

Determination of design specifications of an amashito chili seed fracturing machine using QFD tool

Determinación de las especificaciones de diseño de una máquina fracturadora de semillas de chile amashito utilizando la herramienta QFD

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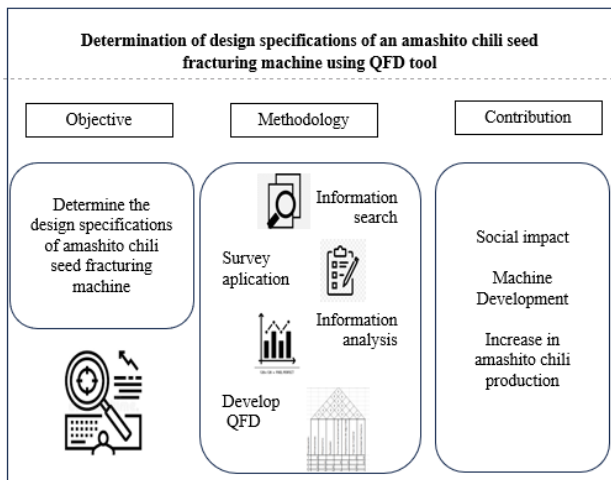


Abstract

The objective of this work is to determine the design specifications of the amashito chili seed fracturing machine to facilitate its cultivation and provide farmers with a system that meets their needs. A survey was carried out in order to know the opinion of farmers. The survey was carried out in the public markets of Paraíso, Comalcalco and Jalpa de Méndez Tabasco, among merchants and producers who are dedicated to the sale and planting of chili. In the analysis of the results, the specifications that are necessary for the machine are found. The results show that sellers and/or producers of amashito chili require a seed fracturing machine to facilitate cultivation. The specifications were translated based on what the client needs using the Total Quality Deployment QFD tool.

Resumen

El objetivo de este trabajo es determinar las especificaciones de diseño de la máquina fracturadora de semillas de chile amashito para facilitar su cultivo y proporcionar a los agricultores un sistema que cumpla con sus necesidades. Se realizó una encuesta con la finalidad de conocer la opinión de los agricultores. La encuesta se realizó en los mercados públicos de Paraíso, Comalcalco y Jalpa de Méndez Tabasco, a los comerciantes y productores que se dedican a la venta y siembra del chile. En el análisis de los resultados, se tienen las especificaciones que para ellos son necesarias en la máquina. Los resultados muestran que los vendedores y/o productores de chile amashito si requieren una máquina fracturadora de semillas para facilitar el cultivo. Se procedió a la traducción de las especificaciones con base en lo que el cliente necesita utilizando la herramienta QFD Despliegue de la Calidad Total.



Machine, Specifications, QFD, Design

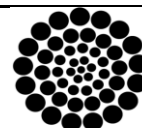
Máquina, Especificaciones, QFD, Diseño

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Introduction

At the Polytechnic University of the Gulf of Mexico, it is essential to develop projects that have a social impact, under this situation arises the project that seeks to design and build a fracturing machine for amashito chilli seeds.

The study mentions that the amashito chilli is a widely consumed species in southeastern Mexico and is obtained from the wild, so there is an area of opportunity, as the seed contains a hard, waxy cuticle that easily prevents germination. In the study, the product Biozyme TF® was used as a seed germination inducer.

According to the study, the low germination of wild chilli seeds, associated with the impermeability of their testa, is one of the factors limiting their propagation.

The use of seed germination techniques has been investigated and used with some other species, and he mentions that seed breaking in maize seed reduces germination. Using three different maize seed varieties with moisture contents between 12 and 20%, subjected to axial compression, there was no cracking at embryo level, but there was cracking at endosperm level, which resulted in reduced germination. The percentage of humidity also affected seed germination. Therefore, it is important to give the necessary force for seed fracture, which does not affect germination.

The authors indicate that the vitabosa seed is an alternative source of protein in animal feed, but the lack of study of this seed has led to its scarce use. They also state the importance of knowing the mechanical and structural characteristics for the creation of post-harvesting machinery.

Regarding the germination of Amashito chilli seeds, he explains that through a statistical analysis of 28 samples of Amashito chilli subjected to different measures of pressure and force, the best results were obtained with an $F=239.7878$ N and a $P=3.75$ N/cm², achieving germination in 92.857% of the samples and with an $F=280.3872$ N and a $P=4.38$ N/cm² 89.286% of the seeds germinated in 9 days.

Research has also been carried out to facilitate the sowing and cultivation processes. The study mentions that many of the agricultural processes are manual and are complemented by the use of impact and cutting tools. Many seeds, including tagua seeds, require a process to separate the shells and this is done manually, affecting health and causing musculoskeletal injuries, so Pineda developed a prototype of a tagua seed shelling machine to improve artisanal production, reducing the shelling time and avoiding the risk of injury.

In his article on the higuerrilla hulling machine, he aims to design a higuerrilla hulling machine that works without electricity and is easy to transport and operate, with the aim of providing a solution to the cultivation problems in the Bajío region of Mexico. For the design of the machine, a mechanical design methodology was applied, including a series of steps consisting of preliminary, basic and detailed design, prototypes and tests, final design and communication. Through the research, efficient results were obtained in terms of the creation of the designed machine.

We can observe that there are already different methods to facilitate the harvesting or manipulation of other types of seeds, however, specifically for the Amashito chilli seed, we only found the use of chemical and natural methods. Therefore, the implementation of the amashito chilli seed cracking machine can be a good option to continue production and to be able to offer a greater variety of derived products.

The QFD Total Quality Deployment is a tool that allows us to translate customer needs into technical specifications. According to 'Quality Function Deployment is a method of product and service design that takes customer demands and expectations and translates them, in successive steps, into satisfactory technical and operational characteristics'.

Conducted research on the use of QFD in service sector companies and 'how it can help these organisations to achieve customer satisfaction, as well as provide them with the necessary information that allows them to know what the customer really values in the service and how this tool can make them more competitive'.

Points out that QFD 'is an important strategic planning technique, capable of changing a company's position in the market and raising it to world-class competitive levels'.

The QFD methodology seeks to 'translate user requirements into quality characteristics, from quality characteristics into part characteristics, from part characteristics into process parameters and from process parameters into production requirements, through a series of phases and matrices'.

This tool has been used in several areas, 'implemented QFD to determine the design requirements of the experimental units to be evaluated at bench scale, during the degradation of oiled waste by different treatments of biobattery ecotechnology.' For his part, he applied the QFD methodology to the design and commercialisation of the product called 'Cuy Faenado'. The application of the tool is also observed in the design of machines, he presents the development of a 3D printer using the QFD methodology approach, emphasising the needs and requirements of the clients who are the students of the engineering faculty of the University of Pamplona.

QFD is a tool that consists of matrices in which information is evaluated and analysed. The information presented contains customer requirements, technical specifications and competitors. This information is evaluated and related to obtain the best design considering the customer. The QFD also called house of quality lists the customer requirements and relates them to the engineering characteristics or technical specifications and shows the correlation between the technical specifications.

The difficulty of germination of the Amashito chilli seed is a constraint for producers to move towards a greater commercialisation of this regional chilli variety. It is important to evaluate the economic, social and ecological potential of the various species of Amashito chilli in order to propose a model that increases productivity and development in the region with a focus on sustainability.

With the construction of the prototype, the aim is to fracture considerable volumes of seeds that can be cultivated in greenhouses and obtain seedlings to be marketed or donated to farmers in programmes in the Tabasco region.

With the previous studies on the necessary force to fracture the chilli seeds and achieve satisfactory results with the sowing and cultivation, we proceeded to follow the steps for the design of systems that goes from the search for similar systems in the market, the detection of the user's needs, the translation into technical specifications, the conceptual design, the detailed design and the realisation of the prototype.

This document aims to translate user needs into technical specifications using the QFD (Quality Function Deployment) tool.

Methodology

Survey application

A survey of 8 multiple-choice questions was carried out, which was applied personally, with the support of students from the Automation and Industrial Control Engineering course at the UPGM, to 42 vendors and/or producers of amashito chilli in the public markets of the municipalities of Paraíso, Comalcalco and Jalpa de Méndez, in the state of Tabasco, with the objective of determining the needs they have with respect to the production of amashito chilli seeds.

It was explained to the respondents that with the results of a previous investigation, the force necessary to fracture the seeds of the amashito chilli was studied and the greatest number of plants were able to grow and be productive. Therefore, there is a concern to be able to offer producers and/or sellers an alternative to improve sowing and cultivation, for which it is necessary to know their needs.

Respondents mentioned that it has been increasingly difficult to grow the seeds in the wild, so they have had to opt for other methods such as chemical products or leaving the chilli to dry for later sowing.

The questions they were asked were aimed at obtaining information on how they currently sow, whether it is really a good business and whether they would like to have the option of a machine that would make sowing easier and what characteristics they would like it to have.

Conducting QFD

An analysis of the surveys was carried out and based on the results, the QFD (Quality Function Deployment) technique was used to determine the specifications of the amashito chilli seed breaking machine. The QFD is a tool that helps us to translate the voice of the customer, i.e. to understand what sellers and/or producers need and convert it into technical specifications, in this case for the design of an amashito chilli seed cracking machine. For the elaboration of the QFD, the first thing we need to do is to determine the requirements of the customers, which were obtained from the surveys applied. Subsequently, an analysis was carried out by the researchers and a weighting of 1 to 5 was assigned to each requirement, with 1 being the least important and 5 the most important. The next phase of the QFD consisted of translating the customer requirements into technical specifications. The relationship between the requirements and the stated specifications was then analysed, assigning 9 for a strong relationship, 3 for a medium relationship and 1 for a weak relationship. No rating was given when no relationship was recognised. See table 1.

Box 1

Table 1
Assessing the relationship between customer requirements and technical specifications.

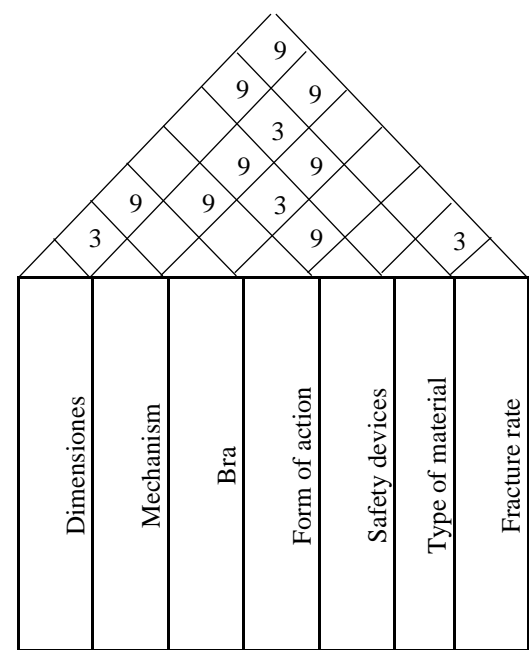
Customer requirements	Technical specifications						
	Weighting	Dimensiones	Mechanism	Bra	Drive form	Safety devices	Type of material
Medium Size	3	9					3
Semi-automatic operation	5	3	9		9	9	9
Movable	5	9	9	9		3	9
Practical	3	9	9	9	3		3
Safe	4	3	9	3	9	9	3
Ease	5	9	9	9	3		3
Do not affect the quality of the chilli	5		9				9
Shorter time	3		9	3	9		9

Source: Own elaboration

The correlation between the technical specifications was also analysed, with a 9 for a strong correlation and a 3 for a low correlation. We did not assign a score to those where there is no correlation.

Box 2

Figure 1
Correlation between technical specifications



Source: Own elaboration

Finally, the absolute weights were obtained by adding the columns of each technical specification and the relative weights by adding the multiplication of the respective weighting with the rating of each column.

Results

Surveys

The results obtained from the application of the survey to sellers and/or producers of amashito chilli are described below.

Of the total number of respondents, 52% were men and 42% were women; there is an equal relationship in gender participation in the sowing and cultivation of amashito chilli. Regarding the reason for the research, which is whether they would like to have a machine to facilitate the sowing of chilli, 81% answered yes and 19% showed no interest in such a machine.

We analysed the reason why they would not like the machine and what they answered can be seen in Figure 2. Of the 8 people who answered that they would not like it, we can conclude that they have no knowledge of the fracturing method, as their comments are based on fear that things will not work out well.

Box 3

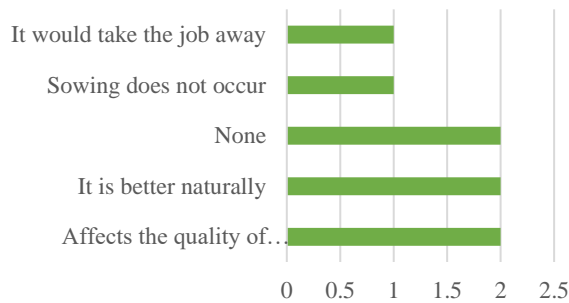


Figure 2

Reasons why they would not like the fracking machine
Source: Own elaboration

Of the 81% of the people who would like to have a fracking machine, the majority answered that it would be easier to plant and cultivate, with 59%. This was followed by the speed with which they could produce, with 15%, and 12% answered that it would be easier to produce chilli amashito because of the shortage that currently exists in the production of chilli. Nine percent answered that they would be able to produce their own chilli amashito and 6% that they would be able to continue selling it. Therefore, we can analyse that most of the people are aware that the machine would bring them benefits. See Figure 3.

Box 4

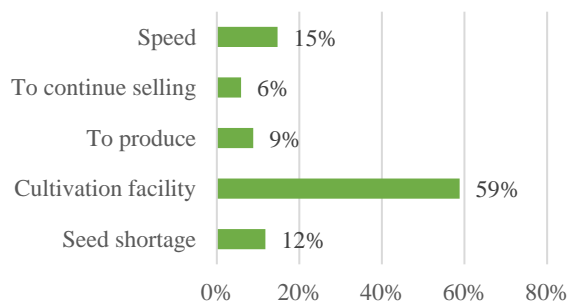


Figure 3

Reasons why they would like the fracking machine
Source: Own elaboration

With regard to the characteristics of the amashito chilli cracker, they were asked about the size (dimensions), the way they would like it to operate and the type of structure they would prefer. In Figure 4 we can see that of the 34 people who agree with the idea of having a fracturing machine, 50% prefer the size of the machine to be medium, 32% prefer it to be small and only 18% prefer it to be large.

Box 5

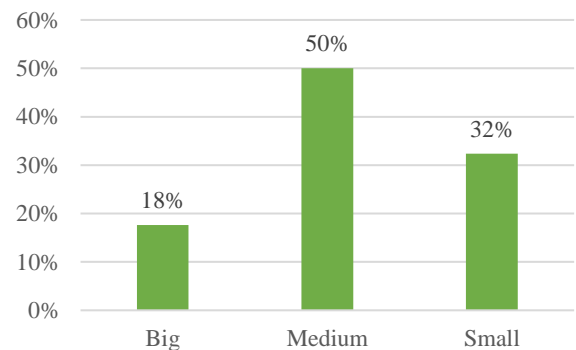


Figure 4

Ideal size for amashito chili seed crushing machine
Source: Own elaboration

Regarding the mode of operation, the percentages do not show a great difference, they are very even. Figure 5 shows that for 38% of the sellers and/or producers, a semi-automatic machine would be the best option. Followed by 32% who mentioned that the manual method would be the most appropriate, and lastly, 30% mentioned a fully automatic machine.

Box 6

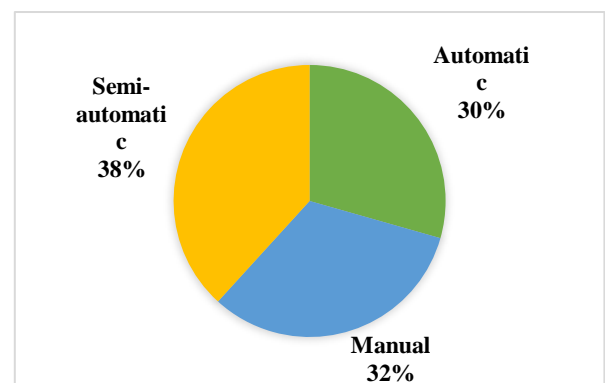


Figure 5

Preferred mode of operation for the machine
Source: Own elaboration

In relation to the type of structure that would be most useful for them, 82% responded that a mobile structure would be the best option and only 18% considered that a fixed structure would be the best option. See Figure 6. It can be seen that the sellers and/or producers prefer a machine that can be moved when necessary.

Box 7

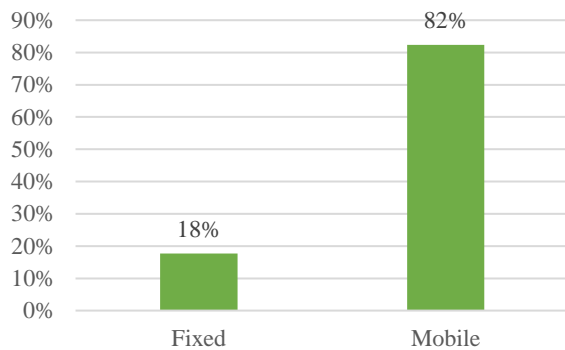


Figure 6

Structure type for amashito chilli seed cracker machine

Source: Own elaboration

Regarding the amashito chilli business, 36% of the vendors and/or producers do have the sale of amashito chilli as their primary source of income, and 64% of the respondents are also involved in the sale of other types of products from which they earn more income. When asked whether they consider the sale of amashito chilli to be a good business, 86% answered yes, while only 14% answered no. Those who answered that it is a good business are not. Those who answered that it is a good business, if they are interested in taking more advantage of chili production, it would be good to ask why it is not their main source of income if they consider it a good business; there is probably a lack of production to be able to offer a variety of products.

Finally, they were asked about the way in which they currently sow the Amashito chilli and the products they sell. 79% of them use the sowing method. Seventy-nine percent use natural sowing, followed by the use of chemical products with 15%, and only 6% use seed fracturing, which is considered important to make this method and the results achieved in the production of chilli peppers known. 86% of the sellers and/or producers responded that the product they offer is natural amashito chilli, only 6% mentioned that they offer processed chilli or both types of product.

There is an area of opportunity here, as they can look for other ways to offer their product and thus increase their income.

QFD

From the QFD conducted we can see the correlation between some technical specifications, for example the dimensions with the fastener, as it is necessary to determine how the machine can be fastened depending on how big it is. In the same way, the mechanism has a strong correlation with the way the device is to be operated, with the safety devices and with the fracture speed.

In terms of customer requirements and technical specifications we can observe that:

- The size has a very strong relation with the dimensions and the speed of fracture.
- Semi-automatic operation with the mechanism, the form of drive and the safety devices to be fitted to the machine.
- The movable device is strongly related to the dimensions, the mechanism, the way of clamping and the type of material.
- Practicality is strongly related to the dimensions, the mechanism and the way of fastening.
- Safety is related to the type of mechanism, the form of actuation and the safety devices.
- Ease is related to the dimensions, the mechanism and the way of fastening.

Finally, the mechanism and the type of material affect the quality of the chilli and fracture in less time is related to the mechanism, the way of actuation and the speed of fracture.

Box 8

Table 2

QDF for the amashito chilli seed cracking machine prototype

	Technical specifications								
Customer requirements	Weighting	Dimensions	Mechanism	Bra	Form of action	Safety devices	Type of material	Fracture rate	
Medium size	3	9					3	9	
Semi-automatic operation	5	3	9		9	9		9	
Movable	5	9	9	9		3	9		
Practical	3	9	9	9	3		3		
Safe	4	3	9	3	9	9	3	3	
Ease	5	9	9	9	3			3	
Do not affect the quality of the chilli	5		9				9		
Less time	3		9	3	9			9	
Absolute weight		42	63	33	33	21	27	33	
Relative weight		17	27	13	13	96	12	12	
		1	0	8	2		0	6	

Source: Own elaboration

The analysis of the information generated in the QFD allows us to have a more complete view of the technical specifications that we must consider for the amashito chili fracturing machine and how the selection of one or the other performer of the function impacts on the other specifications.

The most important specifications are the mechanism, the dimensions, the fastener and the form of drive. The following are the choices of function performers that could meet the required specifications.

Box 9

Table 3

Function executors for the heavier specifications.

Functional specifications	Function executors		
Mechanism	Electromechanical	Tyre	Hydraulic
Dimensions	Small	Medium	Large
Fastener	Handle	Without handle	Wheels
Actuating form	Button	Lever	Sensor

Source: Own elaboration

Based on the experience of the researchers, it was determined that the prototype of the Amashito chilli seed breaker will have an electromechanical mechanism, it will be medium-sized with a dimension of 25 cm wide, 35 cm high and 16 cm deep, it will be held by a handle and the device will be operated by means of a button with its respective emergency stop.

Conclusions

According to the surveys carried out, the producers and sellers of Amashito chilli are in favour of having a seed-cracking machine to facilitate the sowing and cultivation of Amashito chilli.

It was noted that there is a lack of knowledge about the technique of seed fracturing as a support for obtaining large quantities of seedlings and therefore increasing the production of amashito chilli. It would be interesting to provide a small amount of training to producers and/or sellers so that they can learn about the technique, see the results that can be achieved and have greater confidence when using it.

With this research, we were able to identify the client's requirements in order to translate them into technical specifications and proceed with the creation of the prototype of the amashito chili pepper fracturing machine. The QFD tool allowed us to better understand the potential users of the fracturing machine in order to have a clearer idea of the characteristics to be considered.

With the specifications determined, we can now proceed with the design and generate a prototype that can increase the production of amashito chilli for subsequent sale.

Equal gender participation (women and men) in the planting, cultivation and sale of amashito chilli was also found to be positive. However, there is an area of opportunity, as most of them offer natural chilli, but they could offer a variety of products with prepared chilli. (May Guillen, 2014) proposes a methodology to develop skills and abilities in rural women and social entrepreneurs in areas such as agribusiness, marketing and organisational management with the aim of creating social enterprises based on the transformation of plant species representative of Tabasco.

The generation of sustainable solutions to improve agricultural activities is fundamental nowadays. The amashito chilli seed fracturing plant aims to contribute to the development and commercialisation of this species.

Declarations

Conflict of interest

The authors declare that they have no conflicts of interest. They have no known competing financial interests or personal relationships that might have appeared to influence the article reported in this paper.

Authors' contribution

Cintya Margarita Cervantes Castro: Contributed to the project idea, research development and data analysis.

Alejandro García García: Contributed to the development of the research and analysis of the information.

Raquel Angulo Córdova: Contributed to the analysis of the information, revision and editing.

Arquímides de Dios Domínguez García: Contributed with the analysis of the information, revision and editing.

Availability of data and materials

The data obtained in this research are available on request.

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Abbreviations

QFD	Quaility Funtion Development.
TF	PhytoregulatorPolytechnic
UPGM	University of the Gulf of Mexico

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Background

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