Development of a Machine to Control the Level of Washing in Panca Chili Seeds

Anthony De La Cruz, Jaime Cardenas, and Leonardo Vinces

Abstract The washing of Panca chili seeds requires innovative solutions that allow controlling this process. It is necessary to handle variables (conductivity, pH, colorimetry) in the face of the challenge of working with small seeds. At present, there are no machines that are dedicated to the washing of this type of seeds, since in many companies this work is done manually, which is not the one indicated because this technique cannot guarantee homogeneity in the seed washing. In addition, direct handling of this type of seeds can cause irritation to the eyes and skin of the person who maintains contact with the seeds. That is why, it is proposed to make a machine to scale by means of a motorized rotary agitator inside a tank, in order to guarantee the homogeneity of the mixture when washing seeds. The present work will allow to determine, among two different types of agitators (axial and radial), which type of agitator is the most efficient in the washing of seeds of Panca chili, to achieve this objective the measurement of pH and electrical conductivity to the water will be carried after the mixture, after stirring. Finally, the analysis of the tests performed on the mixture obtained and washed by each type of agitator allowed to identify the turbine-type radial agitator, like the one that obtained greater efficiency in the washing of seeds, with respect to the helical agitator and pallets, designed for development of this work, in turn, could also confirm that this type of palette with the conductivity control allows to guarantee the homogeneity of the mixture during washing.

Keywords Stirring · Mixing · Washing seeds · Capsaicin · pH measurement · Electrical conductivity measurement

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1 Introduction

Currently, chili pepper is the sixth most exported product in the non-traditional agricultural sector. In 2017, Peru exported Capsicum for more than 238 million soles, according to the Association of Exporters (ADEX). In addition, it is estimated that the per capita consumption of chili peppers and peppers in Peru is 3.9 kilos per year, the most prominent categories were canned chili peppers (57.4%) and dried chili peppers (38.4%) [1]. Peru has a wide variety of chili peppers, as this is valued from pre-Hispanic cultures for its high nutritional value, exquisite taste, and exotic aroma, native peppers descend from common ancestors that originated in South America, in heights of Bolivia and Peru or in southern Brazil, Peru being the country that has the greatest diversity of this product in the world, among which is the Panca pepper [2].

Seed oil production occurs from dried peppers such as the Panca pepper. This type of pepper is grown in all regions of Peru, especially on the north coast, this product is a food with low caloric intake since it is formed in almost 90% by water. In addition, it has largely capsaicin. This component is what gives it the spicy flavor and serves as an analgesic and anticoagulant, ideal for people at risk of cardiovascular diseases. Likewise, its consumption helps to combat the pain generated by arthritis, stimulates the nervous system, because it causes the body to produce endorphins, regulates blood sugar levels, generates a bactericidal effect, eliminating stomach bacteria, which helps decrease the possibility of stomach diseases [3].

It is thanks to these positive health effects that many products are made from chili peppers, such as oil production, which uses the seeds of the Panca pepper as raw material, which is carefully processed to get to the final product. Thus, to produce chili seed oil it is necessary to perform the washing of the seeds, then the drying and finally the dehydration of the seed. The great challenge within this whole process is to perform the washing, this procedure should be the most appropriate so that at the end of the process a clean seed is obtained and that it always loses a constant amount of itching (capsaicin). Capsaicin is a compound that is found naturally in fruits, although in different proportions. In chili, it usually varies between 0.1 and 1% by weight, although it seems small, that amount is enough to produce the typical sensation of itching [4]. This compound is not uniformly distributed in the fruit; It usually concentrates on the seeds and on the cover that surrounds them (pericarp), these are the hottest areas of chili pepper [5].

The application of capsaicin on the skin or mucous membranes causes burning and hyperalgesia, but repeated application leads to loss of sensitivity to capsaicin; the application of higher doses causes a blockage of the *C* fibers that lead to a long-term sensory deficit. This property has been used therapeutically in neuropathic pain as an option when the other drugs are ineffective. Thus, capsaicin has demonstrated its efficacy after repeated administration in postmastectomy pain, stump pain, reflex sympathetic dystrophy, oral neuropathic pain, fibromyalgia, and especially in diabetic neuropathy and postherpetic neuralgia. Consequently, there is a high interest in finding new drugs analogous to capsaicin [6].

While some studies have been developed, such as the one carried out in 1912, by chemist Wilbur Scoville, who developed a scale with his surname, which measures the degree of itch of a pepper. Scoville assigned the value of zero to sweet peppers, which do not bite [6]. At the other end of the scale, he placed capsaicin to which he gave a value of sixteen million, as the spiciest substance. At the time of washing the seeds, the capsaicin molecules are mixed with the water reducing the concentration of capsaicin in the seeds, therefore, the oil itching (final product) should decrease.

On the other hand, the continuous development of automatic and semi-automatic machines has allowed the performance in the production, operational, and quality control areas to be improved [7]. However, in the processing of seeds, to obtain derivative products (oils, resins, etc.), great advances in automatic machines have not been achieved. This is mainly due to the limitation of the sensors when controlling variables [8]. For example, in Ecuador, the washing of sesame seeds is generally also done manually, due to the complexity of handling the small size of the seed and the little use of sesame seeds in this part. of the world. Given this, projects are also being carried out that allow the washing of this type of seeds and in turn allow the production needs to be met [9].

In the absence of a specific sensor intended to measure the concentration of capsaicin in a mixture, it will be necessary to indirectly measure the amount of capsaicin that is removed in the water during each wash. For this purpose, it has been considered to measure the level of pH and electrical conductivity (Ppm) of the water that has been mixed with the seeds, in this way it is expected to be able to control the level of washing in the seeds, without affecting the organoleptic properties of this. Additionally, it is guaranteed that the experiment will always keep the proportions constant throughout the test (Rpm, exposure time, etc.), all with the intention of guaranteeing the result of the tests performed.

The main objective of this study is to identify the design, process, and control of variables that allow obtaining an efficient machine to wash the seeds of the pepper. To achieve this objective, the washing tank and two types of agitators (axial and radial flow) have been designed, the appropriate water temperature has also been identified, the control of a variable that allows me to know the level of washing and the time of agitation necessary for washing. With each of the agitators, a process of washing pepper seeds will be carried out in a machine made to scale that allows controlling the speed of rotation of the agitator, as well as the washing time for a mixture of two hundred grams of seeds for a liter of water.

2 Description of the Design of the Machine for Washing Chili Seeds

Figure 1 shows the block diagram of the design of the chili seed washing machine. The details of each of the process steps will be described in the following sections.

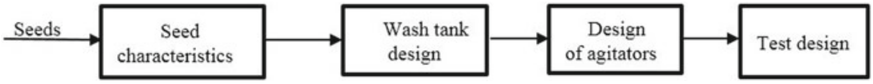


Fig. 1 Block diagram of the machine design for chili seed washing

2.1 Characteristics of the Seeds

Figure 2 shows the diameter and thickness measurements of the chili seed.

In order to find the density of the seeds, we perform the corresponding division. We divide the measured mass of 50 ml of test tube seeds over 50 ml. In order to perform the following calculation, it is necessary to use the data in Fig. 3, which represents the weight of 50 ml of chili seeds.

$$\rho_{\text{semillas}} = \frac{m_{\text{Seeds}}}{50\text{ml}} \tag{1}$$

Fig. 2 Dimensions of diameter and thickness of chili seeds

Fig. 3 Weight of 50 ml of seed

2.2 Design of Agitators

The base of the agitated tanks affects the efficiency of the mixture. Several base forms are shown in Fig. 4. The base should be rounded at the edges instead of the flat; This eliminates sharp corners and bags in which fluid flows may not penetrate, reducing the formation of stagnant areas. The energy required to suspend solids in agitated tanks is sensitive to the shape of the vessel base: according to the type of impeller and the generated flow pattern, the modified geometries are shown in Fig. 4b through

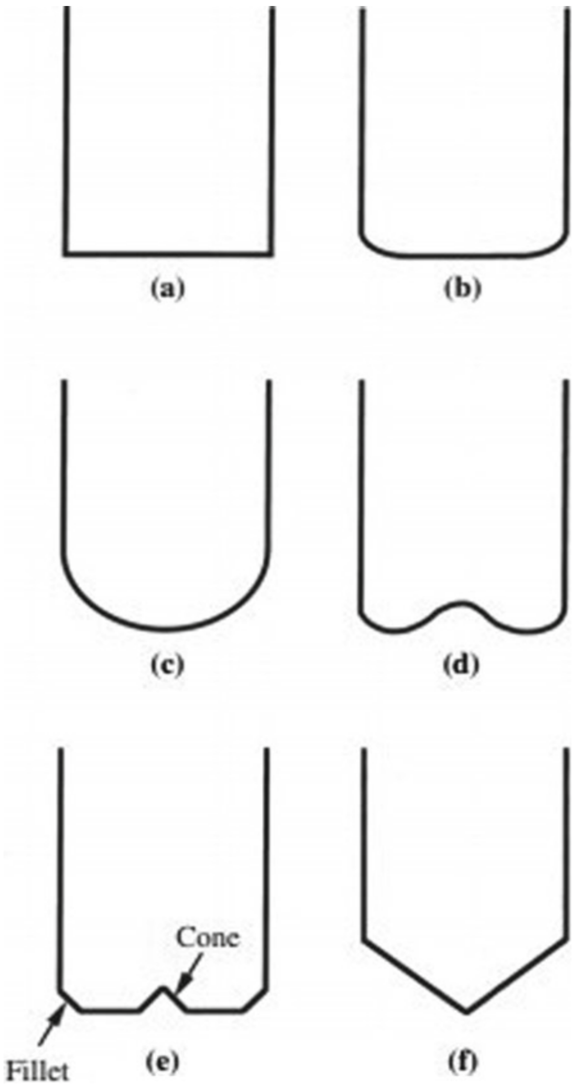


Fig. 4 Different profiles for the base of agitated vessels. Extracted from [10]

(e) are can be used to improve particle suspension compared to the flat bottom tank of Fig. 4a. In contrast, sloping sides or a conical base like the one shown in Fig. 4f promote sedimentation of solids and should be avoided if a suspension of solids is required [8].

To perform the sizing of the tank, it is necessary to know the total volume that the tank must contain. To carry out the design of the washing tank, the use of two hundred grams of seeds will be considered. The ratio between the mass of seeds and water will be 1–5. Therefore, the mass of water needed to wash 200 g of seeds will be 1000 g of water. Finally, the machine must be sized correctly considering the appropriate volume of the container for raw material to be processed in addition to assigning an additional percentage of volume for safety. The water ratio for washing is as follows:

$$m_{\text{Seeds}} = 5 \times m_{\text{Seeds}} \quad (\text{g}) \tag{2}$$

Volume calculation:

Step 1: Calculation of the volume of 200 g of seeds.

$$v_{\text{Seeds}} = m_{\text{Seeds}} \times \rho_{\text{Seeds}} \tag{3}$$

Step 2: Calculation of the volume of tolerance for washing.

$$V_{\text{tolerance}} = v_{\text{Seeds}} \times 0.25 \tag{4}$$

Step 3: Calculation of the total volume.

$$V_{\text{total cylinder}} = V_{\text{tolerance}} + V_{\text{Seeds}} + V_{\text{washed water}} \tag{5}$$

2.3 *Design of Agitators*

At this stage of the process, three types of agitators were designed, which are; straight pallet agitator (Rushton), helical type agitator, and inclined pallet type agitator, which are shown in Fig. 5a–c, respectively.

Table 1 presents the equations for the design of the three wash pallets. These three palettes will be designed in Autodesk Inventor [9] and subsequently manufactured in 3D printers, as shown in Fig. 6. The design and manufacturing process was carried out with the aim of testing in the next stage and thus being able to determine which of them are the most suitable for washing chili seeds.

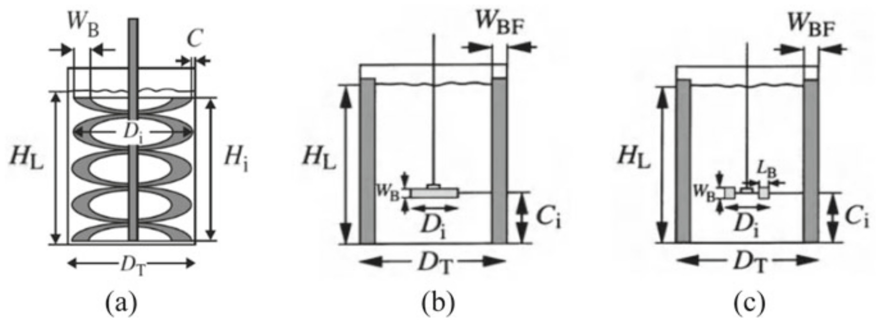


Fig. 5 Types of agitators used in the project

Table 1 Patterns for agitator design

Agitator	D_i/D_T	H_L/D_T	C_i/D_T	W_{BF}/D_T	Number
Turbine Rushton $W_B/D_i = 0.2$, $L_B/D_i = 0.25$	0.33	1	0.33	0.1	6
Inclined turbine $W_B/D_i = 0.2$, $L_B/D_i = 0.125$ 6 blades, 45°	0.33	1	0.33	0.1	6
	D_T/D_i	C/D_i	H_i/D_i	W_B/D_i	
Helical	1.02	0.01	1	0.1	

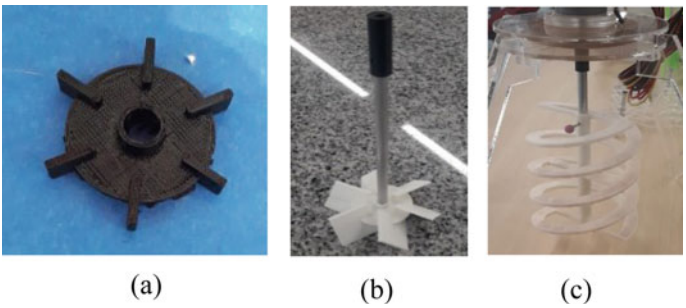


Fig. 6 Agitators designed in the project

2.4 Test Design

In order to establish the level of washing of the seeds, it is necessary to define some measurement variables. For this, the seeds will not be directly analyzed, the water in the mixture will be analyzed at the time of washing. The level of pH and the level of electrical conductivity in the water will be measured after each wash. It is considered that, by washing the seeds, the water can become more acidic. This is mainly due to the substances that expel the seeds. Seed washing is a cyclic process, which is repeated approximately every 15 min. This process is detailed below with the following steps described.

Table 2 Washing process specification

Washed	Washed 1	Washed 2	Washed 3
Sample	Sample 1	Sample 4	Sample 7
	Sample 2	Sample 5	Sample 8
	Sample 3	Sample 6	Sample 9
Time	15 min		
RPM	400		
Temperature	25 °C		

Step 1. Income of raw material selected and weighed previously (200 g of seeds and 1000 ml of water).
Step 2. Start of washing for a time interval of 15 min.
Step 3. After 15 min of washing, proceed to remove a sample of 50 ml where pH and Electrical conductivity should be measured.
Step 4. Start of the second washing period for 15 min.
Step 5. After 15 min of washing, proceed to remove a sample of 50 ml where it is necessary to measure pH and Electrical conductivity.
Step 6. The water in the mixture is changed to new (clean) water. With this change, we will proceed to what we will call "Second Wash" and stages 2, 3, 4, 5, and 6 should be repeated until the appropriate wash number is found, this will be achieved with the precise measurement of the variables described above. Table 2 shows the specifications of the washing process.

3 Results

The following graphs show the measured values of conductivity and pH obtained in each sample during the washing tests, the behavior of the three pallets is also observed at the time of washing (agitating) the seeds. Figure 7 shows that the level of pH between the samples of different pallets is very similar, that is, there is no significant change in the tests, despite the change of pallets. However, there is a significant increase in pH every three samples, that is, after changing the water. This allows us to know the number of washes in which our process is located.

In Fig. 8, it is observed that the conductivity measurement in each sample, of different agitator, has a significant change, that the change of pallet allows obtaining a higher conductivity value. The straight pallet is the one that allows obtaining a higher conductivity value in the samples. Secondly, there is the inclined pallet and thirdly the helical pallet. For the final design of the washing machine, it is recommended to use a straight pallet agitator because it allows for greater agitation and the construction is much simpler than the other two designs.

Additionally, it was observed that the color of the water changes during washing, as the agitation of the seeds increases, and the color decreases each time the water

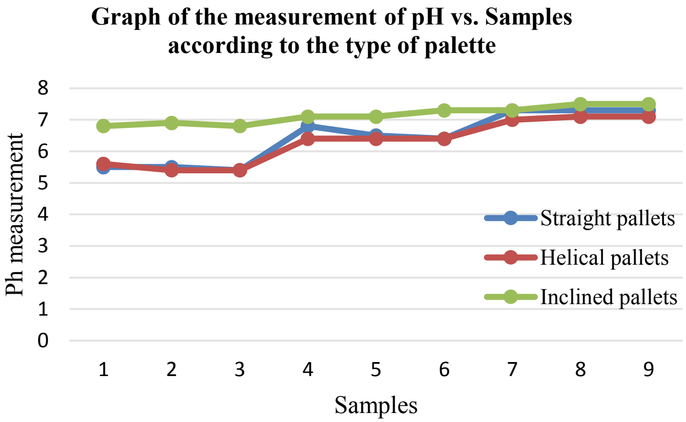


Fig. 7 Graph of the measurement of pH versus Samples according to the type of palette

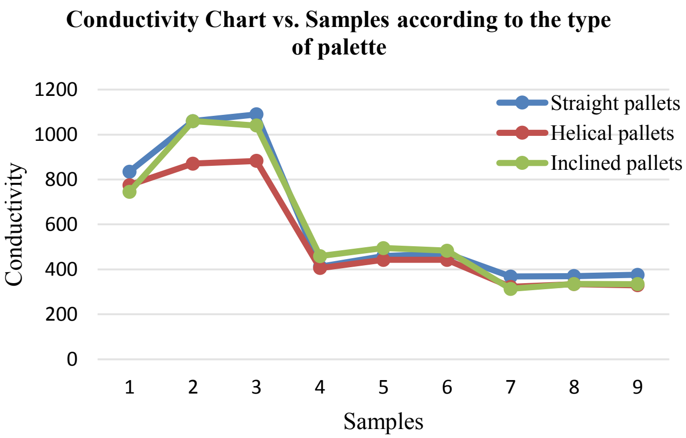
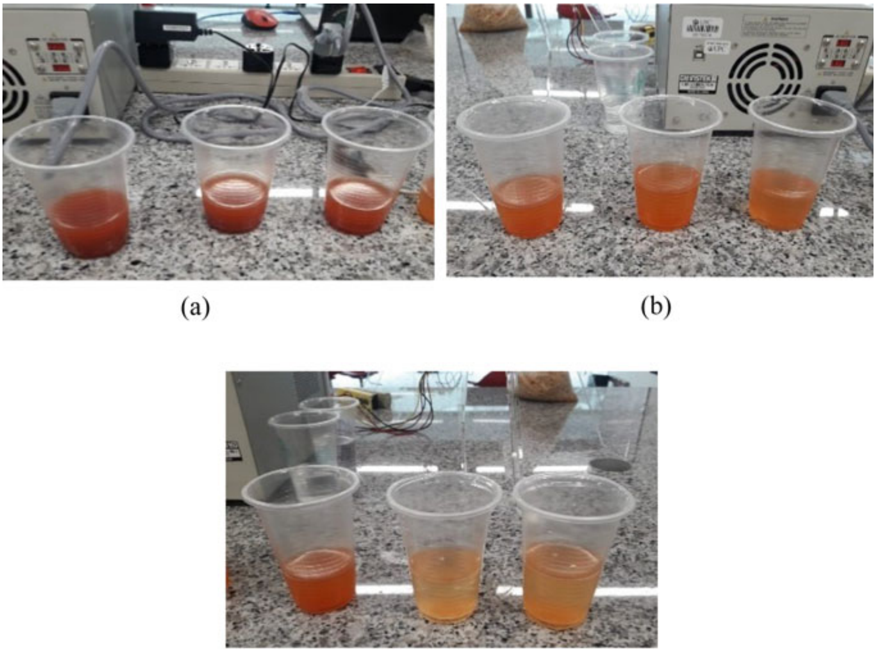


Fig. 8 Conductivity chart versus Samples according to the type of palette

change is made. The control of the level of color in the water could help us to control the level of agitation of the seeds, in this way we could know when to stop stirring the seeds. This can be determined in Fig. 9, since the samples obtained during the washing process, can be observed.

4 Conclusions

The tests carried out determined that the best agitator to wash seeds is that of straight blades, the performance of the blades is shown in Fig. 8. For this test, the time



(a) (b)

(c)

Fig. 9 Images of the samples obtained in the washing process

established to agitate the seeds was 15 min, after this time a variation (increase) of conductivity in the water is obtained. This increase was observed each time the mixture was stirred more. However, the second variable we control (pH) does not provide much information, since it only varies each time the water is changed. An additional test was performed where hot water (40 °C) was used, as a result, the number of washes decreased. This is mainly since the conductivity in the water reaches, in less time of agitation, the values obtained in the first test. It is important to mention that the water obtained during each wash had a reddish color and this increased every time the mixture was stirred; in this way, the water could be analyzed by image processing in order to detect the level of washing.

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