PRODUCT DESIGN IN FOOD INDUSTRY. APPLICATION OF QFD METHODOLOGY FOR IMPROVEMENT OF CHOCOLATE QUALITY

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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 quality characteristics of the finished product. The purpose of this study was to apply the QFD methodology (House of Quality, HoQ) to improve the quality of products in the food industry, taking into account the technological process of chocolate (designing a new product that meets the requirements of consumers), thus providing a synthetic model. The working method consisted in the participation of a number of 200 chocolate consumers, aged between 20-24 years, who provided the list of consumer requirements, prioritizing and weighting them based on a standardized score from 1 to 5 points. The following stages were represented by the transposition of consumers' voice in quantifiable technical requirements, their correlation 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 for chocolate were: the taste of cocoa (25%), the flavor (25%), the fine texture (20%), the small amount of sugar (15%) and an affordable price (15%). Thus, in order to meet consumer requirements, the replacement of sugar with coconut nectar sugar or dates powder as alternative sweetener led to a healthy product, but which will have a higher price compared to the products currently available on the market. However, applying the level II/ III of QFD methodology the low cost was provided by mitigation of price of raw material’s.

Key words: House of Quality, chocolate, improvement, sugar.

Many companies compete to create new products that can speed up their marketing time. A commonly used method for product management is QFD (Rujito H. *et al*, 2020). Its double purpose is to ensure that the true needs of customers are properly developed and 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 Y. and Mazur G.H., 2003). QFD is a comprehensive quality system that aims primarily at customer satisfaction (Pop C., et al, 2020). 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. Usually, conventional QFD consists of the following four phases (Sayadi S. *et al*, 2017; Dvoryaninova O.P. *et al*, 2020; Isharyani M.E. *et al*, 2019):

1. the first stage translates the marketing requirements into technical attributes;
2. the second phase translates the technical attributes into the characteristics of the parts;
3. the third phase transposes the characteristics of the part into manufacturing operations;
4. the fourth phase translates the manufacturing operations into production requirements).

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?).

Currently, there is no product marketed and obtained in Romania on an industrial scale that replaces sugar with date powder or coconut nectar. Therefore, further research is needed to create an industrial production with preferred attributes (sugar-free and suitable for diabetics, lower in calories, high in fiber, without food additives’), based on the quality characteristics provided by the consumer, which is certainly different compared to the traditional chocolate previously produced. Cocoa paste/mass (or liquor) is the product obtained from the fermented, dried, roasted and ground seeds of *Theobroma cacao* L. Cocoa butter

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(the fat pressed from cocoa paste) and sugar, it is the major ingredient of chocolate. The replacement of sugar (with coconut sugar and dates powder) it was the most important change in the recipe and manufacturing technology of chocolate. Coconut sugar is becoming popular as an alternative to beetroot or cane sugar due to its high mineral content and lower glycaemic index (Zdiniakova T. *et al*, 2020; Spink J. *et al*, 2019; Saputro A.D. *et al*, 2019). The raw material for making coconut sugar is coconut sap, which is a sweet liquid obtained by taping of coconut flower. Coconut sugar is produced by heating coconut sap and further solidified or granulated (Karseno E.T.Y. *et al*, 2018). Unfortunately, its market price is about twice as high as that of conventional sugar (Zdiniakova T. *et al*, 2020).

The aim of this study was to apply the QFD methodology in the food industry, taking into account the technological process of obtaining chocolate, thus providing a synthetic model of approach.

MATERIAL AND METHOD

The methodology consisted in the participation of a number of 200 chocolate consumers, aged between 20-24 years (students from three different Food Engineering specialties', 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 for each requirement, correlating them to "the roof" of HoQ 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). Next stapes for the level II and III of QFD methodology are: exploring the product and processes alternative, selecting the best alternative after application of process flowchart with the parameters, the CPs, the CCPs and the critical limits established for each stage of the chocolate technology.

RESULTS AND DISCUSSIONS

Consumer requirements (WHAT?) were represented (*figure 1*) by components of sensory properties: good cocoa taste (25%), good flavor (25%), fine texture (20%); with a lower weight (15%) consumers (in the age group studied) are interested by elements related to their health concern (small amount of sugar) and economic issues (affordable /cheap price).

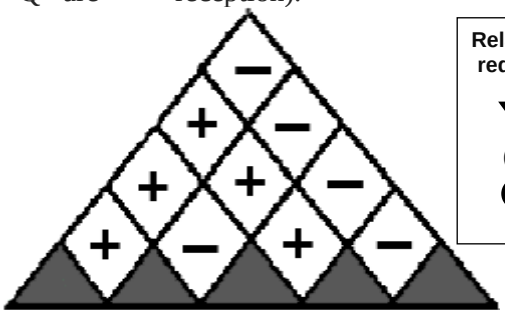
The "customer's voice" was translated practically into the following technical criteria (HOW ?), with related units of measure: Cocoa mass (%); Cocoa butter (%); Times, T°C of each technological stage; Coconut sugar (%), dates power (%); Low cost (lei). To meet these requirements, a new product has been designed, innovative in terms of ingredients traditionally added to chocolate manufacturing technology, replace the sugar with coconut sugar and dates powder (*figure 2*); also the use of additives was avoided and only cocoa mass and cocoa butter of very good quality were used. Some chocolate contains an emulsifier, such as lecithin. Emulsifiers decrease the chocolate's viscosity; when used, not as much cocoa butter is needed to produce the chocolate. The triglycerides quantity and the type of fatty acids of cocoa butter depend on the geographical area from which the cocoa beans come from, being in different polymorphic forms respectively in different amounts (from Cote d` Ivoire, for examples). 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.

At the level of the "foundation" of the HoQ, the higher the values obtained, the more important those characteristics are (good taste, 25.16%, good flavor, 24.68%, and small amount of sugar 23.87%), 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 specific to the QFD methodology (level II/III process design).

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 four competing companies (coded with A, B, C and D), a good position of product Q was obtained (22 points.), compared to the current competitors (13 points for product B, 18 points for product A

and C, respectively 19 points for product D); the weaknesses being represented by the price of the product. This score from ***Benchmarking*** reflects a concrete/quantifiable customer requirements satisfaction. 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. The strengths of product Q are transposed into the technical criteria represented by the elimination of sugar from the ingredients vs. use of coconut sugar and dates powder, elimination of emulsifiers and artificial stabilizers vs. use of cocoa mass and cocoa butter from controlled origin, certified with "Cocoa for Excelence" standards (with declaration of conformities and analysis bulletin from the stage of qualitative reception).

Correlations between technical requirements:
+ + strongly positive
+ middle positive
- - strongly negative
- middle negative



Relations between customer requirements and technical requirements:
▽ = 1, weak relations
O = 3, moderate relations
● = 9, strong relations

Improvement direction / Importance / Technical requirements (HOW?) / (WHAT?) Consumer requirements	1-5	%	⇧ Cocoa mass %	⇩ Cocoa butter%	⇧ Filter Ø (1 mm), Times (min, h), T°C of main stages	⇩ Coconut sugar %, dates powder%	⇩ Low cost (lei)	Benchmarking NEW PRODUCT = Q 1p	2p	3p	4p	5p
Good Taste (of cocoa)	5	25	●	●	O	●	O		B		A,C	D,Q
Good flavor	5	25	●	●	O	●	O		B	C	A	D,Q
Fine texture	4	20	●	●	●	▽	O		B	A	C,D	Q
Small amount of sugar	3	15	▽		●	●	●		B,D	C	A	Q
Affordable /cheap price	3	15	●	●	▽	●	●		Q	A,D	C	B
	20	100%	780	765	320	740	495	=3100				
		%	**25.16**	**24.68**	10.32	**23.87**	15.97	100%				

Figure 1 **HoQ for chocolate**

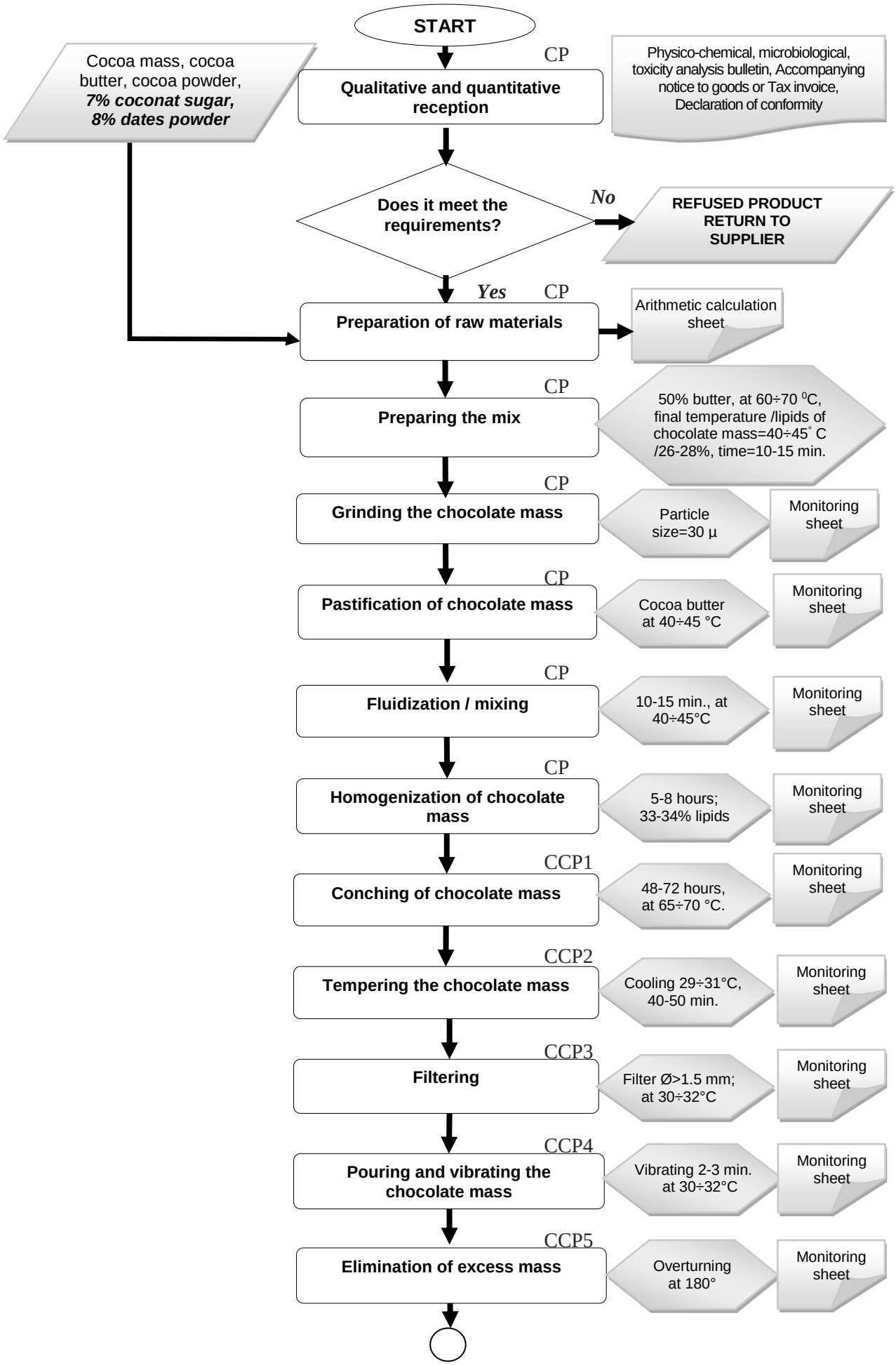
HoQ is only ***the first stage of the QFD method***, therefore further research is needed covering all stages of QFD, in the manufactory plan, in practice, to observe the correlation.

The ***level two*** of QFD matrixes is used during the Design Development Phase, which could discover the assemblies, systems, sub-systems and components have the most impact on meeting the product design requirements and identify key design characteristics.

The ***level three*** QFD is used during the Process Development Phase where are examined which of the processes or process steps have any correlation to meeting the component or part specifications.

The ***level four*** QFD would have list all the critical processes or process characteristics in the "What" column on the left and then determine the "How" for assuring quality parts is produced and list them across the top of the matrix (Isharyani *et al*, 2019).

The first step towards transposing the HoQ outputs into the second matrix of the QFD was based on establishing the specific parameters, the control points (CPs) and the critical control points (CCPs) according to the the HACCP system and implicitly the critical limits to each stage of the technology, to ensure the safety and satisfaction of consumer requirements/desires (*figure 2).*


START
Cocoa mass, cocoa butter, cocoa powder, 7% coconat sugar, 8% dates powder
CP
Qualitative and quantitative reception
Physico-chemical, microbiological, toxicity analysis bulletin, Accompanying notice to goods or Tax invoice, Declaration of conformity
Does it meet the requirements?
No
REFUSED PRODUCT RETURN TO SUPPLIER
Yes
CP
Preparation of raw materials
Arithmetic calculation sheet
CP
Preparing the mix
50% butter, at 60÷70 °C, final temperature /lipids of chocolate mass=40÷45° C /26-28%, time=10-15 min.
CP
Grinding the chocolate mass
Particle size=30 µ
Monitoring sheet
CP
Pastification of chocolate mass
Cocoa butter at 40÷45 °C
Monitoring sheet
CP
Fluidization / mixing
10-15 min., at 40÷45°C
Monitoring sheet
CP
Homogenization of chocolate mass
5-8 hours; 33-34% lipids
Monitoring sheet
CCP1
Conching of chocolate mass
48-72 hours, at 65÷70 °C.
Monitoring sheet
CCP2
Tempering the chocolate mass
Cooling 29÷31°C, 40-50 min.
Monitoring sheet
CCP3
Filtering
Filter Ø>1.5 mm; at 30÷32°C
Monitoring sheet
CCP4
Pouring and vibrating the chocolate mass
Vibrating 2-3 min. at 30÷32°C
Monitoring sheet
CCP5
Elimination of excess mass
Overturning at 180°
Monitoring sheet

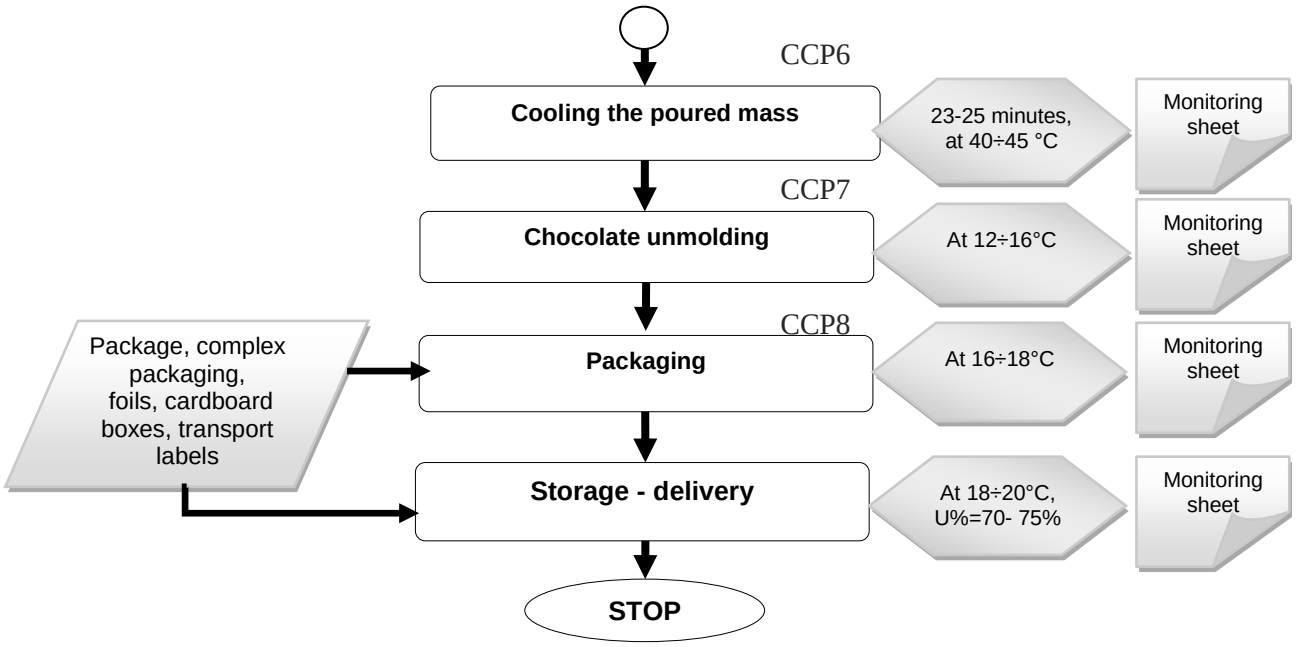


Figure 2 **The flowchart for the new design product (chocolate, Q product)**

Next stapes for the level II and III of QFD methodology are: exploring the product and processes alternative, selecting the best alternative after application of process flowchart with the parameters, the CPs, the CCPs and the critical limits previously established for each stage of the chocolate technology *(figure 3).*

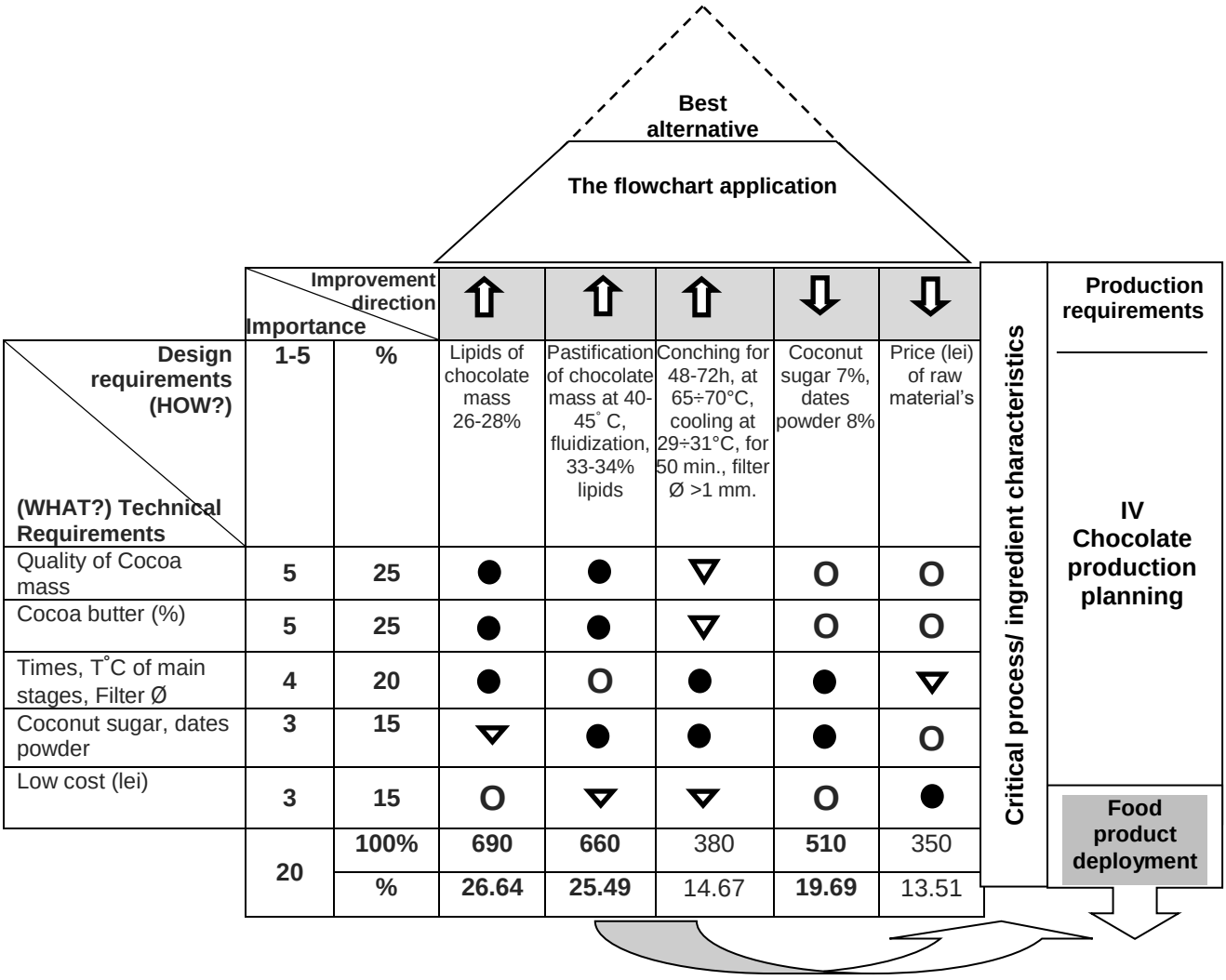


Figure 3 **QFD matrix level II/ III and IV, design requirements for identify key design characteristics of chocolate, synthesis**

For level II/ III of QFD methodology (design requirements for identify key design characteristics of chocolate), the *Technical Requirements (WHAT?)* which were taken from the first phase of the QFD (HoQ), based on the "voice of customers", have been transposed into *Design requirements (HOW?),* as follows:

1. quality of cocoa mass (the good taste of cocoa from HoQ) was provided by certified origin of cocoa with ”Cocoa for Excelence” standards and by the percentage of 26-28% lipids of chocolate mass;
2. the percentage of cocoa butter (the good flavor of chocolate from HoQ) was provided by pastification and fluidization of chocolate mass at 40-45°C, calculating the addition of cocoa butter (minimum 13% by arithmetic calculation sheet) and relating it to the final lipid content of the chocolate mass (33-34% lipids) and by monitoring sheet verification;
3. the critical limits of main stages (technological parameter) for assuring the fine texture from HoQ (times, T˚C, the filter Ø >1 mm.), was provided by conching for 48-72h, at 65÷70°C, cooling at 29÷31°C, for 50 min., filter Ø >1 mm and filtration at 32°C and by monitoring sheet of main steps of flowchart;
4. small amount of sugar from HoQ was provided by the replacement of sugar with coconut sugar (7%) and dates powder (8%) with a further mitigation for future of this proportion.
5. the low cost of chocolate was provided by mitigation of price of raw materials by purchase of cocoa mass, cocoa butter, coconut sugar and dates directly from producers.

CONCLUSIONS

The application of the QFD methodology for the manufacture of chocolate 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 coconut nectar sugar (7%) and dates powder (8%) as alternative sweetener led to a healthy product, but which will have a higher price compared to the products currently available on the market. However, after applying the level II/ III of QFD methodology (design requirements for identify key design characteristics of chocolate), the low cost was provided by mitigation of price of raw material’s (by purchase of cocoa mass, cocoa butter, coconut sugar and dates directly from producers). Then, for customer requirements satisfaction, the quality of chocolate was provided by using the certified cocoa with ”Cocoa for Excelence” standards, the percentage of 26-28% lipids of chocolate mass, the pastification and fluidization of chocolate mass at 40-45°C, the addition of cocoa butter (minimum 13%) and relating it to the final content of 33-34% lipids, the conching for 48-72h, at 65÷70°C, the cooling at 29÷31°C, for 50 min., filter diameter (Ø>1 mm), filtration at 32°C and by monitoring sheet verification of main steps of flowchart.

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