Quality Function Deployment (QFD) in the Spanish olive oil sector

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ABSTRACT

Competitiveness and sustainability of the olive-oil sector are strongly associated with the satisfaction of customer demand and preferences towards quality, safety, and environmental issues. In product design and development, Quality Function Deployment (QFD) provides a comprehensive, systematic approach to ensure agrifood products meet or exceed customer expectations. QFD can be a powerful tool because it can reduce time to market, improve quality, and enhance customer satisfaction. Although QFD has been used in the food industry since 1987, no application has been found in the case of olive oil.

In this study, after identifying customer needs or requirements of different attributes of quality olive oil, by a survey to 439 respondents to determine preference and consumption behaviour, agricultural practices that optimally satisfy these preferences were determined, through a Quality Function Deployment (QFD) model using expert knowledge.

The use of the correlation matrix and then the construction of the "House of Quality" (HOQ), the relative contribution of each of these practices that most satisfy customer needs and desires were designed. These matrices are used to translate higher-level "Whats" or needs into lower-level "Hows" – agronomical practices (technical characteristics) to satisfy these needs.

The findings are helpful for designing agricultural policies and marketing strategies to improve sustainability and competitiveness of Spanish olive oil.

Key words: Olive-oil quality attributes; consumer survey, Oleiculture; Quality function deployment.

I. INTRODUCTION

The growth of competition in the agro-food sector, accentuated by economic globalization, requires companies to promote and implement policies as well as innovative strategies to enhance their products, differentiating them by using distinctive signs of quality, durability, territoriality, alternative modes of production, etc. Innovation offers an excellent opportunity for differentiation, diversification, and product positioning in an increasingly dynamic and demanding market. Also, the growing concern and interest of consumers towards the products they use, security and safety of foods, and environmentally friendly production processes, impose new demands for the agri-food industry (Van der Valk and Wynstra, 2005). A key factor for success in the current market is to understand consumer behaviour, to identify its needs and requirements, and to integrate them into the strategic planning of all stages of production and/or services, processing, and marketing.

In addition to globalisation processes and the growth of social sensitivity towards food security and environmental sustainability, the European common regulatory context promotes an agri-food model which is more competitive, multifunctional, and sustainable. Also, it focuses not only on productivity but also on other functions or externalities that affect the consumers' welfare. In this sense, it is clear that the social dimension deserves major consideration in political decisions, in general, and those related to agri-food sector in particular. As a result, the Directorate General for Health and Consumer Protection has explicitly stated its desire to ensure the integration of interests and preferences of society in the planning, design, and implementation of the Common Agricultural Policy (CAP) (European Commission, 2003). The challenges of food security, the relationship between diet and health, the new requirements and buying habits of consumers and innovative practices that should be implemented by producers, processors and distributors to meet, require the food industry to pay most attention to studies focusing on consumer demands and developing new products and services (Benner et al. 2003; Gellynnk et al., 2003). Numerous empirical studies have illustrated the need to extrapolate the demands of consumers in the planning and designing of new products (Grunert et al. 1996; Bredahl et al. 1998; Bredahl, 2003, Vatthanakul, et al., 2010). This presents a great challenge for a considerable number of food industries in general and for the olive industry in particular. More concretely, in Andalusia (S Spain), the Agro-food Olive System (AOS) including the field of olive production, agro-industry, which transforms them into olive oil as the main product, and distribution and marketing sectors, is of great economic, sociocultural, and territorial importance in the region. Olive oil was chosen as the focal product of this study because it is regarded by consumers as a poorly differentiated product and therefore the results offer an opportunity to develop a more consumer-oriented product while determining a market segment.

The aim of this study is to develop and implement a methodological framework that integrates consumer needs towards the quality attributes of olive oil (organoleptic, sociocultural, environmental, etc.), and the potential production practices, processing, distribution, and marketing in order to satisfy these needs. Ultimately, this involves developing a complete approach to the concept of marketing quality olive oil. The major novelty of this study is a methodological and practical contribution to current research, which has tended to study the problem from a one-dimensional perspective (partial approach): viewing consumers, industry or business separately. To this end, the present study adopts a combined quantitative / qualitative approach. First, the literature was reviewed, followed by several group sessions and informal interviews. Next, a survey was undertaken to collect data on consumer attitudes, preferences, and needs (consumer voice) towards olive oil. Afterwards, a Quality Function Deployment was structured in order to convert and integrate consumer needs into potential detailed agronomic practices that would optimally satisfy these needs. In this paper, due to space limitations, we present only the results related to the farming sector (agricultural practices).

II. METHODOLOGICAL FRAMEWORK

The integration process of the "consumer voice" with the technological possibilities (practices specifications) a Quality Function Deployment (QFD) technique was implemented according to the four chronological steps detailed below:

(1) Identification, definition, and quantification of the quality requirements of olive-oil consumers (Whats)

The first stage of QFD application consists of identifying the consumer's perceived characteristics (consumer voice) of olive-oil quality or consumer needs. For this, informal interviews and focus groups were used to explore numerous consumer issues associated with the purchase and consumption of olive oil. Three group sessions were conducted with selected groups of 8 customers of different profiles (age, sex, educational level, etc.). These sessions enabled direct contact with the group and open participation to bring together different opinions on olive-oil quality and vision of the group in general. The Focus Group is an appropriate approach for commercial purposes to gather qualitative information, particularly in this case, given that olive oil is a fatty product with qualities that are normally difficult for the consumer to discriminate (Brunso et al., 2002, Grunert et al. 2004; van Kleef et al., 2005, Dekhili and d´Hauteville, 2009, Delgado and Guinard, 2011). Based on the information collected, a large list of consumer requests (Whats) towards olive-oil quality was compiled. This information was filtered, avoiding duplicated and ambiguous answers that could not be duly measured or classified. Finally, we developed a final list of 8 needs (see Table 1). This information was then used to design a consumer survey, in order to establish a detailed consumer-consumption profile regarding olive oil. Some questions were included in the questionnaire especially to quantify the importance ascribed to both intrinsic (colour, flavour, acidity, etc.) and extrinsic quality needs (social, environmental, etc.) towards olive oil.

The data was collected by means of 439 face-to-face interviews with persons at least 18 years of age from the region of Andalusia (S Spain). The sample was gathered using a random stratified proportional methodology, using the following socio-demographic variables: place of residence, gender, and age (INE, 2009). The consumers were randomly recruited at, university campuses, shopping areas, and other public places between April and September 2010. The sampling error was 3.10% for the estimation of proportions. Each consumer was asked to complete the questionnaire and to quantify and prioritize the needs (W_{di}) identified previously (taste, colour, price, environmental issues, etc.). A 6-point hedonic rating scale, anchored with the terms: no importance (0), little (1), some (2), important (3), considerable (4), very important (5), was used to indicate consumer opinion. The importance accorded by the consumer (weighted score from the question) was, subsequently directly used to create the "House of Quality" HOQ matrix (the left-hand side of the house of quality; see Table 1).

(2) Identification and definition of practices in the production sector (Hows)

After the literature review (Government of Andalusia, 2006; Parra-López and Calatrava, 2006; Parra-Lopez et al. 2008; Jiménez and Carpio, 2008; Alba et al. 2009; Humanes and Human, 2009; Uceda, 2009; Vega et al., 2009; among others), we held several focus groups during the month of September 2010 with industry experts (farmers, and managers of mills, technicians, researchers, olive-oil quality-analysis laboratories, etc.) to define the technical characteristics potentially usable by different agents (farmers, mills, etc.) to meet the consumer needs identified above.

This process was not only qualitative but also quantitative in order to select only those practices that may technically have relationships or impact with consumer needs. Finally, we chose 82 practices classified into 3 levels of the agri-food chain (47 agricultural practices, 23 industrial and 12 marketing and distribution). Each level of these practices was in turn classified into sub-levels (see Table 1). In this paper, we analyse only the agricultural practices and the degree to which they satisfy consumer quality requirements for olive oil.

(3) Deployment of consumer demand (QFD): Correlation between Whats and Hows

The Quality Function Deployment (QFD) methodology is a matrix approach to design the product or service the customer's voice, translating it, in successive stages, by design features (technical engineering) in order to meet demands and market requirements (Bossert, 1991; Akao, 1997; Karsak et al. 2002; Parra-López et al., 2008). The aim of this method is to translate information gathered during the consumer survey examining customer behaviour and attitudes towards any product (intangibles associated with a product) into product characteristics (measurable product requirements) and to identify the desired directions of improving these characteristics in any new product (Vatthanakul et al., 2010). The QFD was first used in Japan during the 1960s in psychology and marketing to support the product-design process and to enable companies to incorporate consumer preferences into product design in a competitive environment. The method has been widely used by shipping, automotive, and electrical companies. An extensive literature review of case studies and applications of QFD in the agro-industry can be consulted in Benner et al. (2003). Despite the broad application of QFD, its implementation in public planning of agriculture and food industry is missing from the literature. In the olive sector, in particular, no application of this methodology is available, making that present research a practical and innovative contribution.

The basic of the QFD methodology consists of constructing the matrix of the quality or "House of Quality " (HOQ) (Rudolph, 1995; Bech et al. 1997; Januszewka and Viaene, 1999; Benner et al., 2003; Frey et al. 2007; Vatthanakul et al., 2010), which is essentially a matrix that involves the consumer's voice or needs (Whats), with the strategic and technical requirements (Hows) to meet those needs. To determine the contribution of practices (technical characteristics) in satisfying consumer's needs for the quality of olive oil, we constructed the matrix of relationships between the "Whats" and "Hows" at the individual and aggregate level using expert knowledge. For this, 22 experts or stakeholders were interviewed individually (olive growers, oil mills technicians, olive oil distributors, researchers, etc.) to express and quantify the importance of the relationship, this providing a matrix for each expert. The strategic matrix or the matrix of production ($W_{pj,\ di}$) was made by weighting the disaggregated level of relationships (e.g. relationship between "fruity flavour" and olive variety "Picual", Table 1) with the report at the aggregate level (e.g. relationship between "flavour" and "variety"). A 10-point hedonic scale from 0 (no relationship) to 9 (strong relationship) was used (see Ramanathan and Ganesh, 1994; Parra-López et al., 2008). They were able to indicate they have not knowledge for some pairwise relationships of HOQ matrix. The meaning and mathematical treatment of “unknown relationships are different to those of “absence of relationship”. Individually unknown relationships are not considered to calculate the mean whereas non relationships are accounted as null elements. Thus, we established a weight for each expert or decision maker ($W_{pj,\ di\ (e)}$) to

associate each pair of customer needs and practices. The relative contribution average corresponding for each practice (j) and for each need (i) was calculated as the arithmetic mean of the weights of all the experts by this formula:

$$W_{pj,di(expgroup)} = \sum_{e=1}^{E} W_{pj,di\,(e)} / E$$

E being the number of expert.

We used the average expert assessment, which we considered more reliable than individual assessment, since it avoids individual biases and lack knowledge on some topics. Such analyses of the mean opinion are common in the scientific literature on group decision-making (Saaty, 1989).

(4) Weighting of the contribution of practice to satisfy all consumer needs

The total contribution of a practice (W_{pj}) to satisfy each need is calculated by the sum of the relative contribution average of this practice for each need (i) ($W_{pj,\,di}$ (expgroup)) multiplied by the relative importance of each need by consumers (W_{di}):

$$W_{pj} = \sum_{i=1}^{n} W_{pj,di(expgroup)} * W_{di}$$

In our case: n = 8 needs, j = 47 practices.

This information is useful because it can guide the actors in the olive sector towards practices that optimally satisfy consumer needs. A high value of a total contribution of practice suggests the need to orient the design activities or technological development (agricultural policies, strategies, agribusiness, marketing, etc.) towards the implementation of this practice, given that customer demands regarding olive-oil quality are optimally satisfied.

IV. RESULTS

The consumer evaluates a series of quality characteristics in olive oil that can be identified as Total Quality Perceived (TQP). This quality includes not only organoleptic characteristics of olive oil (flavour, colour, acidity, etc.) but also sociocultural (maintenance of the rural population, creation of labour, etc.), territorial, and environmental (sustainability, etc.) ones (see Table 1). The main concerns regarding olive-oil quality that consumer expressed was: the fruity flavour, the low level of acidity, the yellow-greenish colour, reasonable price, and ecological production (see Table 1).

With respect to the agronomic practices considered in this study, more than 60% may be significant to better meet the consumers needs and desires concerning quality olive oil. These are the critical practices that should be taken into account when producing olive according of consumer preferences and priorities.

The House of Quality analysis clearly showed that the most significant agricultural practices that determine the olive-oil quality according to consumer requirements are: the separation of olives from the ground and the trees; harvesting criteria (according to a fruit ripeness index), the method of ground harvest (no picking from the ground), the method of tree harvest (hand picking), the treatment of pests and diseases, transport of the olives from the grove to the mill (in boxes), fertilizers used (organic fertilizers including pruning debris, compost, etc.), treatment of olive fruit fly (*Bactrocera oleae*) (biological control with ground spraying), variety (Picual), treatment of olive moth (*Prays oleae*) (biological control with *Bacillus thuringiensis* at flowering), soil management (soil covered), fertilization (no fertilization), the timing of irrigation (following expert advice). In Table 1, we detail the relative contribution of each of agricultural practices to satisfy consumer needs individually and jointly. For example, "the separation of the olives from the ground and trees" is the practice that most contributes to a "low degree of acidity" and all consumer needs regarding olive oil. Similarly, "variety Picual" and "the harvest of olives following the degree of maturity" proved to be the most suitable practices for ensuring the desired greenish-yellow colour of the oil.

Table 1: The "House of Quality" of olive production sector *(Cont.)*

Agricultural practices / Consumer Demand	**Relative importance** (W_{di})	Olive variety		Soil management				Irrigation		Irrigation system		Timing of irrigation		Analysis of the irrigation–water quality	
		Picual	Hojiblanca	Bare soil, conventional farming (constant tillage)	Bare soil, no tillage, weed control with herbicides	Bare soil, little tillage or shallow tillage, weed control with herbicides	Soil covered	Yes	No	Drip irrigation	Other system (Sprinkler, Flooding, etc.)	On a fixed calendar basis	Following expert advice	Yes	No
Fruity taste	4.3	54.7	58.0	0.0	0.0	0.0	0.0	28.6	11.1	0.0	0.0	0.0	0.0	0.0	0.0
Yellow-green colour	3.3	48.0	25.3	0.0	0.0	0.0	0.0	1.3	1.1	0.0	0.0	0.0	0.0	0.0	0.0
Oil mill and cooperatives sale	3.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PDO Certification	2.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Low acidity	4.1	4.9	5.8	0.0	0.0	0.0	0.0	3.8	2.3	0.0	0.0	3.9	6.0	0.0	0.0
Price	3.8	0.0	0.0	0.0	0.0	0.0	0.0	5.0	6.8	0.0	0.0	0.0	0.0	3.7	1.3
Package	2.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Organic production	2.6	0.0	0.0	34.1	17.5	17.5	49.8	0.0	0.0	0.0	0.0	23.0	30.8	25.9	6.2
Environmentally friendly production	2.4	0.0	0.0	13.8	19.1	32.9	62.7	28.8	35.2	66.9	34.0	22.9	61.0	30.5	12.2
Creating employment in rural areas	1.8	0.0	0.0	0.0	0.0	0.0	0.0	13.1	8.2	0.0	0.0	0.0	0.0	0.0	0.0
Maintenance of the rural population	1.8	0.0	0.0	0.0	0.0	0.0	0.0	9.4	6.7	0.0	0.0	0.0	0.0	0.0	0.0
Total contribution (W_{pj})		413.6	356.7	121.9	91.5	124.6	280.0	271.1	197.7	160.7	81.6	130.5	251.1	154.6	50.4

Table 1: The "House of Quality" for olive production sector *(Cont.)*

Agronomic practices / Consumer Demand	**Relative importance** (W_{di})	Fertilization		Fertilizer-application method			Fertilizers applied		Analysis soil or leaf before fertilization	
		Yes	No	Direct application to the soil	Spray application to the leaves	Other method	Organic fertilizers (including pruning debris. compost. etc.)	Inorganic fertilizers	Yes	No
Fruity taste	4.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Yellow-green colour	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Oil mill and cooperative sales	3.1	-	-	-	-	-	-	-	-	-
PDO Certification	2.9	-	-	-	-	-	-	-	-	-
Low acidity	4.1	1.3	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Price	3.8	3.5	4.5	0.0	0.0	0.0	0.0	5.9	2.3	2.3
Package	2.1	-	-	-	-	-	-	-	-	-
Organic production system	2.6	29.0	39.0	25.3	28.7	16.9	71.0	11.0	40.7	9.7
Environmentally friendly production	2.4	22.4	46.7	24.0	49.8	36.0	69.0	17.0	55.8	21.8
Creating employment in rural areas	1.8	13.6	5.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maintenance of the rural population	1.8	5.6	2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total contribution (W_{pj})		181.9	257.2	123.4	194.1	130.2	350.2	91.9	248.5	86.3

Table 1: The "House of Quality" for olive production sector *(Cont.)*

Agricultural practices / Consumer Demand	**Relative importance** (W_{di})	Treatment of pests and diseases		Treatment of olive fruit fly (*Bactrocera oleae*)			Treatment of olive moth (*Prays oleae*)		Timing of phytosanitary treatments		Location of phytosanitary treatments	
		Yes	No	Mass traps (one trap per tree = pheromones + glue + pyrethroids)	Biological control (Opius concolor)	Non-biological insecticide	Biological control (Bacillus thuringiensis))	Chemical treatments	On a fixed calendar basis or with the first symptoms of infestation	When the infestation surpasses a threshold	The whole orchard	Only the infestation source
Fruity taste	4.3	20.3	5.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Yellow-green colour	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Oil mill and cooperative sales	3.1	-	-	-	-	-	-	-	-	-	-	-
PDO Certification	2.9	-	-	-	-	-	-	-	-	-	-	-
Low acidity	4.1	37.5	3.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Price	3.8	3.8	4.4	0.0	0.0	0.0	0.0	0.0	1.9	1.4	1.7	1.8
Package	2.1	-	-	-	-	-	-	-	-	-	-	-
Organic production system	2.6	43.2	13.6	63.8	74.4	11.3	67.0	11.3	11.1	39.7	16.4	28.1
Environmentally friendly production	2.4	29.0	36.0	41.0	62.0	26.7	64.7	17.8	16.3	46.4	23.3	61.0
Creating employment in rural areas	1.8	11.8	2.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maintenance of the rural population	1.8	7.2	1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total contribution (W_{pj})		471.4	184.8	264.2	342.2	93.3	329.5	72.2	75.1	220.0	104.9	226.6

Table 1: The "House of Quality" for olive production sector *(Cont.)*

Agronomic practices / Consumer Demand	**Relative importance** (W_{di})	Timing of harvest		Method of ground harvest			Method of tree harvest			Separation of olives from the ground and the trees		Transport olives from the orchard to the mill		
		According to a fruit ripeness index	On a fixed calendar basis	By hand	Mechanical means	No picking from the ground	Hand–pole beating	Branch or trunk vibrators	Handpicking	Separation	No Separation	Sacks	Boxes	In the tractor or lorry trailer
Fruity taste	4.3	48.6	33.4	13.4	7.6	33.4	12.3	4.4	14.0	65.8	11.9	15.1	26.8	24.3
Yellow-green colour	3.3	53.5	36.0	7.2	7.2	27.1	3.3	3.3	3.3	45.3	7.0	9.9	6.7	7.3
Oil mill and cooperative sales	3.1	-	-	-	-	-	-	-	-	-	-	-	-	-
PDO Certification	2.9	-	-	-	-	-	-	-	-	-	-	-	-	-
Low acidity	4.1	55.7	16.5	39.1	18.1	50.5	34.9	39.7	51.3	75.4	8.5	14.1	52.3	34.4
Price	3.8	6.7	12.8	15.3	14.3	19.6	12.2	15.4	12.2	8.3	17.5	2.8	4.1	4.1
Package	2.1	-	-	-	-	-	-	-	-	-	-	-	-	-
Organic production system	2.6	28.1	27.3	18.9	22.8	39.3	26.0	16.5	21.8	53.1	18.8	22.5	29.6	18.0
Environmentally friendly production	2.4	2.9	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Creating employment in rural areas	1.8	0.0	0.0	37.2	18.9	12.2	60.1	37.4	54.2	0.0	0.0	0.0	0.0	0.0
Maintenance of the rural population	1.8	0.0	0.0	29.3	13.5	10.7	51.7	31.7	44.4	0.0	0.0	0.0	0.0	0.0
Total contribution (W_{pj})		719.6	452.0	468.1	302.6	658.1	521.4	418.6	562.1	911.5	224.4	224.2	444.4	331.6

V. CONCLUSION

The paper presents a methodological approach to integrate consumer needs concerning olive-oil quality with the practices most appropriate to meet these needs. The olive-oil quality characteristics most requested by consumers incorporate organoleptic (acidity, flavour, colour, etc.), sociocultural (creating employment in rural areas, maintenance of the rural population, etc.) and environmental ones (environmental externalities).

The QFD technique combined with other qualitative methodologies offers a suitable approach that structures the information on customer requirements, especially to link customer needs to design practices. The House of Quality analysis has demonstrated that the separation of ground-harvested olives from tree-harvested, harvesting criteria, the method of the ground harvest, the method of the tree harvest, pest and disease treatment, olive transport from the orchard to mill, fertilizers applied, olive-moth treatment, olive-variety selection, treatment of olive fruit fly, soil management, soil management, fertilization, and timing of irrigation are the agricultural practices that optimally satisfy consumer needs regarding olive-oil quality (optimum technical and social approach).

The proposed methodology has been illustrated in the case of olive oil but it can be considered quite universal, and can also be extrapolated to other products in the olive sector or other agro-food products (wine, meat, milk, etc.) and also to other agents involved in the olive-oil system (processing, distribution and marketing, management, organization, etc.). Quality parameters of olive oil are clearly determined by the different practices conducted at different stages of the agricultural and industry processes, some being specific to each stage.

Any agricultural policy in the olive-oil system, which aims to be effective and to take into account the consumer preferences, should be oriented to promote the implementation of these practices in the olive industry. This would enhance the legitimacy and social support to CAP subsidies for agriculture in general and the olive-oil sector in particular.

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