from “extremely dislike” to “extremely like”. The Friedman Test that is used for non-parametric alternatives such as rank ordering or rating was utilized to analyze the data derived from the customer sensorial experiment.

As the result, one of couverture chocolates was selected as the most preferred product. A trained panel of seven people was established to discover which sensory attributes are the drivers of customers’ preference. A quantitative descriptive analysis was made to evaluate about eighteen sensory descriptors that were selected with the consensus of all participants. These descriptors, that are determined under three predefined categories i.e. flavor, appearance and texture, could be found in the HOWs column of the HOQ in figure 4. By preparing samples, the mean rate of every descriptor was evaluated through a Friedman Test applied on the data made by the trained panel. The results are depicted in the Targets column in figure 4. Attributes such as acidity, sugar, fat content, hardness, adhesiveness and particle size were defined as objective characteristics to be measured through instrumental analysis. To find out the relationship among all attributes and fill the rooms in the roof or central part of the house, Pearson correlation was employed.

Table 4: The calculated correlations in perception of sensory descriptors (Viaene, et al., 1999)

Sensory Descriptors	Relationship Result
Cocoa body-sweetness	0.728
Melting in hand-texture on surface	0.692
Oily mouth coating-melting in hand	0.807
Oily mouth coating-texture on surface	0.854
Acidity-texture on snap	0.894
Aroma-texture on snap	-0.704
Smokiness-texture on surface	-0.750
Sweetness-melting in mouth	-0.788
Acidity-color intensity	-0.893
First bite-color intensity	-0.806
Melting in hand-color brightness	0.836
Texture on snap-color intensity	-0.801

The calculated correlations in perception of sensory descriptors are depicted in table 4 as an illustration. The signs are used to illustrate the relationships in HOQ as follows: ʘ, strong positive correlation ($p<0.01$); O, medium positive correlation ($p<0.05$); ×, negative correlation ($p<0.05$); and #, strong negative correlation ($p<0.01$). The weights of the signs are 9, 3 and 1, respectively. (Viaene, et al., 1999) It seems the sensorial analysis score for every sensory descriptor was compared with another sensory descriptor in the same product out of four possible couverture chocolates.

The absolute importance value of each HOW was calculated by summing up the multiplication of importance values of each WHAT by the correlation weights of the How column. By ranking all absolute scores, the relative importance values were figured out. (Viaene, et al., 1999)

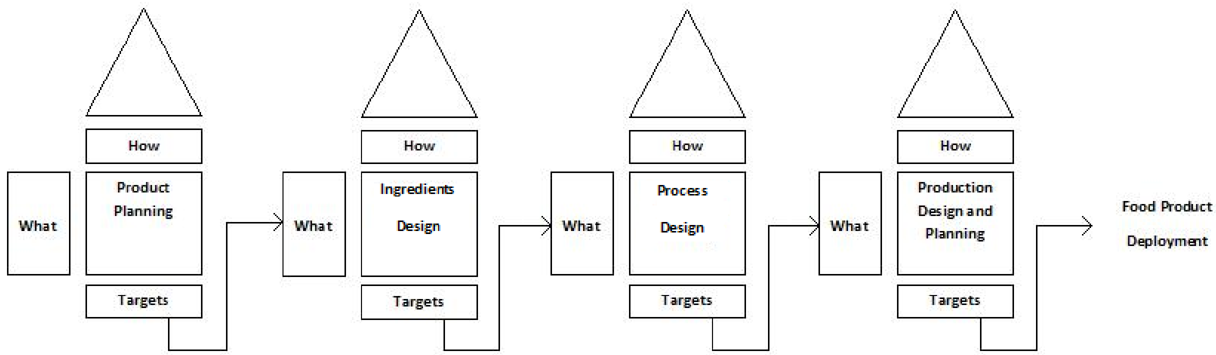

Figure 5: QFD four-phase approach (Benner, et al., 2002)

Finally, in implementation of QFD a four-phase approach involving the product planning, product design, process planning and production planning is interesting to be employed. First, it is the end-product characteristics to be selected. The attributes with the highest ranking in the importance rating section are hired. Moreover, the characteristics with a poor competitive performance or technical difficulty may also be chosen.

To construct the next matrix these selected characteristics are placed on the left-hand side as WHATs of the second matrix. The appropriate components and ingredients satisfying the product characteristics are placed as HOWs of this new matrix. This matrix, with a similar structure to that of HOQ, addresses to what extent the relationships between component and product characteristics are vital. The critical component characteristics as the outcome of the second matrix are located on the left side of the third matrix while the processing operations related items are placed on top. The key process operation parameters are the input of the fourth matrix while the production requirements are the output. (Costa, et al., 2001) In the food deployment procedure the second and third matrix are combined since both ingredients and manufacturing process affect the end-product characteristics. (Benner, et al., 2002)

4.3 Conjoint Analysis

"Conjoint Analysis is a research technique used to estimate or determine how respondents develop preferences for products or services, and to measure the trade-offs people make when making a decision." (Schaupp, et al., 2005)

Conjoint analysis is a decompositional technique since the overall evaluation of a subject is broken down to find out the value of each predictor variable and its appropriate levels. In this technique the predictor variable is often called attribute and the dependent variable is usually an overall evaluation of a subject. (Schaupp, et al., 2005) Three essentially steps should be followed in conjoint analysis. First, the attributes and their appropriate levels should be determined compatiblly with the customer's understanding. Second, an experimental design on the attributes should be planned to construct different hypothetical products. The evaluation of overall preferance rating or ranking of each hypothetical product is asked from the customers at this stage. Finally, as the last step of conjoint analysis, a predictive model with estimating the consumer's part-worth values is being constructed. (Harrison, et al., 1998)

Conjoint analysis allows for a more realistic decision model for a population because of forcing the customers to evaluate the product as a whole. An aggregate decision model is made permiting the null hypothesis of equality in attributes utility in the aggregate decision to be tested.

The basic model in a conjoint analysis is:

$$y = b_1 + b_2 + b_3 + \cdots + b_n + constant + \varepsilon \quad \textbf{(3)}$$

where: y = respondent's preference for the product concept

b_i = beta weights (utilities) for the features

ε = an error term

(Schaupp, et al., 2005)

In 1998 an experiment on a new product that was processed from underused crawfish was made by Harrison, Ozayan, and Meyers. The objective of this study was to investigate the market potential for minced meat products derived from underutilized small crawfish being prepared from different sources such as commercial fishing that creates large amounts of underutilized fish species while the other more desirable species were netted. The attributes were selected as price as a percentage of the current price of fresh crawfish(at levels of 30%,50% and 70%), the product's form (at levels of fresh, frozen, and dehydrated); and the product's flavor (at levels of concentrated and mild). Therefore, there are two three-level and one two-level attributes. A full profile approach contains 18 (3×3×2) profiles for each of two different kinds of final products i.e. the soup base product and the stuffing product. However, to reduce the number of treatments a mixed confounded block design was preferred to be used. Therfore an experimental design was used with four replications with three blocks in each.

To find out the effect of main and interaction treatments on respondents' preferences ANOVA was the tool being utilized. The proposed ANOVA model was spesified as follows:

$$R_{ijkn} = G + P_i + F_J + L_k + (PF)_{ij} + (PL)_{ik} + (FL)_{jk} + (PFL)_{ijk} + B_s + T_r + e_{ijkn} \quad \textbf{(4)}$$

Where R_{ijkn} is the nth respondent's rating for the ijkth combination of attribute levels for the both products; G, is the overall response mean; P_i, is the ith price treatment effect (i = 30%, 50%, and 70% of the fresh crawfish price); F_J, is the jth form treatment effect (j = fresh, frozen, and dehydrated form); L_k, is the kth flavor treatment main effect (k = mild or concentrated crawfish flavor); $(PF)_{ij}$, is the ijth two-way price-form treatment interaction effect; $(PL)_{ik}$, is the ikth two-way price-flavor treatment interaction effect; $(FL)_{jk}$, is the jkth two-way form-flavor treatment interaction effect; $(PFL)_{ijk}$, is the ijkth three-way price-form-flavor treatment interaction effect; B_s, is the sth block effect (s = 1, 2, 3); T_r, is the rth replication effect (r = 1, 2, 3, 4); and e_{ijkn}, is the error regarding the $ijkn$th combination of attribute levels for the nth respondent.

The results are shown in table 5. While the chosen significance level was α = 0.05 the main effects of price and form atributes appeared to be significant for both kinds of products. On the other hand, there is no statistical difference between preference ratings for the flavor attribute neither in seafood stuffing nor in soup base product. Moreover, there is no significant replication or blocks effect as well as any two-way and three-way interaction effect in each product.

Table 5: ANOVA Results for the soup base and seafood stuffing Ingredients derived from crawfish
(Harrison, et al., 1998)

Source of Variation	Degrees of Freedom	Soup/Chowder Base Sum of Squares	Soup/Chowder Base Mean Square	Soup/Chowder Base *F*-Value	Seafood Stuffing Sum of Squares	Seafood Stuffing Mean Square	Seafood Stuffing *F*-Value
Replications	31	47.65	1.54	0.140	74.15	2.39	0.236
Blocks w/in Replication	64	395.00	6.17	0.559	486.44	7.60	0.752
Main Effect Price (*P*)	2	69.57	34.79	3.154*	73.40	36.70	3.630*
Main Effect Form (*F*)	2	482.29	241.15	21.863*	734.18	367.09	36.310*
Main Effect Flavor (*L*)	1	22.56	22.56	2.045	0.03	0.03	0.003
PF Interaction	4	4.11	1.03	0.093	36.21	9.05	0.895
PL Interaction	2	38.64	19.32	1.752	33.30	16.65	1.647
FL Interaction	2	12.67	6.33	0.574	15.85	7.92	0.783
PFL Interaction	4	70.55	17.64	1.599	21.26	5.32	0.526
Error	463	5,107.40	11.03		4,679.02	10.11	
Total	575	6,250.44	10.87		6,153.83	10.70	

Notes: An asterisk (*) indicates the effect is significant at the α = 0.05 level. *PF*, *PL*, and *FL* represent the price-form, price-flavor, and flavor-form two-way interactions, respectively; *PFL* represents the price-form-flavor three-way interaction.

4.4 Kansei Engineering

"Kansei Engineering is a tool translating customer's feelings into concrete product parameters and provides support for future product design." (Schutte, et al., 2004) "It aims at the implementation of the customers' feelings and demands into the product design elements." (Jiang, 2009)

Kansei is about a subjective event, so that everyone is able to absorb and present in an individual way. (Sanabria, et al.) Kansei study looks for the structure of emotions underlying human behaviors. It tries to enhance the creativity with the help of images while using senses or emotions since from a Kansei view images are more effective than words to deliver feelings and concepts of form-giving.

When designing, the imagery skills of the designer i.e. the power to create a mental image and the way to use are of the essence. New appearances of product are created by images generally. Choosing an image, the customer preferences of shapes, colors and atmosphere are communicated. The customers and designers can communicate about the subjective qualities of the new product form through visual materials. Designers try to draw impressive parts on the image to make users to select the items best representing their preferences. The feedback prepares useful information for designer to improve the product. Two-dimensional images could be bases to form 3D designs. (Lee, et al., 2002) Providing 3D prototypes makes customers being involved in feeling the other dimensions of the product like texture, test and odor. Since Kansei data collection and analysis is often complex and connected with statistical analysis different computer software are used.

A framework for Kansei Engineering is proposed by Schutte (2004):

-*Choosing the product domain*
Product domain that is about the overall concept or perfect idea behind the product is selected in the first stage. Target group, user group and product type are defined while choosing a domain.

-*Spanning the semantic space*
The words describing product domain often called Kansei words are selected in this stage. Many resources are to be used while selecting Kansei words. The number of selected words is reduced in different steps. However, it is important not to miss any significant word.

-*Spanning the space of product properties*
All attributes representing the domain are chosen for further evaluation. The attributes with the largest impact on users' feeling are selected thereafter. To collect the product properties different sources such as existing products, customer suggestions, possible technical solutions and design concepts are possible to be used. Factor analysis and the tools like Pareto diagram can assist to make a decision between important and less important features.

-*Synthesis*
In the synthesis step, the link between the product properties and any Kansei word being affected by those properties is made. To establish the links different statistical procedures e.g. linear regression and Neural Networks are employed. Depending on the context, every tool might be used. Linear methods that are easier to work with are preferable than the more complex ones that are sometimes inevitable to be utilized. (Schutte, et al., 2004)

An example to elucidate the functionality of every step was made for a chocolate bar in 2008 by Dahlgaard, Schutte, and Ayas. As the first step, some possible domain definitions were presented as in table 6. Then, to define the relevant Kansei words, manufacturers' and customers' language as the important sources in which the right words could be found were used. Some applicable

Kansei words are delicious, delightful, juicy, light, luxurious, nutritious, tasty, sporty, and unusual.

Table 6: Domain definition for a chocolate bar (Dahlgaard, et al., 2008)

Attributes	Domain1	Domain2
Gender	Male	Male and Female
Education Background	High School	University
Region	Rural Areas	Major Cities
Products	Traditional Chocolate Snack	Healthy Chocolate Snack

To select the attributes in chocolate bar example a set of 14 different properties were identified and presented to target group customers to rate them out of ten points. A Pareto diagram as demonstrated in figure 6 was made using the data extracted from target group assessment. The four most important items were chosen for evaluation: size, shape, color, and brand.

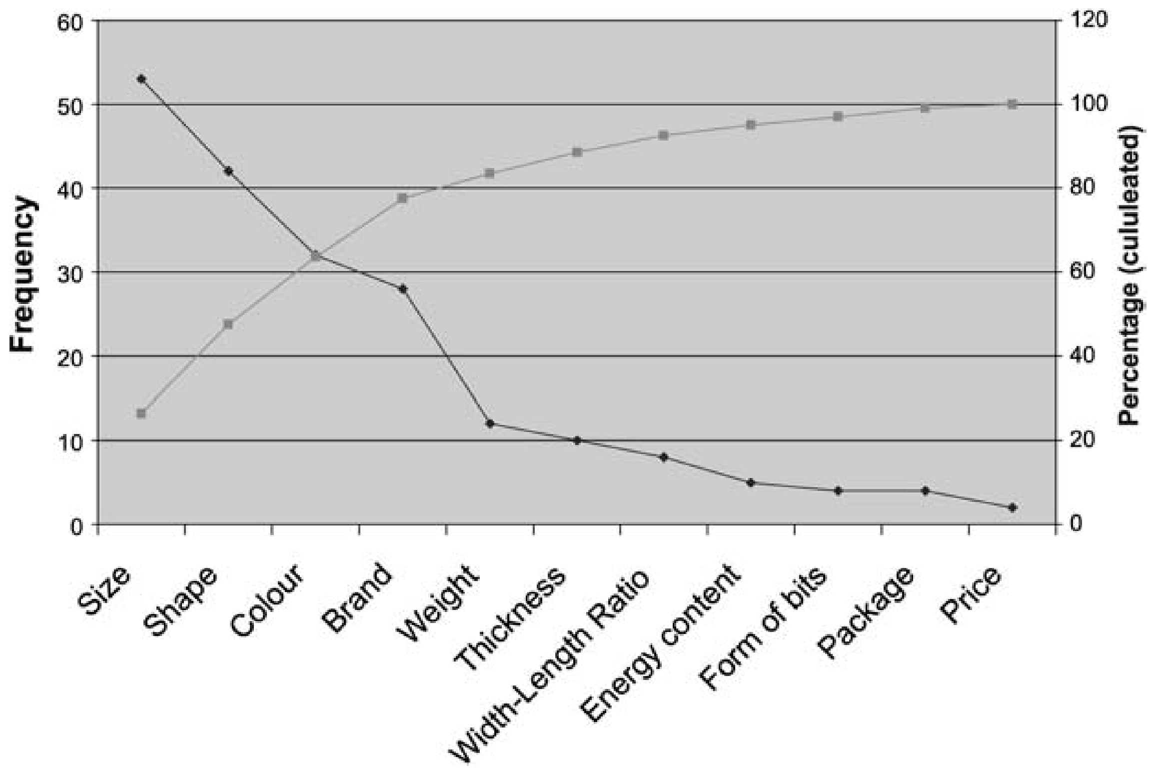

Figure 6: Pareto chart for chocolate bar development (Dahlgaard, et al., 2008)

Partial correlation coefficient (PCC) indicates the relative importance of a specific attribute for the Kansei word: "delicious" in table 7. To have a high impression assuming deliciousness, shape is the most important item to design. CS stands for category score and is equal to the regression coefficients. Based on the results in table 7 an optimal delicious chocolate bar is the one with a large size, light brown color, smooth edges and with the company's brand.

Table 7: Results for the chocolate bar Kansei word "delicious" (Dahlgaard, et al., 2008)

Item	PCC	Category	CS
Size	0.4	Large	0.1
		Small	-0.3
Color	0.4	Light Brown	0.5
		Dark Brown	-0.1
Shape	0.8	Sharp Edges	-0.4
		Smooth Edges	0.5
Brand	0.1	Company's Brand	0.7
		Competitor's Brand	0.3

4.5 Food Kansei

The "Food Kansei Model" tries to formulate the causal relationships between the food product characteristics and perceived quality (Figure 7). In this model, intrinsic and extrinsic attributes are assumed as the characteristics of every product. Intrinsic attributes are the perceptual factors e.g. odor and flavor representing the characteristics of food like the kinds of ingredients. However, extrinsic attributes are external stimuli from the package and advertisements like product name, manufacturer and health-promoting benefits.

The intrinsic attributes of a food are perceived firstly through sensory organs and then converted to pleasantness based on the preference that is a representative of a hedonic scale acquired through different origins like inheritance and dietary habit. The pleasantness through sensory perception is estimated as experienced pleasantness.

The extrinsic attributes are recognized through eyesight and hearing that cause a mental image known as cognition. Attitude is a viewpoint that provides criteria for the image making a food product to be evaluated. The pleasantness through images based on extrinsic attributes is considered as expected pleasantness. Both procedures are correlated to each other resulting in the overall pleasantness for a food product. (Ikeda, et al., 2004)

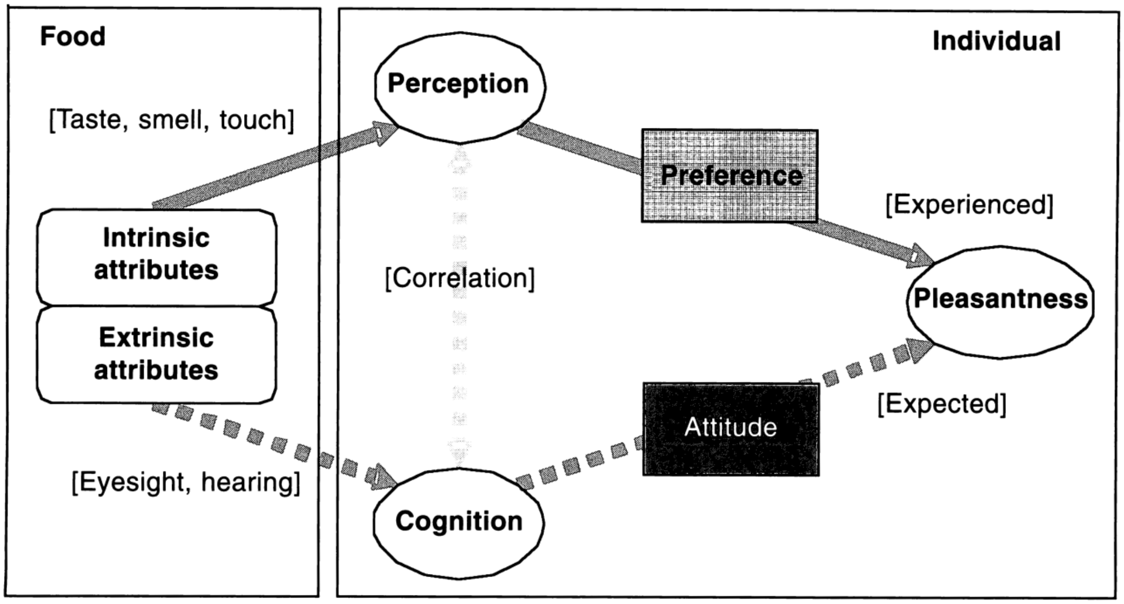

Figure 7: Food Kansei Model (Ikeda, et al., 2004)

A quantitative relationship between physicochemical properties and perceived quality of food products is made correlating instrumental data with sensory data. As a result, sensory characteristics can be translated into instrumental data ensuing in a proper design of the food product. Following the upper route, an instrumental data, a sensory data and a hedonic rating of pleasantness are needed to satisfy every step respectively. (Shibata, et al., 2008)
Figure 8 shows a flow diagram for the optimal design of food product based on the food Kansei model introduced by Shibata, Araki, & Sagara (2008).

In the first step, different samples are prepared. The number of samples should exceed the number of parameters. Next, it is time for data gathering through instrumental and sensory analysis . Sensory intensities of samples are assessed by evaluating different sensory descriptors of appearance like odor, flavor and texture while the ingredients and the physicochemical properties of product are being extracted in a lab through instrumental analysis. Consumers' information processing capacity is limited, and not more than three or four dimensions are used by them in a judging process. Therefore, in the third step, principal component analysis (PCA) will be performed on the sensory data to condense the evaluated responses into simple and few variables, excluding similar factors. (Ikeda, et al., 2004) By applying one-way ANOVA to the instrumental data, insignificant parameters will be kept out as well. (Shibata, et al., 2008)

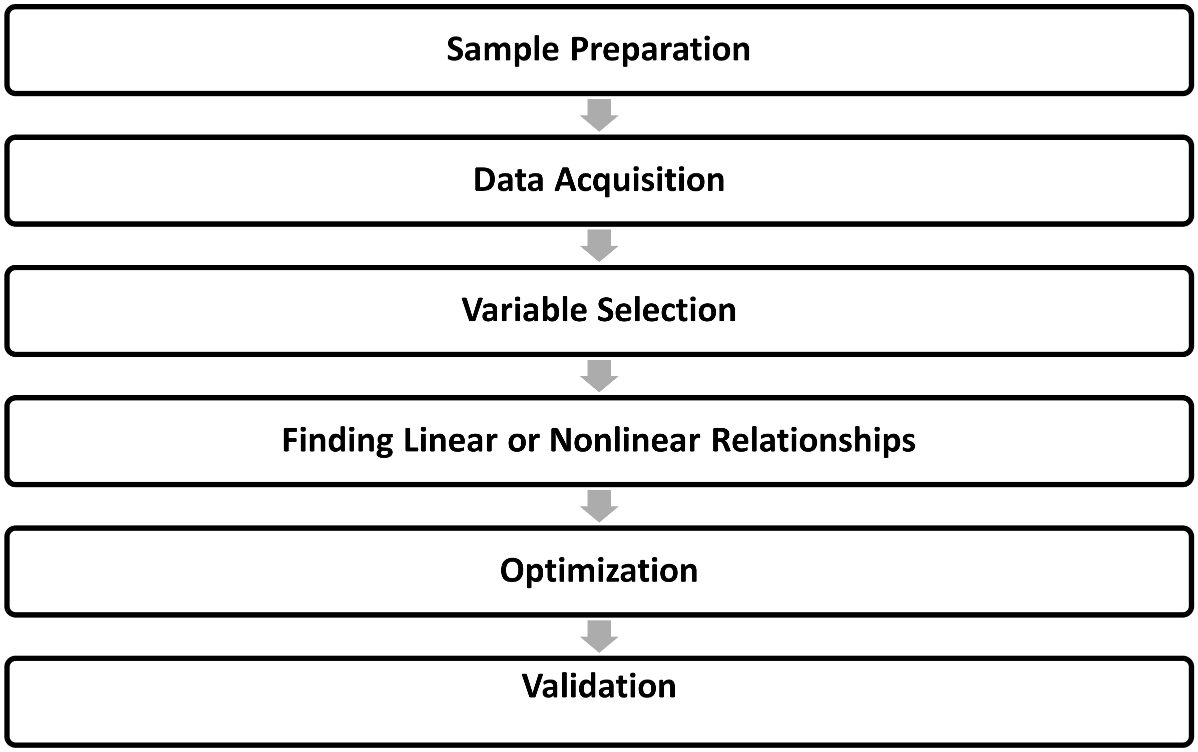

Figure 8: Flow diagram for optimal design of food product based on food Kansei model (Shibata, et al., 2008)

The relationships among selected intrinsic attributes, perceptual factors and hedonic ratings are found out in the fourth level by making food Kansei functions that address the relationship between food-generating pleasantness and food Kansei variables. Wether or not food Kansei functions and variables are properly selected the model would be useful or futile. Several tools may be suggested to make food Kansei functions such as Artificial Neural Networks (ANN). (Ueda, et al., 2008)

Employing ANN a food sensory evaluation process is imagined as a multi-input and multi-output system where the ingredients and sensorial analysis results serve respectively as inputs and outputs of the whole process. By making a link between food composition and sensory evaluation scores, the instrumental analysis results might be used to predict the sensory quality characteristics of food. ANN is a mathemathical simplified model of biological neuron. The model can be described as:

$$y = f(\mu) \qquad \textbf{(5)}$$
$$\text{where} \quad \mu = \sum w_i \, x_i$$

Assuming x_i as an input, y is the output, and w_i is the connecting weight. Here, μ depicts the inner-state of the neuron. (Zhang, et al., 1997)

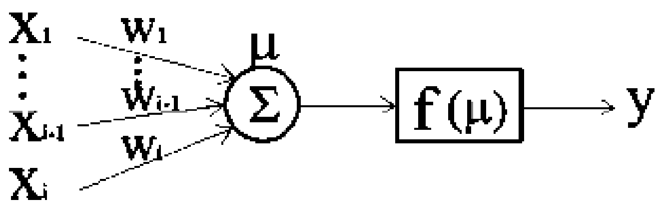

Figure 9: Structure model of artificial neuron (Zhang, et al., 1997)

It is just like brain to recognize the patterns without any specific definition using a series of input-output samples (*Xi*, *Yi*) on what could be called a "black-box" to train a multi-layer feed-forward network in which neurons of each layer receive their input from the previous one. It is an adaptive system that based on the flow of information through the network the structure would be changed. Thus, using ANN the imitation of a sensory evaluation panel for new food samples is possible. A practice was made by Zhang and Chen in 1997 on sensory evaluation ofcoffee.

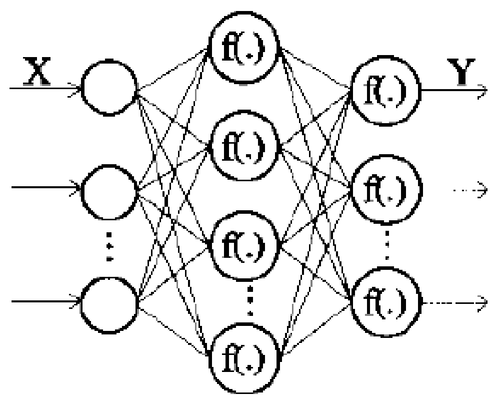

Figure 10: A three layer feed-dorward ANN (Zhang, et al., 1997)

A feed-forward network with three layers (an input layer, a hidden layer and an output layer) was used. (Figure 10) several cups of coffee in various densities were made with a panel of 12 university students. Each member was asked thereafter to taste 25 cups of coffee of the same brand, but different density, and give a feedback on his/her satisfaction. Moreover, 3 more cups of coffee were prepared to test the results of simulation. The component data of samples i.e. "Coffee", "Coffeemate" and "Sugar" as well as the results of sampling are illustrated in table 8.

Table 8: The weights of coffee, coffeemate and sugar of samples and the panel's evaluations
(Zhang, et al., 1997)

	Coffee	Coffeemate	Sugar	Like	Neutral	Dislike
1	0.253	0.5	0.253	0.083	0.083	0.834
2	0.253	0.5	1.000	0.417	0.250	0.333
3	0.253	2.5	0.253	0.167	0.167	0.666
4	0.253	2.5	1.000	0.333	0.334	0.333
5	0.253	2.5	1.753	0.167	0.333	0.500
6	0.253	1.5	0.253	0.250	0.167	0.583
7	0.253	1.5	1.000	0.417	0.417	0.166
8	0.253	1.5	1.753	0.167	0.667	0.166
9	0.500	0.5	0.253	0.002	0.083	0.915
10	0.500	0.5	1.753	0.167	0.333	0.500
11	0.500	2.5	0.253	0.250	0.250	0.500
12	0.500	2.5	1.000	0.500	0.417	0.083
13	0.500	2.5	1.753	0.250	0.500	0.250
14	0.500	1.5	0.253	0.083	0.250	0.667
15	0.753	0.5	0.253	0.001	0.001	0.998
16	0.753	0.5	1.000	0.083	0.002	0.915
17	0.753	0.5	1.753	0.083	0.333	0.584
18	0.753	2.5	1.753	0.250	0.333	0.417
19	0.753	1.5	0.253	0.002	0.083	0.915
20	0.753	1.5	1.000	0.167	0.333	0.500
21	0.753	1.5	1.753	0.417	0.250	0.333
22	0.500	1.5	1.753	0.499	0.499	0.002
23	0.753	2.5	1.000	0.417	0.250	0.333
24	0.600	1.0	1.253	0.333	0.083	0.583
25	0.500	1.5	1.000	0.500	0.333	0.167

The weight data of the three components from the 25 samples were used as inputs along with the percentages of "like", "neutral" and "dislike" as outputs to train the ANN. After running the process of learning the weights of 3 test samples were used as the inputs to test the functionality of the neural network. The results are depicted in table 9.

Table 9: The weights of coffee, coffeemate and sugar of three test samples and the panel evaluations (Zhang, et al., 1997)

	Coffee	Coffeemate	Sugar	Like (NN)	Like	Neutral (NN)	Neutral	Dislike (NN)	Dislike
1	0.300	2.2	0.500	0.197011	0.167	0.148693[a]	0.083	0.697739[a]	0.750
2	0.253	0.5	1.753	0.186134	0.167	0.320919	0.333	0.5011340	0.500
3	0.753	2.5	0.253	0.069023[a]	0.167	0.400511[a]	0.250	0.618625	0.583

Note: [a]the result of the NN did not agree with that of the panel

For test sample 1, the estimation result is more in the “neutral” category and less in the “dislike” category than the real number of panelists; that is about one person in twelve . The result of test sample 2 is somhow correct, while in test sample 3, the estimayion is less in the “like” category and more in the “neutral” category than the actual panel. (Zhang, et al., 1997)

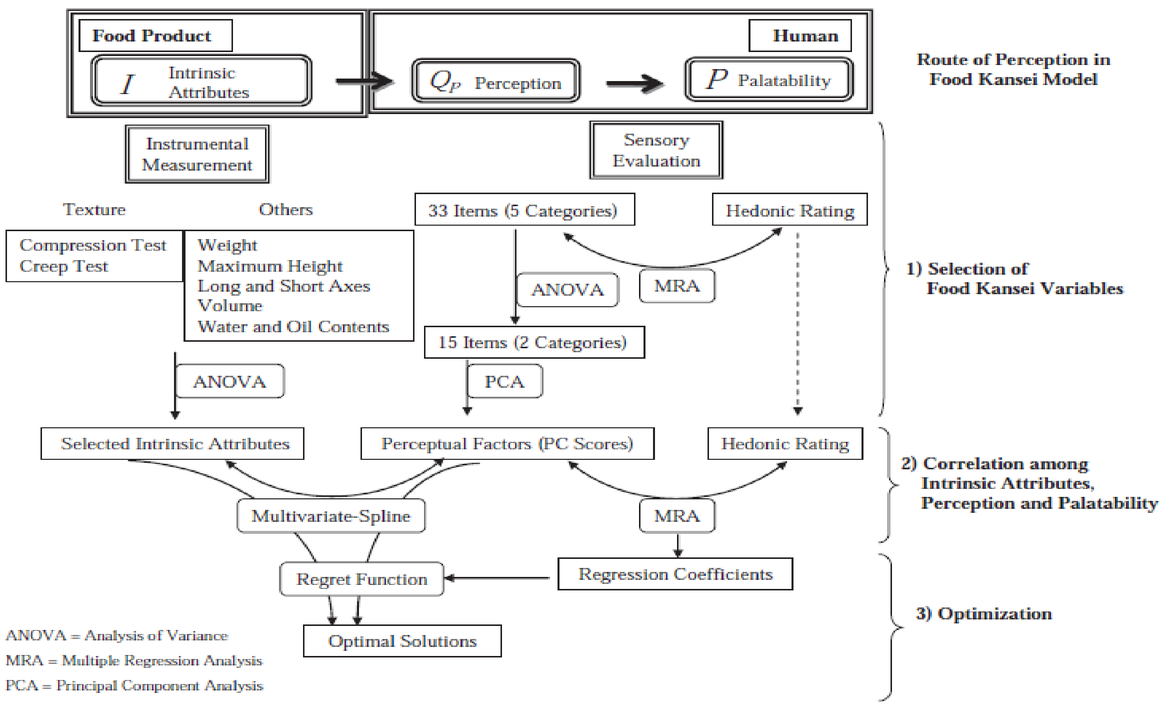

Figure 11: Route of perception in food Kansei model (Shibata, et al., 2008)

On the other hand, Multiple Regression Analysis may be applied to find out the relationships between palatability and principal component scores of perception where multivariate- spline application is employed to correlate intrinsic attributes with perceptions. Multivariate spline is a form of regression analysis as an extension of linear models to model non-linearities and interactions that is more flexible than linear regression models. (Friedman, 1991)

Thereafter, the optimal values of ingredients and physicochemical properties are determined by multivariate-spline and regret function. Multi-response optimization by regret function are implemented to find out the optimal values of the Kansei variables to maximize the hedonic rating of palatability.

Finally, cluster analysis might be applyed to validate the optimum solutions to confirm the optimal combination of physicochemical properties. (Shibata, et al., 2008) Figure 11 may make a better perception about the whole process.

4.6 CA/KE

A new methodology about product development in earlier phase combining Conjoint Analysis and Kansei Engieering was introduced by Barone, Lombardo and Tarantino in 2007.

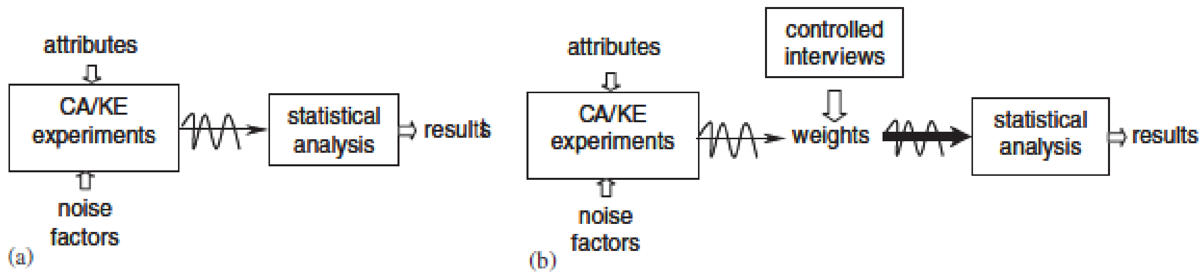

Figure 12: (a) A standard CA/KE procedure and (b) the new proposed methodology (Barone, et al., 2007)

In order to highlight the attributes through all available noises while running a conjoint analysis attribute importance weights are employed in this methodology. The weights are functioning as correction coefficients in the related regression model. To evaluate the attribute importance weights the respondents' evaluation of product profiles gets questioned.

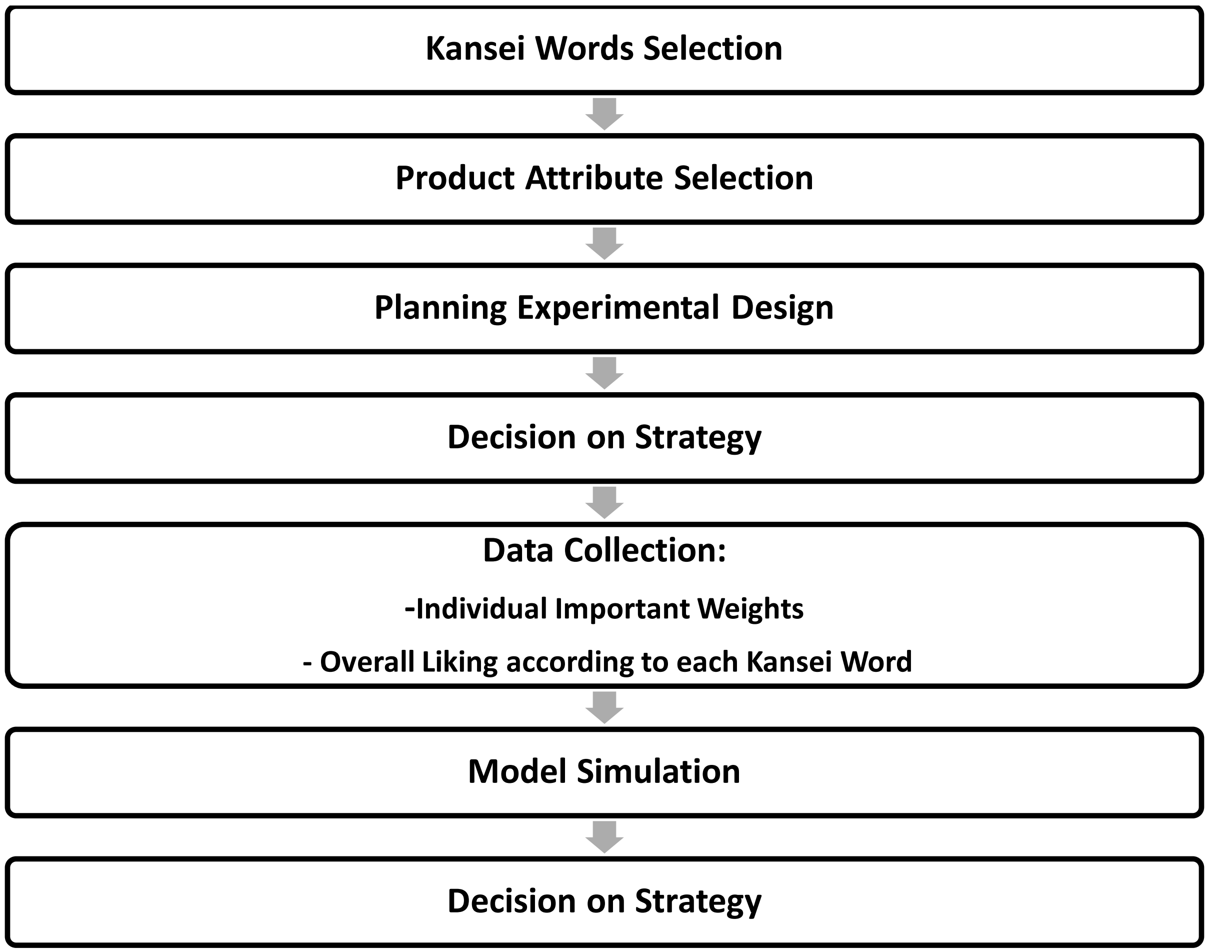

Figure 13: CA/KE Process Map

Choosing the right Kansei words through different sources is the first step to take in this methodology. It is of the essence to reduce the number of Kansei words to a few important numbers . Proper product attributes get selected in the next step. Pareto diagram is a useful tool to find out the most important attributes through a large number of possible properties.

Depending on the number of selected factors assuming the affordablity of the experiment a suitable experimental design eg. a fractional factorial design gets selected. Assuming the expenditure of making prototypes, time and resource consumption, and different involving noise factors a strategy out of three possible strategies –that are described in methodology phase- to make the ptototype in Kansei engineering should be chosen.

Collection of data is the next step in CA/KE methodology. To do so, a sample is selected out of the target segment of the market. An interview is implimented in two phases for each respondent. In the first phase, the individual importance weights of product attributes are assessed by using a software recording the order of preference of the respondent about each attribute plus the appropriate time to select. The choice times are used to determine the relative weights of importance.In the second phase, the prototypes are shown to the respondent to make the answers of the prepared questions according to each Kansei word. The answers are based on an appropriate scale e.g. a five-point Likert scale.Through ordinal logistic regression,after collecting the data, the relationships between respondent evaluation of a Kansei word and product attributes are estimated. Each Kansei word is represented by a different model.

Finally, by finding out the effect of each attribute on fulfilment of each Kansei word the designers would be able to choose the right product development strategy. (Barone, et al., 2007)

5 ANALYSIS

In this chapter, the analysis that is based on the theory is described. The case to study is discussed along with all described methods in the previous chapter.

5.1 Case Study

A case was studied as a reason to start this thesis. Being deep, some points are worth it to be highlighted:

- There is no criterion for a good taste. As an illustration, while sweetness is an important factor in acceptance of a milk chocolate, it is not functioning in the same in any kind of cheese. Moreover, while comparing food products, it is essential to know the concept of use. The way a bottle of ketchup may be used is different from the same bottle full of mustard. In this case, the product is new to the market. As an innovation, no benchmark is available. Therefore, the concept of use is unknown yet to the customer. To test the acceptance of a prototype, the selected product as a reference to make a comparison should satisfy the customer in the same way. The Spanish sauce might not be a good reference for a new product without any predetermined concept of use.
- Mean comparison is not a good scale to compare the same attributes of the two products while the variance of data is neglected. Friedman test, instead, might be a thorough test to make such comparison.
- Overall liking indicates the product acceptance from an entire view, while talking about the attributes a specific dimension of acceptance is being under study. While each sensory descriptor drives overall liking (Moskowitz, 1995), taking the average of all attributes, together with overall liking, to reject or to accept a product is not acceptable.
- The results of this experiment do not show any direction to improve the prototype. That is, the next step of product development is not obvious. The results might just show the probable success or failure of the prototype in the market.

This experiment was a sample out of many unsuccessful food product developments in the industry. The outcomes of such experiments show a need to a step-wise method. Different methodologies have been depicted in empirical study chapter. Each methodology, here, is discussed to take the advantage of.

5.2 QFD

Using QFD to develop a product many advantages might be carried out:

- It tries to make a trade-off between what costumer wants and what company can afford to produce.
- The communication between company divisions is improved.
- Information needed for product development is easier accessible and better documented.
- A product could be compared with competing products.

However, this methodology is not without weak points:

- Completing every matrix is a time consuming process.
- A large list of customer demands might make HOQ matrix more complex.
- Where in many cases a physical industrial product is assembled by several components as constitutive factors, a food product treats in a different way because of possible interactions between ingredients that makes it more difficult to use QFD.
- Different target values might be required for every customer demand as a WHAT that no solution could be provided by QFD.
- Wrong customer wishes might misguide us in product development.
- The company's wills are to some extent neglected by putting the emphasis on the voice of the customer. (Benner, et al., 2002)
- Detachment of food product properties is an arduous effort making it usually impossible to define the sensorial attributes properly.
- The correlations between sensory aspects of a food product are sometimes that much complicated making any effort to fill the roof of HOQ fruitless. Moreover, there is the same scenario in correlation of sensory aspects and technical features.
- Since it is a complex process, many companies leave it incomplete. In most cases, it is just a HOQ to be accomplished.
- It is more suitable for products consisting of individual components.

5.3 Kansei Engineering

Kansei is the next tool studied in food product development. In various aspects it is an important and useful tool some of them are here inscribed:

- Choosing product domain at the first step might prevent straying from the main concept in the next steps.
- Kansei words describe product domain at the same time with company's strategy. Therefore, the company's will are taken into consideration as well as the voice of customer.
- Making a vision of product in the mind of consumer in very early development phases, by using a real image of product, helps the developers to have the results much closer to the time of product release.

On the other hand, it is not a perfect tool in food product development since:

- There is no comprehensive process to choose the attributes regarding any product. The proposed methods such as using customer suggestion sound interesting, but not all-inclusive.
- Since Kansei projects have been more involved in the image of a product it has been mostly used in the package development of food products.

- Kansei engineering introduced by Nagamachi is a computer-based technology. (Nagamachi, 1995) In this way, there is no use of Kansei in food product development as food simulation sounds to some extent weird. In spite of the fact that Nagamachi (1995) inscribed Kansei Engineering as a tool based on computer science, it is not the only way to present a profile to a respondent. Possible strategies to make such experience are:

  - Making a physical prototype, allowing the respondent to interact with it
  - Making a virtual prototype, allowing respondent to face it in a virtual environment
  - Using the products already available in the market

  Because of the need to much resources and time, the first strategy is not suggested to be taken in early steps of product development. On the other hand, virtual prototypes may save time and resources. (Barone, et al., 2007) However, the product attributes like flavor and odor could not be evaluated in this way. It is sometimes preferable not to spend much resource, and use the available products in the market instead. Each selected product represents one of the differently determined profiles. However, the existence noise factors biasing the analysis of results should not be ignored. (Barone, et al., 2007)

5.4 Conjoint Analysis

Conjoint analysis has been an important tool in product development. Some points in use of this useful tool are here highlighted:

- Making a model assuming product attributes as regression coefficients makes it possible to predict the customers' preference about the product.
- Using experimental design, the degree to which an attribute might be effective on the overall acceptance of the product could be evaluated.

To employ conjoint analysis in food product development some important facets should be taken into account:

- Although the importance degree of every factor is determined in conjoint analysis, there is no attempt to find the optimum product.
- In a product, to make any change in the level of an attribute the levels of one or some effective factors should be adjusted. The important point is the difference between an attribute and a factor grammatically. While an attribute is mostly an abstract noun, a factor is usually a concrete noun. As an illustration, when the leg length of a table is selected as an attribute with an impact on the consumer mind, the leg of the table is the factor that must be adjusted. In an ordinary industrial product like that table, making a change in a factor, most of the time, has an effect on just one attribute. However, when talking about a food product it is almost impossible to introduce a specific ingredient as a factor solely accountable for a specified attribute. On the other hand, adjusting any

specific ingredient might affect the levels of more than one attribute. Asking about sensory attributes instead of ingredients to find out the ideal product from the view of customer does not show the direction of improvement in many cases since the degree to which an ingredient should be adjusted to satisfy the taste of customer is unknown.

5.5 Food Kansei

Food Kansei has got the inspiration from Kansei engineering. However, it is almost a different method containing the Kansei concept namely, considering the customers' feelings, at the center. Studying the Food Kansei method, some advantages come to mind:

- Making a model based on product attributes like conjoint analysis makes the prediction of customers' preference possible.
- Product optimization is an important step to be taken by food Kansei. In this way, statistical methods, instead of using trial and error method, are employed to find out the optimum point of a product.

In contrast, from some aspects this method may not satisfy food product developers:

- A few articles have talked about food Kansei, most of them are more involved in variable selection. On the other hand, product optimization has less consideration.
- Asking about the degree of perception of every sensory attribute, the outcome may not be valid. The perception of an individual attribute is usually influenced heavily by other attributes in a food.
- The reason behind sample preparation in the first step and the appropriate number of samples is not that much clear. In Kansei engineering, the samples' type and number are determined according to the selected attributes. However, it is not the same in food Kansei.
- To evaluate the preference of the customers about the developed product there is no sample preparation in optimization phase or after that.
- The focus is more on the product attributes than overall perception of the product.
- Using ANN model, different solutions are made even if the same experimental data are used. (Shibata, et al., 2008)
- Making a large number of descreptive questions at the same time from participants reduces the reliablity of the answers.

5.6 CA/KE

CA/KE is a method combining the merits of conjoint analysis and Kansei engineering together. While all aforementioned benefits in using both methods are included when utilizing this combination, some other points are worth it to be highlighted:

- Determining the effect of each attribute on the overall acceptance from each Kansei word view by utilizing Conjoint Analysis is a breakthrough made by this method.
- Using weighted logistic regression might help to reduce the incoming noises biasing the analysis of results. However, by making a blind test through a food product sampling there is no need to take such strategy.

Still, to use this method in a food product development some details should not be ignored:

- The experiment ends in the effectiveness of every attribute on each Kansei word while there is not any recommendation for product optimization.
- Although in CA/KE, by using Kansei words, while asking about the degree of acceptance, the area to concentrate is better determined, the criteria that a food product could be evaluated is not defined. That is, the domain that a food product under study belongs to should be specified.

6 RESULTS

This chapter presents the results found during this thesis. A method regarding food product development is proposed in three stages along with a pre-phase stage.

Different methods in product development with a focus on food products were studied. The advantages and drawbacks regarding to each method were discussed in Analysis part. Valuable information about market interest, product attributes and production process were achieved employing each method. As a case in point, sensory attributes of a food product were analyzed in many cases by asking through descriptive questions from customers. However, no further step was taken to improve the product thereafter. Some cases concluded in the attributes importance regarding customer preference showing the improvement direction to the company. Nevertheless, no attempt was made to optimize the product afterwards. Moreover, the special characteristic of the food products, that is having unusual interactions of ingredients making such products vary from the other industrial products, had not been taken into consideration while proposing the most methods in product development. In conclusion, no method was found as a comprehensive model in development of a food product. Therefore, with a try to take the advantages of different studied strategies, a methodology in product development with an emphasis on the food products is suggested.

This methodology is delineated in three stages a sampling test is implemented in each. Every stage is represented in a different color in figure 14. A pre-phase stage, furthermore, is defined so that the appropriate preliminaries get prepared.

6.1 Pre-phase Stage

In pre-phase stage, assuming the market interests and based on the company's strategy, Kansei words are defined. "Kansei words are identified a priori from customer needs based on market research." (Jiao, et al., 2006) The subjective words are used to describe a product or service since Kansei Engineering is based on the analysis of product semantics. Consumers from a target segment evaluate a set of product or service designs to decide how much a design satisfies each Kansei word.

"Kansei words are usually expressed in abstract, fuzzy, or conceptual terms, leading to work on the basis of vague assumptions and implicit inference." (Jiao, et al., 2006) Therefore, it is of the essence to choose the right and explicit words as Kansei words. According to Jiao, Zhang, and Helander(2006) Kansei words are mostly adjectives and partly nouns.

As representatives of the consumer's feelings on a product Kansei words could be collected through different ways like a dialogue with the salesman in the shop or looking at an industry magazine. (Nagamachi, 1995)

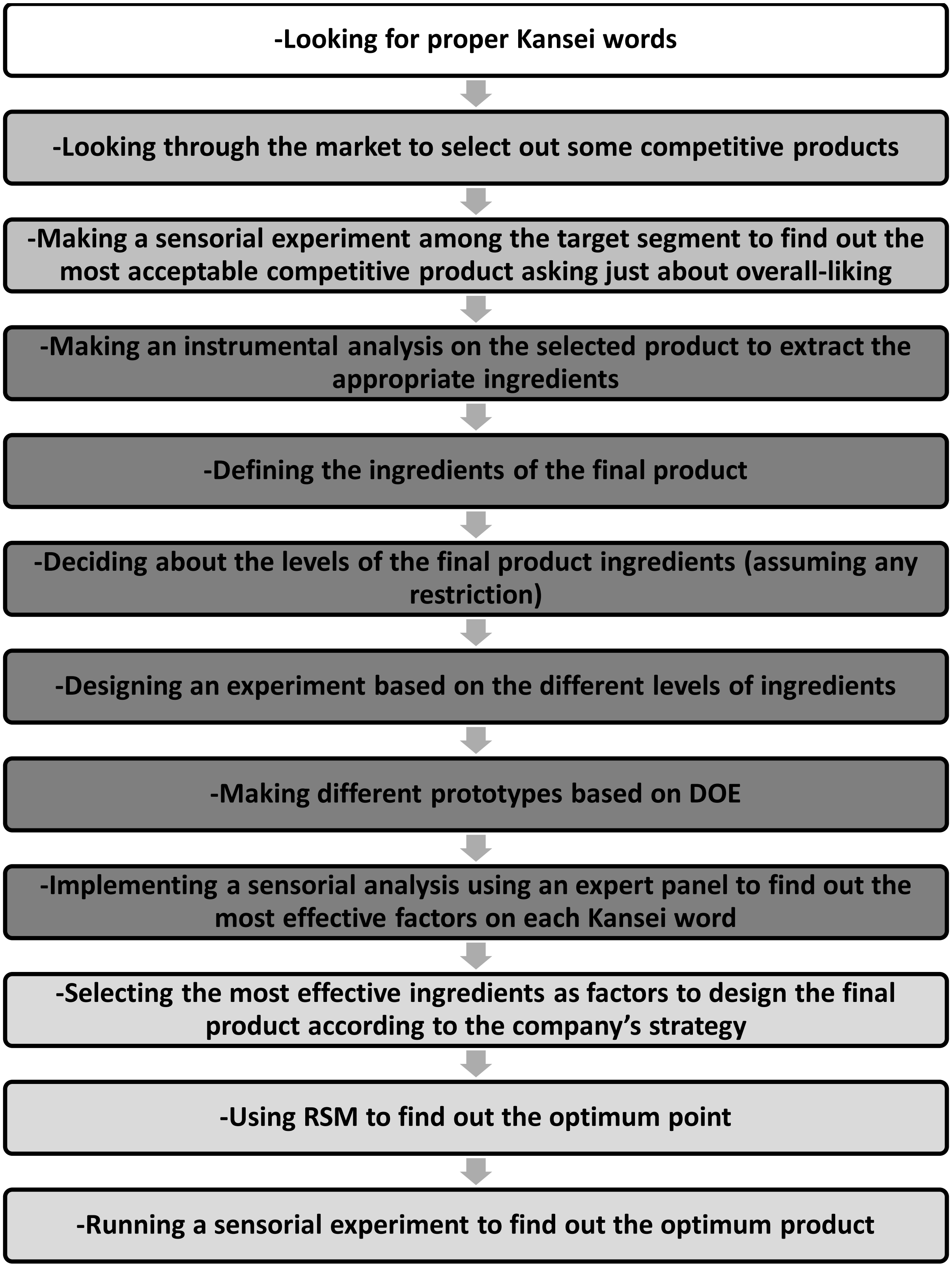

Figure 14: The proposed method in food product development

To have a comprehensive selection of words using all possible sources are recommended even if they seem to be similar. Some suitable sources are:

- Magazines
- Pertinent literature
- Manuals
- Experts
- Experienced users
- Relating Kansei studies;
- Ideas and visions (Schutte, et al., 2004)

(Schutte, et al., 2004)

It is important to mention that a consensus should be made on the segment to be focused on, in pre-phase stage as well.

6.2 Defining the Domain

In the first stage, the zone that the desired product belongs to should be defined according to the market interest. However, it is of the essence to know that a product development may involve:

- Making a completely new food product, that is to develop the ideas to have a new product in the market
- Modifying an existing food product, that is improving an original recipe like by adding or removing the ingredients
- Matching an existing food product, that is copying other products of similar types from the other brands in the market (SEN10)

To modify or match an existing product, competitive products available in the market are to be noticed. Some of them are selected to find the taste of the market. It is important to know the market share or the rank related to each product to choose the leaders of the market. The result of such survey is different products on the table, ready to implement an experiment.

Sensorial analysis gets assisted to find out the best product from the view of the market. In addition to the selected products from the market, any other product with a chance of success in the market could be chosen to take part in the sensorial analysis. Any new interesting recipe is welcome to be presented in the experiment as a new prototype.

Reaching a consensus on the number of samples it is time to implement the sensorial analysis. Some imperatives should be taken into account while running a sensorial testing session:

- Setting the right objective
- Asking the right people

- Asking the right questions
- Eliminating bias
- Achieving scientific control
- Having the right environment (Carpenter, et al., 2000)

To reduce the noises in the experiment the question should be as simple as possible, asking just about the overall liking of the product. Although questioning about the sensory aspects of a product e.g. flavor and texture can supply interesting information about the product, difficulties to be faced in this way may lead to an unreliable outcome.

Emotional responses are associated to a brain area that is different from the region specializing in verbalization and language. Therefore, different processes and neuronal pathways are used to generate emotions and express them verbally. Once asking about consumers opinions in questioners, they are asked to rationalize what have been non-rational before. (Oliveira, 2003) A way that avoids asking rational questions in a consumer research may lead in having results that are more valid. Therefore, the questionnaires are planned in a way asking just about the overall liking of the product. In designing the questionnaire based on ISO13299, to indicate the intensity of each attribute, or the overall liking of each sample, an appropriate response scale should be selected.

According to ISO 4121, “Numerical and verbal response scales are the types most commonly used in sensory analysis. Each assessor gives a response either by selecting it on a questionnaire or by producing it e.g. by writing down a number to represent the perceived intensity or by marking a position on a line”. Moreover, the choice of response scale depends on the objectives of the study, the products under study and the panel. It is necessary that a response scale be:

- Easily understood by the assessors,
- Easy to use,
- Discriminating, and
- Unbiased (ISO 4121)

Experienced by Dawes (2008), comparing to the scores generated from 5-point or 7-point formats it seems a 10-point format produces, with a slender difference, lower scores. In general, the scale with more response options creates slightly lower mean scores relative to the highest possible attainable score. Furthermore, by using ANOVA, Dawes showed that having a scale format with more response options makes respondents to use more scale points. (Dawes, 2008)
According to Aakar (2004), scales with two or three response alternatives are not capable of transmitting much information. On the other hand, by using more than nine point categories a little could be achieved. Moreover, it is preferable to use odd rather than even number of categories since a respondent can choose the neutral choice. (Aaker, et al., 2004)

In marketing research, to plan a survey, it is important to determine sample size. Three factors are essential while deciding about the size of sample: the level of precision, the level of confidence, and the degree of variability in the attributes being measured. The precision level or sampling error is the interval that the true value of the population is supposed to be there where the range is often indicated in percentage points e.g., ±5 percent. The confidence level is based on an idea drawn out of Central Limit Theorem. That is, having a population repeatedly sampled, the average value obtained by those samples is equal to the average value of the population. While the obtained values are distributed normally, if a 95% confidence level is selected, approximately 95% of the sample values are within two standard deviations of the population. However, it is always probable that the obtained sample does not represent the true value of population. The degree of variability refers to the distribution of attributes in the population. A larger sample size is required for a more heterogeneous population given a level of precision. To determine a sample size several approaches could be followed. However, by using table10 it is much easier to define the sample size while the confidence level is 95%. (Israel, 1992)

Table 10: Sample size for different Precision Levels with Confidence Level of 95% and P=0.5 (Israel, 1992)

Size of Population	**Sample Size(n) for Precision(e) of**			
	±3%	±5%	±7%	±10%
15000	1034	390	201	99
20000	1053	392	204	100
25000	1064	394	204	100
50000	1087	397	204	100
100000	1099	398	204	100
>100000	1111	400	204	100

Performing the sensorial experiment among the target segment the best product according to the interest of the market is defined. It is of the essence to notice this product is not the optimum product for the market, but the best out of available or even possible products in the market.

6.3 Discerning the Factor Effects

In the second stage, after finding the zone that the product belongs to, in previous stage, it is time to narrow the area to focus. Therefore, the factors with an important role in designing the product have to be found out.

First, the ingredients of selected product as the outcome of sensorial analysis are defined by an instrumental analysis. That is, the selected product is decomposed to the ingredients by experts in a laboratory. Each ingredient stands for a factor; however, to have a reasonable number of factors some useful tools could be employed. Having many factors, insignificant factors are exluded by applying one-way ANOVA. Moreover, process variables, in addition to the ingredients, could be defined as factors in this stage. Deciding on the number of factors, the factor levels are specified thereafter. Many items and restrictions are influential in deciding on the factor levels. Company's strategy, health issues, physicochemical constraints and financial limits are all effective on the levels to be determined.

In CA/KE methodology, the reason for using attribute important weights is the existence of different kind of noises like cell phone brand or appearance. (Barone, et al., 2007) However, almost having the same kind of foods as samples, especially while the experiment is being performed as a blind test, the presence of such noises is so negligible that no need is to use any correction coefficient. Therefore, to find out the influence of each factor on each Kansei word a design of experiment (DOE) is employed. In choice of experimental design, on account of the fact that it is often impossible to run all of the observations in a 2^k factorial design under homogeneous conditions, blocking as an excellent technique to overcome the unwanted problems is used. (Montgomery, 2005) Therefore, depending on the number of factors, to reduce the number of runs required for an experiment the 2^{k-p} Fractional Factorial Design could be employed.

Table 11: An example with a 2^{6-3}_{III} fractional factorial design for an experiment with 6 factors and 3 Kansei words

	A	B	C	D	E	F	Str.1	Str.2	Str.3
1	0	0	1	1	1	1			
2	1	0	1	0	0	1			
3	0	1	1	0	1	0			
4	1	1	1	1	0	0			
5	0	0	0	1	0	0			
6	1	0	0	0	1	0			
7	0	1	0	0	0	1			
8	1	1	0	1	1	1			

To perform DOE, according to the number of decided runs on an experiment, different prototypes comprising different levels of factors are designed. Prototypes are sampled in the same shape plates differentiated with the codes on the back. It is time the specialists assist to perform the second sensorial analysis. In view of the fact that the market direction of interest was perceived in the first stage, the experts' opinion at this level seems to be satisfactory. Furthermore, having more number of runs, and questions that are more complicated encourages using the experts as the sample population. The experts as a trained panel are asked to assess the

overall liking of each prototype according to each Kansei word. The answers are based on an appropriate scale as same as the first stage showing to what extent each Kansei word is satisfied. An example with a 2_{III}^{6-3} fractional factorial design for an experiment with 6 factors and 3 Kansei words is shown in table 11. The three last columns are the spaces to place the scores according to each Kansei word. The collected data are analyzed through ordinal regression model to estimate a model for each Kansei word.
The outcomes of the second stage are the effects of each factor on every Kansei word.

6.4 Optimization

In the third stage, following the company's strategy, it is time to find out the optimum point regarding the product.

Table 12: A Central Composite Design for three factors

Runs	A	B	C	Y
1	-1	-1	-1	
2	+1	-1	-1	
3	-1	+1	-1	
4	+1	+1	-1	
5	-1	-1	+1	
6	+1	-1	+1	
7	-1	+1	+1	
8	+1	+1	+1	
9	0	0	0	
10	0	0	0	
11	0	0	0	
12	0	0	0	
13	-1.633	0	0	
14	+1.633	0	0	
15	0	-1.633	0	
16	0	+1.633	0	
17	0	0	-1.633	
18	0	0	+1.633	
19	0	0	0	
20	0	0	0	

Since each Kansei word represents one possible strategy to be taken by the company, based on the company's decision, one Kansei word is selected. Knowing the effect of every factor on each Kansei word, the important factors regarding the selected Kansei word come into focus. Once the appropriate process variables are identified, it is time for optimization or finding the set of operating conditions resulting in the best process performance.

Response surface methodology (RSM) is a useful method for modeling and analysis in applications with the aim of response optimization whilst influenced by several variables. With a right design, there is no need to a large number of runs or levels of independent variables whilst a reasonable distribution of data points through the region of interest could be provided. (Montgomery, 2005) The most popular design used for fitting a second-order model is the central composite design (CCD). In general, a CCD with k factors requires 2^k factorial runs, $2k$ axial runs, and about 3 to 5 center points. An example for a three variable design is illustrated in table 12.

However, depending on the test conditions other types of design are preferable to use. An example could be in using Box-Behnken design when there is no interest in using the points with factor-level combinations because of financial or physical process constraints. Table 13 shows a three-variable Box-Behnken design. (Montgomery, 2009)

Table 13: A Three- Variable Box-Behnken Design (Montgomery, 2009)

Runs	A	B	C	Y
1	-1	-1	0	
2	-1	+1	0	
3	+1	-1	0	
4	+1	+1	0	
5	-1	0	-1	
6	-1	0	+1	
7	+1	0	-1	
8	+1	0	+1	
9	0	-1	-1	
10	0	-1	+1	
11	0	+1	-1	
12	0	+1	+1	
13	0	0	0	
14	0	0	0	
15	0	0	0	

Designing the experiment the samples are prepared to implement the final sensorial experiment. Like the second stage, the experts as a trained panel are asked to take part in the sampling. Analyzing the achieved data is the final step to be taken to find out the optimum point.

7 CONCLUSIONS

Studying many methods in product development, no one was found as a comprehensive method in development of a food product. Because of the interactions between the attributes, a food acts differently from the other industrial products, making a need to design a specific method for food products. A procedure in food product development, thereafter, is proposed in three stages in this thesis.

The first assumption to design such procedure was using ingredients as playing factors instead of food attributes e.g. texture or odor. The reason behind is that, to control a specific food attribute as a factor the ingredients should be adjusted, resulting in an unwanted change in other attributes. However, by employing the ingredients as product factors no other ingredient is affected while controlling a specific ingredient as a factor. Moreover, asking people about different product attributes might result in unreliable data since different criteria are used by persons, while asking about that many attributes at the same time. An example could be the definition of sourness and the degree of acceptance of that attribute that might be different among the people. In addition, decomposing the taste of a product to various attributes might make the respondents tedious resulting in unreliable outcomes. Therefore, asking about overall liking is preferred in all stages of the procedure.

Next, the domain the product belongs to is to be specified in the first stage of the method because of not being deviated from the right direction of product development path. Different products are selected from the market to specify the boundary of the realm to focus. However, when the product is totally new to the market another strategy should be achieved, expandable as a further research.

Finally, to find the ideal, product optimization is employed. RSM is a tool proposed to be used in this thesis. However, the other tools such as experimental mixture design could be recruited according to the conditions of use.

8 FURTHER RESEARCHES

Because of the restrictions faced in this project, no empirical test was made on the proposed method. As a further research, different food products could be examined following the structure of the procedure. Although every research might be dissimilar to the others in some facets such as encompassing different ingredients or containing different process attributes, the outcomes should guide the developers in the same way.

The other aspect on which more researches could be made is the development of a product new to the market. In the first step of the proposed method, a domain, representing the area to focus for the further stages of the procedure, is to be defined by selecting many products from the market. However, it needs more investigation to determine the domain while the product is totally new to the market. Therefore, it is the concept of use to be specified at first.

Furthermore, the research could be expanded on the packaging of a food product. By optimizing the exterior appearance of a product, the value of a food could be highlighted. In other words, the success of the product in the market could be guaranteed more.

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APPENDICES

Appendix 1

The appropriate value of α and n_c for different amount of k (Montgomery, 2009)

K	2	3	4	5	5 1/2 Rep.	6	6 1/2 Rep.	7	7 1/2 Rep.
Total number of points	14	20	30	54	33	90	54	169	80
n_c	6	6	6	12	7	14	10	27	12
α (Rotatability)	1.4142	1.6818	2	2.3748	2	2.8284	2.3748	3.3636	2.8284

Appendix 2

Sample interview questions from marketing department:

- How do you usually perform a sensorial experiment?
- How do you define a sampling population?
- Using the company's employees as a sampling population, does not it make the outcomes prone to bias?
- Which one do you prefer: a localized sampling or a wide spread one? Which place is suitable to perform a sensorial experiment?
- How do you motivate the respondents to take part actively in the designed experiment?
- How do you define the market segments? What criteria do you use to make such description?
- How do you share the research information with R&D department?

Sample interview questions from R&D department:

- How do you prepare a prototype to suggest it to marketing department? How do you define the formula?
- To design a new product, to what extent do you use the marketing department suggestions?
- Is it possible for you to extract the ingredients of an unknown product? To what extent?