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PROTOTYPE OF PEANUT PEELING MACHINE (ARACHIS HYPOGAEA) CONSIDERING THE REQUIREMENTS OF PRODUCERS IN THE MIXTECA OF PUEBLA

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Abstract *-The* main objective of this research was to analyze the functionality of a peanut (arachis hypogaea) peeling machine in order to facilitate the peanut peeling process and to address the needs of producers in the Mixtec region of Puebla.
Bawa's method [1] was used, which reflects the basis for this proposal because an analysis is required to design something to calculate as much as possible about the behavior of engineering sciences.
According to the investigation and evaluation of the problem in the Mixteca Poblana region, there are peanut producers who need to invest an economic cost in order to hire laborers to perform the manual peeling, that is, to separate the peanut from the grass. Because of this, there is also a problem for the workers/peons, since the possible consequences of this work are illnesses or risks such as: bites from poisonous animals, dehydration, kidney problems due to the time they spend sitting down, among others.
The proposal of this research based on the peanut productivity of this region and mentioning the efficiency of the peanut peeling machine was taken as a hypothesis the implementation of an engine making it semi-automatic having a time reduction of up to 50% in this activity.

Key words: *Producers, peanut dehulling machine, peanut, design.*

Abstract - The main objective of this research was to analyze the functionality of a peanut peeling machine (arachis hypogaea) in order to facilitate the peanut peeling process and address the needs of producers in the Mixteca region of Puebla.
The Bawa method [1], was used, which reflects the basis for this proposal because an analysis is required to be able to design something to calculate as much as possible about the behavior of engineering sciences.
According to the investigation and evaluation of the problem in the Mixteca Poblana region, peanut producers are detected who need to invest an economic cost in order to hire laborers to carry out manual take-off, that is, to separate the peanut from the grass.
Due to this, a problem is also broken down towards the workers/laborers since when they perform such work as possible consequences result in diseases or risks such as; bites from poisonous animals, dehydration, kidney problems from the time they spend sitting, among others.
The proposal of this research based on the peanut productivity of that region and mentioning the efficiency of the peanut peeling machine was taken as a hypothesis

the implementation of a semi-automatic motor holding it, having a reduction of time of up to 50% in this activity.

Key words **-** Producers, peeling machine, peanut, design.

INTRODUCTION

The Mixteca Poblana is located in southern Mexico and covers an area of 40 square kilometers [2]. Part of the Mixteca Poblana is made up of the municipality of Acatlán de Osorio, which concentrates its economic activities in 12.14% in the primary sector; 19.51% in the secondary sector; 23.23% in commerce and 39.40% in the service sector, with a total gross production of 842 million pesos. Its main economic activity is agricultural production, so the care and work in the fields is paramount, as well as the cultivation of corn, beans and peanuts [3]. The peanut *(Arachis hypogaea L.)* is the most cultivated grain legume in the world for human consumption and for its usefulness in the production of a great variety of products [4]. The peanut (Arachis hypogaea) is an annual plant that belongs to the Fabaceae family (also known as legumes) and to the group of 15 oilseeds and is considered one of the fundamental foods of many countries in the world such as China, Nigeria, Argentina, and India [5]. It probably originated in South America, in Peru, and spread to the New World when Spanish explorers discovered its great versatility in the preparation of different products; later, merchants spread the cultivation of peanuts in Asia and Africa. On the other hand, in Mexico it was already known by the natives before the foundation of Tenochtitlan. The peanut is cultivated in tropical and subtropical climates of Asia, Australia, Africa and America, where they stand out for their production [6]. It is considered a naturally nutritious food, high in calories due to its polyunsaturated oil, rich in vitamins and minerals. The fat (49.24%) and protein (25.5%) content of peanuts is higher than in the case of other legumes, as well as the amount of niacin and thiamine (essential amino acids) [7]. In this sense, peanut stands out for its high proportion of unsaturated fatty acids, especially oleic, to saturated, as one of its benefits [8]. This legume has found its place in the diet and economy of many regions, being the Mixteca Poblana an area of special relevance in its production. This crop has a significant nutritional value, as it provides vitamins and minerals such as iron and calcium, contains no cholesterol and has 25 percent protein. In addition, the foliage and husks are used as fodder for livestock, which maximizes its use in local agriculture and thus generates a source of income for many farming families. During the Autumn-Winter and Spring-Summer Agricultural Cycles of 2023, 37,518 hectares were planted in Mexico, with a total production of 49,299 tons.

299 tons. The states of Sinaloa, Chiapas, Puebla, Guerrero and Oaxaca accounted for 84% of national production. Puebla is positioned as the second largest peanut producing state, with 5,755 hectares planted in 2023, which generated 6,883 tons [9]. The municipalities with the largest planted area are: Acatlán had a production of 1,562.40 tons in 2023, Guadalupe 889.04 tons, San Pablo Anicano 296.18 tons, Tehuitzingo 244.85 tons, San Pedro Yeloixtlahuaca 255.83 tons, and Chiautla 208.48 tons [10]. In the region, families continue with the tradition of planting peanuts, the crop uses a lot of time for its production, since there are many activities that must be performed such as; preparation of the land, selection of the seed, sowing, tilling the soil, determining the time of harvest, digging up and most importantly peeling the peanut from the plant for sale or consumption, peeling the peanut forces farmers to have to hire workers to perform this work manually where they have days of up to 12 hours a day to fill a sack of jute of 40 kilos; In the manual process, the worker constantly bends down, and as a consequence, this causes fatigue due to poor posture and dehydration from exposure to the sun; therefore, the research is based on the development of a prototype of a peanut (*Arachis hypogaea*) peeling machine to facilitate the process according to the requirements of the producers of the Mixteca Poblana. The prototype is intended to be an innovative alternative that will help them to peel peanuts faster and with less effort.

DEVELOPMENT

The present research work was developed at the Tecnológico Nacional de México, Campus Acatlán de Osorio, in the Industrial Engineering career, specifically in the methods and manufacturing laboratory, and field research was also applied through surveys to determine the feasibility of the project.

Obtaining raw material

The peanuts (*Arachis hypogaea*) were collected from the producers of San Vicente Boquerón, auxiliary board of Acatlán de Osorio, so we proceeded to identify the sample selected for the study.

Figure 1. Peanut plant or peanut bush, selected for the study. Source: Own elaboration, 2025.

Figure 2 shows the methodology of Bawa's design process [1], to develop the prototype of the peanut peeling machine.

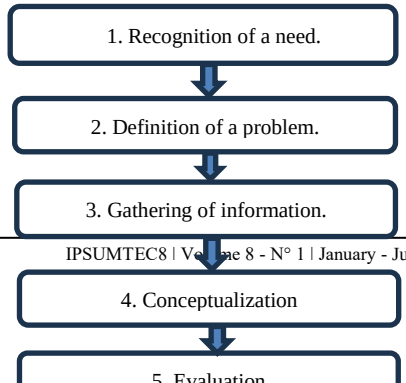

Figure 2. Bawa's design process methodology.

We proceed to develop each of the steps of the methodology.

Recognition of a need:
First a field research was conducted, on the production of peanuts for which it was found that peanuts are produced mainly in the Mixteca baja of Puebla, we also identified that the most difficult part of the crop is to collect the bushes to be subsequently peeled by hand by a group of people to expedite their collection, for several days with working days of up to 12 hours a day.
Subsequently, the sample size was determined.
The following formula [11] was used to calculate the sample size when the population size is known. The municipality of Acatlán de Osorio has 681 peanut producers.

Sample size formula

$$n = \frac{N \times Z_a^{\,2} \times p \times q}{d^2 \times (N-1) + Z_a^{\,2} \times p \times q} \qquad \text{Eq. (1)}$$

Where:

- N = population size
- Z = confidence level
- P = probability of success, or expected proportion
- Q = probability of failure
- D = precision (maximum admissible error in terms of proportion).

$$\frac{681 \times 1{,}96^2 \times 0{,}05 \times 0{,}95}{0{,}03^2 (681-1) + 1{,}96^2 \times 0{,}05 \times 0{,}95}$$

This resulted in 156 producers who were asked the first integrating question:

- If there were a tool to help you peel peanuts would you use it?

2. Definition of a problem:
In Acatlán de Osorio, also known as Mixteca Baja, most of the inhabitants are dedicated to agriculture, specifically to peanut planting.
The pods are harvested by extracting the whole plant from the ground, using a shovel, a strong pitchfork or a mechanical digger. The plants may be left to mature as they are extracted even though the best practice is to allow them to cure in heaps. Three or four stakes, 2 to 2.5 m long, are placed in the shape of a letter "A" with boards across and placed about 50 cm from the base to remove the plants from the ground and allow air circulation within the pile. The plants are placed on the crossed boards, with their top ends facing out, and stacked as high as the stakes will allow.
Once the pods are completely dry they are threshed by hand or with machines, by means of cylinders [12].

Therefore, the most difficult phase of peanut cultivation is to collect the bushes and then they are removed by hand by a group of people to speed up their collection, during several days with working days of up to 12 hours a day. Therefore, it is important to look for alternatives to facilitate the process of peeling peanuts, since the process is currently done manually, and peanut producers hire an average of 5 workers per day to help with these activities. During the work days, the peanut peeling process begins by pulling the peanuts from the bush and placing them in containers and then storing them in sacks; some workers fill up to two sacks per day, but at least they have the task of filling one.
There are problems with activity times, repetitive operations, bad posture and other long-term discomforts.

3.Information gathering:
In 2021 Puebla ranked 4th with 9,333 tons of peanut production [13], one of the peanut producing areas is located in the Mixteca baja, highlighting Acatlán de Osorio and surrounding towns.

The state of Puebla in 2023, planted a total of 5,856.81 ha of peanut, where Acatlán de Osorio reached 1,488 ha corresponding to planting and harvesting of this important legume only in rainfed crops. [14].
According to the results of the interviews to the peanut farmers, and the data obtained in the market research, the following problematic situations were identified to be solved with the proposal of the prototype of a peanut peeling machine.
- Minimize the peanut peeling time compared to the traditional way.
- Facilitate the peanut peeling process.
- Prevent the worker from constantly bending down to reduce fatigue and tiredness.
- Improve working hours.
- To reduce time and movements.

4. Conceptualization
The evaluation criteria for the design of the prototype were identified considering four aspects:
1)Aesthetics: ES (The image of the prototype is evaluated).
2)Handling: MA (Ease of use)
3)Manufacture: FA (The degree of complexity of the manufacture)

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4) Safety: SE (Safety is the integrity of the user for its use and handling).

5. Evaluation.

Design A1

AESTHETICS: It represents an interesting image for the user.
HANDLING: The machine can be easily handled.
MANUFACTURING: The manufacture of the machine requires the use of welding and electrical installation.
SAFETY: It is a prototype that does not present any risk to the user.

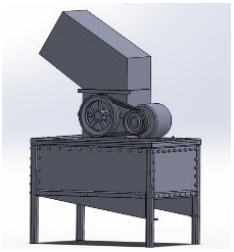

Figure 3. Design 1A.
Source: Own elaboration, 2025.

Design A2

AESTHETICS: The image is pleasant for the user.
HANDLING: The machine is easy to use; but requires improvements in the design.
MANUFACTURING: The manufacturing of the prototype is not complex.
SAFETY: The safety of the prototype represents little risk to the user.

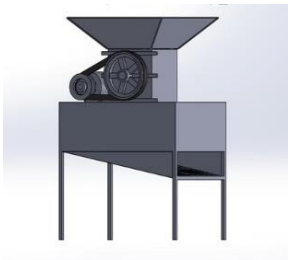

Figure 4. Design 2A
Source: Own elaboration, 2025.

Design A3

AESTHETICS: The image is not striking for the user.
HANDLING: The handling of the prototype is simple, but since it is manual, it easily exhausts the user.
MANUFACTURING: The manufacture of the prototype does not require electrical installation.
SAFETY: The prototype represents little risk to the user.

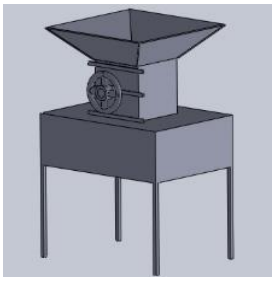

Figure 5. Design 3A.
Source: Own elaboration, 2025.

The most optimal design to be manufactured is *Design A1*, which presents the most suitable criteria for the prototype.
A1, which presents the most adequate criteria for its manufacture and is the best alternative . Therefore, Figure 6 shows the complete *A1* design with its exploded views where the components of the peanut peeling machine prototype can be seen.

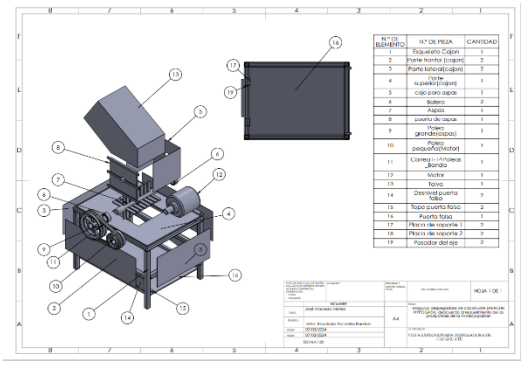

Figure 6. Design 3.
Source: Own elaboration, 2025.

6. Communication of the design.

The final design was presented to a group of ten peanut producers and the opinion of an agronomist who provided feedback for the design proposal before the final prototype was manufactured.
the design proposal before the final prototype was manufactured. The considerations are: the operation of the prototype should be semi-automatic so that it can be easily manipulated by the producers because it will have a ½ Hp motor and a contact switch; another recommendation is to place a false door with mesh in the lower part of the box, to remove the peanut already peeled more easily so that it rotates in a straight line and performs the peanut peeling process efficiently; they recommended that the height of the prototype be 1.50 cm so that it is easy to manipulate.

Prototype manufacturing.

The manufacturing of the prototype was developed considering seven fundamental steps that helped us to

make the final prototype as shown in the diagram in Figure 7.
Step 1.-The prototype was designed in SolidWorks.
Step 2.- Assembly and welding of the base.
Step 3.- Blade assembly.
Step 4.- Calibration of the machine operation axis, bearings, pulley and belt.
Step 5.- Installation of the motor and function tests.
Step 6.- Assembly of the machine cover.
Step 7.- Installation of the damper.

Figure 7.Representative schematic of the manufacturing of the peanut peeling machine prototype.
Source: Own elaboration, 2025.

Figure 8 shows the final prototype of the peanut peeling machine, using design *1A*, which was used to perform the operation tests for the peanut peeling process from the plant or also known as peanut bush.

Figure 8. Final prototype of the peanut peeling machine.
Source: Own elaboration, 2025.

DISCUSSION AND ANALYSIS OF RESULTS

We used the data collection method of a survey by applying the following 11-question form.
1. How many hectares of peanut land do you currently cultivate?
a) Less than one hectare b) 1 hectare c) 1 hectare and more
2. How long does it take to finish peeling the entire peanut crop from the bushes?
a) 1 to 3 weeks b) 1 to 2 months c) depends on the crop
3. How many people work in the process of peeling peanuts?
a) 2 to 5 people b) 6 to 10 people c) 11 to more people
4. How much peanuts are peeled per day per person?
a) ½ costal b) 1 costal c) 1 ½ costal d) 2 costals
5. Do you consider that you spend a lot of money on wages for hired workers?
a) yes b) no
6. How long does it take you to peel the peanuts from a single bush of the peanut plant?
a) from 1 minute to 1:30 b) from 1:30 to 2 minutes c) from 2 minutes or more
7. How long does it take to fill a sack for each person?
a) 1 day b) 1 ½ days c) 2 days
8. Would you like to have a machine that helps you peel peanuts faster?
a) yes b) no
9. Would you like the peanut peeling machine to be operated by a motor or by hand?
a) motor b) manual
10. Do you know of any machine that helps you to peel peanuts faster?
a) yes b) no
11. Do you know and/or use a machine that helps you to peel peanuts faster?
a) yes b) no

Therefore, a survey was conducted among a sample of 156 producers in the Acatlán de Osorio region to identify the viability and acceptance of the market.

The previous results obtained with the help of a survey was that 42.1% of the people interviewed have a land less than one hectare, to plant peanuts, 50. 6% of the interviewees make a time of 1:30 to 2 minutes to take off a peanut bush, also 46.6% of the people fill ½ sack per day, 52.2% use 1 ½ day, to fill the sack, also 53.4% of the interviewees finish peeling all the peanuts from the bushes depending on the amount of their harvest, 48.9% of the interviewees hire 6 to 10 people to help with the peanut peeling process, 95% consider that they spend a lot of money in the salary of the workers, 95% of the interviewees consider that they spend a lot of money in the salary of the workers, and 95% of the interviewees consider that they spend a lot of money to help with the peanut peeling process.
95% of the people surveyed also chose the option of acquiring a machine that helps to peel the peanuts faster, 95% of the people surveyed also chose the option of acquiring a machine that helps to peel the peanuts faster.
Therefore, the market feasibility is shown in Figure 9, corresponding to question 8. Would you like to have a machine that helps you to peel peanuts faster?

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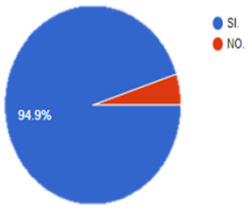
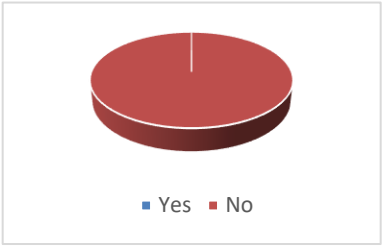


Figure 9. Graph of the decisive question about the interest of the peanut peeling machine.
Source: Own elaboration, 2025.

A 95% acceptance rate was identified on the part of peanut producers in the Acatlán de Osorio region.

Figure 10 shows the results of question 11, Do you know and/or use a machine that helps you to peel peanuts faster, with the result that no producer in Acatlán de Osorio currently knows and/or uses a machine for the peanut peeling process.



Graph of the question showing that producers do not know and/or use a peanut peeling machine.
Source: Own elaboration, 2025.

Tests on the functionality of the peanut dehulling machine.

Tests were carried out to evaluate the functionality of the peanut peeling machine prototype, therefore a sample of 48 bushes (peanut plants) was used, which are equivalent to the filling of a jute sack, and in this way the average time used to peel a single bush of peanuts in the traditional way was considered, having as a result (88 seconds), In comparison with the time used to peel peanuts with the prototype of the peanut peeling machine, the result is (22 seconds). This comparative analysis shows that the prototype of the peanut peeling machine is 75% more efficient in performing the work than the producer, as shown in the graph in Figure 11.

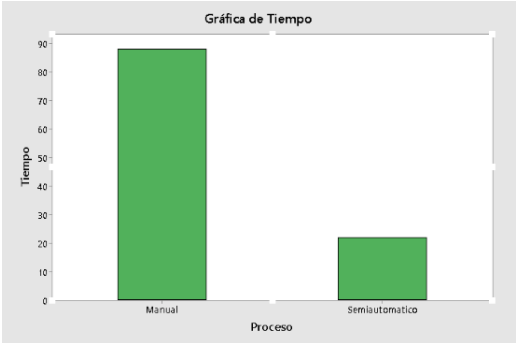


Figure 11. Graph of time in seconds, of the comparative of the peanut peeling machine and the manual method.
Source: Own elaboration, 2025.

A comparison was made with a Peruvian research for the mechanical design of a peanut dehulling and sorting machine, to solve the problem that exists in the village of Collique, which does not have an efficient system for processing this product; if this design is implemented, peanut processing times will be reduced, generating greater income for the population, by selling a better quality product. An analytical and deductive methodology was used to understand the problem and provide a solution to it, using the knowledge obtained in the career and the opinions of experts obtained through interviews, it was possible to establish the design parameters; through the use of surveys and observation guides, the nominal capacity of the equipment was determined at 400 kg/h, to meet the needs of the Collique area. A user's manual, maintenance plan and set of drawings were prepared together with the designed machine [15]. In this case, this type of machine differs from the prototype because it is a decapping and sorting machine, the proposal we offer is in accordance with the needs of local producers to dehull peanuts from the plant with an efficiency of 75%.
In the comparison of the peanut peeling process with the peeling machine prototype, there is a reduction in time, also during these tests the hopper had to be adjusted well because the force generated by the motor made the peanut clusters move faster inside the machine and peel them with more force, achieving greater efficiency than the traditional or manual method.

Therefore, from a Chinese research, on peanut shelling, the mechanical interactions between the shelling parts of the machine and the peanut were analyzed with Hertz theory, providing a theoretical basis for the optimization of materials and parameters of key components. The flexible polyurethane material with good wear resistance was selected and became key shelling components with different bending radii, which shows its suitability for the peanut shelling industry [16], in the case of the proposed peanut shelling machine prototype the main function is the process of peeling the kernel and compared to this machine performs the function of removing the husk and the proposal that we present with the machine focuses on the needs of the producer of the Mixtec region.

On the other hand, in Ecuador they developed a prototype machine capable of classifying grains by weight difference, being able to differentiate up to 15% of weight difference between two fundamental classes of separation, i.e. light grains and heavy grains. Both the forced vibration regime with unbalanced masses and the forced ventilation regime ensured adequate operating parameters for the classification of grains by gravimetry [17]. However, currently farmers in the region hire workers to perform the process manually, this process consists of peeling the peanuts from the bush and

collecting them in sacks, to later sell them or for their own consumption; in other states of the Mexican Republic, producers use the threshing machine, the threshing machine has a cost of $45,000 thousand pesos, so in the Mixteca baja this is not used but it is important to consider this information, the machine has a production cost of approximately $8,400.00 pesos if it is considered to sell it would have an increase of 35%, but even so the cost is lower if it is compared with the threshing machine which its main function is not the process of peanut peeling; another comparison is the salary to workers that the average in the area is $ 200.00 pesos per day of work, and according to the survey conducted 48.9% said that they hire 6 to 10 workers to carry out the peanut peeling process, that is why, when making a cost calculation, if the producer hires 6 workers with a salary of $200.00 pesos for 7 days of work, there would be an approximate expense of $8,400.00 pesos, then the comparative in costs is still higher and this is an advantage for the peanut peeling machine proposal.

CONCLUSIONS

In general, we can describe that the expectations that were raised were met, since the product was accepted with 95%, and the prototype proposes an alternative for peanut peeling in an easier way compared to the traditional method, it was identified that we can adapt improvements in the process of peanut harvesting in the Mixtec region, such as the reduction of time when peeling peanuts, in addition to reducing costs, back pain and repetitive movements.

The advantages obtained from the peanut peeling machine prototype are the following:

- It reduces the time used in this process; so the producer has the opportunity to perform various activities.
- It reduces the working hours; the process that the machine performs for peanut peeling facilitates the operations that have to be done in comparison with those of the peanut peeling machine.
- Reduces physical fatigue.
- Reduces time, movements and bad posture.

We were able to achieve the objective of facilitating the peanut peeling process, having an alternative to replace the traditional way of this process, also by integrating an engine to the tool so that its operation is semi-automatic we were able to reduce the time spent in this process by up to 75%.

In comparison with other research related to peanut harvesting, the proposal of this machine is focused on the peanut peeling process according to the requirements of the producers and their needs focused on the Mixtec region, it is important to note that each locality has its own needs, some are similar and in other cases can be adapted as a process of continuous improvement.

According to the results obtained we can see that the research still presents opportunities for improvement in terms of design and operation to perform more automated functions that allow the producer to have a faster and more efficient system; Therefore, it is fundamental for the optimal realization of this product, having these well-defined bases and an improvement in the manufacture can be made in order to later implement new work methodologies, so that the peanut peeling machine performs the selection according to the size of the legume and separates the fruit from the peanut plant, including the action of the shelling process, which is another development proposal that will allow the producer to reduce the time of the different processes involved in the production and harvesting of peanuts.

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