Quality Function Deployment: Can Improve Innovation Efficiency in the Food Industry?

Marian Garcia[1], Pilar de Carlos[2], Isabel de Felipe[2], Julian Briz[2], Federico Morais[3] and Manuel Navarro[4]

[1] Kent Business School, University of Kent, Imperial College's Wye Campus, Wye, Ashford, Kent, TN25 5AH, UK. marian.garcia@imperial.ac.uk

[2] Polytechnic University of Madrid. ETSI Agrónomos. Department of Agricultural Economics. Ciudad Universitaria s/n. 28040, Madrid, Spain. (Tel.: +34 913365791; fax: +34 3365797

pilar.decarlos@upm.es; isabel.defelipe@upm.es; julian.briz@upm.es

[3] Spanish Food and Drink Federation (FIAB), Diego de León 44, 28006, Madrid, Spain. otri@fiab.es

[4]NCA Consultants, Pza. España 18, 28008 Madrid, Spain. mnavarro@ncagrupo.com

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[1] *Kent Business School, University of Kent, Imperial College's Wye Campus, Wye, Ashford, Kent, TN25 5AH, UK. marian.garcia@imperial.ac.uk*

[2] *Polytechnic University of Madrid. ETSI Agrónomos. Department of Agricultural Economics. Ciudad Universitaria s/n. 28040, Madrid, Spain. (Tel.: +34 913365791; fax: +34 3365797 pilar.decarlos@upm.es; isabel.defelipe@upm.es; julian.briz@upm.es*

[3] *Spanish Food and Drink Federation (FIAB), Diego de León 44, 28006, Madrid, Spain. otri@fiab.es*

[4]*NCA Consultants, Pza. España 18, 28008 Madrid, Spain. mnavarro@ncagrupo.com*

Abstract

This paper considers the implementation of the Quality Function Deployment (QFD) as a methodological framework for the development of new food products. This paper focuses on the beef supply chain and develops a horizontal product's quality deployment as a strategic tool for the implementation of consumer-led product innovation strategies. Difficulties in the prioritisation of parameters and setting of target values for the desired performance level of each parameter would limit the implementation of a complete 'four-phase' model in the sector. Thus, the use of complementary management tools, such as SWOT analysis and Failure Mode and Effect Analysis (FMEA) would be necessary to develop more suitable process designs to the specific requirements of the sector.

1. Introduction

The development of new products and how the process is organised and managed within the firm is a key area in management research due to the high failure rate of new products and the resulting waste of limited resources. Thus, with the knowledge of the risks involved in developing new products and the high failure costs, researchers and practitioners are confronted with the difficult task of choosing the winners from the losers at the earliest stage possible.

This paper focuses on the food industry where a large number of new products are introduced in the market each year. However, estimates for the number of new products failures are as wide-ranging as those for new product introductions. Approximately 60%-80% of new food products fail (Goldman, 2005). New product introductions are only the tip of the iceberg where many projects fail before the launch resulting in the loss of considerable time and expenditure. For each product going into test market, another 13 have been developed at lab level or gone through preliminary production viability assessment before being rejected (Fuller, 1994).

The reasons behind these high new food product failure rates are varied. First, there are factors related to the new product development (NPD) process itself. Developing new products is an increasingly complex and sizeable activity, with only a low rate of commercial success. The complexities surrounding the NPD process are exacerbated by the market characteristics of the food industry. Food markets are mature and overall volume growth is fairly static in size (if not value). Some food categories are nearing product saturation with too many products, especially line extension, which can confuse consumers (Harris, 2002).

This 'defensive-imitative' behaviour exhibited by the food industry has important consequences given the increasing consolidation in food retailing (Garcia Martinez and Burns, 1999; Garcia Martinez and Briz, 2000). Global retail groups have been able to leverage their bargaining power more effectively, driving down manufacturers' margins with the resulting impact on innovation and research and development (R&D) expenditure. Development budgets in food companies are typically dwarfed by advertising, promotion and other marketing expenditures. R&D spending in food companies typically represents only 1% to 2% of revenues, compared to 8% to 15% of revenues in the high-tech sectors (Bargman and Pomponi, 2004). Moreover, new food branded products face increasing competition from retailers' own labels for shelf space which has led to a reduction in the number of products displayed, in particularly secondary brands (Fernandez Nogales and Gomez Suarez, 2005).

However, market opportunities still exist for those food companies that embrace innovation and respond to changes in consumer demand and food-related lifestyles. Developing new products and being innovative requires companies to have a deep understanding of the consumer, the market and the environment in which they operate but most importantly to effectively apply this knowledge to the development of new products that meet consumer's expectations. This calls for the implementation of an effective, structured and consumer-oriented NPD process.

This paper considers the practical implementation of the Quality Function Deployment (QFD) as a methodological framework for the development of new food products. QFD is considered as the most complete and comprehensive methodology for planning the goals of a stream of processes in order to align them with customer's requirements (Holmen and Kristensen, 1998). To date, however, the practical implementation of QFD in the food industry has been quite limited due to the partial adaptation of QFD models to the specific requirements of the food industry. This paper simulates a product's quality deployment for the beef sector as a strategic planning tool for the implementation of consumer-led product innovation strategies by translating consumer demands into new product design features. The study follows a chain approach through the development of a horizontal deployment design of all quality parameters along the beef supply chain.

2. The Quality Function Deployment

2.1. The Philosophy

QFD is a planning process for the design of new products. It provides a systematic method for translating 'customer requirements' into design and process parameters – 'company requirements' (King, 1992). In doing so, QFD helps companies to reduce two types of risks: firstly, the non-correspondence between product specifications and the needs and wants of a predetermined target group of customers; and secondly, the non-correspondence between the final and the original product specifications (Holmen and Kristensen, 1998).

From a R&D perspective, QFD can be seen as a set of planning tools that help companies introducing new or improved products/services faster to the market by controlling their development process and focusing on customer satisfaction (Hofmeister, 1991; Cohen, 1995; Costa, 2003). QFD can help companies identify and discard misguided concepts before they enter the development pipeline (Kathawala and Motwani, 1994). While maintaining and enhancing quality design, QFD has helped to reduce design time by 40% and design cost by 60% (Hauser, 1993). These improvements result from increased communication between functional teams at early stages of the NPD process and from ensuring that this customer focus is kept throughout the development process (Hauser and Clausing, 1988; Urban and Hauser, 1993).

2.2. QFD Implementation

QFD is based on the belief that products should be designed to reflect customers' demands and needs. Therefore, the project requires top management commitment and organisational support, clear definition of project objectives and the creation of a cross-functional team including members from all functional areas involved in NPD and market introduction and product testing (Costa et al., 2001).

The literature refers to two main QFD implementation methods based on the generation of a cascade of matrix-shaped charts:

a) The generic approach, known as '*Akao matrix of matrices'* (Akao, 1990). This is the most comprehensive QFD implementation model based on a scheme of 30 matrices or quality tables, where each matrix details a specific aspect of the development process (Cohen, 1995).

b) The focused approach, known as '*the Four-Phase approach'* (Figure 1) which is the most common QFD implementation technique where the physical product can be described as several components assembled together to obtain the final product (Hauser and Clausing, 1988).

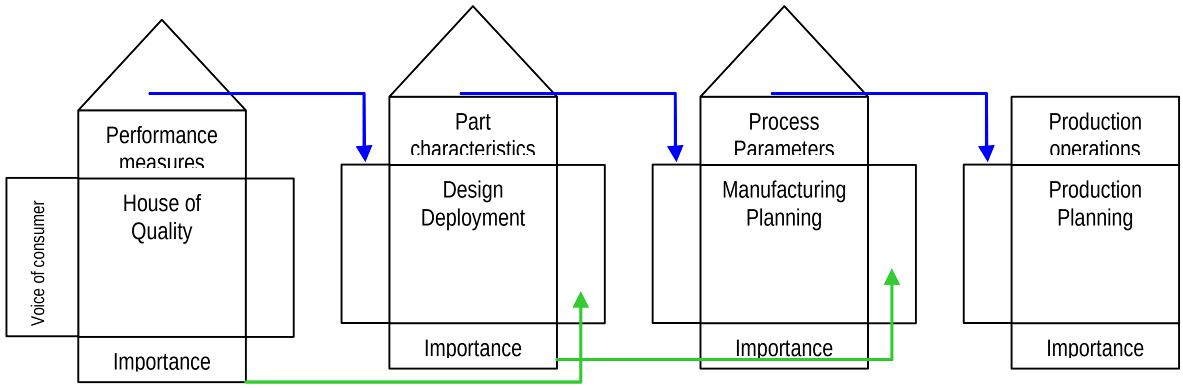

Figure 1. The Four-Phase Method (Source: Benner et al. (2003))

The Product Planning Matrix (PPM) is the first stage in QFD's four-phase approach (Figure 2). This matrix includes a number of 'rooms' that are sequentially filled in order to translate customer demands into product requirements (or product attributes) (Hofmeister, 1991; Charteris, 1993). The PPM's first room concerns the 'Voice of the Customer'. This is considered as the most critical step in a QFD project since these customer demands (also known as customer attributes – CAs or 'WHATs') are the guiding principles of the whole development process and a misinterpretation at this stage may seriously compromise the process outcome (Cohen, 1995).

Once CAs have been determined and established, the next step is to understand where the company and its competitors stand in terms of satisfying these demands in the marketplace by completing the *Strategic Planning Room* (Figure 2) (Hauser and Clausing, 1988). Then, the QFD team has to decide which of these product requirements (also called HOWs) can be incorporated in the final product in order to satisfy customer demands (Costa et al., 2001). This is represented in the PPM by the *Voice of the Company Room* (Figure 2). It determines whether a relationship should exist between a CA row (WHAT) and a company requirement column (HOW).

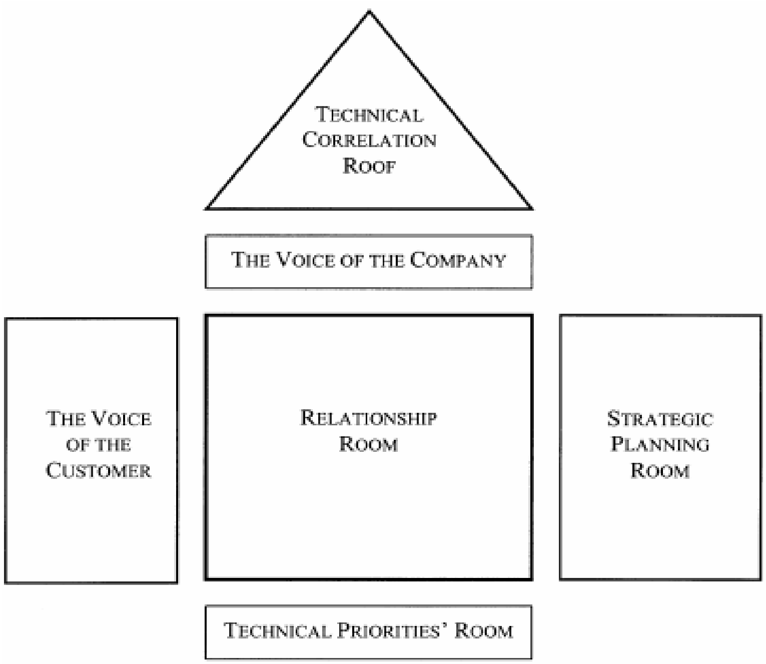

Figure 2. The Product Planning Matrix (PPM) (Source: Costa et al. (2001))

The following step consists in filling out the roof, the *Technical Correlation Roof* (Figure 2) where correlations between the HOWs are identified. The purpose is to determine the positive (synergistic) and negative (trade-off) ways in which HOWs influence each other (Holmen and Kristensen, 1998). The QFD team must now fill the core of the HOQ, the *Relationship Room*, where each WHAT (*Voice of the Customer*) and HOW (*Voice of the Company*) are linked by a cross-functional project team, with sufficient experience in the field under investigation.

The last task in building the PPM is filling the *Technical Priorities Room* (Figure 2). If values from competitor products are known these can be shown in the lower matrix - the *Technical Competitive Assessment*, and used by the design team to establish the target values of own products (Dalen, 1996). The *Technical Competitive Assessment* is then compared with the *Customer Competitive Assessment* (in the Strategic Planning Room). This enables determining inconsistencies between the way the customer and the company are evaluating the existing products (Hofmeister, 1991; Cohen, 1995; Govers, 1996; Costa et al., 2001). In addition, the *Customer* and the *Technical Competitive Assessment,* the *Sales Points,* the *Relationship Room* and the *Customer Importance Ratings* all contribute to determine the *Target* Values, or HOW MUCH's.

Most studies have concentrated on the development of the PPM since it contains the most critical information a development team needs regarding the company's relationship with customers and its competitive position in the marketplace (Costa et al., 2001). The PPM provides a company with the goals they should try to reach in the intended product. However, it does not indicate what part, processes or production plan the company needs to realise these goals (Hauser and Clausing, 1988). Hence, once the PPM has been constructed, additional matrices can be made to further guide the actions for the development team.

3. Implementation of QFD in the Food Industry

The literature on the application of QFD in the food industry is limited (for a review see Benner et al., 2003). Research has mostly focused on the implementation of the first matrix, the PPM (Charteris, 1993; Rudolph, 1995; Dalen, 1996; Holmen and Kristensen, 1998; Costa et al., 2001; Benner et al., 2003). While QFD is regarded as a suitable and promising method to increase the innovative performance of the food industry, research indicates that QFD still needs significant development and understanding before the method can be extensively applied in new food product development (Dekker and Linnemann, 1998; Costa et al., 2001; Benner et al., 2003).

Several authors have proposed modifications to the QFD model in order to make it applicable to the development of new food products. Hofmeister (1991) proposed the QFD Food Industry Roadmap in which two alternative roads are defined for deploying the 'Voice of the Customer' throughout the NPD process: the packaging deployment road and the food deployment road (Benner, 2005). Modifications of the first matrix, the PPM, are also found in the literature. Holmen and Kristensen (1996) divided CAs into intermediate users requirements and end-users requirements. They added an incompatibility matrix to the right side of the relationship matrix to show incompatibilities between these demands which are considered as an input to the NPD process. They also suggested some upstream and downstream extension to the PPM to incorporate the involvement of other stakeholders in the NPD process (Holmen and Kristensen, 1996; 1998).

These studies suggest that QFD could be useful in increasing the innovative performance of food R&D if adaptations of the model are made and the specific characteristics of food ingredients taken into account (Benner et al., 2003). Food products cannot be described just as a set of attributes, which together fulfil consumers' needs (Costa et al., 2001). Interactions between attributes can play a decisive role in achieving consumer satisfaction. Foodstuffs are complex products with which people have equally complex relationships (Costa et al., 2001). Raw materials show a natural predisposition for variation that does not suit well with the somewhat inflexible character of QFD charts regarding changes (Dekker and Linnemann, 1998). Many food ingredients show many interactions and some HOWs could affect more than one WHAT. These interactions and the large list of customer demands are often seen as the major bottlenecks of using QFD in new food product development (Hofmeister, 1991; Dekker and Linnemann, 1998).

4. A Horizontal Deployment Design for the Beef Supply Chain

To increase QFD's practical application in food R&D, this paper simulates a product's quality deployment for the beef supply chain as a strategic planning tool to ensure the translation of consumer product quality and safety demands into new product design features. The Spanish beef sector is facing increasing global competition through greater liberalisation of international markets and reform of the EU CAP (progressive reduction of export subsidies) (Guesdon, 2005). As a result, the sector needs to become more market oriented and implement effective, structured and consumer-oriented food product development processes by incorporating the 'voice of the customer' into their internal processes.

The deployment design builds on the limited literature on QFD projects in the food industry and adapts the QFD methodology to the specific characteristics of the beef sector. To incorporate the specific requirements of different actors in the beef supply chain, the study develops a horizontal deployment design of all quality parameters along the beef supply chain by constructing a PPM for each actor in the chain (Figure 3).

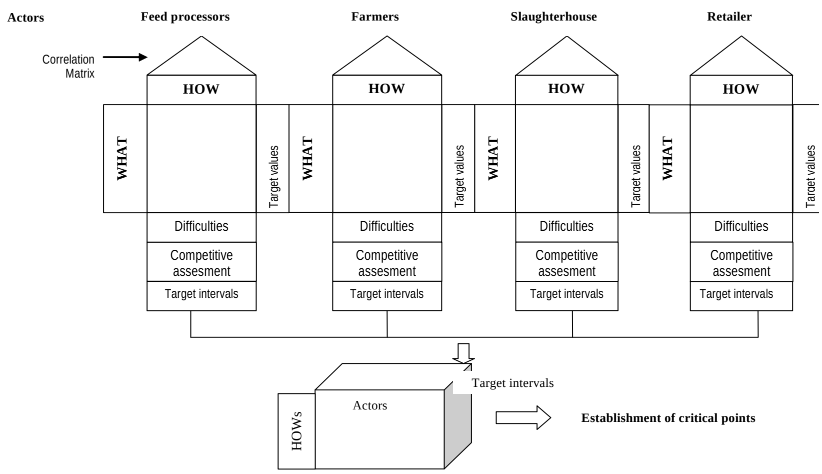

Figure 3. Horizontal Deployment of consumer demands in the beef supply chain

Consumer demands for beef products (WHATs) were obtained through a combination of both qualitative (focus groups) and quantitative (conjoint analysis) techniques. Results indicated intrinsic cues (i.e., external appearance, visible fat and presence of sinew) as the most valued perceived product characteristics to infer quality at the point of sale. Factor analysis[1] was conducted to measure the underlying structure of the intrinsic and extrinsic cues and four factors were extracted and collectively accounted for 60% of the total variance (Table 1).

1. A varimax rotation was conducted and the standard criterion of an eigenvalue >1 was applied to determine the appropriate factor structure.

Table 1. Voice of the Consumer

Quality Characteristic	Quality Parameter	Importance[1] (mean value)
Origin & guarantee (22% of variance)	Presence of PDOs	2.44
	Origin	2.90
	Presence of a retailer brand	1.72
Tenderness & freshness (15.5% of variance)	Presence of sinew	3.92
	Visible fat	3.96
	Best before date	3.34
Cooking & knowledge (121% of variance)	Cut	3.31
	Price	2.91
	Cooking information	2.11
External appearance and assistance (10% of variance)	Butcher's recommendations	3.68
	Colour, freshness	4.29

[1] 1: Not important - 5: Very important (N=511)

A key challenge was the large number of HOWs obtained (68 parameters). Hence, to make the process manageable we deployed quality characteristics for each actor in the chain independently. Next, we constructed the relationship matrix where each WHAT (Voice of the Customer) and HOW (Voice of the Company) were linked. Table 2 shows the relationship matrix at farmer level. Approximately only 30% of all HOWs included in the analysis were key determinants of 80% of the WHATs.

Table 2. Relationship matrix at farmer stage

Company characteristics / Customer requirements WHATs		IMPORTANCE	ANIMAL CHARACT.						BREED	FD	ADIT.		CARCASE			PROF	CONTROL				COSTS	COM.		
			Breed	Final Weight	Gender	age of the animal at slaughtering'	Growing period	Fattening period	Breeding method	Fodder	Use of additives	Protein concentrates	Carcase yield	Carcase Fat content	%muscle/%bone	Formation of the operator	Hygiene level	Law compliance	External controls	Quality label	Charges	Coordination with suppliers and customers	**Absolute importance**	**Relative Importance**
Origin & guarantee	Presence of PDO	2.44	9	3	1		1				3	1			1			9	1	9	9	9	498	18
	Origin	2.90		3	3	1					3	1		3	3		3	9	9	9	1	9	539	19
	Presence of a retailer brand	1.72		3	1	1	1	3	9	1	9		3	3	3	1	3	3	3	3	3		208	7
Tenderness & freshness	Presence of Sinew	3.92	3	9	9	9	1	3	3	3	1	9	9	9	9	9	1	1	1	1	3		245	9
	Visible fat	3.96	3		3		1		3					9	9	3	1		1	1	1		127	5
	Best before date	3.34												3		3	9	9	1	1		9	177	6
Cooking & knowledge	Cut	3.31	1	9	1	3	1	3	1					9	9	9					9		38	1
	Price	2.91	3		9	1			1				3	9	3		3	3	9	3	1	9	210	8
	Cooking information	2.11																					290	10
External appearance and assistance	Butcher's recommendations	3.68	3		9	3								9	9	9				3	3		194	7
	Colour, freshness	4.29	1	9	9	9	1	3	3	3		3	3	9	9	3	9	3	1	1	9	3	261	9
Competitive assessment (1-worse, 5- better)	Our organizations		2	4	4	1			5	1	1	4	4	4	4	4	5	5	5	4	2	3		
	Mercosur		3	4	3	4	3	3	4	4	4	3	2	5	3	2	2	1	2	1	4	3		
Difficulties (Technical, organizational, economic, legislative)			4	3	3	1	1	2	1	3	2	1	3	4	2	4	4	4	1	1	4	3		
Importance (absolute)			73	125	159	103	21	43	69	28	43	53	66	223	197	136	99	102	68	81	131	107		
Importance (relative)			3	4	6	4	1	2	2	1	2	2	2	8	7	5	4	4	2	3	5	4		

During the discussion sessions, participants were unable to provide a chain technical competitive assessment, underlying the low level of coordination between actors in the chain. Hence, target values were based on the importance ratings. In order to assess different business strategies to achieve the target values for each parameter, we constructed a chain correlation matrix to determine the positive (synergetic) and negative (trade-offs) ways in which quality parameters influence each other along the chain (Table 3).

Based on the results, each organization should focus their efforts on the target parameters. A competitive assessment is essential to determine the minimum value for each parameter. As long as an organisation is not able to identify its competition and compare itself against its competitors, it would not be in a position to make informed decision regarding the allocation of resources (i.e., time, money, people, etc.). Moreover, information on the correlations between parameters might encourage closer relationships between actors in the beef chain since each one would be aware of the impact of their actions on the parameters and the interactions with other stakeholders' parameters.

5. Conclusions and Recommendations

QFD allows companies to be proactive by adjusting the product concept to market requirements. Companies also need to assess their own capabilities and competitive advantage in the marketplace (strengths and weaknesses) as well as their competition and future (market, industry, and environment) developments (opportunities and threats). Once the company has undertaken an internal capability and competitive analysis together with an external competitive assessment, it would be in a position to make informed trade-off decisions regarding the prioritisation of parameters and setting of target values for the desired performance level of each parameter. The simulation exercise showed that though QFD could be a promising method to increase the innovative performance of the beef sector, the sector still has many structural weaknesses that limit its wider application. Hence, the use of complementary management tools, such as SWOP analysis and Failure Mode and Effect Analysis (FMEA) would be necessary to estimate qualitative or quantitative parameters and to build more robust process designs.

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Table 3. Beef Supply Chain Correlation Matrix

● Negative ○ Positive | N-nominal | m- Minor Improvement | M – Major Improvement

Breed	Final weight	Gender	Final age	Growing period	FAtting period	Livestock management system	Farm size	Kina of rations	Sort of foodstuffs	Foodstuffs quality	Ratio feed/fodder	Use of additives	Use of protein concentrates	Use of hormones	Type of instalations	Temperature	Animal welfare	Density	Transportation time	Carcase yield	Level of fat	%muscle/%bone	Carcase color	Bewilderment method	Bleeding efficiency	Time of maduration	Kina of maduration	Maduration pH	Water Retention Cpacity	Type of quartering	Colour	Texture	Fat	Storing time	Storing temperature	Lighting in shop	Display in shop	Labelling	Operador training	Sales time	Safety standards	Law fulfilment level	Third part inspection system	Quality labels	Animal origin	Fatting place
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