

Technological development for the optimization of the extraction of pecan nuts

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Abstract

The objective of this article is to show the results derived from a proposal for the optimization of the extraction process of the *Carya illinoensis* Koch walnut, implementing the use of technological development as a fundamental part of the process. The foregoing, in search of new technological tools for the producers of this fruit and thus contribute to economic development by reducing costs, increasing efficiency and increasing production by optimizing processes. This investigation takes as a sample a local producer located in the rural community 'Lo de Nava', Jerez de García Salinas, Zacatecas. To carry out the extraction process, 100 walnut samples were analyzed, of which 45 had the extraction process applied manually and the remaining 55 had an optimized process for the separation of the almond, this with in order to collect the data for statistical analysis and know the results of the research approach. That said, the proposal to address the problems outlined is the development of a mechanized process whose objective is to adequately separate the almond and the shell, derived from an analysis of internal structural efforts that facilitate the process of obtaining the fruit, the increased production and improvements in marketing. The statistical method used for the data analysis is Chi square ($X^2_{\text{calculated}} = 8.13$, which is greater than $X^2_{\text{critical}} = 3.841$), with a level of significance ($\alpha = 0.05$), so the decision is in the rejection zone for H_0 ; satisfying the acceptance of the alternative hypothesis H_1 . The results show that the implementation of technological development in the walnut extraction process depends on the method used for said process, since with this implementation there is a greater extraction of the entire fruit in less time, obtaining higher quality in relation to the processes reviewed in this investigation; this is reflected in the increase in sales, as it has a competitive advantage that fosters the development of producers. It is concluded that companies should focus on the innovation of their processes through technological development, which are of importance for the region where the analysis was carried out; likewise, the techniques that provide an analysis to detect their needs, centralize efforts and obtain an efficient result must be considered.

Keywords: *Carya illinoensis*, optimization, process, production, technological development.

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Introduction

According to Díaz (2008), the pecan walnut, producer of the *Carya illinoensis* Koch nut, includes tree plants that produce a fruit, in which during the maturation phase the pericarp and mesocarp dry and the endocarp (shell) and seed (almond) are considered a walnut. The pecan nut has a much more pleasant flavor than the others and is characterized by its different uses in pastry shops, bakeries, bisqueteries, confectioneries, ice cream parlors, ice cream parlors and ice cream shops, since it has a high nutritional value.

The pecan nut is a dried fruit, appreciated and consumed worldwide for its particularly pleasant flavor and its richness in healthy components. The world production of pecan nuts is led by the United States of America and Mexico, the first has 55% of world production and the second with 38%, the countries that contribute the rest are South Africa, Australia and others (International Nut and Dried Fruit, 2014). This fruit is grown mainly in the eastern and southern United States of America, with the main producers being the states of Georgia, Texas, New Mexico, Arizona, Louisiana and Oklahoma (USDA-NASS, 2011). The Spanish called the pecan tree walnut and its fruit, the pecanera, they named it 'walnut'. In different regions of the country it is differentiated from other walnuts with the name of 'paper shell' (Toole, 1965; Brison, 1976).

The pioneering introduction of commercial plantations in Mexico was made in 1904, in the state of Nuevo Leon. In the state of Chihuahua, the first commercial orchards were established in the year of 1946, while in the Lagunera region the exploitation of walnut began in 1948. Since those years, the area planted with walnut trees has increased notably throughout the entire northern region of the country. For 1991, Mexico contributed 15% of world walnut production, occupying the second place in production (INEGI, 1991). Currently, the most outstanding Mexican states in walnut production are Chihuahua, Sonora, Coahuila and Durango with relative shares of 63.14%, 13.39%, 10.83% and 5.74%, respectively (SIAP, 2018).

According to the orographic characteristics, soil type and climate of the municipality of Jerez de Garcia Salinas, it can be considered that it has the elements for the proper development of the pecan nut culture. Empirically, it is identified that, in the Jerez de García Salinas region, Zacatecas, the walnut production season begins in early October and is concentrated in the month of November, when the trees reach their maximum production, which it can be extended until December, depending on weather conditions, since frost and wind accelerate the natural fall of the fruit, which is also forced by means of vibration artificially applied to the trees.

According to Orona (2013), in the state of Zacatecas the walnut is of great importance, since the northern region of the state is part of the center of origin of this species. The production of walnuts in Mexico at the level of states for 2010 is presented in Table 1. According to Geronimo (2011), production is the process of creating the goods and services that the population can acquire to consume it and satisfy their needs. This process is commonly carried out in companies, which are integrated into productive branches and these in economic sectors.

Table 1. Walnut production in Mexico, 2010.

Estates	Harvested area (ha)	Production (t)	Yield (t ha ⁻¹)
Aguascalientes	177	342.4	1.93
Coahuila	1 2910.9	10 247.5	0.79
Chihuahua	3 9420.6	39 764.9	1.01
Durango	4 069.8	3 652.1	0.9
Guanajuato	86	92.6	1.08
Hidalgo	738.7	2 389.2	3.23
Nuevo Leon	3 807.3	1 679	0.44
San Luis Potosi	122	466	3.85
Sonora	7 437.5	16 102.9	2.16
Tamaulipas	89.5	165.6	1.85
Zacatecas	43	69.8	1.62
National total	68 902.3	74 972	1.1

In agriculture, as in other economic activities, technological developments are constantly emerging that increase productivity. One way to get these developments to farmers is training. According to Nakano *et al.* (2018), training is an effective method to spread new technologies, increase productivity, and decrease rural poverty. Given that training has a high cost, the challenge for these authors is to choose the best method at the lowest cost to bring knowledge to farmers (Nakano *et al.*, 2018).

It is worth mentioning that these companies act as generators of innovations in their processes and products, since this provides them with competitive advantages. To develop innovation, a company must first of all seek, identify, and evaluate alternative knowledge from different sources, and then identify potentially useful knowledge. The company must then transfer this knowledge, from the available sources, and seek that it permeates the entire organization (Zhou and Wu, 2010).

According to Carbajal (2010), technological capabilities imply the opportunity to enhance the opportunities and possibilities for the development of technological innovation, with the intention of strengthening individual and collective capacities to promote what people and societies want and can be. The development of technological innovation, although sometimes depending on individual skills, requires a cultural and political context.

This context involves the collective, groups or societies, which must have a minimum of conditions to achieve technological development. This minimum of conditions has to do with the technological capabilities that must be present in the collective to be able to do what the communities want to do and be. This extension of the notions of capacities and operations from the individual to the collective and to the technological sphere is carried out from a procedure by analogy in which the characteristics of such ideas are compared to that of technological capacities.

For example, Porter (1980) refers to capacity not as an opportunity to do, but as an increase in activities, products and productivity. Idea that refers to the container metaphor: increasing capacity is how to add capacity to support the company's objectives or its participation in the market, while avoiding overcapacity in the industrial sector.

It also conceives of capacity in terms of the size of additions, as if capacity were increasing in size and production: future technology is important because it is necessary to forecast the probability that current additions to capacity will become obsolete or that changes allow for effective increases in capacity at the current facility site.

Zhou and Wu (2010) have identified the most common benefits of technological capabilities. In order of importance are the possibility of designing an adequate and comprehensive strategy, flexibility for process and product innovation, and identification of where to allocate available resources. Combs *et al.* (2011) since companies increasingly depend on the optimal use of these to be able to innovate.

In line with this, Benner and Tushman (2003) state that companies must invest decisively in building technological capabilities. This is to develop skills and abilities in order to use various resources properly and to know how to do things. Today, it is considered that, to the extent that companies accumulate experiences, knowledge and self-learning, they manage to take more advantage of their skills.

According to Tartabull (2015), an essential role in technological development corresponds to universities and technology centers. In this regard, Barge *et al.* (2011) refer that in most developed countries technology centers are considered an important element of the national and regional technological infrastructure, they represent an essential link in the provision of services to companies, ranging from applied research and technological development to other support services, such as consulting, diagnosis and technical assistance.

On the other hand, science and technological development can be considered to be mutual between companies and educational institutions; therefore, for Tartabull (2015), a base element for achieving development is focused on the use of science and technology, materialized through the innovation processes that are executed at different levels, it is essential to establish strategic alliances, especially between universities and the business sector, Othman (2011) classifies it as a cooperation that benefits both parties, mainly, if it is analyzed that one provides solutions and the other scenarios for capacity building that cannot be achieved from the performance of the intramural university, a process that will again result in a benefit for the industry, as a source of inputs for most of the graduates of the different disciplines, hence the need for training programs that take into account the demands of the industries, this generates capacities that point the sustainability of development from multiple angles and any of them is very interesting ante in his particular analysis.

For Aström *et al.* (2008) a technological development center (TDC) is that organization that spreads knowledge acquired through its own research processes, aimed at its clients putting it into practice within their own operations. They present themselves as strategic partners of

companies in order to further develop and strengthen their innovative and competitive status. For their part, Barge-Gil and Mondrego (2007), consider as a quality of a TDC their dedication to the provision of innovation and technological development services for companies and industrial sectors.

For Valencia (2019), technology transfer is possible under the research, development and innovation (R+D+i) scheme, a process in which TDC are part of the process of transmitting know-how between the different sectors. The knowledge emanating from TDC allows achieving high levels of competitiveness and develops innovation as a result of investment that transforms knowledge into money derived from satisfying the diverse needs of the market. Therefore, TDC are specialized structures for carrying out tasks to generate added value for different products or services in certain industries.

Mas-Verdu (2008) recognizes the role of the TDC and the universities, which together allow the generation of the necessary infrastructure for innovation, being service providers aimed at promoting various phases of the innovative activity of companies, mainly in the generation and acquiring knowledge and technology, as well as preparing for production and marketing.

According to Orona (2007), the marketing of walnuts is an equally important aspect of production, and in this sense, it was identified that 88% of producers sell their product in packaged form (direct), that is, without adding value. The remaining 12% sells part of their production without shell, achieving prices three times higher than those they receive when selling directly.

Price is determined in the United States of America market according to the forces of supply and demand, as well as its quality determined by the size and color of the almond (Espinoza *et al.*, 2009). Ojeda *et al.* (2010), points out that it is necessary to implement strategies that give added value to walnuts by conducting market studies for walnuts, derived products, and seeking marketing alternatives. In addition, fluctuations in the price of walnuts impact the demand for inputs. The cultivation of walnut in Mexico is of interest since it is the second world producer of this product.

Rostow (1973) indicates that economic growth goes through five stages (traditional society, conditions prior to the initial impulse, the initial impulse or takeoff, the march towards maturity and the era of high mass consumption), specific conditions such as propensity to savings and investment and the spirit of initiative generate a readiness for technological advancement in order to move from traditional societies to mass consumption societies.

For Rostow (1973), the take-off stage includes a rapid growth of certain guide sectors, with modern industrial techniques that allow spreading technological development. Its approach fits with the impulse of technological development centers since it seeks to incorporate advanced production procedures. The criticism of his approach lies in the fact that these stages are imaginary, since the advanced countries have not registered a single path to achieve economic growth, but often did not go through these moments to achieve their advanced levels of development.

The objective of this work is to analyze the relationship that exists in process optimization, through the implementation of technological development in the process of walnut extraction, adapting the needs of companies regarding the existence of innovative processes that they facilitate its growth and functionality, this whole process is obtained by performing a statistical analysis Chi-square test that allows the variables to be related to extracted data and validate the hypothesis of the analyzed data.

Materials and methods

Study location

The study was carried out in a 20-year-old walnut orchard in production, with a density of 100 trees ha⁻¹, established within the Lo de Nava community, located in the Jerez de García Salinas Municipality of the state of Zacatecas, Mexico and located in GPS coordinates, longitude (dec): -102.926389 and latitude (dec): 22.73250, the town is located at a medium altitude of 2 080 meters above sea level.

With the information obtained, from each walnut on the extraction process in which the correlation between the implementation of technological development for the optimization of the extraction process and the manual extraction method of the walnut will be evaluated, to obtain the function of adequate production. With this object, a sample of 100 walnuts is taken, which is classified in Table 2 of association, finding the following results:

Table 2. Association and observed values.

Type of walnut extraction method	Manual extraction	Technological development for the optimization of the extraction process	Total
Extraction in pieces	20	25	45
Extraction whole	10	45	55
Total	30	70	100

The data was analyzed using a statistical Chi-Square model. Where 1) type of extraction methods were handled as factors (manual extraction *vs* use of technological development); and 2) optimization for obtaining the fruit (in pieces *vs*. whole) according to the size of the product from the garden. Therefore, the following is formulated: do these data allow us to affirm that the use of technological development is independent of the extraction method? An alpha significance level= 0.05 will be used. The analysis of these values is determined in Table 3, obtaining the expected values that allow calculating the statistical test in relation to the value of the frequency distribution table, which are noted in italics, for proper identification.

Table 3. Association and expected values.

Type of walnut extraction method	Manual extraction	Technological development for the optimization of the extraction process	Total
Extraction in pieces	13.5	31.5	45
Extraction whole	16.5	38.5	55
Total	30	70	100

From the tabulated data, the obtained values are identified, which represent the proportion reached of each of the extraction methods, so when performing the analyzes in the Chi square statistical method, they yield the following results: $X^2_{\text{calculated}} = 8.1289$, which is greater than $X^2_{\text{critical}} = 3.841$, so the decision is in the rejection zone for H_0 as shown in Figure 1.

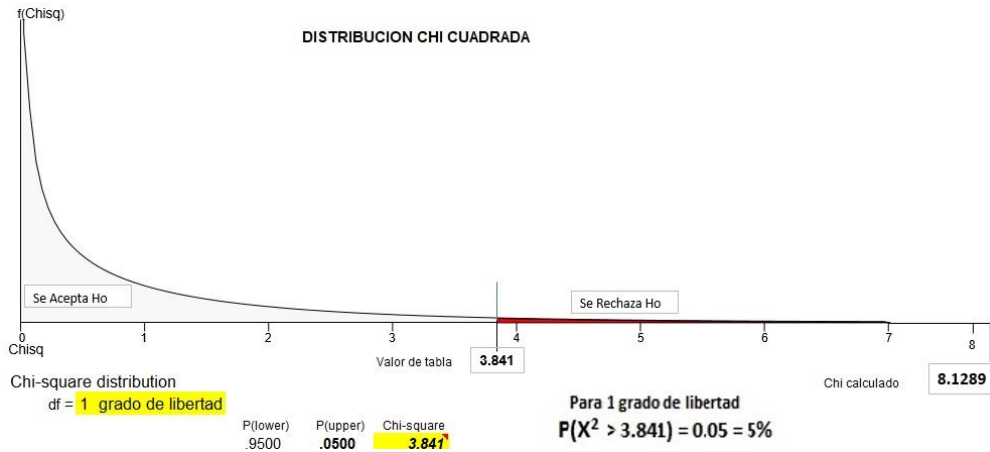


Figure 1. Chi square distribution to obtain degree of rejection of H_0 .

Therefore, the alternative hypothesis is accepted, which states that the variables of the implementation of technological development for the optimization of the process and the extraction method are dependent, considering this for the best extraction of the whole walnut, this gives a greater margin to obtain higher productions of better quality in relation to the sale value of the fruit, for which the optimization of the walnut extraction process is essential for the adaptation of technological development within the agro-industrial area.

Results and discussion

In accordance with the obtaining of the collected data, derived from the tests carried out, the variables to be analyzed are determined, such as the extraction method and the optimization of the extraction process, these are determining factors within the analysis and aspects such as efficiency, improvement of the whole extraction process of the walnut, the procedure for the best commercialization of the fruit, the adequate infrastructure and the equipment optimized for the process, among other characteristics.

The results of the analysis for the producer 'Lo de Nava' located in the Jerez de García Salinas municipality of the State of Zacatecas are presented below. Of the data analyzed for the 100 pieces of walnut that were taken as a sample for the application of a structural effort, 30 of them were selected for the manual extraction method, of which 20 were extracted in pieces and 10 entirely, obtaining an optimization of 33% efficiency in whole product; on the other hand, of the 70 units in which technological development was used, 25 were extracted in pieces and 45 entirely, therefore, there is a 64% efficiency in the extraction of the whole fruit.

Derived from the data obtained and the hypothesis test by the statistical method of Chi Square test, resulting in a $X^2_{\text{calculated or test}} = 8.1289$ value, which is greater than the $X^2_{\text{critical or table}} = 3.841$ value, which was intended to submit the obtained data testing hypotheses referring to frequency distributions that allow us to determine that the null hypothesis (H_0) is rejected and the alternative hypothesis (H_1) is accepted, indicating that the variables of the implementation of technological development for the optimization of the process and the extraction method are dependent, so the use of new machinery and equipment helps to better extract the whole walnut.

In contrast to what was found, the manual extraction method shows an efficiency in the extraction of the whole walnut of 33% and the method of technological development used in the optimization of the extraction of the walnut obtained a 64% extraction efficiency of the entire fruit, the results coincide with Carbajal (2010), Technological capacities imply the opportunity to enhance the opportunities and possibilities of the development of technological innovation, with the intention of strengthening individual and collective capacities to promote what people and societies want and can be.

Derived from the importance of adapting the needs for equipment and infrastructure that allows harvesting and processing the fruit, an analysis of the producer's infrastructure is carried out with the aim of taking advantage of the available resources to facilitate innovation and production of the walnut, the trend described by Zhou and Wu (2010) have identified the most common benefits of technological capabilities. In order of importance are the possibility of designing an adequate and comprehensive strategy, flexibility for process and product innovation and identification of where to allocate available resources.

The producers of the locality 'Lo de Nava' must consolidate as a walnut producing association, which invest capital in addition to lowering government funds to support infrastructure and equipment, that's agree with Benner and Tushman (2003) refer that companies should invest in a way determined in building technological capabilities.

By having an optimized process that allows the production of enter walnuts, it allows producers of this fruit to obtain better quality, production and distribution of the product for its commercialization at a better price within the national and international market, according to Orona (2013). Commercialization. Regarding the marketing channels, in the producers of stratum 1, bulk marketing predominates without prior selection due to not having enough resources to carry out other forms of marketing. In stratum 2, the way of marketing in bulk without previous selection and in bulk selected by size and in stratum 3 the predominant form of commercialization is in bulk selected by size, in which these producers have the best infrastructure and resources to carry out the selection of the walnut.

Conclusions

Walnut producers in the northern part of the country have more advanced ways of extracting walnuts than those in the Municipality of Jerez de García Salinas, Zacatecas, because in this place there are producers that only market without adding value to their product and also, without resorting to the use of technological development as a tool for optimizing the process of fruit extraction and, therefore, receive lower prices for their product because their product sales are in

bulk because they do not have the appropriate technology and process to the maximum use of the product already processed, and even, since they do not have a recognized own brand that identifies them as companies that have an optimal, quality and efficient extraction process, which gives variety within the type of extraction method for a better marketing of your product and derivatives.

This situation depends on the vision and advice that the producers receive both in adequate processes that are simplified and in an efficient design and planning in the installation of equipment with production capacity that allows the passage to technological development, so it is necessary to have adequate technological capacity, both in infrastructure and technological equipment that allows the development of companies, innovation being a tool that provides access to the optimization of processes within any industry that tends to technological growth.

In this case, the recommendation is to strengthen, train and promote the technological development of companies by innovating technological processes, machinery and equipment that help facilitate the processes, and in addition to advising similar companies that already have this process underway and Thus, to strengthen the industrial and economic growth of the state, with greater training and integration not only in production but also in the industrialization of the product through machinery that increases productivity in the fruit extraction stage.

The adoption of this type of equipment allows the optimization of the walnut extraction process, therefore the technological development applied within the company increases productivity, thus increases the efficiency within the process for the extraction of whole walnuts, and thus it strengthens the commercialization of the product, which is what the businessmen want in order to export their product through different distribution channels nationally as well as internationally.

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