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APPLICATION OF QFD METHODOLOGY (HOUSE OF QUALITY) FOR PRODUCTION OF FRUIT ICE CREAM

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Abstract

Quality Function Development (QFD) is a systematic approach specific to quality management that facilitates product development by ensuring consumer requirements meeting (customer voice), these being taken into account from the design phase, then during the entire technological process, being reflected in the finished product. The purpose of this study was to apply the QFD methodology (House of Quality, HoQ1,) to improve the quality of products in the food industry, taking into account the technological process of obtaining fruit ice cream (the Q product), thus providing a synthetic model. The working method consisted in the participation of a number of 240 ice cream consumers, aged between 20-24 years, who provided the list of consumer requirements, prioritizing and weighting them based on a score from 1 to 5. The following stages were represented by the transposition of consumers' voice in quantifiable technical requirements, their correlation at the "roof" level, establishing the relations between technical measures and the customer's voice by using predefined symbols, establishing the direction of improving the quality of the new product, assessing current competition and determination of target values. Following the analysis, the most important consumer requirements were the amount of fruit added (20.8%), the lack of hazardous additives (20.8%), the creaminess (16.7%) and the lack of ice crystals (16.7%). Thus, in order to meet consumer requirements, the replacement of sugar with maple syrup, artificial stabilizers and emulsifiers with pectin (0.4%) and yolk (0.5%), led to a more nutritious and healthier product, but which will probably have a higher price compared to the products currently available on the market.

Key words*: fruit ice cream, quality function deployment*

INTRODUCTION

Creating new products that meet the desires of consumers is not easy, careful research is needed so that the products made are necessary for consumers. Many companies compete to create new products that can speed up their marketing time. A commonly used method for product management is QFD (Rujito et al., 2020). QFD has been practiced by world-renowned companies since 1966. Its double purpose is to ensure that the true needs of customers are properly developed/implemented throughout the design, construction and delivery of a new product, whether assembled, processed, maintained or even software, and to improve the product development process itself (Akao and Mazur, 2003). QFD is a comprehensive quality system that aims primarily at customer satisfaction.

It focuses on maximizing customer satisfaction, looking for both spoken/explicit and unspoken needs, translating them into actions and models, followed by their communication throughout the organization (Mazur, 2015).

QFD has recently become a widely used quality management tool in product design and development (Van et al., 2018). More recently, the QFD method is used in all stages of manufacturing: planning, design, processing and production of products, and the results of applying QFD in all stages are interdependent. (Dvoryaninova et al., 2020).

QFD facilitates the product development process, ensuring that customer requirements are taken into account throughout the technological process, and then reflecting its voice in the final product. (Zhebo et al., 2019).

QFD is used to receive customer feedback throughout the planning, development, engineering and manufacturing stages for any product (Van et al., 2018). This technique helps organizations to allocate resources and coordinate their skills according to customer needs by reducing costs and the production cycle (Karsak et al., 2015), helping to measure

the impact of organizational learning through innovation (Bhattacharya, 2010; Wasserman, 1993).
QFD is a well-structured inter-functional planning technique, a methodology for continuous product improvement, focusing on multifunctional teams to integrate the voice of consumers in the stages of planning, development, engineering, and manufacturing (Bhattacharya, 2010; Govers, 2001).
The main goal of QFD planning should be to maximize customer satisfaction (Wasserman, 1993; Bhattacharya, 2010).
QFD originated in Japan in the 1970s and has been applied in several fields (Akao, 1990), for product development, concept evaluation, service design and comparative evaluation of competitors. Practically, customer desires for a particular product or service can be represented by a set of intangible marketing requirements (MR). Next, a number of technical attributes (TA) that have an impact on MRs must be determined and performed for product development or service design. Usually, conventional QFD consists of the following four phases (Chan et al., 1999; Lin et al., 2010): the first stage translates the marketing requirements into technical attributes; the second phase translates the technical attributes into the characteristics of the parts; the third phase transposes the characteristics of the part into manufacturing operations, and the fourth phase translates the manufacturing operations into production requirements (Wang and Chen, 2012).
QFD is used for decision-making issues with clear numbers and recently many extended versions of this concept have been proposed.
The main planning tool used in QFD is the Quality House (HoQ). HoQ is a house-shaped matrix that connects the customer's wishes (WHAT?) and how the product will be designed and made to meet the customer's wishes (HOW?) (Rujito et al., 2020; Jones, 2005; Smith, 2009). At the level of the literature, different approaches of the QFD methodology are observed, depending on the vision of the authors. Benner, 2003 argues that the application of QFD in the food industry is more complicated than the current literature suggests. However, QFD proves useful if adaptations are made to the method and the specific characteristics of the food ingredients are taken into account. It has been highlighted that the method has been successfully applied in the field of food development, for example, chocolate bars (Viaene, 1999), filled chocolate (De Pelsmaeker et al., 2015), instant rice noodles (Waisarayutt and Tutiyapak, 2006), pie dough (Pinto and Paiva, 2010), wheat flour (Kristianto et al., 2012), fruit (Miguel et al., 2007), meat (Rosado et al., 2011; Park et al., 2012), mineral water (Moldovan, 2014), olive oil (Sayadi et al., 2017), fish (Dvoryaninova et al., 2020), but also for a number of functional foods (Pinto and Paiva, 2010) and biologically active additives (Ermolaeva et al., 2018).
Since 2015, the QFD methodology has been transposed into the international standard ISO 16355, which includes eight parts structured in several editions, the latest from 2017, and others that are still in progress, making QFD much more credible and practical.
The aim of this study was to apply the QFD (HoQ, Quality House) methodology in the food industry, taking into account the technological process of obtaining fruit ice cream, thus providing a synthetic model of approach.
Fruit ice cream is in fact an ice cream based on dairy products, in which, after freezing the mix, fruits (cherries, raspberries, strawberries etc.) are introduced, pre-sprinkled with powdered sugar and allowed to spread as much as possible (Țibulcă and Jimborean, 2008).

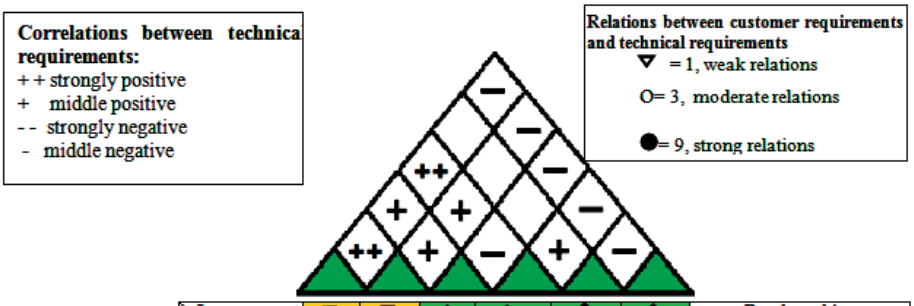
MATERIALS AND METHODS

The methodology consisted in the participation of a number of 240 ice cream consumers, aged between 20-24 years (students from three different Food Engineering specialities, because the QFD methodology recommends the use of multidisciplinary work teams), which provided the list of consumer requirements (Figure 1), prioritizing and weighting them based on a score from 1 to 5. The next steps were to transpose consumers' "voice" into quantifiable technical requirements (design requirements), establishing measurement units of for each requirement, correlating them to the roof to identify possible technological problems, establishing the relationship between technical measures and the customer's voice using pre-defined symbols, establishing the direction to improve the quality of the new

product (which are technical criteria that require a decrease or increase to meet customer requirements), the assessment of current competition (establishing the strengths and weaknesses of the newly designed product, Q) and determining the target values (which need to be improved).

RESULTS AND DISCUSSIONS

Consumer requirements (WHAT?) were represented by elements related to their health concern: the amount of fruit added/high fiber content (20.8%), the lack of hazardous/harmless additives for health (20.8%), components of sensory properties, creaminess/pleasant taste (16.7%), lack of ice crystals (16.7%), availability in different packaging quantities (12.5%) and accessible price (12.5%). To meet these requirements, a new product has been designed, innovative in terms of ingredients traditionally added to ice cream manufacturing technology, replace the sugar with concentrated maple syrup (Figure 1); also the use of artificial additives was avoided and only yolk (0.5%, emulsifier) and pectin (0.4%, stabilizer, gelling agent etc.) were used, along with the realization as far as possible, of this type of ice cream, at production costs as low as possible by using dairy raw materials such as: buttermilk butter, buttermilk powder, whey powder.



Technical requirements / Consumers requirements	Importance 1-5	%	Improvement direction ⇩ % balanced sugars lipids %	⇩ maple syrup, yolk, pectin%	⇧ high fruit pieces %	⇧ protein%, times, T°C, specific stages	⇧ different weights (g), pans, glasses, waffles,	⇧ low cost (lei)	Benchmarking NEW PRODUCT = Q A product 1p	B product 2p	C product 3p	4p	5p
1. Creamy, pleasant taste	4	16.7	●	●	O	●		▽			B	A, C	Q
2. No hazardous ingredients / additives, harmless to health	5	20.8	●	●	O	▽		●		B	C	A	Q
3. With many pieces of fruit / high fiber content	5	20.8	●	●	●	▽		O		B	A	C	Q
4. Without large ice crystals	4	16.7	●	●	●	●	●	O		B	C	A	Q
5. In different packing quantities	3	12.5				▽	●	●	A		B, C	Q	
6. Affordable /cheap price	3	12.5	●	O	▽	O	O	●	Q		A	C	B
	24	100%	788	712	463	392	300	541	=3196				
		%	24.6	22.3	14.5	12.3	9.4	16.9	100%				

Figure 1. HoQ for new fruit ice cream (the Q product)

The "customer's voice" was translated practically into the following technical criteria (HOW?), with related units of measure: balanced amount of carbohydrates/lipids, use of maple syrup instead of sugar, use of yolk (0.5%) and pectin (0.4%) in exchange for artificial emulsifiers and stabilizers, the addition of a higher quantity (over 20%) of whole fruits (raspberry, cherries, sour cherries) or pieces (strawberries, apricots etc.), ensuring a specific amount of protein of dairy origin, observance and monitoring of times and temperatures specific to the stages of the technological flow, ensuring the packaging of ice cream in casseroles, glasses, waffles, briquettes with different weights and selling, as much as possible, at the lowest possible price (by using dairy raw materials such as: buttermilk, powdered buttermilk, whey powder).

The ingredients of the Q product are shown in the production flow chart (Figure 2).

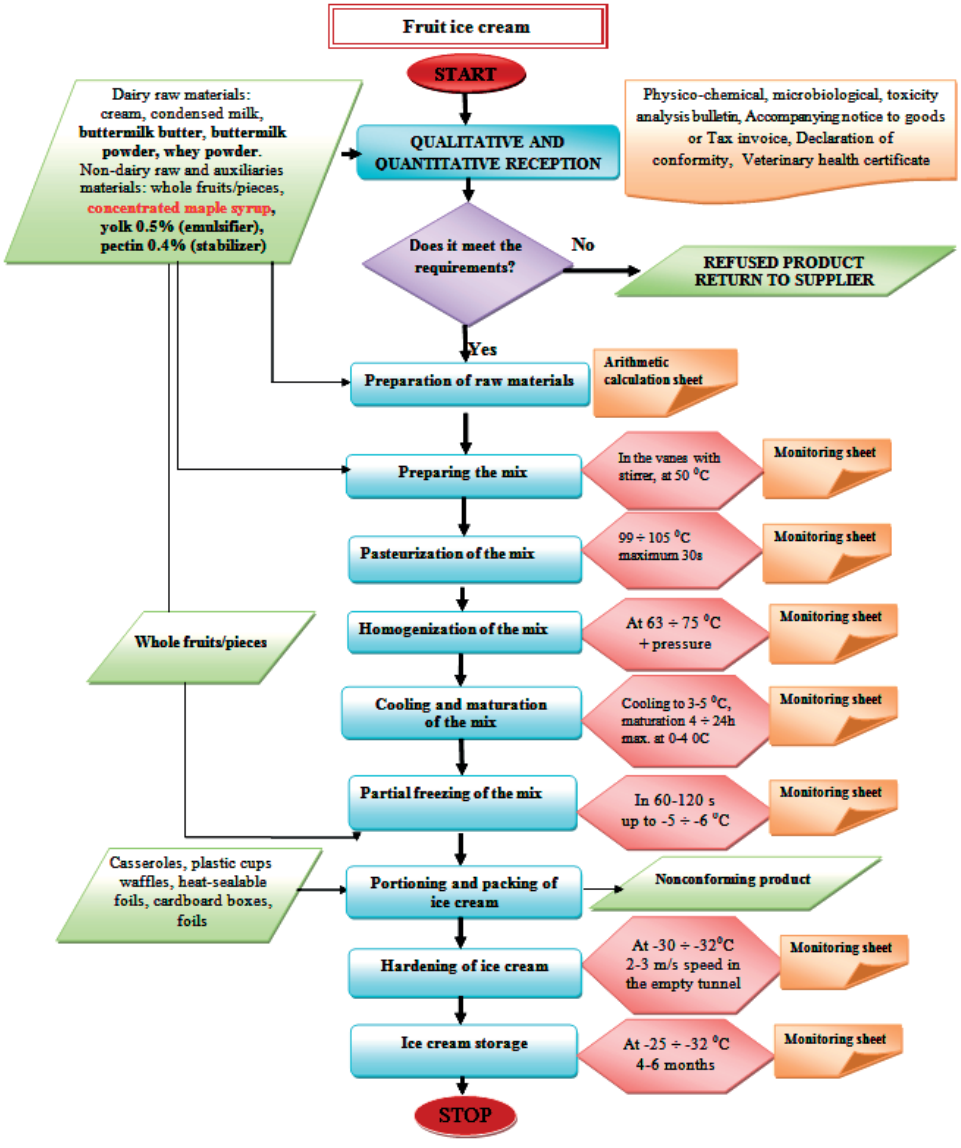


Figure 2. The production process flow chart of new fruit ice cream (adapted, using Usturoi, 2007; Țibulcă, 2008; Banu et al., 2009)

The direction of improving the technical characteristics aims to maintain the balanced level (%) of lipids, carbohydrates (concentrated maple syrup) and to increase the other characteristics.
Predetermined symbols are used to determine the relations between the customer's voice and quantifiable technical measures (WHAT vs. HOW) placed in the cell located at the intersection of each row vs. column (Figure 1.).
At the level of the "foundation" of the HoQ, the higher the values obtained, the more important those characteristics are, because there are strong correlations between them (HOW MUCH); the results from the first house (HoQ 1. product planning) are further used in the following matrices /houses specific to the QFD methodology (HoQ 2. process design, HoQ 3. manufacturing process planning, HoQ 4. production characteristics planning).
The room on the right side of the HoQ is the assessment of current competition (Benchmarking) used to measure the success of the newly designed product that competes with those on the market; thus a scale from 1 to 5 is used for the assessment (1 indicates a requirement that is not met and 5 indicates a requirement that is fully met).
By averaging the numbers in each column, depending on the score obtained, a measure of the degree of customer satisfaction for each product under study is obtained. Following the comparative analysis of the newly designed Q product, with products of three competing companies (*Aloma*, *Amicii* and *Betty Ice* - coded with A, B and C), a good position of product Q was obtained (25 points.), compared to the current competitors (17 to 21 points); the weaknesses being represented by the price of the product and the possibility of packaging in different quantities (imprinted in production cost/selling price).
The strengths of product Q are transposed into the technical criteria represented by the elimination of sugar from the ingredients vs. use of maple syrup, elimination of emulsifiers and artificial stabilizers vs. use of egg yolk adding a large amount of fruit (over 20%). This score reflects a concrete/quantifiable analysis related to customer requirements. The determination of target values is based on the values established by the evaluation of competing products and product Q, establishing strategies to maintain strengths and improve weaknesses.
In order to meet the requirements of consumers throughout the technological process of manufacturing Q fruit ice cream the technological parameters related to each stage must be strictly observed and monitored (Figure 2).

Thus:
1. The use of concentrated maple syrup (12%), pectin (0.4%) and egg yolk (0.5%) ensures compliance with the following consumer requirements: creamy ice cream, without ingredients/additives dangerous/ harmless to health and without large ice crystals;
2. Nutritional sweeteners (concentrated maple syrup) lead to a decrease in the freezing point, to the achievement of the body and texture of the ice cream, more even than fats and proteins (Usturoi, 2007);
3. Pectin (stabilizer) helps to achieve a fine, velvety consistency, avoiding the formation of large ice crystals, evenly distributing the components and maintaining the microcrystalline structure of the product;
4. The preparation of the raw materials is carried out according to an exact arithmetic calculation, and that of the mix, into the hunt, with stirrer with heating system, respecting the order of introduction of the components;
5. The pasteurization of the mix destroys pathogenic bacteria improving technological quality of the product;
6. The homogenization of the mixture is necessary to obtain a stable fat emulsion together with the addition of egg yolk (0.5%);
7. Cooling and maturation of the mix, in addition to preventing development the remaining microorganisms in the mix, has the role of hydrating proteins, solidifying fats, improving the consistency, texture, melting resistance, foaming capacity (aeration) of ice cream;
8. The absence of large ice crystals, fine structure, is ensured by a high freezing speed, using sharp scraping blades during it;
9. Deep hardening or freezing of ice cream should be done quickly to avoid the formation of large ice crystals;

10. Storage of hardened ice cream must be carried out without temperature variations, in order to avoid recrystallization; also the avoidance of recrystallization is ensured by the use of pectin in a concentration of 0.4%.

Unlike competing products, no sugar is used in the manufacturing technology of product Q and neither emulsifiers or stabilizers obtained by chemical synthesis.

Product ingredients currently available on the market are the following:

- water, milk reconstituted from skimmed milk powder, sugar, glucose syrup, vegetable oil, dextrose, sweet whey powder (milk), berries 3.7%, concentrated berries puree and juice 1.33%, modified corn starch, egg yolk powder, stabilizers (guar gum, gum carob, carrageenan, processed Euchema seaweed), emulsifiers (mono and diglycerides of fatty acids), acidifier (citric acid), flavors (product A);
- water, sugar, 15% berries, vegetable fat (coconut oil), whole milk powder, glucose syrup, skimmed milk powder, modified starch from potato, acidifier (citric acid), dextrose, emulsifiers (mono and diglycerides of fatty acids), stabilizers (carob seed gum, guar gum, pectin), flavors, salt (product B);
- reconstituted skim milk, 10% fructose, fiber (inulin) 6%, vegetable fat (coconut oil), sweetener (stevia) 0.04%, emulsifier (mono and diglycerides of fatty acids), stabilizers (guar gum, gum carob, carrageenan), acidifier (citric acid), natural dye (red beet), flavors (product C).

The addition of whole fruits (raspberry, cherries, sour cherries) in Q product avoid the release of specific enzymes and the exposure to ambient air of sectioned parties that influence the loss of vitamin C by oxidation (Murariu et al., 2014) along with adding them after the stage of partial freezing of the mix.

CONCLUSIONS

The application of the QFD method for the manufacture of fruit ice cream makes it possible to transfer consumer requirements into a set of controlled (quantifiable) characteristics and transposes these requirements into technological operations, forming a continuous flow of information; this ensures that all elements of the production system are aimed at meeting consumer requirements.

In the example approached, in order to meet consumer requirements, the replacement of sugar with maple syrup, artificial stabilizers and emulsifiers with pectin (0.4%) and yolk (0.5%), respectively, led to a more nutritious and healthy product, but which will probably have a higher price compared to the products currently available on the market.

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