TAKING INTO ACCOUNT THE CONSUMERS' EXPECTATIONS,PUBLIC HEALTH POLICIES AND FOOD PRODUCT DESIGN

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ABSTRACT

This work is part of a project of the National Research Agency, which includes nutritionists and researchers of different academic laboratories. The present paper introduces some methods used to identify and evaluate consumer needs and preferences. We also propose a model in order to find a compromise between consumers' expectations, PNNS (French national program of nutrition and health) regulations, technical and economical constraints of frozen pizza producers. Furthermore we want to represent and to weight consumers' expectations that will be used as inputs for a QFD (Quality Function Deployment) matrix. The suggested model is based on consumer research methods and proposes a field of product solutions that takes into account the different expectations. For that purpose, we consider a pairwise comparison test of pizzas with consumers in order to identify their perceptions towards these products. Afterwards, we propose another test in order to determine the importance of the pizza attributes. From these results and taking into account the recommendations of PNNS and their technical and economical constraints, the producers will generate models of pizzas. Later on, a tasting test with consumers is considered, so we can determine the set of preferred pizzas which will represent the intended field of the possible solutions.

Keywords: *QFD, AHC, AHP, LSLR, Pairwise Comparisons*

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1. INTRODUCTION

The purpose of the new nutritional program (PNNS) [1] has an impact on the way meals are prepared. In fact, what PNNS recommends is to increase the consumption of fruits and vegetables and to reduce the amount of sugar, salt and fat. However, these recommendations are against both industrial and consumer preferences. Indeed, salt and sugar are flavor enhancer, appreciated by consumers and by industrials as they make it easier to regulate the production process and thus limit the cost of production.

The research problem discussed in this paper consists of establishing a field of solutions between the expectations of consumers of a frozen pizza, PNNS regulations and constraints of frozen pizza producers. Consequently, we propose a model to find a compromise between these requirements. The determination of customer preferences will specify the nature and importance of the product parameters for characterized groups of consumers. The intersection of these results later in the QFD (Quality Function Deployment) matrix with the recipe and the processes making parameters will enable the establishment of the solutions' field stated before.

We organize this paper as follows. We first introduce some user centered design methods and some of their applications in section 2. Next, we describe our model in section 3. Following, section 4 explains the expected results. Finally, we conclude and present the perspectives of our research in section 5.

2. STATE OF THE ART AND GOALS OF RESEARCH

Consumer centered design methods are utilized to analyze consumer needs and to take into account their perceptions in the development of new products. Van Kleef et al. [2] present ten consumer research methods and techniques and different fields of application: marketing, research and development, innovation... In Japan, methods such as Kansei Engineering (Nagamachi, 1970) [3] applied in the automotive industry and QFD (Akao, 1966) [4] have been developed to meet the customer needs and to 'incorporate their voice' throughout the stages of product design [2]. In fact, the QFD shows the correlation between the customer requirements and the product design attributes (Figure 1), these requirements are classified and weighted in the QFD matrix. There exists some methods for weighting the design attributes, such as AHP (Analytic Hierarchy Process) (Saaty, 1980) [5] and the pairwise comparisons methods (Fechner, 1860). Pairwise comparisons methods are indeed used to evaluate the weights of an element (product, attribute…) compared to other elements in a pairwise comparison test. Other methods besides AHP found in the literature are: the Least Square Logarithmic Regression (LSLR) (De Graan, 1980 ; Lootsma, 1981), the Row Column Geometric Mean (RCGM) proposed by Koczkodaj and Orlowski and presented in [6] ... The pairwise comparisons methods are used in the perceptual evaluation of products (dashboards [7], table glasses [8] ...).

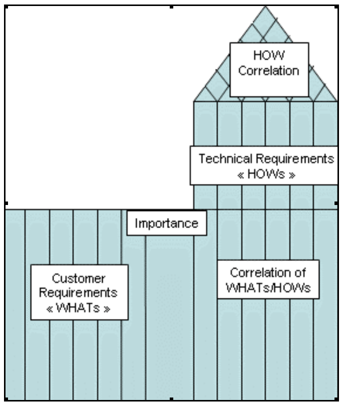

Figure 1: Illustration of a QFD extract

In the model we propose afterwards, we chose to use two pairwise comparisons methods: LSLR and the eigenvectors of AHP (Saaty, 1980) [5]. We use LSLR in a products comparison test with consumers. In fact, with this method, it is possible not to report all the comparisons between products, therefore it is a preferable method for evaluating several products (over eight) [7] and when the consumer has difficulty to express their preference between two products. As for the eigenvector method of AHP, it is simple to apply and appropriate when the number of comparisons is not important. This method assumes that each pairwise comparison is associated with exactly one opinion and therefore requires one opinion by comparison [6]. Thus, this method incorporates subjective judgments that we need in our model to determine the priorities of product attributes for a particular consumer and to build our QFD.

Dagher's thesis [9] proposed a protocol to define a product space in the case of wristwatches and car headlights design. This protocol is based on some of the aforementioned methods, Ascendant Hierarchical Clustering (AHC) (Hair et al., 1998) and descriptive statistics methods such as the principal component analysis (PCA) (Hotelling, 1933). In fact, the protocol structuring guided the construction of our model which articulates these different methods. We will adapt this protocol to our problem while adding stages that will contribute to drawing up the model.

We are inspired by the car headlights design application in order to establish a field of possible solutions and to find a compromise between the frozen pizza consumers' expectations, the PNNS recommendations and the technical and the economical producers' constraints.

We use the QFD and the eigenvector method to represent and to balance the consumers' expectations which we call semantic attributes of the pizza.

3. MODEL– EXPERIMENTATION

In this section, we present the experimental conditions of the tests with consumers. We also describe the different stages of the proposed model (Figure 2).

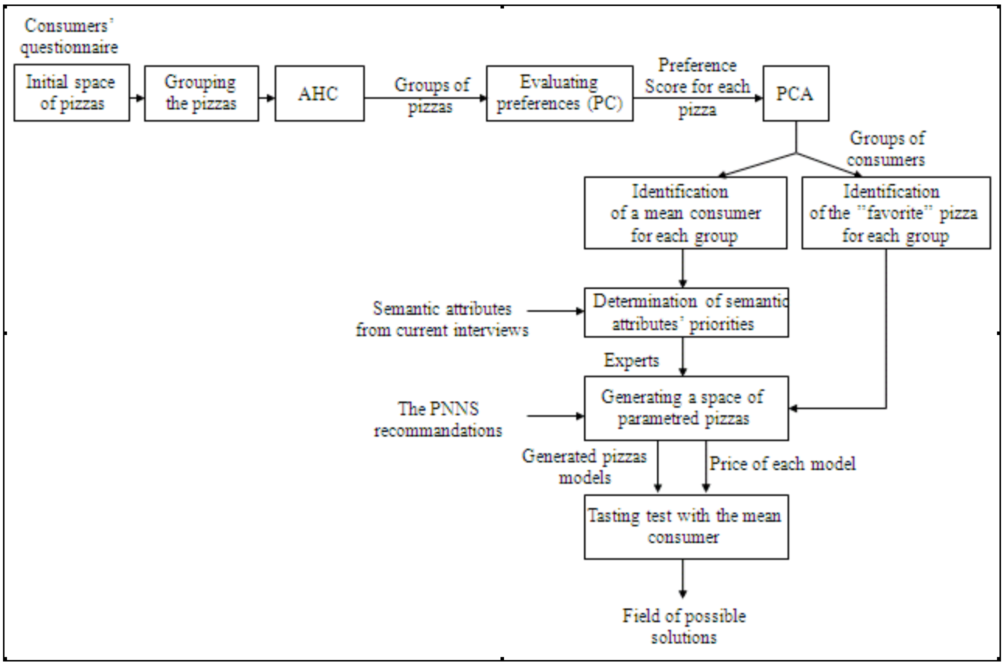

Figure 2: Establishing the field of possible product solutions and the semantic attributes priorities

3.1. Experimental conditions

- *Initial space of pizzas*

Firstly, we choose 20 pictures of different pizzas (variability factors: diameter, dough thickness, ingredients amount) that will be presented via the Internet to a panel of consumers.

- *Panel*

We chose a diversified panel of 200 consumers (age, gender, income level). All of them consume a frozen pizza at least three times a year. We ask them to mention their ages, income level ... and to distribute the pizzas into coherent groups (a minimum of two groups, a maximum of four groups). The order of presented pizzas was randomized. Only pictures will be shown since a tasting of 20 products by the panel does not make sense.

3.2. Grouping the pizzas

For each consumer, we associate a dissimilarity matrix (pizzas in rows and columns). It is filled with "0" if two pizzas are in the same group and "1" if they are not considered in the same group. The overall dissimilarity matrix is equal to the sum of each matrix filled by a consumer (Figure 3).

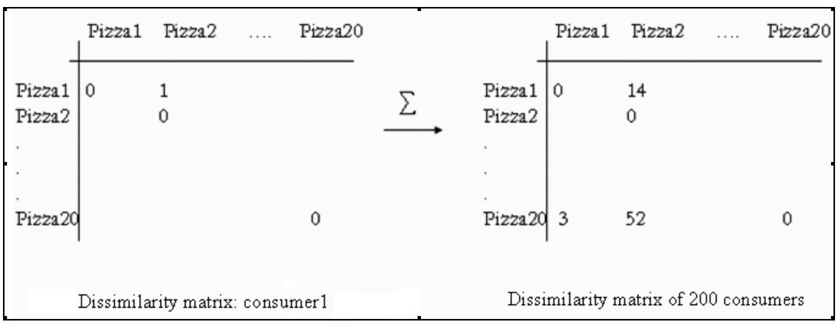

Figure 3: Overall dissimilarity matrix extract (200 consumers)

3.3. AHC

We apply an AHC on overall matrix in order to get homogeneous partitions of pizzas that will be used for future comparisons. Actually, each element of the overall matrix represents a dissimilarity distance between two pizzas. Applying the AHC led to a hierarchical tree or dendrogram provided in figure 4. The dendrogram is used to determine the number of partitions of pizzas that really exist [10]. The pizzas are given on the x-axis, the height of each branch of the tree describes the dissimilarity between these pizzas. Ward's method [9] enables to make partitions; the tree will be cut at a given level to define partitions of pizzas. We assume that we will get four groups of pizzas after applying the AHC method. Figure 4 shows possible classification results.

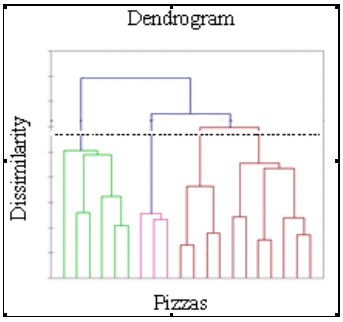

Figure 4: Illustration of an ascendant hierarchical clustering (20 pizzas)

3.4. Evaluating preferences – Pairwise comparisons (PC)

We conduct a pairwise comparison test with the consumers of pizzas groups thus obtained. In fact, the pairwise comparisons methods are easy to implement and usually provide a value of discrimination more important than the direct assessments on a hedonic scale [9]. In order to carry out the test for evaluating preferences with 200 consumers and then to determine the preferences scores for 20 pizzas, we draw our inspiration from the car headlights design application presented in Dagher's thesis [9]. The order of presenting pairs of pizzas was randomized in each group (in the previous section, we obtained four groups). In each group, the consumer has to compare two pictures of pizza (Figure 5). Afterwards, we ask them to indicate the most preferred pizza in each of the four groups, then to make a pairwise comparison of this pizza with three pizzas they like in the remaining three groups (Figure 5). A category scale of seven levels shown in figure 5 can be used. The linguistic variables constituting this scale are: (more preferred, preferred, somewhat more preferred, no preference, a bit less preferred, less preferred, much less preferred). This scale is respectively represented as follows: (>>,>, > =, =, <=, <, <<).

Therefore, we convert this category scale into a ratio scale (Lootsma, 1993), that is as follows: (8, 4, 2, 1, 1/2, 1/4, 1/8), each scale level which we note Cij estimates the importance of two pizzas i and j thus compared.

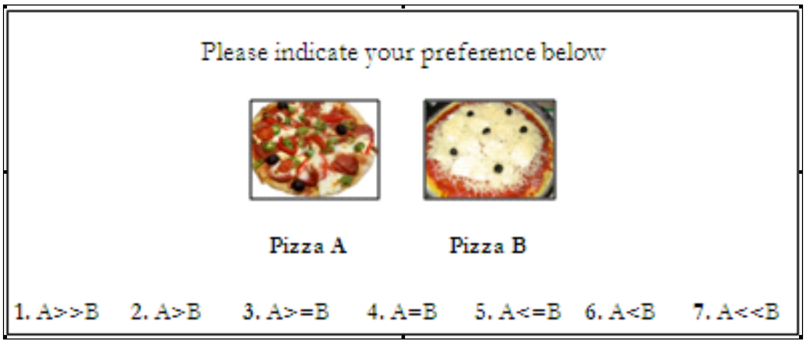

Figure 5: Pizza preference test

For each consumer (200 consumers), we have a square comparison matrix (Cij). The dimension of the matrix is 20 and Cij ≈ pi/pj, where i, j = 1 … 20 and pi, pj represent respectively the preference scores of the pizza i and the pizza j (Figure 6).

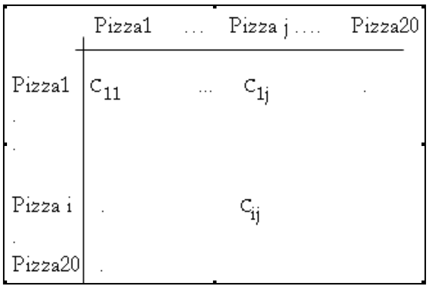

Figure 6: The pairwise comparison matrix

In order to assess the preference scores pi (i = 1…20), of 200 consumers, we choose the LSLR method. As stated in section 2, LSLR tolerates sparse pairwise comparison matrix [7]. The consistency of comparisons for each consumer has to be checked. A consistency assessment index (Limayem and Yannou, 2004) is calculated to identify incoherent subjects. If the consumer is inconsistent in their judgments, they will be eliminated from the further study. So, we keep only coherent consumers in the following.

3.5. PCA

Let *c* be a number of coherent consumers. At this model stage, we wonder whether there is a group of consumers who like the same pizza. We opt for PCA in order to determine the consumers' groups. In the PCA, we have a two-dimensional array containing subjects in lines and variables in columns. The aim of this method is to find a better representation of the subjects in a factorial space that contains a minimum of variables (factorial axis), which are the principal components and on which subjects will be projected. Computer programs enable the extraction of the principal components [10] and represent subjects and variables in a factorial plan. PCA analytical discussion [10] can be found in (Piggott and Sharman, 1986).

In our study, the consumers represent the subjects of the PCA and the pizzas are the variables. After the pairwise comparison test stated above (see section 3.4.), we get a table: the lines represent *c* consumers, and columns consist of 20 pizzas. The table includes preference scores of the consumer i towards the pizza j: scorei,j; i=1… c; j=1…20 (Table 1).

Table 1: Preference scores : Consumers x Pizzas

Pizza / Consumer	Pizza 1	Pizza2	…	Pizza j	…	Pizza 20
Consumer 1	score$_{1,1}$	score$_{1,2}$	…	score$_{1,,j}$	…	score$_{1,20}$
Consumer 2	score$_{2,1}$	score$_{2,2}$	…	score$_{2,,j}$	…	score$_{2,20}$
. . .	. . .	. . .	. . .		. . .	
Consumer i	score$_{i,1}$	score$_{i,2}$	…	score$_{i,j}$	…	score$_{i,20}$
. . .	…	…	…		…	
Consumer c	score$_{c,1}$	score$_{c,2}$	…	score$_{c,j}$	…	score$_{c,20}$

We apply a PCA on table 1. Figure *7* shows an example of results. Then, let us suppose that we distinguish on the graph four different groups of consumers. In order to determine the most preferred pizza of each group of consumers, we calculate the average of the preferences scores on each column (Table 1), for each group of consumers. Consequently, we deduct which pizza has a highest score and which we call the "favorite" pizza of the group in question.

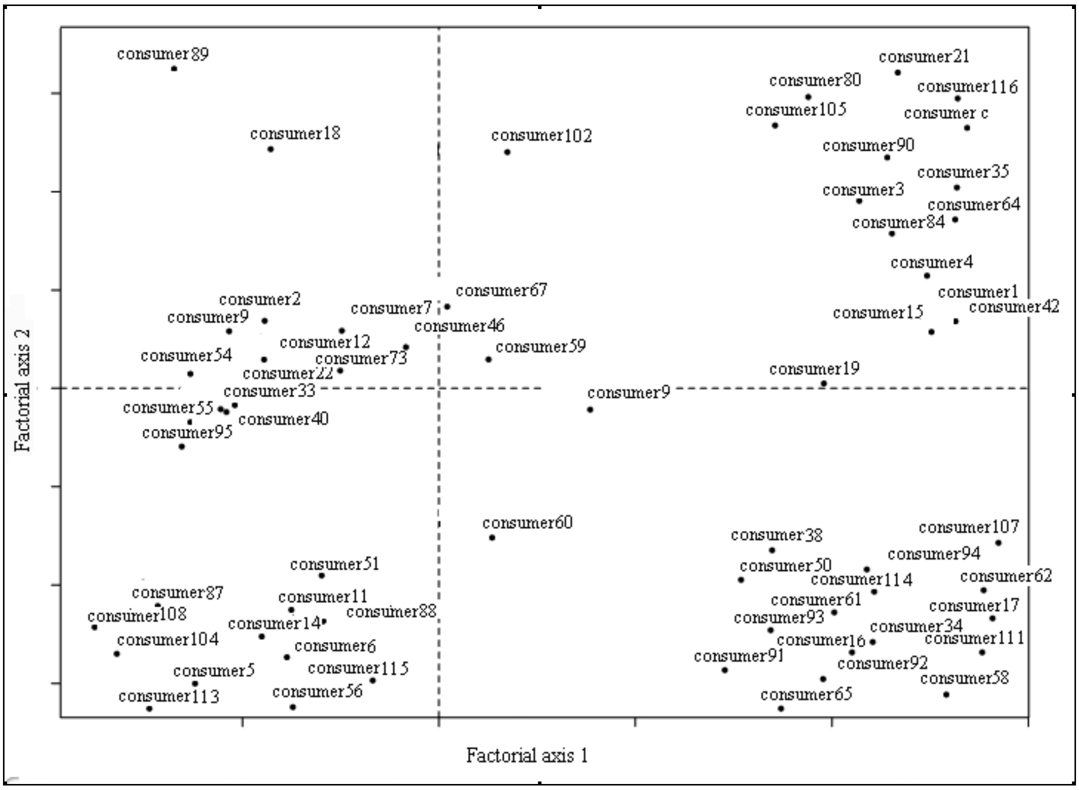

Figure 7: Illustration of consumers' projection on the factorial plane

3.6. Determination of semantic attributes priorities

Semantic attributes priorities really represent the weights of "What" column of the QFD called "Importance" column (Figure1). In this stage of our model, we identify a representative subject in each of the four consumers groups determined by the application of the PCA. The representative or mean subject is one whose preference score for "favorite" pizza of his group is the closest to the average of preferences scores of consumers in the same group for that pizza. Let i be a mean consumer and group i, the group of consumers to which he belongs; i = 1 ... 4.

Then, we carry out a pairwise comparison test of pizza's semantic attributes with this consumer. The semantic attributes are determined from the current interviews. In fact, as part of AlimInfo project, interviews with consumers are under way. The objective of these interviews is to identify the semantic attributes of pizza. Later on, we suppose that we have *n* semantic attributes.

We use the AHP method to determine the importance that subject i attaches to each pizza semantic attribute: the importance of the expected pizza semantic attribute according to their insights and which we call the "perfect" pizza. We are inspired by a wristwatches application (Dagher, 2008) [9] in order to perform the test: subject i has to compare pairs of pizza semantic attributes. A category scale of five levels is used and represented as follows: (attribute j is more preferred than attribute k, attribute j is preferred to attribute k, indifference, attribute k is preferred to attribute j, attribute k is more preferred than attribute j); j, k = 1 ... *n*. Afterwards, we convert this category scale into a ratio scale (Lootsma, 1981). The ratio scale is represented as follows: (4, 2, 1, 1/2, 1/4). Then, we apply Saaty's eigenvector method to determine the weight of each semantic attribute. The sum of all of the attributes weights should be equal to 1.

After determining semantic attributes weights, a consistency assessment index can be calculated in order to verify the consistency of subjects' judgments. If the mean subject i is incoherent when comparing attributes, we separate them from the test and we choose another mean subject from the same group, and we conduct the same test with them. We apply the same approach for each mean subject of the three other consumers groups so as to weight the semantic attributes of the "perfect" pizza of each group.

In the present section, we have determined semantic attributes priorities of the "perfect" pizza. These priorities could be represented in the "Importance" column of the QFD, with the corresponding semantic attributes. However, with these semantic attributes weights, do we obtain a field of pizzas that both meets the recommendations of PNNS and the producers' technical and economical constraints? In fact, we will try to answer this question in the next section (3.7.). The field of possible solutions we are looking for must also take into account the consumers' expectations such as organoleptic quality and pizza price, but at this point, no consumer has tasted any pizza. Furthermore, in the tests carried out till now we have not addressed the price issue yet. In fact, this issue will be treated in section 3.8.

3.7. Generating a space of parametred pizzas

In this stage of the model, pizza makers are involved, we distinguish: experts of the formulation (the recipe) and experts of production (the choice of the processes and settings).

They have to set the design parameters on which depend the semantic attributes of the product. For instance, these parameters are the amount of salt, the cheese mass, the thickness of the dough ... Several levels are proposed for different design parameters; these levels take into account the PNNS regulations. Moreover, experts will have the semantic attributes weights of the "perfect" pizza according to the mean consumer in each group as stated earlier. Then, experts can generate several new products (or models) for each group while exploring different levels of these criteria and considering the "favorite" pizza of each consumers group which has been determined after the application of PCA (Section 3.5).

We assume that experts generate *m* models of pizzas for each of the four consumers groups. In fact, this new space of *m* pizzas takes into account the recommendations of PNNS and the techno-economical constraints of pizza makers. Later on, we have to determine if these *m* models also take into account expectations of each group of consumers as far as organoleptic quality and pizza prices are concerned.

3.8. Tasting Test

We dispose of *m* models of pizzas generated by the experts from the "favorite" pizza of the consumers group i (i = 1 ... 4). With these *m* models, we conduct a tasting test with the mean subject i, in addition we tell him the price of each model in order to determine the pizzas they prefer as far as taste and prices are concerned. Finally, and after this tasting test, we can get a pizza or a field of pizza solutions which is acceptable by the subject i, therefore by the group i of consumers, and which takes into account the expectations of the latter group of consumers, PNNS regulations and the constraints of pizza producers.

4. RESULTS

The expected results are to propose a model that generates a space of products which takes into account the expectations of groups of consumers, PNNS regulations and the constraints of frozen pizzas makers. The priorities of product attributes that are inputs of QFD matrix may depend on the groups of consumers. Consequently, it is possible to reach different QFD matrices that represent each of these groups. So, in our case of study, we will have four matrices, and if we examine the demographic data (age, sex ...) of consumers of each group, it is possible the latter consumers belong to the same socio-professional group. Consumers of the same group could also share other characteristics that remain to be determined.

With the proposed protocol, we assume that, after carrying out the test with 200 consumers, we obtain groups of consumers. The protocol remains applicable in the different case (no groups of consumers), therefore, we can select a subset of consumers to realize the tasting test.

5. SUMMARY AND PERSPECTIVES

In this paper, we presented some of consumer centered design methods and others used in data analysis. Then, we proposed a model which generates a product space that meets antagonistic constraints, namely the expectations of frozen pizza consumers, PNNS recommendations and the constraints of pizza makers. With the ascendant hierarchical clustering method, we identified groups of pizzas. After applying the principal component analysis, a graphic visualization allowed us to explore consumer groups. Afterwards, the pairwise comparison method allowed us to determine consumer preferences and to weight product attributes which are inputs of the QFD matrix.

As perspectives of this work, we can think about an association between the design parameters of the pizza and the consumers' expectations, and an association between theses expectations and the cost of pizza. In fact, such an association allows the producers to predict the cost of the pizza while varying the different levels of design parameters. An association between the demographic data of consumers groups and the semantic attributes of the pizza could also be interesting.

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