

**ECONOMIC VIABILITY OF PRICKLY PEAR PRODUCTS****María Belén Bravo Avalos**

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Abstract

A documentary review was carried out on the production and publication of research papers related to the study of Tuna Derived Products and their economic viability through the analysis of a survey applied to a specific population seeking to know their intention to consume products whose raw material comes from Tuna. The purpose of the bibliometric analysis proposed in this document is to know the main characteristics of the volume of publications registered in Scopus database during the period between 2016 and 2021, achieving the identification of 464 publications. The information provided by said platform was organized by means of tables and figures categorizing the information by Year of Publication, Country of Origin and Area of Knowledge. Once these characteristics were described, a qualitative analysis was used to refer to the position of different authors on the proposed topic. Among the main findings of this research, it is found that Mexico is the country with the highest number of publications, with 120. The area of knowledge that made the greatest contribution to the construction of bibliographic material referring to the study of the economic viability of products derived from prickly pear was the area of Agriculture and Biological Sciences with 283 published documents. On the other hand, the study was able to determine that 53.17% of those surveyed would be willing to consume prickly pear jam, 26.72% would consume wine and 20.11% would like to consume prickly pear tonic, as they consider that it would be a good idea since the fruit contains many nutritional and medicinal properties that would be good to take advantage of in different products.

Keywords: Products derived from Prickly Pear, Economic Viability.

1. Introduction

Tuna is an oval berry, fruit of the Nopal (*Opuntia spp*) which is a native plant of America and reproduces in arid and semi-arid zones. In countries such as Mexico, there are about 23 kinds of edible Tuna, among which are white, purple, red, orange and yellow. However, the green and white shells are the most consumed, accounting for 95% of the total production in that country, which reaches 400,000 tons (Sumaya-Martínez, Suárez, Cruz, Alanís, & Sampedro, 2010). Mexico is the

Latin American country with the highest annual production of prickly pear, but exports only 1.5% of it, while Italy, which is the country with the highest export volume worldwide, exports more than 3% to markets in the United States, Canada and Europe, thanks to its installed capacity and effective mechanisms for packaging and distribution networks that make it efficient, meeting high quality standards to compete in the international market (Mandujano, Golubov, & Reyes, 2002).

The increase in the consumption of this fruit is due to the analysis of its chemical composition, which consists of 85% water, 14% sugars, and 1% protein. Likewise, its properties have been compared with other fruits such as apples, grapes, pears and bananas, which are high in Vitamin C. It should be noted that the nutritional contribution of prickly pear depends on its properties and varies according to physical, chemical and biological factors, such as the time of maturity, the variety of the species, factors in the harvest and post-harvest (Gurrieri, et al., 2000)..

Ecuador, being a country with an important agricultural potential, has managed to stand out in the cultivation of exotic fruits such as Tuna, for which Marketing plans have even been designed for the analysis of the economic viability of the exploitation of this product, which has increased in recent years, popularizing it in markets and supermarkets in the country; however, marketing has presented difficulties as it is a fruit that requires certain special care during its post-harvest, and due to ignorance, much of this production is lost (Rea, 2018). Therefore, a debate has been established in the evaluation of the feasibility in the commercialization of products derived from Tuna, from the documentary review of its scientific production to the evaluation of the purchase intention of current consumers and possible new buyers, leading to the completion of this article with the purpose of answering the question: How has been the production and publication of research works related to the study of the economic feasibility of the commercialization of products derived from Tuna?

2. General Objective

To analyze from a bibliometric and bibliographic perspective, the production of high impact research papers on the variable economic viability in the commercialization of products derived from Tuna during the period from 2016 to 2021.

3. Methodology

Quantitative analysis of the information provided by Scopus is carried out under a bibliometric approach on the scientific production related to the study of the economic viability in the commercialization of products derived from Tuna. Also, from a qualitative perspective, examples of some research papers published in the area of study mentioned above are analyzed from a bibliographic approach to describe the position of different authors on the proposed topic. Likewise, the results of a survey-type tool applied to a specific population are presented, in order to know their intention to purchase products derived from this fruit.

The search is performed through the tool provided by Scopus and the parameters referenced in Table 1 are established.

	PHASE	DESCRIPTION	CLASSIFICATION
PHASE 1	DATA COLLECTION	Data was collected using the Scopus web page search tool, through which a total of	Published documents whose variables of study are related to Criminal Law, present and future

		424 publications were identified.	perspectives. Research papers published during the 2016-2021 period. Without distinction of country of origin. Without distinction of area of knowledge. Without distinction of type of publication.
PHASE 2	CONSTRUCTION OF ANALYSIS MATERIAL	The information identified in the previous phase is organized. The classification will be made by means of graphs, figures and tables based on data provided by Scopus.	Word Co-occurrence. Year of publication Country of origin of the publication. Area of knowledge.
PHASE 3	DRAFTING OF CONCLUSIONS AND FINAL DOCUMENT	After the analysis carried out in the previous phase, the study proceeds to the drafting of the conclusions and the preparation of the final document.	

Table 1. Methodological design.**Source:** Own elaboration (2022)

3.1 Tools

For the market study, two surveys were conducted, the first one was directed to the association's current clients with the objective of measuring the satisfaction of the association's jam, tonic and wine products in order to identify the factors that affect the commercialization of these products. The second survey is aimed at potential consumers who are the inhabitants of the Guano canton to determine if there is unsatisfied demand for jam, tonic and wine. In this way, it will be known whether or not production can be increased in the association *El Granjero Guaneño*.

3.2 Population

The population to apply the surveys of this research are current and potential customers of the association *El Granjero Guaneño* in the Guano canton, province of Chimborazo; in the first case,

according to the association's records, current customers are 80 people. While for the second case are the inhabitants of the canton Guano according to data from the 2010 census of INEC and according to their projections for the year 2017 will be of 47,394 inhabitants (INEC, 2010). The target market will be the economically active population (53.3%), which represents 25,261 inhabitants for whom the corresponding sample will be determined.

3.2.1 Sample

No sample will be determined for current clients. To obtain the sample of the population of the Guano canton, a statistical design was used to determine the size of the sample and the number of surveys to be carried out in this research.

The formula was applied to finite populations, i.e., less than 100,000 inhabitants:

$$n = \frac{Z^2 * P * Q * N}{E^2(N-1) + Z^2 * P * Q} \quad (1)$$

Where:

n = the sample size.

N = population size (25,261).

Z = Value obtained by confidence levels. It is a constant value that, if its value is not available, is taken in relation to the 95% confidence level and is equivalent to (1,96 as most usual)

e²: Error under a given confidence level (0.05). P:

Probability of occurrence of the event*.

Q: Probability of NOT occurrence of the event *.

*If data for *p* and *k* are not available, 50% is generally applied for each of these, considering that their sum should be 100%).

Based on the economically active population of the Guano canton, and with an error percentage of 5%, the values in the formula were replaced to obtain the optimal number of surveys to be conducted.

$$n = \frac{1,96^2 * 0,5 * 0,5 * 25261 (2)}{0,05^2 (25261 - 1) + 1,96^2 * 0,5 * 0,5}$$

$$\frac{24260,66}{64,1104}$$

$$n = 378,42 \cong 378$$

According to the statistical model used, the number of surveys to be conducted with potential customers will be 378.

4. Results

4.1 Results of the documentary analysis

4.1.1 Word co-occurrence

Figure 1 shows the co-occurrence of keywords within the publications identified in the Scopus database.

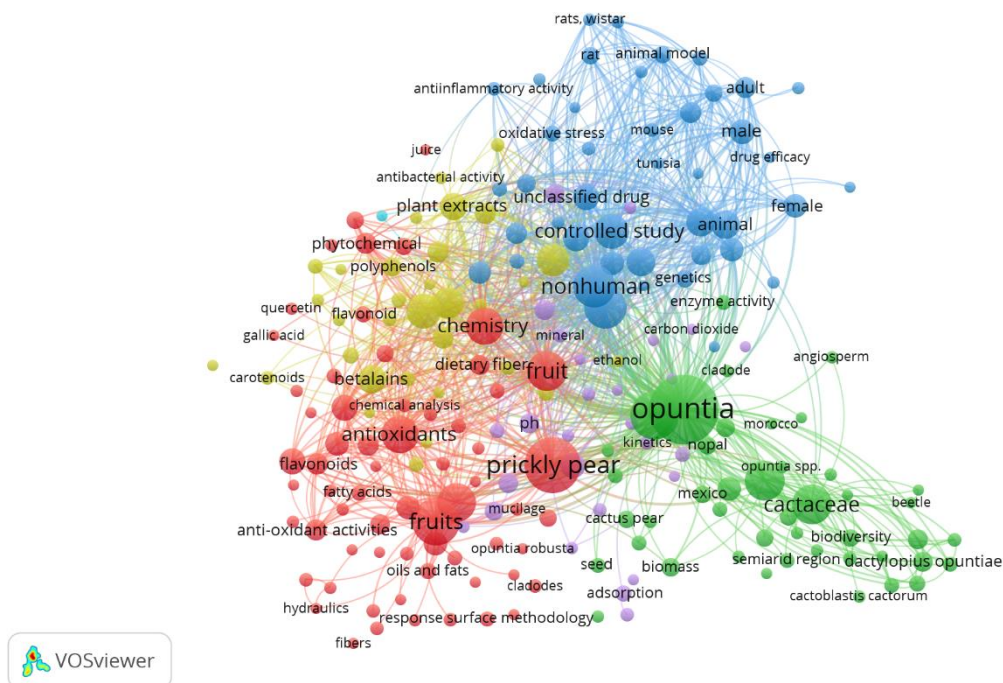


Figure 1. Word Co-occurrence

Source: Own elaboration (2022); based on data provided by Scopus.

Opuntia, the scientific name of Tuna, is the most used keyword in the research identified through the execution of Phase 1 of the methodological design proposed for this research, linked in the same way to research related to Nopal ethanol, Cactus, Biodiversity, among others. Tuna is also one of the keywords most frequently identified in research works that focus on the study of dietary fiber, antioxidants, oils and fats, chemical analysis, which allow inferring that there is a theoretical basis in the published works that analyze the chemical components of Tuna, and its contribution to the recommended nutritional table in food intake. This allows to know the properties of the mentioned fruit and which would be its applications to products derived from it. Up to this point, it is only evident from Figure 1 that the scientific community has focused its efforts on knowing the characteristics of Tuna rather than the economic viability of its commercialization, since up to the date of writing of this document, no key words were identified within the Co-occurrence that indicate a feasibility analysis for the creation of companies or brand positioning.

4.1.2 Distribution of scientific production by year of publication.

Figure 2 shows how the scientific production is distributed according to the year of publication, taking into account that the period from 2016 to 2021 is taken.

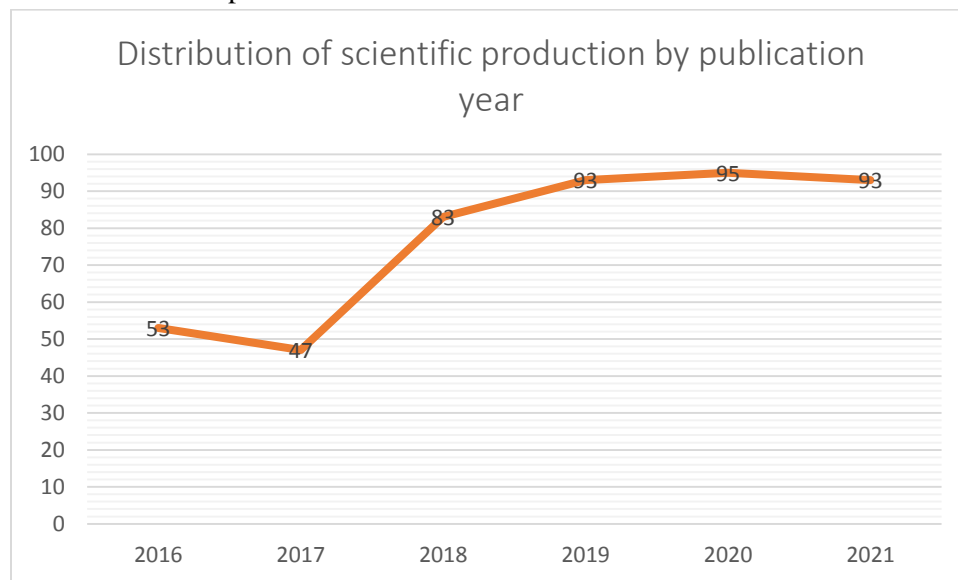


Figure 2. Distribution of scientific production by year of publication.

Source: Own elaboration (2022); based on data provided by Scopus.

The annual distribution of scientific papers reported by Scopus shows a particular behavior in the determination of their volume, starting the analysis in 2016, the number of research papers published in high impact journals indexed in the mentioned database, reached a total of 53 copies, passing in 2017 to 47. In 2018, the growth in the volume of production becomes notorious, to the point that a total of 83 publications were registered. By 2020, this figure would reach 95 published research papers, being that the highest number of records according to Scopus. Among these is the article entitled “*Forage Cactaceae of the genus Opuntia in different phenological phase: Nutritional value*”. (Pessoa, et al., 2020). whose objective was to evaluate the bromatological composition, carbohydrate fractionation, in vitro digestibility and gas production of forage cactus varieties of the genus *Opuntia*, associated with different phenological phases. Their main findings determine that, within the known variety of this type of plants, IPA-20 (*Opuntia ficus-indica* Mill) is the one with the highest concentration of total carbohydrates. The in vitro digestibility of the mature phase was also higher in all varieties except APP (Tuna Africana).

For 2021, the total number of scientific publications referring to the study of the economic viability in the commercialization of products derived from prickly pear was 93 documents, among which the article entitled “*Fermented functional beverage made with apple polysaccharides, tibicos and pectics from prickly pear (Opuntia ficus-indica L. Mill) peels*” was identified (Álvarez, et al., 2021). whose purpose was to explain the technical details in the elaboration process of a fermented beverage whose raw material was exotic fruits. In this way, the article shows step-by-step details in the elaboration of this beverage, including the post-harvest treatment, as well as the nutritional contribution of the product. One of the main contributions is that the use of ultrasound improves the

extraction of polygalacturonic acid from pectic polysaccharides of prickly pear peels, which could be used to obtain fermented products from tibicos and apples with a longer shelf life.

4.1.3 Distribution of scientific production by country of origin.

Figure 3 shows the distribution of scientific production according to the nationality of the authors.

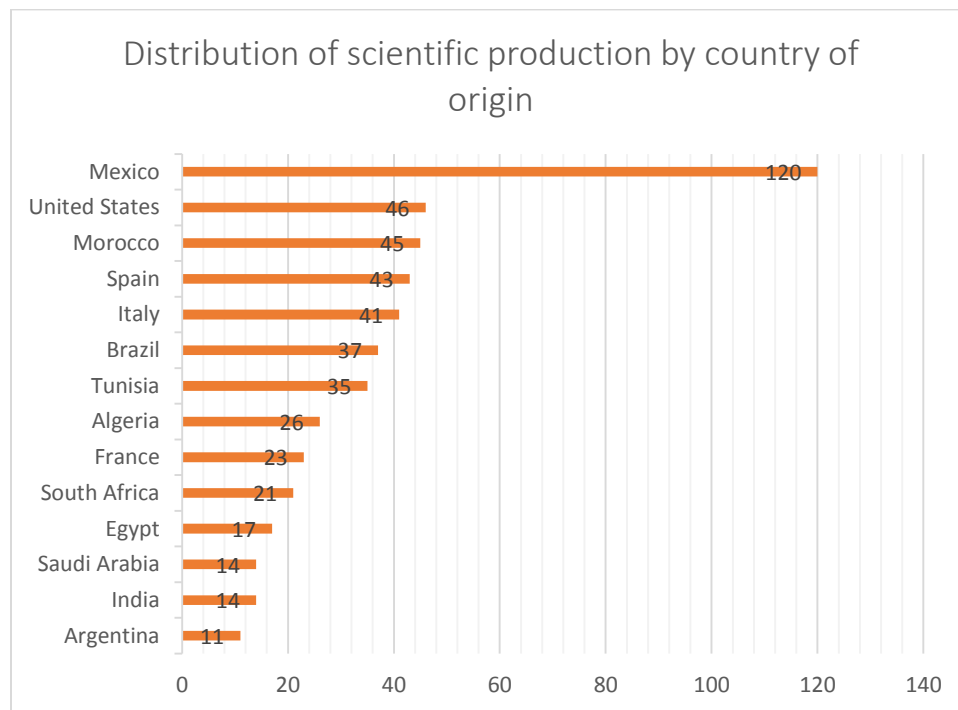


Figure 3. Distribution of scientific production by country of origin.

Source: Own elaboration (2022); based on data provided by Scopus.

Mexico was the country with the highest number of research papers published in high impact journals indexed in Scopus database, referring to the study of the economic feasibility of commercialization of Tuna derived products during the period 2016-2021, with a total of 120 publications. Followed by the United States and Morocco with 46 and 45 documents respectively. Spain is in fourth place, registering a total of 43 publications made during the period indicated above, within these, is the article entitled “*Edible parts of Opuntia Ficus Indica: a food and nutritional security perspective*” (Barba, et al., 2020) whose objective was to explain the nutritional contributions that products derived from prickly pear have on the people who consume them. The high content of vitamins and minerals that are part of the diet of all people and the state of health are highlighted. Preserving optimal levels of nutrients within the products consumed is vital in the fulfillment of nutritional objectives, therefore, the study focuses on the nutritional values contained in the edible parts of Tuna. It also focuses on proposals to guarantee food safety.

At this point, it is worth noting that the production of scientific publications, when classified by country of origin, presents a special characteristic and that is the collaboration between authors with different affiliations to both public and private institutions, and these institutions can be from the same country or from different nationalities, so that the production of an article co-authored by different authors from different countries of origin allows each of the countries to add up as a unit in

the overall publications. This is best explained in Figure 4, which shows the flow of collaborative work from different countries.

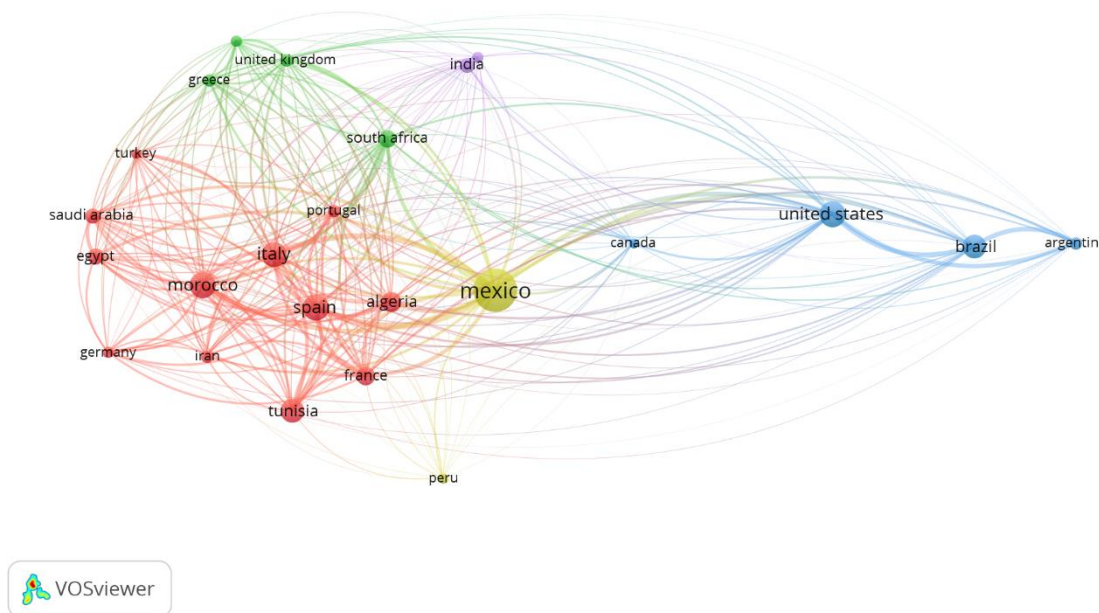


Figure 4. Co-citations between countries.

Source: Own elaboration (2022); based on data provided by Scopus.

In addition to being the country with the highest number of publications registered according to Scopus, Mexico is also one of the countries with the highest participation of international authors. The projects presented by Mexican institutions are co-authored by researchers from the United States, Italy and Spain. Of the Italian authors, the article entitled “*Characterization of prickly pear shell flour as a bioactive and functional ingredient in bread production*” stands out (Parafati, Restuccia, Palmeri, Fallico, & Arena, 2020). whose objective was to evaluate the addition of prickly pear peel flour (PPFF) to bread dough as a source of nutrients and bioactive compounds. The analysis led to evaluate the physical, chemical and nutritional composition of PPFF, as well as its content of bioactive compounds betalains and flavonoids. Through this analysis, it was determined that it contains high levels of fiber and carbohydrates, as well as a high number of polyphenols and betalain compounds. The exercise consisted of adding different concentration levels of PPFF (5, 10, 15, 15, 20, 20, 50 % w/w) to the bread formulations as a possible functional ingredient.

The study established that at any concentration level except 50%, good yeast dough properties were demonstrated, then this compound was tested in bread baking. The article concluded that of all the PPFF concentration levels, 10% achieved the highest value in terms of yeast capacity and, consequently, specific bread volume as well as the best score in terms of sensory evaluation.

4.1.4 Distribution of scientific production by area of knowledge

Figure 5 shows the production of scientific publications distributed according to the area of knowledge through which the different research methodologies are executed.

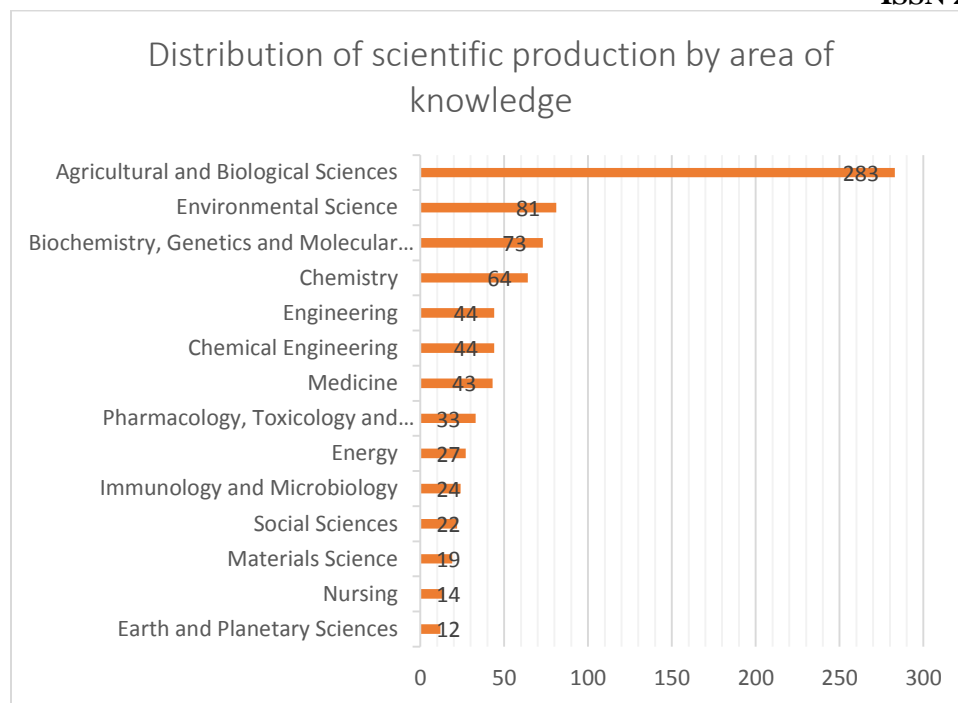


Figure 5. Distribution of scientific production by area of knowledge.

Source: Own elaboration (2022); based on data provided by Scopus.

Agriculture, and Biological Sciences was the area of knowledge through which a greater number of publications were carried out according to Scopus, a total of 283 documents framed in the different theories derived from the aforementioned area. Within this group of articles is the one entitled “*Impact of prickly pear extract on the quality parameters of meat patties after cooking* (Parafati L. , Restuccia, Palmeri, Fallico, & Arena, 2021) whose objective was to evaluate the effect of the addition of prickly pear extract (PPE) on the quality parameters of cooked meat patties. After evaluating different aspects in the study of the feasibility of using this type of product, it was concluded that the addition of PPE can be proposed as a natural tool to improve the quality parameters of cooked beef patties and obtain an advantage for both the food industry and consumers by increasing the yield of the cooked product.

Environmental Sciences occupies the second place with 81 publications, followed by Biochemistry, Genetics and Molecular Biology and Chemistry with 73 and 64 documents respectively. Within this classification, the dominance of theories that frame the areas of knowledge related to the work of the earth and its compounds is notorious, as well as those areas that specialize in the study of the chemical components of biological material.

4.2 Main results of the survey.

At this point, the main data obtained from the survey applied to current and potential consumers of Tuna products were analyzed.

4.2.1 Data collection and analysis: current clients

Question 1. Do you consider the following factors of the association's products to be appropriate?

Quality

This question asks whether consumers believe that the quality of the jam, tonic and wine products produced by the association is adequate or not. The results obtained are presented in Tables 2, 3 and 4.

		Frequency	Percentage	Valid percentage	Cumulative percentage
Valid	Yes	78	97.5	97.5	97.5
	No	2	2.5	2.5	100.0
	Total	80	100.0	100.0	

Table 2. Adequate quality of jam**Source:** Buenaño Carmen, 2018

		Frequency	Percentage	Valid percentage	Cumulative percentage
Valid	Yes	76	95.0	95.0	95.0
	No	4	5.0	5.0	100.0
	Total	80	100.0	100.0	

Adequate quality of the tonic

Source: Buenaño Carmen, 2018

		Frequency	Percentage	Valid percentage	Cumulative percentage
Valid	Yes	77	96.3	96.3	96.3
	No	3	3.8	3.8	100.0
	Total	80	100.0	100.0	

Table 4. Adequate wine quality.**Source:** Buenaño Carmen, 2018

Analysis and interpretation: The tables show that most of the current customers consider the quality of the products to be adequate, with values of 97.5%, 95% and 96.3% for the jam, tonic and wine products, respectively.

Taste

Tables 5, 6 and 7 show the results obtained when asked if the taste of the jam, tonic and wine products is considered satisfactory.

		Frequency	Percentage	Valid percentage	Cumulative percentage
Valid	Yes	79	98.75	98.75	98.75
	No	1	1.25	1.25	100.0
	Total	80	100.0	100.0	

Table 5. Satisfaction with the taste of the jam**Source:** Buenaño Carmen, 2018

		Frequency	Percentage	Valid percentage	Cumulative percentage
Valid	Yes	38	47.5	47.5	47.5
	No	42	52.5	52.5	100.0
	Total	80	100.0	100.0	

Table 6. Satisfaction with the taste of the tonic**Source:** Buenaño Carmen, 2018

		Frequency	Percentage	Valid percentage	Cumulative percentage
Valid	Yes	75	93.75	93.75	93.75
	No	5	6.25	6.25	100.0
	Total	80	100.0	100.0	

Table 7. Satisfaction with the taste of wine**Source:** Buenaño Carmen, 2018

Analysis and interpretation: The tables show that 98.75% of the current customers surveyed are satisfied with the flavor of the jam, 52.50% think that the flavor of the tonic is not completely satisfactory and 93.75% are satisfied with the flavor of the wine. It is observed that the flavor of the tonic is a factor that affects the marketing of the tonic.

Presentation

Tables 8, 9 and 10 reflect the information obtained about the presentation of the products jam, tonic and wine, whether it is considered adequate or not.

		Frequency	Percentage	Valid percentage	Cumulative percentage
Valid	Yes	59	73.75	73.75	73.75
	No	21	26.25	26.25	100.0
	Total	80	100.0	100.0	

Table 8. Consideration of appropriate presentation of the jam**Source:** Buenaño Carmen, 2018

		Frequency	Percentage	Valid percentage	Cumulative percentage
Valid	Yes	23	28.7	28.7	28.7
	No	57	71.3	71.3	100.0
	Total	80	100.0	100.0	

Table 9. Consideration of appropriate tonic presentation.**Source:** Buenaño Carmen, 2018

		Frequency	Percentage	Valid percentage	Cumulative percentage
Valid	Yes	8	10.0	10.0	10.0
	No	72	90.0	90.0	100.0
	Total	80	100.0	100.0	

Table 10. Consideration of appropriate presentation of wine.

Source: Buenaño Carmen, 2018

Analysis and interpretation: it can be observed from the tables that 73.75% of the current clients surveyed think that the presentation of the jam is adequate, 71.3% say that the presentation of the tonic is not adequate and 90% of the respondents consider that the presentation of the wine is not adequate. It can be mentioned that the presentation of the tonic and wine is a factor affecting the marketing of the tonic and wine.

4.2.2 Data collection and analysis: potential consumers

General data

Age

Table 11 shows the results obtained regarding the age of the respondents.

		Frequency	Percentage	Valid percentage	Cumulative percentage
	18-25 years old	94	24.9	24.9	24.9
Valid	25-35 years old	111	29.4	29.4	54.2
	35 or more years	173	45.8	45.8	100.0
	Total	378	100.0	100.0	

Table 11. Age of respondents

Source: Buenaño Carmen, 2018

Question 1. Do you know the association “El Granjero Guaneño”?

		Frequency	Percentage	Valid percentage	Cumulative percentage
Valid	Yes	49	13.0	13.0	13.0
	No	329	87.0	87.0	100.0
	Total	378	100.0	100.0	

Table 12. Knowledge of the association

Source: Buenaño Carmen, 2018

Analysis and interpretation: Of the total number of respondents, only 12.96% know about the association “El Granjero Guaneño” and its products, while 87.04% do not; this is due to the lack of publicity and marketing of the association.

Question 2. What products of the association “El Granjero Guaneño” do you consume?

Table 13 shows the information obtained from the question about the products consumed by the association “El Granjero Guaneño”.

		Frequency	Percentage	Valid percentage	Cumulative percentage
Valid	Marmalade	26	6.9	6.9	6.9
	Tonic	17	4.5	4.5	11.4
	Wine	9	2.4	2.4	13.8
	Another	1	.3	.3	14.0
	None	325	86.0	86.0	100.0
	Total	378	100.0	100.0	

Table 13. Products consumed from the association's association

Source: Buenaño Carmen, 2018

Analysis and interpretation: of all respondents, 85.98% do not consume any of the association's products because they do not know the association. Of the people who consume products of the association, 6.88% consume jam, 4.50% consume tonic and 2.38% consume wine, which are the products offered by the association.

Question 3. Would you be willing to consume a tuna-derived product, which would it be?

The table 14 shows the results obtained on whether people are willing to consume products such as jam, tonic and wine derived from prickly pear.

		Frequency	Percentage	Valid percentage	Cumulative percentage
Valid	Marmalade	201	53.2	53.2	53.2
	Tonic	76	20.1	20.1	73.3
	Wine	101	26.7	26.7	100.0
	Total	378	100.0	100.0	

Table 13. Products consumed from the association's association

Source: Buenaño Carmen, 2018

Analysis and interpretation: of the total respondents, 53.17% would be willing to consume prickly pear jam, 26.72% would consume wine and 20.11% would like to consume prickly pear tonic, as they consider that it would be a good idea since the fruit contains many nutritional and medicinal properties that would be good to use in different products.

Conclusions

From the bibliometric analysis proposed for the development of this article, it can be concluded that Mexico was the country with the highest number of scientific publications registered in Scopus database during the period 2016-2021 in the world, from which it is possible to infer that due to the great variety of Tunas that are developed in the different geographical spaces, thanks to the environmental conditions of this country, they arouse the interest of the scientific community affiliated to Mexican institutions which have widely analyzed the viability in the exploitation and commercialization of this product and its derivatives. The present study confirms the versatility identified in terms of the different products derived from Tuna, ranging from the consumption of the fruit itself to inputs for bakery products, and even raw material for the production of biodiesel.

The position of the different authors regarding the commercialization of this type of products shows an interesting positivism regarding the analysis of the properties of Tuna and its nutritional contribution to people's diet, so the main argument at the time of designing marketing proposals should be based on the properties of this product and its contribution to the conservation of consumers' health.

The tool applied to both consumers and potential customers yields interesting data that can be taken as a theoretical basis for the design of marketing plans and feasibility studies to evaluate the impact that products derived from Tuna could have on the market. Data such as the consideration of current customers with respect to the quality of products such as jam, tonic and Tuna wine, is optimal; 97.5%, 95% and 96.3% respectively, state that they perceive a high-quality product.

Similarly, it was determined that 98.75% of the current clients surveyed are satisfied with the flavor of the jam, 52.50% think that the flavor of the tonic is not completely satisfactory and 93.75% are satisfied with the flavor of the wine. It is observed that the flavor of the tonic is a factor that affects the commercialization of the tonic, so there is an opportunity for improvement in terms of the flavor of the tonic.

Finally, it is important to analyze the opinion of potential customers regarding the possibility of consuming products derived from prickly pear, for which the study determined that 53.17% of those surveyed would be willing to consume prickly pear jam, 26.72% would consume wine and 20.11% would like to consume prickly pear tonic, as they believe it would be a good idea since the fruit contains many nutritional and medicinal properties that would be good to take advantage of in different products.

This study concludes by highlighting the importance of knowing aspects such as the volume of scientific publications related to the analysis of the economic viability in the commercialization of products derived from Tuna, considering the possibility of establishing theoretical bases in possible market and feasibility studies for its subsequent marketing plan.

References

- Álvarez, S., Rocha-Guzmán, N., Moreno-Jiménez, M., Gallegos-Infante, J., Pérez-Martínez, J., & Rosas-Flores, W. (2021). Functional fermented beverage made with apple, tibicos, and pectic polysaccharides from prickly pear (*Opuntia ficus-indica* L. Mill) peels. *Journal of Food Processing and Preservation*.

- Barba, F., Garcia, C., Fessard, A., Munekata, P., Lorenzo, J., Aboudia, A., . . . Remize, F. (2020). Opuntia Ficus Indica Edible Parts: A Food and Nutritional Security Perspective. *Food Reviews International*.
- Gurrieri, S., Miceli, L., Lanza, M., Tomaselli, F., Bocono, P. R., & Rizzarelli, E. (2000). Chemical characterization of sicilian prickly pear (*Opuntia ficus indica*) and perspectives for the storage of its juice. *Journal Agriculture and Food Chemistry* , 5424-5431.
- Mandujano, M., Golubov, J., & Reyes, J. (2002). What you always wanted to know about cacti but never dared to ask. *Biodiversitas*, 4-7.
- Parafati, L., Restuccia, C., Palmeri, R., Fallico, B., & Arena, E. (2020). Characterization of prickly pear peel flour as a bioactive and functional ingredient in bread preparation. *Foods*.
- Parafati, L., Restuccia, C., Palmeri, R., Fallico, B., & Arena, E. (2021). Impact of prickly pear extract on the quality parameters of beef burger patties after cooking. *Food Bioscience*.
- Pessoa, D., Pereira de Andrade, A., Rodrigues, M. A., Teodoro, A., Cordeiro, d. S., Leal de Araújo, N. d., . . . Cardoso, D. (2020). Forage cacti of the genus *Opuntia* in different with the phenological phase: Nutritional value. *Journal of Arid Environments*.
- Rea, S. (2018). MARKETING PLAN FOR THE COMMERCIALIZATION OF PRICKLY PEAR PRODUCTS MADE BY THE FAMILY MICROENTERPRISE “LOS GAVINOS” IN THE PARISH OF SALINAS CANTON IBARRA PROVINCE OF IIMBABURA. *Bachelor's thesis, Escuela Superior Politécnica de Chimborazo*.
- Sumaya-Martínez, M. T., Suárez, D. T., Cruz, C. N., Alanís, G. E., & Sampedro, J. G. (2010). INNOVATION OF HIGH VALUE-ADDED PRODUCTS FROM THE MEXICAN PRICKLY PEAR. *Mexican Journal of Agribusiness*, 435-441.
- Albergamo, A., Mottese, A. F., Bua, G. D., Caridi, F., Sabatino, G., Barrega, L., . . . Dugo, G. (2018). Discrimination of the sicilian prickly pear (*Opuntia ficus-indica* L., CV. muscaredda) according to the provenance by testing unsupervised and supervised chemometrics. *Journal of Food Science*, 83(12), 2933-2942. doi:10.1111/1750-3841.14382.
- Alencar, B. R. R. A., Dutra, E. D. D., Sampaio, E. V. D. S. B., Menezes, R. S. C., & Morais, M. A. (2018). Enzymatic hydrolysis of cactus pear varieties with high solids loading for bioethanol production. *Bioresource Technology*, 250, 273-280. doi:10.1016/j.biortech.2017.11.042.
- Alexandre, E. M. C., Coelho, M. C., Ozcan, K., Pinto, C. A., Teixeira, J. A., Saraiva, J. A., & Pintado, M. (2021). Emergent technologies for the extraction of antioxidants from prickly pear peel and their antimicrobial activity. *Foods*, 10(3) doi:10.3390/foods10030570.
- Alhamdaoui, K., Benqlilou, C., & Essalmani, H. (2021). Enhancing oilseeds cold pressing techniques based on hazop analysis for prickly pear seeds, *Opuntia ficus-indica* (L.) mill. *Nova Biotechnologica Et Chimica*, 20(1) doi:10.36547/nbc.815
- Ali Alsaad, A. J., Altemimi, A. B., Aziz, S. N., & Lakhssassi, N. (2019). Extraction and identification of cactus *Opuntia dillenii* seed oil and its added value for human health benefits. *Pharmacognosy Journal*, 11(3), 579-587. doi:10.5530/pj.2019.11.93.
- Ali, N. F., & Abd-Elsalam, I. S. (2020). Antimicrobial characteristics of wool fibers treated with chitosan-propolis nano composite and dyed with natural dye extracted from red prickly pear. *International Journal of Agricultural Technology*, 16(2), 223-236. Retrieved from www.scopus.com

- Ali, R. F. M., El-Anany, A. M., Mousa, H. M., & Hamad, E. M. (2020). Nutritional and sensory characteristics of bread enriched with roasted prickly pear (*Opuntia ficus-indica*) seed flour. *Food and Function*, 11(3), 2117-2125. doi:10.1039/c9fo02532d.
- Al-Kubaisy, K. N., Al-Essa, L. Y., & Shawagfeh, M. T. (2016). Stimulation of hepatocytes repair by fruit juice of *Opuntia ficus indica* in anti cancer drug cyclophosphamide (CP)-induced liver toxicity in mice. *Annual Research and Review in Biology*, 10(1) doi:10.9734/ARRB/2016/23569.
- Al-Naqeb, G., Fiori, L., Ciolli, M., & Aprea, E. (2021). Prickly pear seed oil extraction, chemical characterization and potential health benefits. *Molecules*, 26(16) doi:10.3390/molecules26165018.
- Álvarez, S. A., Rocha-Guzmán, N. E., Moreno-Jiménez, M. R., Gallegos-Infante, J. A., Pérez-Martínez, J. D., & Rosas-Flores, W. (2021). Functional fermented beverage made with apple, tibia, and pectic polysaccharides from prickly pear (*Opuntia ficus-indica* L. Mill) peels. *Journal of Food Processing and Preservation*, 45(9) doi:10.1111/jfpp.15745.
- Alves, F. A. A. L., De Andrade, A. P., Bruno, R. L. A., Silva, M. G. V., De Souza, M. F. V., & Dos Santos, D. C. (2017). Seasonal variability of phenolic compounds and antioxidant activity in prickly pear cladodes of *Opuntia* and *Nopalea* genres. *Food Science and Technology*, 37(4), 536-543. doi:10.1590/1678-457x.19316.
- Alves, J. N., Araújo, G. G. L., Pereira, L. G. R., Gonzaga Neto, S., Menezes, D. R., Voltolini, T. V., . . . Campos, F. S. (2020). Incorporating oldman saltbush hay and prickly pear in diets for red sindhi calves. *South African Journal of Animal Sciences*, 50(3), 403-414. doi:10.4314/sajas.v50i3.7.
- Alwadai, H. M. (2019). Assessment of invasive plant species, *Opuntia* spp. (prickly pear) in Raydah protected area, Aseer, Saudi Arabia. *Applied Ecology and Environmental Research*, 17(5), 10807-10822. doi:10.15666/aeer/1705_1080710822. doi:10.15666/aeer/1705_1080710822
- AlZahabi, S., Sakr, O. S., & Ramadan, A. A. (2019). Nanostructured lipid carriers incorporating prickly pear seed oil for the encapsulation of vitamin A. *Journal of Cosmetic Dermatology*, 18(6), 1875-1884. doi:10.1111/jocd.12891.
- Amador-Rodríguez, K. Y., Serralta-Macías, R., Flores-Benítez, S., Valera-Montero, L. L., Guzmán-Maldonado, S. H., Gallegos-Vázquez, C., & Silos-Espino, H. (2019). Chemical and potentially functional compounds of selected prickly pear fruit seeds (*Opuntia* spp.). [Chemische und potentiell funktionelle Verbindungen von Samen ausgewählter Feigenkaktus-Genotypen (*Opuntia* spp.)] *Mitteilungen Klosterneuburg*, 69(3), 141-153. Retrieved from www.scopus.com
- Amani, E., Marwa, L., Hichem, B. S., Amel, S. -, & Ghada, B. (2019). Morphological variability of prickly pear cultivars (*Opuntia* spp.) established in ex-situ collection in Tunisia. *Scientia Horticulturae*, 248, 163-175. doi:10.1016/j.scienta.2019.01.004.