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Journal Economic Development

Definition of Journal

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Support the international scientific community in its written production Science, Technology and Innovation in the Field of Social Sciences, in Subdisciplines of trade, international economic activity, aspects of international trade and finance, international relations and international political economy, general aggregate models, quantitative approach, mixed approach.

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Knowledge Area

The works must be unpublished and refer to topics of trade, international economic activity, aspects of international trade and finance, international relations and international political economy, general aggregate models, quantitative approach, mixed approach and other topics related to Social Sciences.

Presentation of Content

In the first article we present, *Criticality analysis of production equipment in a coffee processing company*, by VELÁZQUEZ-VÀSQUEZ, Diana Jhosemy, VÁZQUEZ-ROSAS, Sergio, HERNÁNDEZ-SÁNCHEZ, Uriel Alejandro and CABALLERO-LÓPEZ, Emma Isabel, with adscription in the Universidad Tecnológica del Centro de Veracruz; with a second article, *Reviewing the Mesquite (Prosopis laevigata) Potential to Strengthen the Sustainability of the Mexican Food System*, by DÍAZ-BATALLA, Armando, RONQUILLO-DE JESUS, Elba, RODRÍGUEZ-ORTEGA, Alejandro and DÍAZ-BATALLA, Luis, with adscription in the Universidad Politécnica de Francisco I. Madero; as third article we present *Program for estimating the average wind energy density in a region using 17 methods*, by MERAZ-BECERRA, Fernando & CARRILLO-MARTÍNEZ, Jesús María, with adscription in the Universidad Tecnológica de La Laguna; as fourth article we present S*elf-esteem and its relationship with purchasing behavior in young university students in the southwestern area of Guanajuato*, by URIBE-PLAZA, María Guadalupe, MENDOZA-GARCÍA, Patricia Del Carmen and GARCÍA-PICHARDO, Sandra Ivette, with adscription in the Universidad Tecnológica del Suroeste de Guanajuato (UTSOE).

Content

Article **Journal Economic Development**
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Criticality analysis of production equipment in a coffee processing company

Análisis de criticidad de los equipos de producción en una empresa procesadora de café

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Abstract

This project seeks, through the implementation of a criticality analysis, to control and improve the availability of the equipment, allowing a correct planning and programming to carry out the maintenance activities and also not to affect the internal processes when intervening with repair activities. The research is developed through a quantitative approach since observation is applied in order to collect numerical information. This work was developed in the field, it is a descriptive type of research, its purpose is to observe, describe and determine the level of criticality in the maintenance equipment. In addition to the design, a criticality analysis was carried out on 357 pieces of maintenance equipment using the risk matrix tool, of which 120 were critical according to the evaluation carried out. These critical equipment were prioritized to receive more frequent and rigorous preventive maintenance, with the objective of minimizing possible failures and guaranteeing the company's operational continuity. In addition, an action plan was established to address the deficiencies identified in the non-critical equipment to improve its performance and extend its useful life.

Criticality Analysis, Reliability, Maintenance

Resumen

En el presente proyecto se busca, a partir de la implementación de un análisis de criticidad controlar y mejorar la disponibilidad de los equipos, permitiendo una correcta planificación y programación para llevar a cabo las actividades de mantenimiento y así mismo no afectar a los procesos internos al intervenir con actividades de reparación. La investigación se desarrolla mediante un enfoque cuantitativa puesto que se aplica la observación para poder recolectar información numérica. El presente trabajo se desarrolló en campo, es una investigación de tipo descriptivo, tiene como propósito observar, describir y determinar el nivel de criticidad en los equipos de mantenimiento. Se logró además de diseñar, llevar a cabo el análisis de criticidad sobre 357 equipos de mantenimiento mediante la herramienta matriz de riesgos, de los cuales 120 resultaron críticos de acuerdo a la evaluación realizada. Estos equipos críticos fueron priorizados para recibir un mantenimiento preventivo más frecuente y riguroso, con el objetivo de minimizar posibles fallas y garantizar la continuidad operativa de la empresa. Además, se estableció un plan de acción para abordar las deficiencias identificadas en los equipos no críticos y así mejorar su rendimiento y prolongar su vida útil.

Análisis de criticidad, Confiabilidad, Mantenimiento

Citation: VELÁZQUEZ-VÀSQUEZ, Diana Jhosemy, VÁZQUEZ-ROSAS, Sergio, HERNÁNDEZ-SÁNCHEZ, Uriel Alejandro and CABALLERO-LÓPEZ, Emma Isabel. Criticality analysis of production equipment in a coffee processing company. Journal Economic Development. 2023. 10-29: 1-6

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Introduction

The use of risk analysis techniques involves searching for and evaluating scenarios that may have a negative impact on a facility or production line, identifying the most risky scenarios and issuing recommendations for actions to minimise the risk (Aguilar-Otero et al., 2010). Criticality analysis is based on the evaluation of the risks associated with each process, system or equipment, considering factors such as the probability of failure and the impact it may have on the operation. In addition, this methodology allows identifying opportunities for improvement and establishing preventive maintenance strategies to minimise unplanned downtime (Díaz-Concepción et al., 2019).

The criticality analysis method allows knowing the level of importance and priorities of facilities, systems and activities it allows establishing ranges to make a representation of the probability and frequency of occurrence of events or errors, as well as possible occasional events (Omar Campos-López et al., 2018). Criticality analysis is a widely used tool in risk management, as it allows identifying and prioritising those events that could have a greater impact on the operation of the Facility, System, Equipment or Device. In addition, this technique facilitates decision-making by providing a clear and concise visual representation of the associated risks (Daquinta-Gradaille et al., 2018).

This analysis allows identifying the critical elements that could have a significant impact on the operation of the plant and establishing the necessary preventive and corrective measures to minimise the associated risks (Álvarez, David; Rosero, Laura.; García, 2019). In addition, it helps to optimise resources by focusing efforts on those elements that are most important for the safe and efficient operation of the plant (Castillo-serpa, 2009).

Risk assessment within the industry considers the probability or frequency of a failure occurring and considers the impact of that event on production, labour and repair costs (Parra et al., 2021).

These assessments allow identifying and prioritising the most significant risks for the company, with the aim of implementing appropriate preventive and mitigating measures (Suresh and Jayadeva, (2023). Furthermore, they provide a solid basis for strategic decision-making in terms of investment in safety and improvements in industrial processes (Bernardino-Flores et al., 2018).

Reliability Centered Maintenance (RCM) is a methodology that serves as a basis for the elaboration of maintenance plans contemplating preventive or predictive strategies (SAE - Society of Automotive Engineers, 1999). RCM is based on the detailed analysis of equipment and systems, identifying critical functions and potential failure modes (García Reyes, 2013). From this information, the most appropriate maintenance strategies are selected to maximise operational reliability and minimise associated costs. This methodology has proven to be effective in various industrial sectors, allowing management to be optimised (Díaz-concepción et al., 2012).

Methodology

Quantitative research is applied to understand frequencies, patterns, averages and correlations in order to understand cause and effect relationships, test hypotheses or theories based on statistical analysis (Hernández Sampieri et al., 2014). The effects of such research can be represented by numbers or graphs. For the collection of information, observation will be used to determine the coding of events and to be able to express them in numbers. Therefore, the present work is considered as quantitative research since observation is used to collect numerical information. This work was carried out in the field, it is a descriptive type of research, its purpose is to observe, describe and determine the level of criticality in the maintenance equipment. It will also allow us to analyse and evaluate the factors and failures that affect the maintenance process. The methodology consists of two stages, which are described in figure 1.

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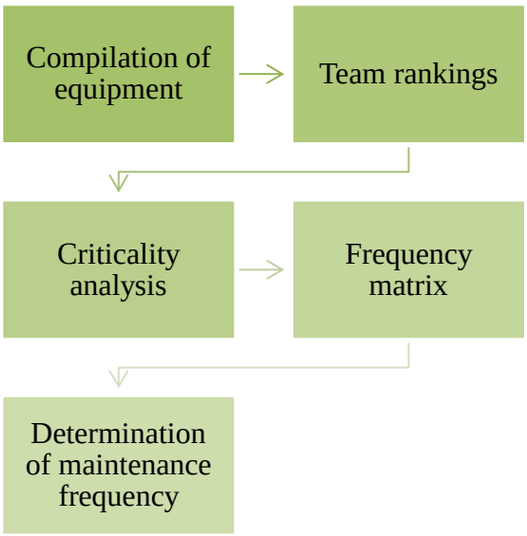

Figure 1 Methodology applied

The first step of the methodology consists of compiling the technical information of the equipment in plant 1, then we proceed to the classification of the equipment, where we will start by compiling all the equipment in the industrial area, then the classification will be made taking into account mainly how many of the equipment failures cause plant stoppage, on this it will be decided whether a piece of equipment is critical, main or auxiliary.

The third step, the criticality analysis is developed from the result obtained in the classification, on the number of critical equipment results a criticality analysis will be applied in which to determine the criticality of a unit or equipment a frequency matrix must be used by consequence of the failure. The frequency of failures and the impacts or consequences that the equipment will suffer if a failure occurs must be represented. Finally, the frequency of maintenance should be determined by considering the weights of the impact on safety, spare parts, labour and the probability of failure, thus obtaining the risk value.

Results

A format was designed to have a control of the equipment, considering elements such as; work area, name of the equipment, quantity of equipment in stock and a bar code was generated to facilitate the control of the maintenance activities, an example is shown in figure 2.

In order to carry out the criticality analysis, it was first necessary to define the criticality of the equipment based on its impact on the coffee production process and the existence of a spare part in case of failure or breakdown. In this way, it was possible to carry out a pre-study that helps to focus on the equipment that is only 1 in stock in the plant and, in addition, the equipment that most frequently presents eventualities.

POSICION	AREA DE TRABAJO	EQUIPO	CANTIDAD	CODIFICACION
1	2	TRANSFORMADOR	1	
2	2	SISTEMA DE DESMINERALIZACIÓN DEL AGUA	15	
3	2	SUAVIZADOR DE AGUA	1	
4	2	MOTOR TRIFASICO BONORA	1	
5	2	BOMBA CENTRIFUGA MULTIETAPAS	1	
6	2	MOTOR TRIFASICO WEG	1	
7	2	MEDIDOR DE GAS	1	
8	2	QUEMADOR DE ALTA PRESION	1	
9	2	CALDERA INDUSTRIAL SERIE 500	1	
10	2	CALDERA INDUSTRIAL SERIE 400	1	

Figure 2 Coding of equipment

As a result of having a total of 120 pieces of equipment considered critical for causing plant stoppages due to their failures, the criticality analysis must be applied to these pieces of equipment. In order to carry out the analysis, we proceeded to establish the variables that were considered in the analysis, through brainstorming and according to the department's indicators, 4 variables were identified as criteria or headings to determine the severity (impact) of said equipment when affected by eventualities. Table 1 shows the variables and the weighting given to support the severity.

Variable	Ponderation
Industrial safety	.25
Spare parts	.20
Labour	.30
Consequences	.10

Table 1 Variables and weighting of weights to assess impact

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Subsequently, Como proceeded to give a value to the variables determined to obtain the severity for the industrial safety variable in figure 3, the reference values are observed, it is considered as 0 when there is no effect on people or equipment and it is qualified with 4 when the failure or condition generates permanent disability or death, to one or more people.

For the spare parts variable, 0 was established as 0 when only cleaning and adjustment of the current installed spare parts is required, while a weight of 4 was established when specific parts need to be purchased or made abroad.

Figure 3 Standardised weights for variables

In order to obtain the gravity value the formula 1 was used.

$$G = SG * K_{SG} + R * K_R + MO * K_{MO} + C * K_C \quad (1)$$

In order to assign a value to the Probability of failure, it was decided to take the useful life of the critical equipment as a reference. And as we have been working on the development of the analysis, we again use a scale with values from 1 to 5 to define the probability that some of the equipment in question will present eventualities, each value representing the years of life of the critical equipment.

Each of the values represents the years of life of the critical equipment. Figure 4 shows the scale defined and used.

Figure 4 Probability of failure

To obtain the risk value of the critical equipment, the product of the value assigned to the probability of failure and the value obtained with the above formula for severity (impact) was determined. The formula 2 is applied to obtain the product of the risk value:

$$Riesgo = G * PFallo \quad (2)$$

To obtain the risk level of the equipment, four risk levels were used in relation to the severity and estimated probability of failure. 4 values to show the criticality that was collected as a final result. Given that the equipment to which the analysis was applied was already considered critical equipment in terms of the plant stoppage it can cause when it fails, these values were used to give a risk level result for the equipment. The criteria are shown in table 2 and are used to estimate the level of risk according to the product obtained in formula 2.

Risk	Value	Action
Very Serious	> 13	Requires urgent attention
Significant	9 a 12	Mandatory preventive measures
Appreciable	3 a 8	Planned preventive measures
Secondary	< 3	Subject to continuous observation

Table 2 Risk estimation

Finally, a column was added to the matrix to establish the frequency with which preventive maintenance is to be carried out for the equipment in question. This function is determined with the frequency from formula 3 in Excel.

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$si.conjunto(M30 \geq 15, \text{MENSUAL}, M30 \geq 9, \text{CUATRIMESTRAL}, M30 \geq 3, "SEMESTRAL")$ (3)

Table 3 shows the maintenance frequency considering the values obtained in (2), obtaining the periodicity of maintenance according to its severity.

Frequency of maintenance	Estimated value of the risk
Equipment is highly critical and requires full attention	15
Equipment is medium critical, requires attention.	9
Equipment is low critical, requires attention.	3

Table 3 Maintenance frequency

Figure 5 shows 6 pieces of equipment in the boiler and services area, of which the steam generator, gas burner and the 800 CC boiler motor have a very high risk level. On the other hand, with a high risk level, the tower fan, cooling unit and tank feed pump have a great impact when they fail, as they generate multiple consequences, such as not allowing other operators to continue with their coffee processing activities.

MATRIZ									FRECUENCIA
DESCRIPCION	S I (0.25)	R (0.20)	MO (0.30)	C (0.10)	Pfallo	G	Riesgo	Nivel de riesgo	MANTENIMIENTO PREVENTIVO
GENERADOR DE VAPOR HURST800 CC	4	2	4	4	5	3.6	18	MUY ALTA	MENSUAL
QUEMADOR DE GAS POWER FLAME	3	2	4	3	5	3.05	15.25	MUY ALTA	MENSUAL
VTF MOTOR 30HP DE CALDERA 800 CC	2	2	4	4	5	3.1	15.5	MUY ALTA	MENSUAL
VENTILADOR TORRE DE ENFRIAMIENTO 1	3	2	2	4	5	2.85	14.25	ALTA	CUATRIMESTRAL
UNIDAD ENFRIAMIENT AGUA HELADA CHILLER	2	2	3	4	5	2.85	14.25	ALTA	CUATRIMESTRAL
BOMBA ALIMENTACION AGUA CISTERNA	2	2	2	3	5	2.3	11.5	ALTA	CUATRIMESTRAL

Figure 5 Probability of failure

The result of the first classification of all the equipment in plant 1 of the coffee processing company is shown in table 4, with four variants of the classification. Of the 120 critical equipments analysed, a total of 13 equipments present a very high risk level, 93 equipments with a high risk level and 14 equipments with a medium risk level.

Of which respectively they should be subject to monthly preventive maintenance for equipments with a very high level, every four months for equipments with a high level and every six months for equipments with a medium level.

Clasification	Total number of teams
Critical equipment	120
Main equipment	200
Auxiliary equipment	35
Non-operational equipment	2
Total	357

Table 4 Classification of equipment

Conclusions

In addition to the design, a criticality analysis was carried out on 357 pieces of maintenance equipment using the risk matrix tool, of which 120 were critical according to the evaluation carried out. After completing the analysis of the critical equipment and presenting recommendations as well as following up on the project for future work, the following conclusions can be drawn: It is important to identify the different equipment with which the plant works on a daily basis, to have a history of equipment failure or otherwise an analysis already applied in which the variables that determine its criticality can be appreciated (Hidalgo et al., 2023).

It is important to have spare and replacement parts in stock, so as to avoid wasting time in the time it takes to obtain the necessary spare parts. It is important to train and keep informed the operators who handle the equipment, so that in case of any failure they immediately know what to do and/or who to notify about the current failure. It is necessary to adapt the next maintenance plans according to the results obtained in the criticality analysis. In order to provide adequate continuity to the present project, it is necessary to adapt the next maintenance programme according to the results obtained in the criticality analysis, so that in this way the seriousness of a critical piece of equipment can be considered if it is not attended to at the right time in order to avoid causing multiple losses in the plant.

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Article **Journal Economic Development**
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Reviewing the Mesquite (*Prosopis laevigata*) Potential to Strengthen the Sustainability of the Mexican Food System

Revisando el Potencial del Mezquite (*Prosopis laevigata*) para Fortalecer la Sustentabilidad del Sistema Alimentario Mexicano

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Abastract

The stability of the planetary system and the protection of natural resources for future generations are the most important challenges for humanity. Given the food system impact on planetary boundaries, to develop strategies and technologies to reach sustainability has a great relevance. A restructuration of the world food system elements including resilient species, in a new framework different to the current agricultural practices, is a suitable option. In this context the mesquite (*Prosopis laevigata*), a tree with nitrogen fixing capacity and adapted to dryland, is described as a species that, with its outstanding biological and nutritional properties, is a strategic element to reach a healthier and sustainable food system.

Legume, Protein, Sugars

Resumen

La estabilidad del sistema planetario actual y el resguardo de los recursos naturales para las generaciones futuras son los retos más importantes a los que se enfrenta la humanidad. Dado el impacto que el sistema alimentario representa para la estabilidad de los limites planetarios, el desarrollo de estrategias y tecnologías que permitan alcanzar la sustentabilidad es de la mayor relevancia. La reestructuración de los elementos del sistema alimentario mundial incorporando especies de mayor resiliencia en esquemas diferentes a las actuales prácticas agrícolas es una opción viable. En este contexto se describe al mezquite (*Prosopis laevigata*), un árbol con la capacidad de fijar nitrógeno y adaptado al semidesierto, como una especie que por sus características biológicas y nutrimentales es un elemento estratégico en la búsqueda de un sistema alimentario más sano y sustentable.

Leguminosa, Proteína, Azúcares

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The Food System

Despite efforts and plans to colonise the moon or Mars, the earth is currently the only source of resources for the more than eight billion humans that inhabit it (Perchonok *et al*., 2012). The water, energy, materials and food needed for today's societies can only be obtained from this planet, whose resources are finite. The impact that human societies exert by demanding resources and generating waste has exceeded the safe limits for the continuation of human activities on earth as we know it.

Of the nine established planetary boundaries, humanity has irreversibly damaged biodiversity, climate change and the nitrogen cycle (Rockström *et al*., 2023). If the current scenario is a major challenge, meeting the needs of more than nine billion people in 2050 is an even greater challenge. The way humanity consumes resources and produces waste must be reconsidered and restructured, with the aim of achieving a balance with the environment and not compromising the future of the next generations.

Food production, which today's society demands, is one of the most responsible elements of global stress. The current food system uses 50% of the habitable surface, consumes 70% of water, produces 30% of greenhouse gases, is mainly responsible for land use change, deforestation, loss of biodiversity, soil degradation and pollution of the atmosphere and water (Crippa *et al*. 2021). On the other hand, the structure of the current food system maintains a condition of malnutrition for a large part of the population, which allows the prevalence of malnutrition in infants and women of reproductive age mainly, while at the same time allowing high rates of overweight and obesity in children and adults (Global Nutrition Report, 2021).

In Mexico, 15 % of women of reproductive age suffer from some degree of anaemia, only 28 % of children between 0 and 5 months are exclusively breastfed, undernutrition in children under 5 is 14 %, overweight in children under 5 is more than 6 %, 36 % of children between 5 and 19 are overweight and 15 % obese, more than 30 % of adults are obese and more than 60 % are overweight (Global Nutrition Report, 2021).

The structure of the current food system, which affects the environment and generates conditions of malnutrition, has been described as a syndemic, referring to the global prevalence of undernutrition and obesity, associated with climate change and integrating two of the main challenges facing modern societies, human health and planetary health (Swinburg *et al*., 2019).

While the food system has a direct link to the concept of syndemia, described above, it is made up of different elements and each of these elements has a greater or lesser impact on human health or planetary health. Considering the current production and consumption of 15 food groups (chicken, dairy, eggs, fish, fruits, legumes, nuts, olive oil, potatoes, processed red meat, refined cereals, sugary drinks, red meat, vegetables and whole grains) and their impact on health (type 2 diabetes, embolism, coronary heart disease, colon cancer and mortality) and the environment (greenhouse gas emissions, land use, water use, acidification and eutrophication) it is possible to identify the implications of each food group and the differences and similarities between them. (Clarka, Springmanna, Hilld & Tilmane, 2019).

This analysis shows that the fruit and vegetable group has a low impact on both human health and planetary health, while the legume group has a low impact on both aspects except for land use, on which it has a medium impact, nuts have a medium impact on acidification and a high impact on water use, whole grains have a low impact on human health, but on planetary health they have a medium impact on water use, land use and eutrophication, potatoes have a low impact on planetary health.

But on human health they have a medium impact on colon cancer and diabetes, olive oil has a low impact on all indicators except water use, refined grains have a medium impact on mortality and coronary heart disease and on planetary health it has a medium impact on water use, land use and eutrophication, sugary drinks have a high impact on human health, specifically, they have a medium impact on mortality and stroke, but they show a high impact on coronary heart disease, but show a high impact on coronary heart disease, colon cancer and diabetes.

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While in planetary health they only have a medium impact on eutrophication, fish has a low impact on human health, but in planetary health it has a medium impact on water use and acidification and a high impact on greenhouse gas emissions and eutrophication, eggs have a medium impact on mortality, colon cancer and diabetes and on greenhouse gas emissions, acidification and eutrophication, dairy has a low impact on human health, but in planetary health it has a medium impact on water use and acidification and a high impact on greenhouse gas emissions and eutrophication, dairy has a low impact on human health, but on planetary health they have a medium impact on greenhouse gas emissions, water use, land use, acidification and eutrophication, chicken maintains the same profile as described for dairy, red meat has a medium impact on the five human health indicators and a high impact on the five planetary health indicators, and finally processed red meat has a high impact on the five human health and planetary health indicators (Clarka, Springmanna, Hilld & Tilmane, 2019).

From the above it should be noted that the production and consumption of food groups with low impact on human health, coincides with that they are the food groups that have a low impact on planetary health, so the food system should be integrated from this food group as a priority (fruits, vegetables, legumes and whole grains) and in turn the production and consumption of food groups with high impact on human health, coincides with these being the food groups that have a high impact on planetary health, so the food system should be integrated from this food group in lower proportion (animal products, specifically, red meat, processed red meat) (Clarka, Springmanna, Hilld & Tilmane, 2019).

It is clear that not all food groups have the same impact on human health and planetary health, and that foods of animal origin have the greatest impact on planetary health; specifically, these food groups use 80% of the arable land area and produce 70% of the greenhouse gases from the food system, but account for only 18% of the calories consumed in the human diet (Clarka, Springmanna, Hilld & Tilmane, 2019; Swinburg *et al*. 2019).

While animal-based food groups have a high impact on planetary health, these foods represent the main source of good quality protein in the human diet, so a strategy aimed at limiting or reducing their production and consumption must consider alternative sources that will substitute for this source of protein, which does not result in high impacts on human or planetary health (Climateworks Foundation, 2021). Although new technologies such as precision fermentation, cellular agriculture or the adoption of insect protein have been identified as possible useful tools for obtaining alternative protein, plant protein is the main source of protein for the human diet that is most viable in the short term (Climateworks Foundation, 2021), so the search for and adoption of crops that offer advantages in the production of good quality protein that can be integrated into the global food system is a fundamental part of achieving a sustainable food system, friendly to human health and planetary health.

Considering the food groups that give structure to the diets maintained in the context of the current food system and generating a change that favours human health and planetary health seems a viable strategy to achieve a sustainable food system. In response to this trend, a global sustainable diet has been proposed (Willett, 2019), which specifically calls for reducing the consumption of most animal-based foods by half and increasing the consumption of plant-based foods by more than 100 percent, with particular emphasis on increasing the consumption of legumes as a major source of protein (Willett, 2019).

Legumes, due to their ability to fix atmospheric nitrogen and accumulate it in the form of protein reserves in their seeds and to demand less water during their production, are a food group whose production and consumption are strategic in reducing the impact of the food system on planetary health and also on human health, given their important contribution of protein, complex carbohydrates, minerals, fibre and active compounds (Semba, Ramsing, Rahman, Kraemer & Bloem, 2021). Given the important role that plant protein sources play in the restructuring of the current food system, initiatives have been undertaken with the aim of describing new raw materials whose agronomic, nutritional and gastronomic characteristics can be incorporated into a sustainable food system.

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The already well-known soybean, pea, canola, fava bean, lentil, bean, peanut, quinoa, sorghum, sunflower seeds are being integrated to a greater extent into the development of high-demand food products and lesser-known raw materials such as chia, quinoa, lupine, flaxseed, hemp, pumpkin seed, sesame and mesquite are being valued with outstanding results (Good Food Institute, 2021). The restructuring of the current food system to one that is more sustainable and less dependent on animal protein will not depend on monoculture and will be made possible by the integration of multiple protein sources, including plant protein, whose production is closely linked to the context of countries and regions.

The Mesquite

In the pre-Hispanic cosmovision, reflected in different codices (Borgia, Tudela, Fejérváry-Mayer), the existence of a cosmic axis supported by four sacred trees is proposed, one of these trees is a precious mesquite (Quetzalmizquitl), on which an eagle perches (López-Austin, 2018). For the hunter-gatherer, immigrant, semi-nomadic groups originating from the north that arrived in the Basin of Mexico (also pejoratively called Chichimecas), the mesquite was a fundamental part of their subsistence in the semi-desert, their diet was mainly made up of mesquite pods, nopales, flowers, biznagas and tunas that they complemented with bushmeat that they hunted thanks to their great skill with the bow made of mesquite root (Valdés, 2017).

The relevance of mesquite for the inhabitants of the Mexican semi-desert was such that it was included in the name of important regions that were later modified, such as San Luis de Mezquitique, whose name was changed to San Luis Potosí (Durán-Sandoval, 2015). There is evidence of the use of its pod in the elaboration of everyday products, in the human diet and for livestock; its use in the elaboration of mesquite wine, a distilled alcoholic beverage made from mesquite pods, prohibited in 1785 by the Spanish crown, stands out (de Orozco Y Berra, 1855). The mesquite is a tree that has accompanied the human societies that inhabit the semi-desert, particularly those that, due to the inhospitable nature of their territories, have based their development on the home and gathering, for which agriculture is not viable due to the low availability of water and the low fertility of the soil.

The genus *Prosopis* is a group of tree species of the family Fabaceae, also known as mesquite, which includes 44 species distributed mainly in arid and semi-arid regions of Asia, Africa and America. (Felker, Takeoka & Dao, 2013). Species of the genus Prosopis were an important crop for indigenous peoples before the arrival of the Spanish (Felker, Takeoka & Dao, 2013). The mesquite complex is firmly established on more than 3.5 million hectares in north-central Mexico and includes the following native species, mainly: P. *glandulosa, P. juliflora, P. velutina, P. pubescens, P. reptans, P. articulata, P. tamaulipana, P. palmeri* and *P. laevigata* (Rodríguez-Sauceda, 2014). Mesquite, being a legume, has the capacity to fix atmospheric nitrogen; it can fix up to 50 kg of nitrogen per hectare per year. Considering that nitrogen, unlike calcium, phosphorus and potassium, does not exist in mineral form in the soil, its fixation from atmospheric nitrogen is a determining factor in carbon fixation and soil fertility, even more so than water availability (Puppo & Felker, 2021).

Nitrogen fixation of mesquite in the semi-desert allows subsequent carbon sequestration and activation of the microbiome, reduces soil density, improves the condition of the rhizosphere, increases water infiltration, increases the cation exchange capacity of the soil and reduces nutrient leaching (Puppo & Felker, 2021). For every kg of nitrogen fixed by a mesquite tree, 12 kg of carbon are sequestered. Considering the extent of the semi-arid regions of the world, which represent 25% of the land surface and 35% of the territory of the Mexican Republic, the semi-desert represents an opportunity for carbon capture and storage if its biodiversity is properly managed (Puppo & Felker 2021; Díaz-Padilla, 2011).

The environmental services offered by mesquite are very important, but its use as a source of food and materials seems to be even greater. In this sense, it is important to highlight that 35 % of the territory of the Mexican Republic maintains semi-desert conditions, and that these regions are home to 33 % of the national population (Díaz-Padilla, 2011), a population that demands food and services and for whom mesquite can be a real opportunity for development, which is why mesquite was once considered a sacred tree, but is nowadays more of a forgotten resource.

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In Mexico, the genus *Prosopis* or mesquite can be found in most of the states of the republic, with a specific distribution, where wild populations of *P. odorata* can be found in Sonora, Chihuahua, Tamaulipas and Baja California; *P. glandulosa* in Coahuila, Nuevo León and Tamaulipas; *P. velutina* in Sonora*; P. articulata* in Baja California and Sonora. articulata in Baja California and Sonora; *P. tamaulipana* in Nuevo León, San Luis Potosí, Tamaulipas and Veracruz; *P. laevigata* in Aguas Calientes, Chiapas, Durango, State of Mexico, Guanajuato, Guerrero, Hidalgo, Jalisco, Michoacán, Morelos, Nuevo León, Oaxaca, Puebla, Querétaro, San Luis Potosí, Tamaulipas and Zacatecas; and *P. juliflora* in Yucatán. The most widely distributed species in Mexico is *P. laevigata*, which can be found in the arid and semi-arid regions of 17 states in northern and central Mexico (Palacios, 2006).

The species Prosopis laevigata, which we will refer to as mesquite, is a tree adapted to semi-arid regions that is between 4 and 12 metres tall, but can reach up to 15 metres or be a 3-metre shrub depending on the conditions of the environment in which it grows (Palacios, 2006). Mesquite can develop a deep root that extracts water from the subsoil and allows the development of a microclimate around its canopy, in which other species can develop.

The foliage of mesquite has pinnae and leaves with 6 to 10 mm leaflets and thorns, it produces inflorescences 10 cm long and indehiscent fruits or legumes, also called pods, 12 to 20 cm long. Mesquite flowers from February to April, fruits from April to July, and mature pods can be found from July to September. Each mature pod may contain 10 to 18 oval, flattened seeds, 5 to 7 mm long (Figure 1) (Palacios, 2006).

Figure 1 The mesquite tree (Prosopis laevigata). a) Mesquite tree in sapling, b) Mesquite flower, leaf and thorns, c) Green mesquite pods, d) Mesquite tree with fruit, e) Mesquite sedes

As mentioned above, mesquite was an important resource for the nomadic populations of the north and centre of the Mexican Republic, who developed techniques to use it as human food, in animal feed, in the manufacture of tools, weapons and furniture, to obtain gums, honey, fuel and for medicinal uses, however, its use as human food has been considerably reduced and its use as fuel and in the production of charcoal stands out as its main form of exploitation and use. Today, with the advent of agriculture and the displacement of many wild species used by our ancestors, there is little reason to consider better utilisation of wild species such as mesquite. It will be the better understanding of the characteristics and properties of these species that can recover their relevance and their integration in the strengthening of current food systems.

In the State of Hidalgo there is an extensive region with a semi-arid climate (comprising 30 municipalities and more than a third of the state) that has been historically known as the Mezquital Valley. In this region, where mesquite trees abound, specifically the Prosopis laevigata species, its inhabitants talk about the use of mesquite pods for human consumption, however, in practice it is no longer a current activity and is rather anecdotal. Villagers also refer to the use of mesquite pods as fodder, a practice that is becoming less frequent, but there is one activity associated with mesquite that is active and of great interest, and that is the use of mesquite firewood as fuel in the preparation of the "barbacoa de hoyo" (barbecue pit).

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The Mezquital Valley is a region with special conditions, although it has a semi-arid climate, irrigated agriculture is by far the main economic activity in the region, where up to 20 tons of corn can be harvested per hectare, this important agricultural activity is driven by the availability of an irrigation system.

The irrigation water used in the Mezquital valley is wastewater from the valley of Mexico, about 50 m3/s arrives in the Mezquital valley where it is used in flood irrigation of more than 100,000 hectares, an activity that has been carried out for more than 100 years and has given rise to one of the largest sewage irrigated agricultural systems in the world (Díaz-Batalla *et al*., 2013).

The availability of wastewater in the Mezquital valley allows intensive agriculture and the organic matter load that this water contains favours soil fertility characteristics and crop productivity, however, it also brings other pollutants, mainly a high microbial load, salts, metals and a complex mixture of organic compounds.

In another sense, wastewater implies a source of contamination, which impacts soil stability, aquifers, biodiversity, human health and of course food safety (Díaz-Batalla, *et al*., 2013). These features make the Mezquital Valley a region with a complex food system that departs from the criteria of good agricultural practices, food safety and sustainability.

In this context, mesquite in the Mezquital Valley, despite being in an area that naturally favours its development, has been displaced from daily use by crops such as maize or forage such as alfalfa, which has left it exposed to a degradation of its value and with little reason to include it in the current food system, beyond its use as fuel or firewood.

Despite these conditions, mesquite populations in Hidalgo still dominate the landscape of the Mezquital Valley and maintain a diversity that is manifested in the presence of materials of diverse phenotypes, which are not exempt from pests and diseases incubated by their natural niche and as a result of direct or indirect human influence (Figure 2).

The integration of mesquite into the food system of the Mezquital Valley and the Mexican semi-desert represents a disruptive opportunity in which a species outside the context of current agricultural production, which fixes nitrogen, which is a tree, which grows in the semi-desert and which does not conform to established agricultural cycles, can contribute to strengthening regional sustainability.

Figure 2 Mesquite pods. a) Mesquite pod phenotypes, b) Paxtle (*Tillandsia usneoides*) attached to mesquite

Mesquite pods

Mesquite (*Prosopis laevigata*) produces a fruit or pod that can be seen in its mature state between July and September. A mature pod can be recognised by the loss of chlorophyll and a decrease in moisture content. Mature pods may be straw-coloured, reddish or dark, with more or less twisted shapes. The maturity of the mesquite pod coincides with the rainy season, so a large amount of ripe fruit falls to the ground when the rain falls and gets wet, and the presence of moisture favours the deterioration of the pod and the attack of pests, mainly bruchids (Parra-Gil, 2020).

Harvesting, by hand or with a pole, of the mesquite pod should be carried out taking into account its state of maturity and moisture content, with particular attention to the presence of thorns that can cause injuries. Once harvested, the pod must be dried immediately (humidity less than 12%) and stored in a place protected from humidity and harmful fauna. If these basic aspects are not taken into account, the pod will deteriorate, yields will be reduced and the probability of conditions for the development of fungi and aflatoxin production in the material will increase (Mom, 2020).

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The mature mesquite fruit is a legume or pod with particular characteristics. The mesquite pod is an indehiscent fruit, with a developed mesocarp and a woody rind that protects the seed, three characteristics that differentiate it from the rest of the legumes, which in general have dehiscent pods, without a mesocarp and without a woody rind to protect the seed (Figure 3).

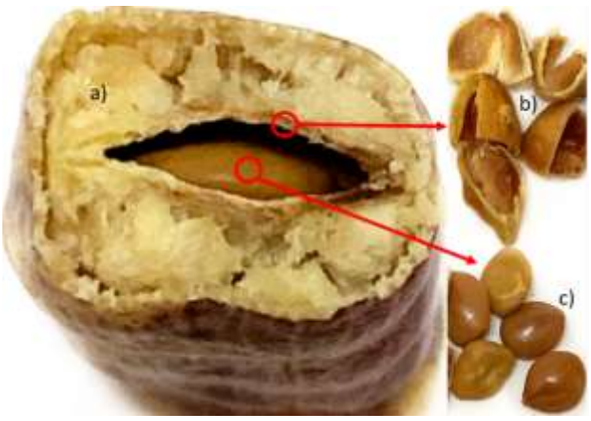

Figure 3 Anatomy of the mesquite pod. a) Cross section of the pod showing the mesocarp, b) Woody bark protecting the seed, c) Mesquite seed

Considering the mature and dry mesquite pod, 16 to 18 % of its weight is constituted by the seed, 30 to 35 % by the woody bark and the rest by the mesocarp (Díaz-Batalla, Hernández-Uribe, Castro-Rosas, Téllez-Jurado, & Gómez-Aldapa, 2018). The annotation and composition of the pod suggests the development of pod utilisation processes aimed at its different fractions, in such a way that the properties of the mesocarp, the woody bark and the seed are used optimally.

The different fractions of the pod have a contrasting composition, while the mesocarp has a large amount of free sugars (45 %), mainly sucrose and its protein content does not exceed 10 %, in the seed the main component is protein with more than 35 % and the woody bark that protects the seed is a material consisting mainly of lignin and cellulose (Díaz-Batalla, Hernández-Uribe, Castro-Rosas, Téllez-Jurado & Gómez-Aldapa, 2018).

When the mesquite pod is considered as a single fraction, integrating the mesocarp and the seed in a single material and excluding the woody bark, it is clear that the result will present an intermediate composition given the sum of these two fractions.

Where protein has levels of between 12 and 13 %, sugars 30 % and fibre around 15 % (Díaz-Batalla, Hernández-Uribe, Castro-Rosas, Téllez-Jurado & Gómez-Aldapa, 2018). Of the sugars present in mesquite mesocarp, sucrose stands out for its quantity, but glucose, fructose and xylose are also present; this quantity and combination of sugars suggest an important potential use of this raw material in the area of industrial fermentations. As an example of the use of this material as a substrate for industrial fermentations, there is a patent application for the process of obtaining a distilled alcoholic beverage called VIGATE (reference to the mesquite laevigata species) (IMPI, 2021a).

In relation to the composition of mesquite seed, its high protein content and amino acid profile have been reported, defining it as a good quality protein, which has appropriate levels of essential amino acids, with particularly high levels of arginine, lysine and sulphur amino acids (Díaz-Batalla, Hernández-Uribe, Gutiérrez-Dorado, Téllez-Jurado, Castro-Rosas, Pérez-Cadena & Gómez-Aldapa, 2018). Seed flour can be processed using emerging and versatile technologies such as extrusion processing to improve its technological and nutritional properties and maintain its nutraceutical properties (Díaz-Batalla, Hernández-Uribe, Gutiérrez-Dorado, Téllez-Jurado, Castro-Rosas, Pérez-Cadena & Gómez-Aldapa, 2018), an example of this is the patent application on obtaining an extruded mesquite seed-based food with functional properties (IMPI, 2021b).

The nutritional profile of mesquite seed and its processing by extrusion has shown its high nutritional and nutraceutical value in preventing the development of dyslipidaemia in a biological mouse model (Díaz-Batalla, Castro-Rosas, Falfan-Cortés, Téllez-Jurado & Gómez-Aldapa, 2021).

The structure and composition of mesquite pods offer opportunities for innovation and the development of new sustainable products to meet the demand for industrial inputs and healthy foods.

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Conclusions

Because of its historical relevance, environmental context, geographical distribution, biological resilience, nutritional value, nutraceutical properties and technological versatility, mesquite and its pods have the potential to be incorporated into the national agroindustry, favouring food sovereignty and the sustainability of the Mexican food system.

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Program for estimating the average wind energy density in a region using 17 methods

Programa para estimación de la densidad de energía promedio del viento en una región mediante 17 métodos

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Abstract

Mexico has an estimated wind potential of 70 GW, however, until 2022 only 7.3 GW were used. This is due, among other factors, to the lack of analysis of the wind resource in many of the country's regions, especially in those where the wind potential is not evident. The lack of automatic meteorological stations (AMS) that measure and record wind speed and direction, as well as the necessary amount of data to make a reliable wind resource estimate, are the main causes of this lack of characterization. Therefore, this article describes the development of a program in Matlab that allows obtaining the average energy density per hour (MEDH) of a region using exact methods and the Weibull probability density function (WPDF) using 15 different methods to determine its parameters C and K. The accuracy of the 15 results obtained from the Weibull PDF is obtained from its comparison with the value obtained from the integration of the power curve and the use of the cube root of the average cubic velocity (Vrmc). The developed application provided the necessary information to evaluate the wind resource of the analyzed region using 16 approximate methods whose error did not exceed 15% and tended to decrease when the data had a Gaussian distribution.

Energy, Power, Wind, Weibull, Analysis

Resumen

México tiene un potencial eólico estimado de 70 GW, sin embargo, hasta el año 2022 solo se aprovechaban 7.3 GW. Esto se debe entre otros factores, a la falta de análisis del recurso eólico en muchas de las regiones del país, especialmente en aquellas donde el potencial eólico no es evidente. La falta de estaciones meteorológicas automáticas (EMA) que midan y registren la velocidad y dirección del viento, así como la cantidad necesaria de datos para realizar una estimación del recurso eólico confiable son las causas principales de esta falta de caracterización. Por lo anterior, en este artículo se describe el desarrollo de un programa en Matlab que permita obtener la densidad de energía media por hora (DEMH) de una región a partir del uso de métodos exactos y la función de densidad de probabilidad de Weibull (FDPW) utilizando 15 métodos distintos para determinar sus parámetros C y K. La exactitud de los 15 resultados obtenidos a partir de la FDP de Weibull es obtenida a partir de su comparación con el valor obtenido a partir de la integración de la curva de potencia y el uso de la raíz cubica de la velocidad cúbica promedio (Vrmc). La aplicación desarrollada proporcionó la información necesaria para evaluar el recurso eólico de la región analizada empleando 16 métodos aproximados cuyo error no supero el 15% y tendió a disminuir cuando los datos tenían una distribución Gaussiana.

Energía, Potencia, Viento, Weibull, Análisis

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Introduction

In 2022, 73.9% of electricity production in Mexico was from fossil fuel-based generation plants. Combined cycle, conventional thermal, turbogas and coal-fired power plants accounted for 58.1%, 6.3%, 4.6% and 4.3% of this percentage, respectively. While the use of renewable energies such as hydro, wind, solar, nuclear, geothermal and biomass was limited to 10.7%, 6.1%, 4.9%, 3.2%, 1.3% and 0.03%, respectively (CIPP, 2023). Since 2014, the distribution between the use of renewables and oil derivatives had not changed significantly.

To address this problem, Mexico undertook a series of energy, political, economic and social reforms with the aim of enabling the significant introduction of renewable energy power generation systems (Cancino et al., 2011). These reforms were cancelled, however, Mexico will comply with the commitments agreed in the 2015 Paris Convention, generating 35% of electricity from renewable energy by 2030 (Lopez, 2022). Wind energy in Mexico is abundant, has a high energy density, its exploitation is viable and it is widely distributed throughout the territory, which makes it one of the best alternatives for electricity production (Pérez-Denicia et al., 2017).

However, until 2021 in Mexico only 7312 MW of the total wind potential, which has been estimated at around 70 GW (MEP, 2023), was being exploited. This problem is due, among other factors, to the lack of wind resource characterisation in many of the country's regions due to the lack of EMAs that measure and record wind speed and direction, as well as the necessary amount of data to make a reliable estimate. Accurate methods such as power curve integration require the analysis of wind speed recorded every second for at least one year.

Seeking to contribute to the exploitation of the wind resource throughout the country, and especially in those regions with no obvious wind potential, this article describes the development of a Matlab program to obtain the measured energy density per hour (DEMH) of a region from the use of exact methods and the Weibull probability density function (WDPF) using 15 different methods to determine its C and K parameters.

The accuracy of the 15 results obtained from the Weibull PDF is obtained from their comparison with the value obtained from the integration of the power curve and the use of the Vrmc. The program also displays a normalised histogram of wind speeds and compares it with the probability curves obtained from the FDPW. This application requires wind speed and direction data recorded at a height of 10 metres, every 10 minutes, for at least one year.

Theoretical background

The wind energy potential can be estimated from an exact empirical method or by numerical methods that approximate the parameters of interest in the region. The former involves the analysis of the topography of the terrain and its roughness coefficient, the local temperature and pressure and the wind speed to obtain the mechanical wind power which in conjunction with its direction will determine the wind energy potential of the wind. The second involves the use of probability density functions (PDF) such as Weibull to estimate the wind behaviour and thus the wind potential of the region.

Instantaneous power in the wind

The kinetic energy in air of mass m moving with velocity V, is (Patel, 2006):

$$Ec = \frac{1}{2}\, m\, V^2 \qquad (1)$$

The power available in a free air stream is the flow of kinetic energy per unit time through the cross-sectional area of the rotor blade of the wind turbine. (Patel, 2006):

$$Pa = \frac{EC}{t} = \frac{1}{2}\frac{m}{t}\, v^2 = \frac{1}{2} M v^2 = \frac{1}{2}\rho\, A\, v^3 \qquad (2)$$

Where P is the instantaneous mechanical power of the wind in motion (w), M is the mass flow rate (Kg/s), ρ is the density of air (Kg/m^3), $A = \pi r^2$ is the area swept by the rotor blades (m^2) and v is the air speed (m/s).

Energy density, wind energy and power coefficient

Power at a location is the power of the wind in a region over a given period of time, measured in Watt * Second. ($W * s$) or Joule (J).

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According to equation (2) the instantaneous power in the wind is related to the air density, the wind speed and the swept area. In turn, the swept area is directly related to the length of the blades of the wind turbine that would be installed in the studied region if it were found to be technically feasible. This is problematic, because in many cases during the estimation of the wind resource the wind turbine to be used has not yet been chosen, which is why the application developed does not calculate the energy, but rather the energy density expressed in $\frac{J}{m^2}$. For similar reasons, the developed application does not calculate the energy density taking into account the power coefficient since its value also depends directly on the wind turbine to be installed.

Average energy density per second obtained from the integration of the instantaneous power density curve (DEMS_IDPI).

1. The instantaneous power density in the wind (IPD) is calculated from each of the 52560 wind speeds recorded by the EMA every 10 minutes for at least one year in the region of interest, as expressed in equation 7.

$$DPI_i = \frac{1}{2}\rho\, {v_i}^3 Cp \quad (3)$$

Where v_i is the i-th wind speed recorded in the region.

2. The annual instantaneous power density curve of the region of interest is generated.

3. The instantaneous power density curve is numerically integrated with respect to time to obtain the cumulative wind energy density for the year. (DEV_{ANUAL}):

$$DEV_{ANUAL} = \left(\frac{1}{2}DPI_1 + \sum_{i=2}^{n-1} DPI_i + \frac{1}{2}DPI_n\right) \quad (4)$$

It is sometimes necessary to multiply the DEV by a factor T that compensates for the gaps between each discrete measurement recorded by the EMA, typically 10 minutes, so T usually has a value of 10. Equation (9) summarises this.:

$$DEVT_{ANUAL} = \left(\frac{1}{2}DPI_1 + \sum_{i=2}^{n-1} DPI_i + \frac{1}{2}DPI_n\right)T \quad (5)$$

4. Assuming samples are taken every 10 minutes, the units of the$DEVT_{ANUAL}$ are$\frac{W*min}{m^2}$, razs value to be multiplied by 60 in order to obtain in $\frac{W*s}{m^2} = \frac{J}{m^2}$. Finally, the energy density accumulated during the whole year is divided by 31104000. ($1\ year = 365\ days = 8760\ horas = 518400\ minutos = 31104000\ seconds$).

$$DEMS = \frac{DEVT}{31104000}\ \left[\frac{J}{m^2}\right] \quad (6)$$

Hourly average energy density obtained from cube root of mean cubic velocity

Monthly wind speed varies around$\pm$ 30% $a \pm$ 35% above the average wind speed at a typical location during the year (Patel, 2006). Therefore, the wind speed used to determine the power density in (6) should be (Pishgar-Komleh et al., 2014):

$$V_{rmc} = \left(\frac{1}{n}\sum_{i=1}^{n} vi^3\right)^{\frac{1}{3}} \quad (7)$$

Finally, the average energy density extracted from the wind (DEMV) will be obtained in a period that will depend on the quantity and frequency with which the measurements have been made. (Patel, 2006):

$$DEMS = \frac{1}{2}\rho\, {V_{rmc}}^3\ \left[\frac{J}{m^2}\right] \quad (8)$$

Average energy density per second obtained through the Weibull probability density function.

FDP of Weibull

The PDF indicates the probable frequency at which the specified velocity will occur in the study region. The Weibull PDF is given by (Murthy, 2017; Patel, 2006; Ozat & Celiktas, 2016; Wu et al., 2011):

$$f(v) = \frac{k}{c}\left(\frac{v}{c}\right)^{k-1} e^{-\left(\frac{v}{c}\right)^k} \quad (9)$$

where v is the wind speed(m/s), $k > 0$ es the form factor (dimensionless) and $c > 0$ is the scaling factor(m/s).

Weibull Cumulative Distribution Function

The cumulative distribution function is the accumulation of relative frequency of each wind speed interval, defined by (Murthy, 2017; Patel, 2006; Ozat & Celiktas, 2016; Wouet al., 2011):

$$F(v) = \int_0^v f(v)dv = 1 - e^{-\left(\frac{v}{c}\right)^k} \quad (10)$$

Characteristic Wind Speed Values Using the Weibull PDF

Knowing the Weibull parameters, the root mean cubic velocity, the mean cubic velocity, the most probable wind speed and the highest wind speed can be calculated from equations 17, 18, 19 and 20, respectively. (Justus, 1977; Akdag & Guler, 2015; Christofferson & Gilette, 1987).

$$V_{rmc} = \int_0^{Vmax} v * f(v)\, dv \quad (11)$$

$$V_{rmc}^3 = \int_0^{Vmax} v^3 * f(v)\, dv \quad (12)$$

$$V_{mp} = c\left(1 - \frac{1}{k}\right)^{\frac{1}{k}} \quad (13)$$

$$V_{max} = c\left(1 - \frac{2}{k}\right)^{\frac{1}{k}} \quad (14)$$

Substituting Equation 12 into Equation 8 gives the average energy density per second:

$$DEMS = \frac{1}{2}\rho\, Cp \int_0^{Vmax} v^3 * f(v)\, dv \ \left[\frac{J}{m^2}\right] \quad (15)$$

After some calculations:

$$DEMS = \frac{1}{2}\ \rho\, c^3\, \Gamma\left(\frac{k+3}{k}\right)\ \left[\frac{J}{m^2}\right] \quad (16)$$

Estimation methods for Weibull parameters

Table 1 summarises the formulas corresponding to the 15 methods used to calculate the Weibull c and k parameters, and also gives a general description of the process followed to program them.

Materials and Methods

The development of the application was carried out in the mathematical development platform Matlab 2017a. The program consists of a function that contains the mathematical algorithms to determine DEMS using the three methods mentioned above.

The 15 methods described in Table 1 for calculating the C and K parameters of the FDPW are also encoded in this function. The program also has options to generate graphs relevant to determining a region's wind resource, such as: the wind rose, the normalised histogram of wind occurrence, the normalised distribution of the probability of occurrence of each speed generated from the 15 methods for generating the WTPF, the instantaneous power curve, the graph of wind behaviour and a graph comparing the normalised histogram of wind speed with the 15 curves of probability of occurrence generated from the WTPF, which in this article will serve to demonstrate the accuracy of each method used to determine the parameters of the WTPF.

	Procedure	Mathematical expressions	
		Shape parameter (k)	Scale parameter (c)
STDML (Lysen, 1983)	Simplification of STDMJ to estimate *c* parameter (38).	$k = \left(\frac{\sigma}{\bar{v}}\right)^{-1.086}$ (17)	$c = \frac{\bar{v}}{\left(0.568 + \frac{0.434}{k}\right)}$ (43)
STDMJ (Justus et. al,1977)	1. It requires only the knowledge of the wind mean speed $\bar{v}$ and the standard deviation σ, to estimate k; (15) for STDMJ or (16) for SMOM. 2. In both cases c is determined by (43).	$k = \left(\frac{0.9874\,\bar{v}}{\sigma}\right)^{1.0983}$ (18)	$c = \frac{\bar{v}}{\Gamma\left(1+\frac{1}{k}\right)}$ (44)
SMOM [17]			
PWMM (Usta,2016)	1. $\bar{C}$ is calculated from $\bar{v}$ and wind speed values v_i (18). 2. k and c are determined by (17) and (43).	$k = \frac{\ln(2)}{\ln(\bar{C})}$ (19) $\bar{C} = \frac{\bar{v}}{\frac{2}{n(n-1)}\sum_{i=1}^{n} v_i(n-i)}$ (20)	
AMLM (Christofferson & Gilette, 1987)	It requires only the knowledge of the wind speed values v_i, to estimate k (19), C ins obtained from (43).	$k = \frac{\pi}{\sqrt{6}}\left(\frac{n(n-1)}{n\left(\sum_{i=1}^{n}\ln^2(v_i)\right)-\left(\sum_{i=1}^{n}\ln(v_i)\right)^2}\right)^{\frac{1}{2}}$ (21)	
PDM (Akdag & Dinler, 2009)	1. The energy pattern factor (Epf) is calculated from $\bar{v}$ and wind speed values v_i (21). 2. k and c are determined by (20) and (43).	$k = 1 + \frac{3.69}{Epf^2}$ (20) $Epf = \frac{\overline{v^3}}{(\bar{v})^3} = \frac{\frac{1}{n}\sum_{i=1}^{n} vi^3}{\left(\frac{1}{n}\sum_{i=1}^{n} vi\right)^3}$ (22)	
NEPFM (Akdag & Guler, 2015)	1. The Epf is calculated from $\bar{v}$ and v_i values (21). 2. k and c are determined by the following expressions (22 and 44 respectively) and coefficients.	$k = \frac{a4\,Epf^4 + a3\,Epf^3 + a2\,Epf^2 + a1\,Epf + ao}{b4\,Epf^4 + b3\,Epf^3 + b2\,Epf^2 + b1\,Epf + bo}$ (23)	$c = \frac{\bar{v}*(k^2+d1\,k+d0)}{k^2+c1\,k+c0}$ (45)
		$a0 = -0.220374$; $c0 = 0.225761$; $a2 = -5.789610$	$c0 = 0.225761$
		$a3 = 2.151430$; $c1 = 0.134704$; $b0 = -1.272850$	$c1 = 0.134704$
		$b1 = 3.691150$; $d0 = -0.35144$; $b3 = -0.800468$	$d0 = -0.35144$
		$b4 = 0.992007$; $d1 = 0.711818$	$d1 = 0.711818$
GM (Jamil et. al, 1995)	1. The wind speed data must be in the form of a frequency distribution. 2. The elements are divided into bins. 3. After some calculations over (10) equation (23) is obtained, which can take the form $y = mx + b$ (24-27). 4. Calculate $\bar{x}$ and $\bar{y}$ by (28) and (29) respectively, and Subsequently k (30) and b (45). 5. Determine c with the calculated values of k and b (46).	$k\ln(v) - k\ln(c) = \ln(-\ln[1-P(v)])$ (24) $y = \ln(-\ln[1-P(v)])$ (25); $x = \ln(v)$ (26); $b = -k\ln(c)$ (27); $m = k$ (28). $\bar{x} = \frac{1}{n}\sum_{i=1}^{n} f_i\, x_i$ (29) $\bar{y} = \frac{1}{n}\sum_{i=1}^{n} f_i y_i$ (30) $k = \frac{\sum_{i=1}^{n} f_i(x_i-\bar{x})(y_i-\bar{y})}{\sum_{i=1}^{n} f_i(x_i-\bar{x})^2}$ (31)	$b = \bar{y} - k\bar{x}$ (46) $c = e^{\left(-\frac{b}{k}\right)}$ (47)
Iterative methods			
MLM (Jhonson & Kotz, 1970)	1. A potential value of k, k_i is determined by (31). 2. If the AE between k and k_i is the required $k = k_i$. 3. After that, c is calculated whit (47).	$k_i = \left(\frac{\sum_{i=1}^{n} v_i^{k_i}\ln(v_i)}{\sum_{i=1}^{n} v_i^{k_i}} - \frac{\sum_{i=1}^{n}\ln(v_i)}{n}\right)^{-1}$ **(32)**	$c = \left(\frac{1}{n}\sum_{i=1}^{n} v_i^k\right)^{\frac{1}{k}}$ **(48)**
MMLM (Mohammadi et. al, 2016)	1. The wind speed data must be in the form of a frequency distribution whit its elements divided into bins. 2. A potential value of k, k_i is determined by the following expression, based on the relative speed frequency in bin i, $f(\overline{vi})$, the number of bins, n, and the speed in every bin, v_i (32). 3. If the AE between k and k_i is the required $k = k_i$. 4. After that, c is calculated whit (48).	$k_i = \left(\frac{\sum_{i=1}^{n} v_i^k\ln(v_i)\ f(v_i)}{\sum_{i=1}^{n} v_i^k\ f(v_i)} - \frac{\sum_{i=1}^{n}\ln(v_i)\ f(v_i)}{f(\overline{vi})}\right)^{-1}$ **(33)**	$c = \left(\frac{1}{f(\overline{vi})}\sum_{i=1}^{n} v_i^k\ f(v_i)\right)^{\frac{1}{k}}$ **(49)**
WAsP (Solyali et. al, 2016)	1. From the actual values of k and c, X should be calculated (33). 2. Equalize equation 34 to zero, and calculate the value of k from a root-finding algorithm like Brent's method. 3. After that, c is calculated whit (43).	$X = e^{\left(-\frac{1}{k}\right)^k}$ **(34)** $-\ln(X) = \left(\bar{v} * \left(\frac{\sum_{i=1}^{n} v_i^k}{n\Gamma\left(1+\frac{1}{k}\right)}\right)^{-1}\right)^k$ **(35)**	$c = \frac{\bar{v}}{\Gamma\left(1+\frac{1}{k}\right)}$ **(44)**
MOM (Arslan et. al, 2014)	1. CV_{MOM} is calculated using wind speed values v_i (35). 2. Different values should be proposed to k_i, to obtain a CV_{MOMi} coefficient (36). 3. If the AE between CV_{MOM} and CV_{MOMi} is the required $k = k_i$. 4. After that, c is calculated whit (43).	$CV_{MOM} = \left[\frac{\left(\sum_{i=1}^{n} v_i^m\right)^n}{\left(\sum_{i=1}^{n} v_i\right)^k} - 1\right]$ **(36)** $CV_{MOMi} = \left[\frac{\Gamma\left(1+\frac{m}{k}\right)}{\Gamma^2\left(1+\frac{1}{k}\right)} - 1\right]$ **(37)**	
LMOM (Arslan et. al, 2014)	1. CV_{L-MOM} is calculated using v_i values (37). 2. Different values should be proposed to k_i, to obtain a CV_{L-MOMi} coefficient (38). 3. If the AE between CV_{L-MOM} and CV_{L-MOMi} is the required $k = k_i$. 4. After that, c is calculated whit (43).	$CV_{L-MOM} = \left[\frac{\left(\sum_{i=1}^{n}\left(\frac{n-i}{n-1}\right)v_i\right)\left(\frac{1}{n}\right)}{\left(\sum_{i=1}^{n} v_i\right)\left(\frac{1}{n}\right)} - 1\right]$ **(38)** $CV_{L-MOMi} = \left[1 - \left[2^{-\left(\frac{1}{k}\right)}\right]\right]$ **(39)**	
MS&SDM (Allouhia et. al, 2017)	1. The relation $\sigma/\bar{v}$ must be calculated. 2. If the AE between the result of (39) and the relation $\sigma/\bar{v}$ is the required $k = k_i$. 3. After that, c is calculated whit (43).	$\frac{\sigma}{\bar{v}} = \frac{\left[\Gamma\left(1+\frac{2}{k}\right) - \Gamma^2\left(1+\frac{1}{k}\right)\right]^{\frac{1}{2}}}{\Gamma\left(1+\frac{1}{k}\right)}$ **(40)**	
EEM (Silva, 2003)	1. The wind speed data must be in the form of a frequency distribution. 2. The elements are divided into bins. 3. CI coefficient is calculated using (43). 4. An approximation error can be determined using (41). 5. When this error is the desired one $k = k_i$. 6. After that, c is calculated whit (49).	$CI = \frac{\left(\overline{v^3}\right)^{\frac{1}{3}}}{\Gamma\left(1+\frac{3}{k}\right)}$ **(41)** $\sum_{i=1}^{n}\left[W_{ei} - e^{-\left(\frac{(2m-i)v}{\sigma}\right)^k} + e^{-\left(\frac{(2m-i)v}{\sigma}\right)^k}\right]^2 = \sum_{i=1}^{n} E_{ri}^2$ **(42)**	

Table 1 Methods for determining the c and k parameters of the Weibull PDF

Results

The functionality of the realised programme was tested on the wind speed and direction data recorded every 10 minutes by the EMAs described in table 2

Name	State	Latitude	Length	Year Consulted
Cuatrociénegas	Coahuila de Zaragoza	27.002	-102.073	2022
La Flor	Durango	26.55	-103.99	2022

Table 2 Automatic weather stations consulted

Tables 3 and 4 show the average power density per second for the Cuatrociénegas and La Flor regions, respectively. In all cases, the value obtained from the integration of the power curve (taken as a real reference value), the average quic velocity and the 15 methods from the Weibull PSD are included. Figures 1 and 2 show the comparison of the normalized histogram of wind speed, with the Weibull probability functions generated from the 15 methods to obtain the parameters c and k quoted in table 1 for the Cuatrociénegas and La Flor stations, respectively.

Method		Result [J/m^2]	Error [%]
DEMS_IPI		149.2645	-
DEMS_VRMC		149.3654	0.1
DEMS_FDPW	STDML	231.6817	55.2
	STDMJ	151.2102	1.3
	SMOM	151.9111	1.8
	PDM	148.8199	0.3
	PWMM	149.3654	0.1
	WAsPM	149.3654	0.1
	MLM	156.078	4.6
	MMLM	154.0008	3.2
	NEPFM	149.3668	0.1
	AMLM	154.4457	3.5
	MS&SDM	152.5536	2.2
	LMOM	153.6086	2.9
	MOM	152.5536	2.2
	GM	138.8379	7
	EEM	149.3654	0.1

Table 3 DEMS EMA Cuatrociénegas

Method		Result [J/m^2]	Error [%]
DEMS_IPI		38.6911	-
DEMS_VRMC		36.4533	5.8
DEMS_FDPW	STDML	49.6261	28.3
	STDMJ	34.3731	11.2
	SMOM	34.5805	10.6
	PDM	36.2586	6.3
	PWMM	36.4533	5.8
	WAsPM	36.4533	5.8
	MLM	35.0504	9.4
	MMLM	35.3355	8.7
	NEPFM	36.4479	5.8
	AMLM	34.3804	11.1
	MS&SDM	34.7779	10.1
	LMOM	32.9516	14.8
	MOM	34.7779	10.1
	GM	33.9713	12.2
	EEM	36.4533	5.8

Table 4 DEMS EMA La Flor

Discussion

According to tables 3 and 4, most of the methods for determining the parameters of the Weibull PDF present an acceptable accuracy, with errors lower than 15%. It can be noted in the case of the EMA Cuatrociénegas that 14 of the 15 methods used to calculate the Weibull parameters present an error of less than 3%. The Lysen standard deviation method has an error of 55%.

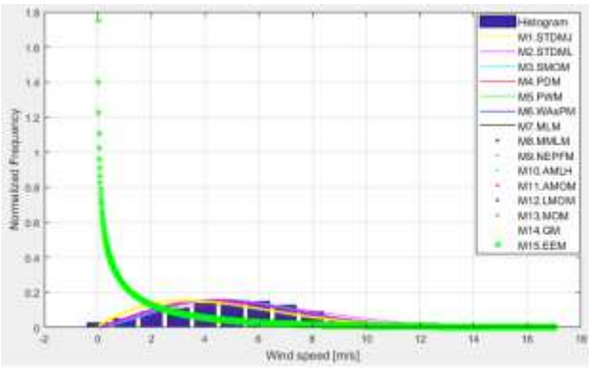

Figure 1 Histogram of the wind occurrence and Weibull probability functions in Cuatrociénegas.

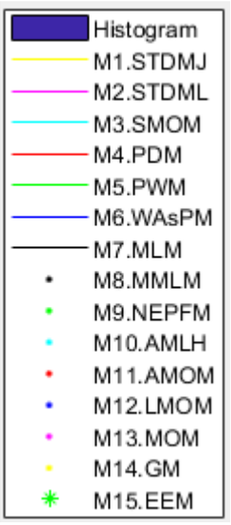

Figure 2 Histogram of wind occurrence and Weibull probability functions at La Flor

The reason why the accuracy of the methods is superior when implemented with the EMA Cuatrociénegas data can be inferred by analysing figures 1 and 2, where it can be observed that the probability curves corresponding to most of the Weibull PDFs fit better to the normalised wind speed histogram when the data distribution resembles a Gaussian distribution with the highest percentage of occurrence positioned in the centre of the curve.

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It can be seen that specifically the EEM method presents a higher accuracy when the data distribution is not Gaussian.

Conclusion

From the case studies it can be concluded that most of the methods used to approximate the measured energy density represent an acceptable degree of accuracy, especially when the data distribution resembles a Gaussian distribution. During the analysis of different case studies other than those presented in this article, it was possible to detect another factor that has an impact on the accuracy of the methods used to determine the Weibull parameters is data with a multimodal distribution, in which the ranges with the highest percentage of occurrence are separated by ranges with lower frequencies, forming asymmetric data distributions. This type of distribution forms the future work of this research.

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Self-esteem and its relationship with purchasing behavior in young university students in the southwestern area of Guanajuato

La autoestima y su relación con el comportamiento de compra en los jóvenes universitarios en la zona suroeste de Guanajuato

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Abstract

Consumer behavior is the study of people who help shape their identity (Solomon, 2008). Being a consumer starts from the first stages of life, with the experience in shopping the involvement with the articles is generated by the fact of how it is seen, the influence of advertising and the sense of satisfaction that generates emotions and the desire to repeat the purchase. process; For this reason, personality is involved in the acquisition of goods (Roa, 2013). In this way, in this research, the self-esteem evaluation test proposed by Coopersmith, and an online questionnaire, with a Cronbach's alpha of 0.761, have been applied to 141 students of the Technological University of the Southwest of Guanajuato, of business careers. The relationship between self-esteem and buying behavior. Among the main results, an average level of self-esteem presented by young people was found, it is identified that there is no direct relationship between the level of self- esteem and purchasing behavior, likewise, there is no relationship between self-esteem and satisfaction with the purchase. Therefore, the proposed hypotheses are rejected.

Self Esteem, Purchase, Satisfaction

Resumen

El comportamiento del consumidor es el estudio de las personas que ayudan a moldear su identidad (Solomon, 2008). El ser consumidor inicia desde las primeras etapas de vida, con la experiencia en las compras se genera el involucramiento con los artículos por el hecho de cómo se ve, la influencia de la publicidad y el sentido de satisfacción que genera emociones y ganas de repetir el proceso; por tal motivo en la adquisición de bienes se involucra la personalidad (Roa, 2013). De esta manera en esta investigación se ha aplicado a 141 estudiantes de la Universidad Tecnológica del Suroeste de Guanajuato, de las carreras de negocios, el test de evaluación de autoestima propuesto por Coopersmith, y un cuestionario online, con una alfa de cronbach de 0.761 buscando la relación entre la autoestima y el comportamiento de compra. Entre los principales resultados se encontró un nivel medio de autoestima que presentan los jóvenes, se identifica que no hay relación directa entre el nivel de autoestima y el comportamiento de compra, así mismo, no hay una relación entre la autoestima y la satisfacción con la compra, por lo que las hipótesis planteadas son rechazadas.

Autoestima, Compra, Satisfacción

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Introduction

The study of consumer behavior is a large branch that focuses on investigating from a broad aspect the analysis of the actions that people perform to investigate, acquire, use, evaluate and recommend products, services, places or ideas that satisfy their needs. It also covers aspects related to what is consumed, why, when, where, how often and under what conditions, reaching a final result which is the acquisition of products or services, thereby determining a possible satisfaction and welfare of the consumer; or dissatisfaction in the purchasing process.

Consumption is an extremely important aspect in contemporary society, since it is a fundamental object in the market process of economies, and thus a propeller of business development. That said, consumption is all economic activity that is directly linked to the satisfaction of needs.

Based on this relationship it is difficult to understand what young people look for in consumption, a study mentions that aspects such as society, familiarity with technology, the use of social networks and their constant communication in these are considered, given that the fact of sharing or interacting on virtual platforms and the constant search for experiences that allow to communicate it, as a new way of belonging; it is part of the lifestyle of young people today, so it influences their consumption (Injuve, 2015).

Understanding by this that young people according to an investigation in the process of buying clothes, consider aspects such as durability, that it is of good quality or combine and the important thing is that some of the celebrities they follow, use it, likewise athletic brands are the most popular, according to Piper Jaffray in a market study done in the United States; in Mexico there is no data in this regard as mentioned (Jaet, 2018).

In this context, another study mentions that young Mexicans are the age group that prefers to spend their money in the present rather than save it for the future (26%) (Ortíz, 2021).

In relation to self-esteem, self-esteem is a positive attitude of the individual towards himself/herself. When it is present in high levels, it indicates perceiving oneself as a competent being. The subject thinks he/she is important; he/she values him/herself for what he/she represents; he/she does not show fear of respecting him/herself (Rosenberg, 1965).

In this way the present work aims to know the relationship between the level of self-esteem and its relationship with the purchasing behavior of the university students of the Technological University of the Southwest of Guanajuato of the business profile, using quantitative, descriptive research of correlational type to establish a relationship between the factor of self-esteem that conditions the way of consumption of the young people studied and their satisfaction, this will be done through the Coopersmith's Self-Esteem scale: Questionnaire that is applied on self-esteem to the students to know their internal (personal), and external (family and social) aspect; this with the purpose of describing the level of self-esteem of the students that will allow reflecting on the consumption processes that induce a purchase behavior.

Literature Review

For the present work it is important to explain what self-esteem is as a natural component of multiple dimensions that functions as a moderator of behavior and as a determining factor in the personal and social development of individuals; in the case of consumer purchasing behavior, it is studied as an internal factor in the concept of self, thus influencing the final result of consumption. Self-esteem is a positive attitude of the individual with himself (Rosenberg, 1965), when it is present in high levels, it indicates to perceive oneself as a competent being. The subject thinks he/she is important; he/she values him/herself for what he/she represents, does not show fear of respecting him/herself (Riso, 2006), low levels of self-esteem can lead to negative attitudes in the subject (Montoya & Sol, 2001). For this reason, it has been considered that self-esteem can be defined as an evaluation that the individual generates about himself, expressing a positive or negative perspective and seeks to point to what he feels capable or successful (Coopersmith, 1967).

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In this sense, it can be considered subjective, since the individual may approve or disapprove of this perception (Serrano, 2013).

The Coopersmith self-esteem scale, a self-esteem inventory created by Coopersmith in (1967) and validated by Lara-cantú, Verduzco, Acevedo and Cortés (1993), which measures the personal judgment of self-worth and consists of 25 items with dichotomous answers "yes" and "no", with reliability indexes of α= 0.81, was used for the technical note. To understand the importance of measuring self-esteem, it is considered relevant to understand that there are different levels at which it can be found; each individual reacts in different ways to similar situations (Ocho, Campos, Gómez, & Lima, 2021).

Low self-esteem can lead to feelings of apathy, isolation, low capacity to love and passivity, while high self-esteem is related to people who are involved in more active lives, with feelings of control over circumstances, less anxious and better able to tolerate internal or external stress, are less sensitive to criticism, tend to have better physical health, enjoy their interpersonal relationships and value their independence (Rosenberg, 1962).

Regarding the application of the measurement of self-esteem in the literature studied, it was found that there are differences in the level of self-esteem between the sexes, which is maintained when comparisons are made for each age group with the exception of the 17-25 years age group. This data is interesting given that previously significant differences had been reported between the sexes at 12 years of age, in favor of males; which indicates that the most marked differences in self-esteem between the sexes occur between 12 and 25 years of age (Lara, Verduzco, Acevedo, & Cortés, 1993).

Another study carried out among university students shows that general self-esteem has levels where 51% of the total have medium self-esteem, 24.5% have a low level of self-esteem, and 24.5% have a high level of self-esteem. Therefore, it can be affirmed that more than half of the university students have a medium level of self-esteem, while the levels of low and high self-esteem are equal.

This difference could be due to the fact that early and strong attachment bonds were not established within the family (Gonzales & Guevara, 2016).

The relationship between the level of self-esteem and the purchasing process has not been directly addressed in the youth of the area, the literature found mentions a study where no influence of self-esteem on the adolescent participants was reported that incites them or leads them to buy compulsively, since the result of the test of association of that study was Sig. = .83 (p >.05), denying the relationship between these two variables, which can be understood because according to these authors the culture in which adolescent consumers are immersed has much more influence on their buying behavior than problems related to self-esteem (Muñoz , 2019).

Consumer behavior is the starting point for understanding the stimulus-response model. Environmental and marketing stimuli enter the buyer's awareness and characteristics, and the decision-making process leads to certain purchase choices (Kotler & Armstrong, 2008). Buying behavior then studies the behavior of final consumers who are individuals, families or groups of individuals who purchase a good or service for their own consumption. In this way people have different tastes and preferences for products or services for this reason something that may please a person will not necessarily be to the liking of other consumers; this is also due to different factors such as: cultural ones, which are acquired by the person from an early age; social factors involve reference groups where people tend to share and buy with similarities with each other; personal factors, which are involved with the different stages of life of the person that tends to change their purchasing desires and influence the decision of a product and, finally psychological factors, these also tend to influence the buying habits of the person where aspects focus on personality and motivation (Davila & Rafaele, 2021).

In another concept, purchasing behavior is a process governed by cultural, social, psychological and personal factors which are related to processes such as the acquisition in purchase of a good that has the purpose of satisfying a need, as well as the purchasing behavior linked to the effort, time that the person spends for the search, use and disposal of the product. (Schiffman & Lazar, 2010).

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A study developed in young women suggests that most of the people who are easily affected by compulsive buying behavior have low self-esteem, as this influences their need to obtain goods seeking to increase it through these acquisitions (Cantero & Bertolín, 2015), which temporarily eliminates the negative emotionality (Denegri, 2010) that characterizes and motivates compulsive buyers to buy.

Continuing with this approach, it has been determined that there is an important relationship between feelings of compulsion or impulse towards purchases and certain psychosocial phenomena, in this case, the weakness in self-esteem (Denegri, 2010), this means that when self-esteem is at a low level, individuals show negative feelings of inferiority, sadness and guilt, externalized from needs (physical and emotional) that have been unsatisfied. Following this premise, it has been proposed that self-esteem is presented at a low level, so people try to compensate by acquiring objects which, although they may favor their personal image or social status, induce them to feel happy momentarily, generating a temporary elevated mood, which can disguise all of the above (Rodríguez, Saucedo, Hernández, & Gutiérrez , 2017).

Given that people as consumers make purchasing decisions every day that are complicated to understand, it becomes vitally important to study consumer behavior and specifically the factors that affect their tastes and preferences when acquiring a product, which is why we seek to learn more about this topic and its relationship with self-esteem.

There is abundant information based on theories, characteristics, buying processes and cultural, social and psychological factors that directly affect and influence consumer buying behavior and therefore in decision making, therefore knowing the customer and especially the what, when and how of their behavior becomes very useful information for decision making in a company, Therefore, understanding the buying behavior of consumers is not an easy task, since the patterns of consumer behavior have changed significantly, influenced by the excess of advertising messages that support the marketing theory creating the needs and a lifestyle in consumption.

Expressing with this that people's consumption habits have constantly changed through advertising, every so often, products or services come on the market that are exhibited, consumed or generate needs or desires to consumers, which transmit information to specific social groups to encourage them to buy a product or service, as mentioned in a study how advertising influences the buying behavior of students of the Bachelor of Marketing Management, Promotion and Sales of the University Extension of Aguadulce, which showed in the analysis of the results that 48. 8% are induced by advertising to buy some type of product that perhaps they did not believe necessary and 71.3% consider that the presentation of the products is fundamental in the purchase decision (Pedreschi & Nieto, 2020), with this more information is obtained on the purchasing behavior of young people.

Another study mentions among the main findings that 78% of young people are motivated to shop by their friends, only 19% are influenced by their parents and six out of 10 are seduced by sales and advertising, as well as 15% of teenagers go to shopping malls mainly in search of clothes and shoes. Nearly 70% know a specialized clothing store where they go every time they need to add something to their closet. Currently, it seems that many young people like to be different and know where and how to choose their attire, have a certain taste for brands and do not accept imitations (Nielsen, 2012), the results show that when deciding what and where to buy an item of clothing, young people are not influenced to a large extent by the tastes and preferences of their friends, nor by singers, opinion leaders, or television. However, it is important for young people the opinion of their family and the image they show to society, which is why the clothes they wear are in accordance with the image they want to project, and thus refers to self-esteem and the concept of self.

There is not much information on the relationship of self-esteem and the purchasing behavior of young people; but, according to a study conducted by the National Commission for the Protection and Defense of Users of Financial Services, young Mexicans also spend more than they earn; their disbursements are divided as follows: 34.1% of their budget is spent on food, beverages and tobacco, 18.8% on transportation, 14% on educational services and 33.1% on miscellaneous expenses.

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Of the total respondents, 54% make purchases that go outside their budget at least once a month (Condusef, 2019).

Another study shows that when using expensive name brands, which is the preference of many consumers, and despite the fact that they may lack sufficient income, they spend their salary on clothes and products that are not within their reach and this could be the cause of low self-esteem, lack of identity, reaching a social status that others do not have, or even, the search for a symbol of belonging, the idea that with a product or service people reach a certain status or style that others do not have, considering then that they are aspirational, help to achieve standards, goals, ideals, emotions and forms (Olguín & Rojas, 2018). In this way, it is considered important to know the relationship between the level of self-esteem and consumer purchasing behavior in young university students.

Methodology to be developed

Methodology

In this work, a quantitative, descriptive correlational type research was developed.

Objectives

1. To know the level of self-esteem of the young people of the business profile of the Technological University of Southwest Guanajuato.

2. To relate the level of self-esteem with the purchasing behavior of the young people of the business profile of the Technological University of Southwest Guanajuato.

3. To relate the level of self-esteem with the purchase satisfaction of the young people of the business profile of the Technological University of the Southwest of Guanajuato.

4. To identify which branch of products are most purchased by young university students.

Hypothesis

H1. The level of self-esteem of young people with a business profile at the Technological University of Southwest Guanajuato is high.

H2. The level of self-esteem has a strong correlation based on the purchasing behavior of young university students with business profile at the Technological University of Southwest Guanajuato.

H3. The level of self-esteem is considered to have a strong correlation with the level of purchase satisfaction of young university students with business profile at the Technological University of Southwest Guanajuato.

Participants and sample

In determining the sample size, given the nature of the study, the target population was set at young students of the Technological University of Southwest Guanajuato (UTSOE). The virtual survey was applied through Microsoft forms to 141 students, aged 15 to 23 years, from the municipalities of Valle de Santiago, Salamanca, Jaral del Progreso, Huanímaro and other municipalities in the state of Guanajuato.

The population of young university students with the business profile was considered with a total of 290 items, a degree of reliability of 90% and an error of 5%, obtaining a sample of 141 young people.

Instrument

The "Coopersmith Self-Esteem Test", developed by Stanley Coopersmith (1960), designed to evaluate levels of self-esteem, and suitable for research with young people, was used for the present investigation 25 items, with yes and no response options. For the sample of 141 university students from the Business Development and Marketing area and for the Business Innovation and Marketing degree at the Technological University of the Southwest of Guanajuato, in Valle de Santiago, Guanajuato. The reliability through Cronbach's Alpha was 0.828.

Regarding the consumer behavior survey, it was designed based on the needs and feelings of the possible purchase with 21 Likert scale items with a Cronbach's alpha of 0.878.

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The present research, in accordance with its purpose, will be conducted through a correlational study, since it seeks to "know the relationship or degree of association that exists between two or more concepts, categories or variables in a particular sample or context" (Hernández, Fernández , & Baptista, 2014), evaluating the degree of association between the level of self-esteem and the purchasing behavior of young university students in Valle de Santiago, Guanajuato. It will be a cross-sectional study, since the data collected through the application of the different instruments were given at a specific time and not over time. On the other hand, the data analysis will be quantitative, using the SPSS program.

The reliability of the instrument is related to the global data that are obtained statistically and represented in Cronbach's Alpha, therefore it can be said that an instrument is reliable when the results exposed from it are also used for other research and provide the same results (Supo, 2013). In the case of the questionnaire applied, a Cronbach's alpha of 0.761 was obtained, which is an acceptable value.

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Abstract (In English, 150-200 words)

Objectives
Methodology
Contribution

Abstract (In Spanish, 150-200 words)

Objectives
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Contribution

Keywords (In English)

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Introduction

Text in Times New Roman No.12, single space.

General explanation of the subject and explain why it is important.

What is your added value with respect to other techniques?

Clearly focus each of its features

Clearly explain the problem to be solved and the central hypothesis.

Explanation of sections Article.

Development of headings and subheadings of the article with subsequent numbers

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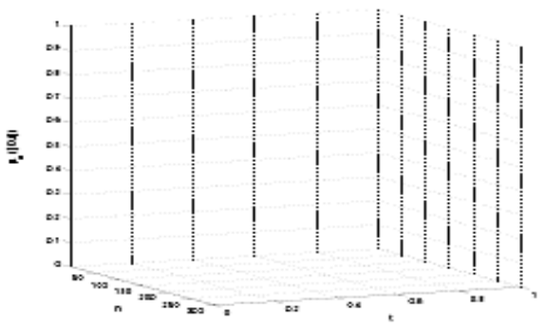

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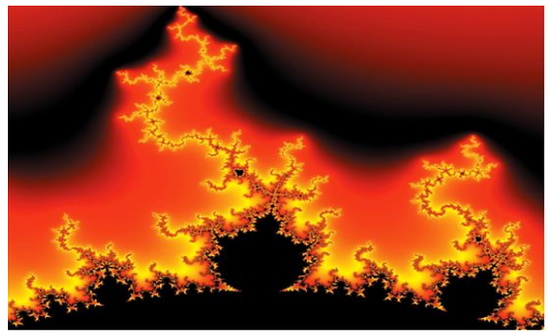

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