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# **RINOE Journal-General Economics**

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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 General Economics: Role of economics, Role of economists, Relation of economics to other disciplines, Relation of economics to social Values, sociology of economics; Teaching economics: Precollege, Undergraduate, Graduate.

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## **Presentation of Content**

In a first article we present, *Configuration of organizational trust in the automotive sector in Mexico. A Sociological Look at organizations* by PÉREZ-MAYO, Augusto Renato, ROQUE-NIETO, Nohemí, GUERRERO-SANCHEZ, Pablo and GUEVARA-AREVALO, Julio Jesús Alberto, with adscription in the Universidad Autónoma del Estado de Morelos, in the next article we present, *Control of management practices and their impact on the competitiveness of companies in Mexico* by BARRAGÁN-VÁZQUEZ, Carlos Hugo, GARCÍA-MARTÍNEZ, J Jesús, REYES-FONG, Teodoro and HERNÁNDEZ-RUIZ, Lorena, with adscription in the Universidad de Colima, in the next article we present, *Antioxidant evaluation of food grade extracts obtained from soursop (*Annona muricata*) fruit* by DENIZ-GONZÁLEZ, Pedro de Jesús, RODRÍGUEZ-CARPENA, Javier Germán, BAUTISTA-ROSALES, Pedro Ulises and GRAGEOLA-NUÑEZ, Fernando, with adscription in the Universidad Autónoma de Nayarit, in the last article we present, *Soursop fruit storage: Edible coating based on *Hibiscus sabdariffa* mucilage* by DE LOS SANTOS-SANTOS, Miguel Angel, BALOIS-MORALES, Rosendo, JIMÉNEZ-ZURITA, José Orlando and LÓPEZ-GUZMÁN, Graciela Guadalupe.

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## Configuration of organizational trust in the automotive sector in Mexico. A Sociological Look at organizations

## Configuración de la confianza organizacional del sector automotriz en México. Una Mirada Sociológica de las organizaciones

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### Abstract

Results of the type of organizational trust are presented in two automotive agencies, from Morelos and Querétaro. The diagnosis of the type of organizational trust is made through the sociology of organizations, the theory of organizational behavior and the model of Lewicki and Bunker. It is measured using a quantitative, inductive, explanatory, and cross-sectional methodology. The Lewicki and Bunker (1996) model was used. For the level of behavioral or calculative trust, Querétaro 81.72% and Morelos 88.89%, a low level of this type of trust is shown in both states. It means that employees are at a confidence level of 18.28% and 11.11% respectively. In Cognitive or Cognitive confidence, in Querétaro 89.68% and in Morelos 89.91%, so the real level of this confidence is 10.32% and 10.09%, respectively. Finally, affective or identifying trust, a low level of trust was detected, for Querétaro 88.39% and for Morelos 90%, so the percentage of this type of trust is 11.61% and 10%, respectively. What brings consequences: lack of leadership, lack of clear objectives, lack of teamwork, dissatisfied customers. These are traditionalist and bureaucratic organizations, a formal structure, with established norms and policies, far removed from the construction of identifying trust.

**Analysis, Confidence type, Automotive sector**

### Resumen

Se presentan resultados del tipo de confianza organizacional en dos agencias automotrices, en Morelos y Querétaro. El diagnóstico del tipo de confianza organizacional se hace a través de la sociología de las organizaciones, de la teoría del comportamiento organizacional y del modelo particular de Lewicki y Bunker. Se mide utilizando metodología de tipo cuantitativo, inductivo, explicativo y de corte transversal. Se utilizó el Modelo de Lewicki y Bunker (1996). Para el nivel de confianza conductual o calculativa, Querétaro 81.72% y en Morelos 88.89%, se muestra en ambos estados un bajo nivel de este tipo de confianza. Significa que los empleados se encuentran en un nivel de confianza de 18.28% y 11.11% respectivamente. En la confianza Cognitiva o Cognoscitiva, en Querétaro 89.68% y en Morelos 89.91%, por lo que el nivel real de esta confianza es de 10.32% y 10.09%, respectivamente. Por último, la confianza afectiva o identificativa, se detectó un bajo nivel de confianza, para Querétaro 88.39% y para Morelos 90%, por lo que el porcentaje de este tipo de confianza es de 11.61% y 10%, respectivamente. Lo que trae como consecuencias: falta de liderazgo, falta de objetivos claros, falta de trabajo en equipo, clientes insatisfechos. Se trata de organizaciones tradicionalistas y burocráticas, estructura formal, con normas y políticas establecidas alejándose en mucho de la construcción de una confianza identificativa.

**Análisis, Tipo de confianza, Sector automotriz**

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## Introduction

In the social sciences there are three intelligibility cores that have studied the organizational factor called organizational trust: social constructivism, social capital and the practices of being able to know and tell the truth. As a strategic element within organizations, social capital is constituted by reciprocity and trust, and these two articulated elements are what determine the behavior of social relations among the members of a community (Palacio *et al.* 2011). In the social constructivist perspective Giddens (1991) defines trust as the acquisition of trust rights in people or abstract systems, made on the basis of an "act of faith". From the practices of being able to know and tell the truth, Foucault's (1982) contributions are mentioned in which trust is indispensable as a way of explaining truth. It is important to understand that trust in any theoretical perspective evolves and is in constant construction from the family organization itself to the so-called companies. It is precisely the importance of studying this factor and its level of existence or type as a competitive and strategic value.

For any of the three perspectives, models are required that organizations must practice for their construction. In organizations there are organizational factors that must begin to be measured from the moment they are born and this measurement is constant and vital since they can affect the performance and stability of the organization as such. This is the case of organizational trust.

*If people like you, they will listen to you, but if they trust you, they will do business with you*  
(Zig Ziglar)<sup>1</sup>

This universally known phrase from motivational speaker Zig Ziglar sums up the importance of companies seeking and gaining the trust of their customers and thus creating brand loyalty. Why do consumers buy a certain brand? Why do consumers not change brands? Why do consumers always buy the same brand? Why do consumers stop buying a brand? These are some of the questions asked by market researchers who apply behavioral sciences, statistics and mathematics to obtain optimal results.

In order to achieve consumer loyalty, there must be a long way to go and a solid backing of organizational values which derive in a good reputation. When the consumer identifies with that good organizational reputation, and being sure that he will not be disappointed, he will give his valuable vote of confidence. When the trust towards the brand is prolonged for a period of time, the consumer will become loyal.

## The context

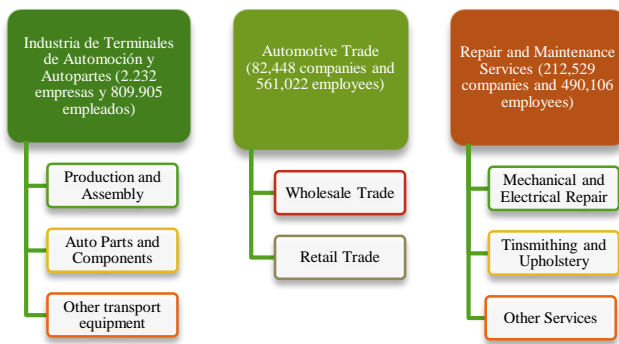
At the end of the last century in Mexico there were no more than ten brands selling automobiles, but today the consumer has approximately 30 different brands. And all of them try daily to gain the customer's trust and achieve loyalty with different strategies that give them their cognitive reason and with the human resources they have to do so. The insistence and application of loyalty strategies of the companies has allowed these sales to evolve over the years. For such sense we can demonstrate it by exemplifying from 2011 to 2017, we will see that in 2011 905,886 units were sold and in 2017 1,530,317. But for 2019 1,317,931 were sold and for 2020, on the other hand, a total of 949,353 new cars were sold. The difference was minus 368,578 units. Sales went down.

This represents an increase of 69%, or an average annual growth of 11.5%. (Ama, 2017) and for 2019 to 2020 the difference translates to -28%. There are many questions that arise from this data: What does an automotive brand need to gain customer trust and loyalty? What are the automotive brands that are gaining market positioning, such as Kia, Hyundai and Mazda, doing? What have automotive brands, such as Ford, GMC and Nissan, stopped doing to lose market positioning?

The Mexican Automotive Industry (IAM) contributed around 3% of Mexico's Gross Domestic Product (GDP), making it the second largest industrial activity in the country, second only to the food manufacturing industry. The IAM, in its different branches, directly employs almost 1.9 million workers, in almost 300,000 companies, according to the 2014 economic census conducted by the National Institute of Statistics and Geography (INEGI). It is an active participant in the Mexican Economy (Eggers, 2016).

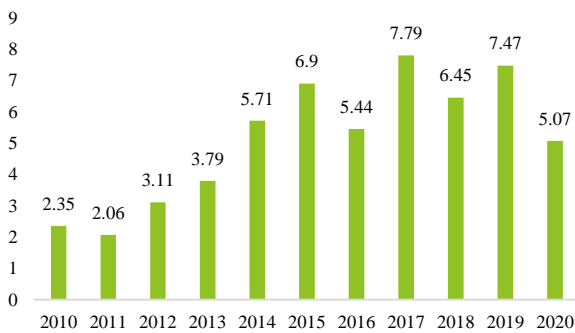
<sup>1</sup> Si le gustas a la gente, te escucharán, pero si confían en ti harán negocios contigo.

The IAM is structured as follows (Eggers, 2016):



**Figure 1** Automotive Industry Structure  
Source: Eggers Muñoz, L. (2016)

The development of the IAM has been thanks to both foreign and domestic new investments. Foreign Direct Investment FDI in the automotive sector from 2010 to 2020 brought in US\$5.075 billion during 2020 (Statista, 2020).



**Graph 1** Foreign direct investment (FDI) in Mexico's automotive industry from 2010 to 2020 (in billions of U.S. dollars) (Statista, 2020a)

According to data from the Bank of Mexico, the balance of the automotive trade balance, which is the result of exports minus imports, grew 13.3 percent annually between January and May 2019, standing at US\$36.16 billion. (Martinez, 2019)

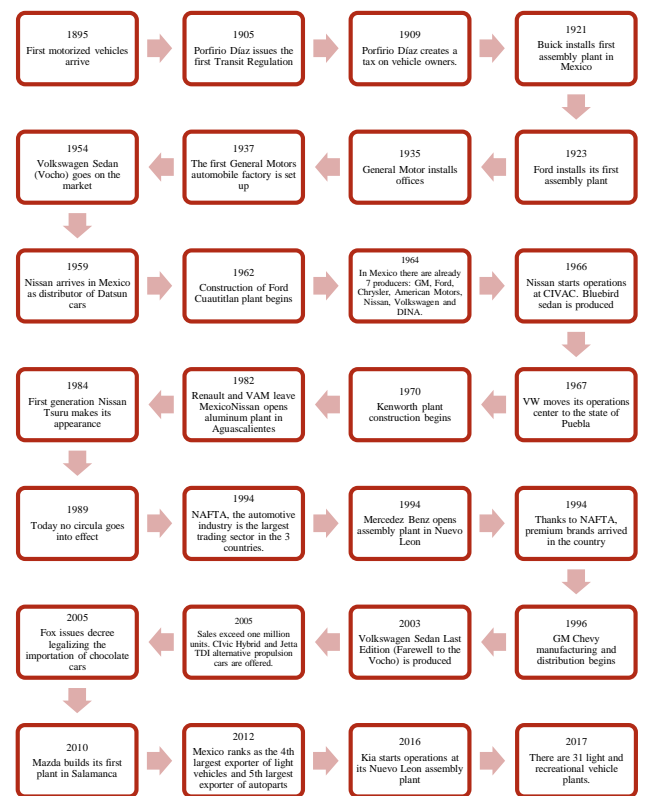
It also exceeds foreign exchange inflows from tourism and oil exports. The IAM surplus has made it possible to offset trade imbalances, both in the manufacturing sector, as well as in the entire Mexican economy. In fact, the national economy model has prevailed during the last few years thanks to the IAM (Eggers, 2016).

The Mexican Automotive Industry in the eighties began its career in the Top Ten in the World, when General Motors and Ford decided to export automobiles from Mexico to the United States, thus obtaining better profits.

In the nineties, new investments were detonated again thanks to the negotiation processes of the North American Free Trade Agreement (NAFTA). Development was increasing at the beginning of the 21st century, but in the last quarter of 2008 the real estate crisis in the United States caused the depression of the automotive industry that put Chrysler and General Motors on the verge of bankruptcy, and Barack Obama, President of the United States at that time, had to implement an emerging financial rescue.

This triggered new restructuring processes throughout the industry, and put Mexico as the main supplier of automobiles for the U.S. market, seeing the potential it had for raw materials and cheaper labor. The third wave of investments came with new plants such as Ford in Chihuahua, Chrysler in Saltillo, Nissan in Aguascalientes, Honda in Celaya, Volkswagen in Silao, Mazda in Salamanca, Audi in Puebla and Jac in Ciudad Sahagún. In 2018 NAFTA is struggling to survive in the face of a U.S. president who blames its economic problems on China and Mexico, and the IAM is looking for new markets, new opportunities to continue growing (Eggers, 2016).

**Timeline of the Mexican Automotive Industry**



**Figure 2** AM timeline  
Source: Eggers, 2016

## The Problem

Brands face several challenges for the positioning of new light vehicles, one of them is to renew the older and obsolescent vehicle fleet, since the average age of the vehicle fleet is 13 years old.

The second challenge is to reduce the importation of used vehicles (chocolate cars), which have a negative effect on the environment, the economy, and road and highway safety. This has affected the development of the domestic used vehicle market and has damaged the growth potential of the new vehicle market.

In 2020, the number of used vehicles imported into Mexico exceeded 124,000 units, which represented a decrease of about 22.1% compared to the volume of used vehicle imports recorded in 2019. (Statista, 2020b)

Brands are facing other challenges such as seeking the repeal of the New Automobile Tax and the Tenure Tax, as well as increasing the deductible limit in the ISR and VAT on the acquisition of new vehicles, which has not changed since 2008, amount allowed of \$175,000.00, which is only enough for very few vehicles in the market. The IAM brings great benefits to the country's economy, but the economic policies have not paid back to the same extent to increase the development of the industry within the country. All these challenges the brands must face them in unity as an industrial sector, allying themselves to preserve and prosper (Eggers, 2016).

But the great challenge faced by brands is among themselves, looking for a better market share, and although the market in Mexico has increased, the diversity of brands has also had a greater boom since the XXI century.

The number of light vehicles sold in Mexico fell below 35,000 units in April 2020, representing a decrease of more than 64.5% compared to the sales volume reported during the same month of the previous year. The shocking slowdown in auto demand is related to the health emergency situation declared by the Mexican government due to the COVID-19 outbreak at the end of March 2020. (Statista, 2020c)

Coupled with this last challenge is the leadership factor in organizations or companies, to a large extent the results obtained so far in automotive companies are due to this factor. Already Deloitte (2020) raises since 2018, that considering that organizations used to describe agile change as adjustments the plane in full flight, coupled with the pandemic of COVID-19 has rewritten the rules of upheaval in modern times. Those who lead any organization, from corporations to institutions to families, are not fixing the plane in the air, they are building it. Times like these need leaders who are resilient in the face of such dramatic uncertainties.

As we move into the recovery phase of the crisis, resilient leadership recognizes and reinforces the critical shifts from a "today" to a "tomorrow" mindset for their teams. It perceives how major market and societal changes related to COVID-19 have caused substantial uncertainties that must be navigated and seized as an opportunity for growth and change. In the midst of these uncertainties, resilient leadership requires a larger number of followers, who must be fed back and encouraged by building greater trust: Calculative, Cognitive and Identifying.

Resilient leadership starts by anticipating what success looks like at the end of recovery (how the business will thrive in the long run) and then guides their teams to develop a set of rapid, results-based sprints to get there. Building this type of leadership builds confidence.

## Literature review

The human being by nature tends to trust, since he is born he trusts his mother first and then his father, because he has been the center of attention of the mother since his womb and trusts her, but as he grows, he begins to trust or distrust other people in his environment, this trust has to be built as it happens with the baby, it depends largely on the stability and relationship with its context. Trust is a social construction where communication is a determining factor to achieve it in the company as a whole. It is understood then that trust is a variable that is apparently hidden, but permeates not only interpersonal relationships, but encompasses organizations at all levels, making visible the alienation of this to the objectives of the organization. Likewise, trust from the behavioral theory "focuses on effectively applying the human aspects of organizations" (Lockward, 2011, p.471).

Within the management of organizations, trust plays a role and can be viewed from three perspectives according to this author (Lockward, 2011):

1. Economic approach: according to Arrow, trust enables economic exchange activities, as it facilitates efficient transactions, communication and reduces transaction costs (Arrow, 1971).
2. Opportunistic Approach: Williamson: described opportunism as the pursuit of self-interest over that of the other person, decreasing the degree of trust in the affected party (Williamson, 1985).
3. Focus on people's attributes or values: Stephen Robbins mentions that confidence in having hope that the other party will not act opportunistically (Robbins, 2004).

### Dimensions for the study of trust in the organization

Models help us to understand. By obtaining results, a specific situation through representation or simulation. There are several models of trust, where each of them exposes the elements that must exist for trust to exist (Rojas, 2015).

- A) **Unidimensional Psychological Model.** Russue suggests that trust is "a psychological state comprising the intention to accept vulnerability based on positive expectations of another's intentions or behavior" (1998). In this Model trust involves an emotional or affective factor. McKnight, Cummings, and Chervany (1998) attempted to account for these findings by arguing that a moderate to high level of initial trust is based on three factors: (a) personality factors that predispose an individual to trust others in general, (b) institution-based structures that ensure protection against distrustful actions on the part of the other, and (c) cognitive processes that allow individuals to quickly process information and make initial judgments or form initial impressions that the other is trustworthy.

- B) **Two-dimensional psychological model.** The two-dimensional approach A more recent approach to the structure of trust views trust and distrust as dimensionally distinct constructs. This approach tends to view trust and distrust as having the same components (cognition, affect, and intentions) as the unidimensional approach, but treats trust and distrust as separate dimensions (Lewicki 1998).

- C) **Transformational Psychological Model.** The third psychological approach suggests that there are different types of trust and that the very nature of trust transforms over time. These models have developed as researchers attempted to achieve two goals: to understand the nature of trust as relationships develop beyond simple transactional exchanges to other forms of relationships (Fiske, 1991) and to understand whether "deep" trust in close relationships is phenomenologically different from trust.

### Reliance on traditional or classical theory

This had three stages, Scientific Management, Bureaucratic Management and Managerial Management (Lockward, 2011). Taylor in his work Shop Management 1903, states that employees should be distributed scientifically in opposite work services where materials and working conditions are adequate, so that standards can be properly met and labor laziness is combated. And one of the four principles of scientific management is cooperation between management and workers, and this should be based on trust (Taylor, 1903).

Weber (1967), the most important theorist of Bureaucratic Administration proposes the types of leadership in organizations and depending on which of them is at the head of the organization, will be the type of existing trust.

The bureaucratic model developed and implemented will dictate the relationship and level of trust between managers and employees. The characteristics of this model are:

- Authority and responsibility must be clearly defined.
- Hierarchy of authority.
- Promotions based on technical qualities of personnel.

- Written administrative functions and decisions.
- Separate Property Management.
- Clear rules and procedures uniformly applied to executives and employees.

Fayol (1916), in his work *Management Administration*, established trust as an essential element for the achievement of goals, since the executive had to gain the trust of his subordinates, so that they would obey him using rationality. In addition, he stated that people should be made aware of their work and responsibilities, and thus feel more confident to interact and avoid defensive behaviors or negative environments. Top management must gain the trust of employees in order to lead them to obtain the desired results in the organization.

Barnard (1886), creator of the "Informal Organization" category of analysis, which is found in all formal organizations, believed that it created the bonds of trust necessary for communication to flow in all directions.

### **Trust models used by automakers with their suppliers**

Sako (1992) explained the differences between the arm's length model and the Partner Model. In the former, the manufacturer requires the supplier to reduce costs and extend credit terms, which causes suppliers to go bankrupt. In the Arm's Length Model, the client (car manufacturer) puts different suppliers in competition for a product or service, and the one that offers the lowest cost and best credit conditions will be the one that can work for the car manufacturer (Martín, 2009).

The Partner Model, used by Japanese companies, uses Lean Manufacturing as its main tool, providing the customer with what is needed in the necessary time. And this can only happen when the supplier is involved in the production process of the car manufacturer. Thus, it should not include in the product something that is not required by the manufacturer (Martín, 2009).

The Partner Model also includes tools such as Total Quality, Just in Time, Kaizen, Theory of Constraints and Process Reengineering (Martín, 2009). And precisely the model proposed for this analysis is based on these characteristics Martín and Peligros make a very interesting review of the subject.

### **Analysis of the trust model according to Lewicki and Bunker**

First, from the systemic perspective, citing two of Professor Luhmann's main books called *Social Systems* (1991) and another called *The Society of Society* (2007), four conditions must be met in the operation of trust. First, there must be a mutual commitment that must be tested on both sides, between alter and ego. If the commitment is not tested, then the possibility of accepting or rejecting the bet would not operate. Second, the exact situation in which such a commitment is to be tested must be well known. The situations in which we are involved, both for alter and ego, are familiar to us and therefore become familiar to us.

Third, trust can only be offered and not demanded. There is no order from beyond that imposes on us the offer of trust since that would imply a demand in which one cannot be free to refuse the offer. Therefore, trust is only voluntary since it does not depend on previous prescriptions or on any moral foundation. Fourth, trust is earned with the risk involved, i.e., one of the parties must be expected to accept the offer of trust.

Thus, trust is built as relationships mature with the frequency of interaction, the duration, and the diversity of challenges that the relationship partners encounter and face together. Each of these components is essential.

If the parties interact frequently and over a long period of time, but only superficially, or if they have a frequent and issue-rich exchange, but do so only around a limited and narrow problem, or if they interact on many issues, but do so infrequently, these conditions limit the maturing potential of the relationship (Lewicki, 2006).

Thus, trust and distrust increase in strength (depth) and breadth (high areas of influence) as a function of the frequency, duration, and diversity of experiences that affirm trust in positive expectations (trust) or trust in negative expectations (distrust). First, as a relationship grows, it may increasingly reflect a large number of positive experiences that have reinforced trust and few, if any, negative experiences that have increased distrust.

This creates conditions of high trust and low distrust. Within interpersonal relationships, high trust/low distrust relationships are expected to develop as both parties develop a shared interdependence and actively pursue common goals. Second, relationships may develop to reflect many negative experiences that have increased distrust and few positive experiences that have increased trust.

This creates conditions of low trust and high distrust (Lewicki, 2006).

Lewicki and Búnker mention that trust occurs at three levels:

1. Calculation: when based on the calculation of costs and benefits.
2. Knowledge: develops over time and is based on the predictive behavior of both participants.
3. Identification: with the desires and intentions of others.

Explaining these categories of analysis further, we have that:

### **Calculative confidence**

This occurs when the supplier obtains the predicted results or fears retaliation from the vehicle manufacturer in case of non-compliance. In the automotive sector, reputation is a very valuable intangible asset that generates new customers (Lewicki, 2006). Deterrence-based trust (CBT) is based on whether the other will keep his or her word; it exists "when the potential costs of discontinuing the relationship or the likelihood of retributive action outweigh the short-term advantage of acting in a distrustful manner" (Lewicki, 2006).

CBT can be strengthened in three ways: repeated interactions (enhancing the benefits of the relationship over time by improving each party's ability to know and predict the other's behavior), multifaceted interactions (enhancing the likelihood of trust stability by increasing the number of "interaction points" between the parties), and "reputation as hostage" (threatening the potential offender with reputational damage within his or her professional network if trust does not work). KBT is based on knowing the other, understanding what the other wants and prefers, and understanding how the other thinks and responds.

### **Cognitive trust**

When the automaker and suppliers exchange information in order to predict each other's performance. And thus, together they can improve processes, materials, costs and time (Lewicki, 2006).

Knowledge-based trust (KBT); this type of trust is based on the ability to know and understand the other well enough to predict and control their behavior. Even if the other is predictably unpredictable at times, repeated interactions and multifaceted relationships will enhance understanding of the other. This interaction strengthens the foundation of CBT and builds its own foundation of trust by improving the knowledge and predictive ability of the other (Lewicki, 2006).

KBT is enhanced by regular communication and "courtship": that is, getting to know the other; learning a lot about the other's reputation, trustworthiness, and integrity; and determining the "interpersonal fit" between self and other. They argue that a combination of strong CBT and KBT creates the basis for greater trust building: "The combination of deterrence and knowledge can eliminate the potential harm of allowing your partner to gain knowledge about you when there is no simultaneous deterrence. IBT is based on greater identification with each other. The parties share and appreciate each other's desires, intentions, wishes and values. One party can serve as an agent for the other because they know they have interests in common and their own interests will be protected or defended by the other.

### **Identifying trust**

It is characterized by a mutual understanding between manufacturer and supplier to the extent that each can act on behalf of the other. They can anticipate each other's needs. This occurs when they share values, convictions or beliefs (Lewicki, 2006).

Identification-based trust (IBT) occurs when one party fully internalizes the preferences of the other, so that it identifies with the other (Lewicki 2006).

IBT occurs when the combined processes of deterrence and knowledge seeking lead to a full internalization of the other's preferences. IBT develops as parties create joint products and goals, adopt a common name, locate in proximity, share common values, and can be further strengthened as these activities increase in frequency and intensity.

Rusbult argued that trust moves through three stages: predictability (consistency of the partner's behavior) to dependability (trustworthiness and honesty), and finally to a "leap of faith," based on "the conviction that the partner can be trusted to respond to one's needs in an attentive manner, now and in the future" (Rusbult, 1999).

Moreover, "the three stages of trust are not mutually exclusive; each stage is necessary for strong feelings of trust to develop" (Rusbult, 1999). These researchers presented data asserting that dependence promotes strong commitment, that commitment inspires pro-relationship acts such as accommodation and willingness to sacrifice the other, that the perception of these acts increases partner trust, and that trust increases the partner's willingness to become more dependent on the relationship (Weiselquist, Rusbult, Foster, & Agnew, 1999). Lewicki and Bunker (1995, 1996) describe these transformation points as "frame shifts" (fundamental changes in the dominant interpersonal perceptual paradigm) in the relationship.

The shift from CBT to KBT indicates a shift from an emphasis on differences or contrasts between self and other to an emphasis on commonalities between self and others. The shift from KBT to IBT is one from simply learning about the other to a balance between strengthening common identities and maintaining one's own distinctive identity in the relationship.

### Design and Analysis

According to Figure 14, the present research is carried out under the quantitative approach, the sample is made up of 30 people out of a total of 100 employees in the administrative, sales and service areas of the new vehicle agency in Querétaro and 30 people out of a total of 90 employees of the new vehicle agency in Morelos, and the tool used to collect the data is the questionnaire.

Approach	Quantitative
Unit of analysis	New vehicle agency
Technique	Case study
Tool	Lewicki and Bunker Model (1996)
Research design	Transversal
Scope	Exploratory/Descriptive
Population	60 people (30 in Morelos and 30 in Querétaro)

**Table 1** Research design

Source: Own elaboration based on Hernández and Christian Paulina Mendoza Torres (2018)

### Data collection instrument

For this research, the Lewicki and Bunker confidence model was used, which has been applied mainly in the automotive industry worldwide, but little explored for automotive companies in Mexico. Furthermore, this instrument has a Cronbach scale reliability index of 0.98. The measurement instrument was applied to 60 employees of the agencies that allowed us to conduct the study in Querétaro and Morelos, taking the questionnaire directly to the workplace, in working hours and respecting anonymity. The measurement instrument consisted of 55 measurable items with a Likert scale, where each question was rated from 1 to 5 how much the respondent agreed with each premise, where 1 means totally disagree and 5 means totally agree.

The scale is as follows:

1. Strongly disagree.
2. In Disagreement
3. Neutral.
4. Agreed
5. Totally agree.

These questions were also divided into specific topics to measure the employee's trust in the company, which are as follows:

Behavioral / Confidence / Calculative  
Cognitive/Cognoscitive Confidence  
Affective/Identifying Confidence  
Commitment  
Trust  
Familiarity  
Communication  
Reputation  
Opportunism  
Satisfaction

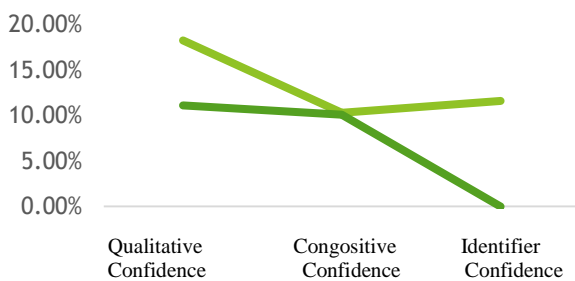


**Results**

The results obtained from the application of the instrument based on Lewicki and Bunker's trust model are shown below. This indicates the level of trust that exists in these two companies in Morelos and Querétaro.

For the first level of trust, Behavioral or Calculative Trust, Queretaro showed 81.72% and Morelos 88.89%, showing in both states a low level of this type of trust. Therefore, employees have a level of this type of confidence of 18.28% and 11.11%, respectively. In the second level of Cognitive or Cognitive trust, a low level of trust was obtained in Querétaro 89.68% and in Morelos 89.91%, so the actual level of this trust is 10.32% and 10.09%, respectively. Finally, the third level of trust, Affective or Identifying Trust, a low level of trust was detected, for Queretaro 88.39% and for Morelos 90%, so the percentage of this type of trust is 11.61% and 10%, respectively.

According to these results, we can plot in the Lewicki - Bunker model the levels of trust of employees towards the organization.



**Graph 2** Comparison of confidence levels between the automotive companies studied in Querétaro and Morelos  
 Source: Information obtained from the application of the instrument in 2019

**Conclusions**

The pandemic year 2020 has been very complicated for the world. This sector has not been indifferent to the health and economic crisis in the world. A total of 949,353 new automobiles were sold during the entire year 2020. The difference with 2019 (1,317,931 sales) is minus 368,578 units, which translates to -28.0%. The slump in sales has been greater than that of the 2009 economic crisis and the largest since 1995, when the market declined 61.8%, according to AMIA figures.

Dealerships closed, factories halted, the time it takes for brands to adapt to digital sales, and the damage to consumers' pockets were the main causes of the slump.

The Mexican Automotive Industry (IAM) has been one of the strongest and one of the largest contributors to the GDP for more than 50 years, and continues to grow. Mexico is among the top 10 producers of automotive vehicles. Mexican states such as Aguascalientes, Nuevo León, Estado de México, Morelos, Guanajuato, Chihuahua, have improved their economic output thanks to the assembly plants that have generated direct and indirect sources of employment. Almost 2 million workers depend on this industry.

Reviewing, studying and analyzing this organizational factor called Organizational Trust is crucial to build a proposal to build the trust of workers and customers.

Trust is operationalized as the level of cooperative behavior, it is presumed that changes in the level of cooperation of individuals - for whatever reason - reflect changes in their trust (Lewicki, 2006). Trust is composed of several elements credibility, honesty, competence and predictability (Galli, 2003). Relationships mature with the frequency of interaction, duration, and diversity of challenges that relationship partners encounter and face together. Thus, trust and distrust increase in strength (depth) and breadth (context width) as a function of the frequency, duration, and diversity of experiences that affirm trust in positive expectations (trust) or trust in negative expectations (distrust).

Consultants and researchers Lewicki and Bunker mention that trust occurs at three levels: 1) Calculation: when it is based on the calculation of costs and benefits. 2) Knowledge: it develops over time and is based on the predictive behavior of both participants. 3) Identification: with the desires and intentions of others.

The use of this model to two car agencies to know the level of trust. With the help of the instrument (questionnaire) we were able to detect their level of trust, and also some other indicators such as Familiarity, Communication, Commitment, Reputation, Opportunism and Satisfaction which are important factors for Trust to exist.

The employees of the organization we studied showed a low level of trust in all three levels, calculative, cognitive and identificatory. This means that they do not feel satisfied with the salary they earn, nor the benefits and rewards package (calculative trust), there is no adequate communication from the leaders since the employees are not clear about the objectives and direction of the organization (cognitive trust), the human factor is not considered in the strategic planning of the organization, and it is noticeable by not aligning the organizational objectives with those of the employees (identificative trust) so they do not share common values (cognitive trust).

Trust is a fundamental part of social capital, which generates commitment (Luhmann, 1996) and teamwork. Without these valuable elements, it is difficult for employees to do their job properly and this lack of trust, most likely, can be transmitted to customers. This can lead to dissatisfied customers, a decrease in service quality, a decrease in sales and a bad reputation.

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## Control of management practices and their impact on the competitiveness of companies in Mexico

### Prácticas de control de gestión y su impacto en la competitividad de las empresas en México

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#### Abstract

Competitiveness has different meanings. All of them contain common elements that allow them to be classified into four dimensions: stakeholders, human factor, innovation, finance and market penetration. Goals: The main objective of this research is to analyze the relationship between the use of resources and capacities and financial performance in small and medium microenterprises (Mipymes) of the three sectors in Mexico. Methodology: Regarding the method of obtaining information, the data obtained from the application of 360 surveys were used, covering SME units from the sectors: industrial, commerce and services; in the main cities of the country. A theoretical model was designed to contrast the 3 specified hypotheses, and it was validated with a linear regression model. Contributions: Finally, it is concluded that this empirical study, framed in the contingent approach, has been able to show that human factors and innovation explain to a greater extent their influence on financial performance. And that technology, although it contributes to performance, conflicts when the human factor intervenes in the implementation of said technology. Thus, constituting a sustainable competitive advantage for business success.

**Financial Performance, Technology, Innovation, Human Factor**

#### Resumen

La competitividad tiene diferentes acepciones. Todas ellas contienen elementos comunes que permiten clasificarse en cuatro dimensiones: partes interesadas, factor humano, innovación, finanzas y penetración de mercado. Objetivos: El objetivo principal de esta investigación es analizar la relación entre el uso de los recursos y capacidades y el rendimiento financiero en empresas micro pequeñas y medianas (Mipymes) de los tres sectores en México. Metodología: En cuanto al método de obtención de la información, se utilizaron los datos obtenidos de la aplicación de 360 encuestas, abarcando unidades Pyme de los sectores: industrial, comercio y de servicios; en las principales ciudades del país. Se diseñó un modelo teórico para contrastar las 3 hipótesis especificadas, y se validó con un modelo de regresión lineal. Contribución: Finalmente, se concluye que este estudio empírico, enmarcado en el enfoque contingente, ha podido mostrar que los factores humanos y de innovación explican en mayor medida su influencia sobre el rendimiento financiero. Y que la tecnología, si bien contribuye al desempeño, entra en conflicto cuando el factor humano interviene en la implementación de dicha tecnología. Constituyendo así una ventaja competitiva sostenible para el éxito empresarial.

**Innovación, Productividad, Industria del turismo, PyME's**

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## Introduction

The main objective of this research is to analyze the relationship between the use of resources and capacities and financial performance in micro, small and medium-sized companies (Mipymes) of the three sectors in Mexico, taking as a research guide the theory of contingency and, specifically, the management control model proposed by Maiga, et. al. (2014) who suggest four categories of analysis that companies must attend to when developing a competitive advantage: technology, innovation, human resources and information management systems.

To approach the object of study, a quantitative investigation was developed, where a factorial analysis was carried out, from which findings were made that allowed contrasting the research hypotheses that relate each of the independent variables (degree of technology, degree of innovation and human factor) with the dependent variable (financial competitiveness).

Regarding the method of obtaining information, the data obtained from the application of 250 surveys were used, covering SME units from the sectors: industrial, commerce and services; in the occident of the country.

The article has been integrated into five parts. In the first one is given introduction to the object of study.

The second is made up of the conceptual framework in which information on the SME sector in Mexico is presented, as well as a review of the literature of empirical and theoretical studies that support the analysis.

The third section makes a brief description of the database used, the approach of the variables and hypotheses, as well as the applied methodology.

The fourth section presents and analyzes the results of the quantitative study. In the end, it is concluded according to the hypotheses raised, the main findings are discussed and future lines of research on this topic are proposed.

## Literature review

In relation to the theoretical reference that was addressed in this article, this section exposes the theory of contingency, management control systems and the global and national panorama of MSMEs in Mexico.

### The contingency theory

The theoretical foundation of this research is the contingency theory, which considers the study of companies and their financial performance as the basis (Simons, 1987; Otley, 1980; Ouchi, 1977). The contingency theory has been widely adopted by some researchers and used this theoretical framework for their work related to the analysis of such systems in organizations (De Antoni, 2020; Cruz, 2015).

To face the global challenges of MSMEs, they have to achieve and sustain competitive advantages. One of the most relevant competitive advantages is the use of organizational resources and capacities (Washington, 2013; Pérez-Cruz, 2016).

Therefore, and based on these arguments, the main starting question is: ¿is there a significant relationship between organizational resources and capacities and financial performance in MSMEs in Mexico?

### Management control systems and their effect on financial performance

Tomás (2015), the description and definition of accounting systems for management (ASM) and the terms management accounting (MC), and organizational controls (CO), are sometimes used interchangeably reference to a series of practices such as the cost of products and budgets, while the ASM refer to the systematized use of the cg to achieve organizational goals.

Meanwhile, the ASM are broader and more complete systems that include other types of controls, such as personnel controls. On the other hand, CO are sometimes used to refer to comprehensive controls within specific activities and processes such as statistical quality controls and just intime, among others (Preciado & Cruz, 2012).

The ASM have been defined in different ways. Hansen et. al. (2021) refers to the ASM as the formalized processes and systems that use information to maintain or alter the patterns of activity in an organization. Said definition includes planning systems, reporting systems and monitoring processes, which are based on the use of information (Hansen & Mowen, 2014).

Cevallos (2021) argue that in broader terms, a ASM would be designed to support the organization to adapt to the environment in which it is established, and to provide the best results desired by its stakeholder group.

The scheme proposed by Amstrong and Tylor (2023) divides the field of control between strategic planning, control management and operational control, to define the ASM as the processes through which managers ensure that resources are obtained and used effectively and efficiently to meet organizational objectives.

However, this approach has led to a disconnect between the ASM and strategic planning and between the CM and operational control (AlGhazzawi & Lennox, 2009) and (Ala-Heikkilä, 2021).

Cisco et. al. (2016) affirms that the ASM have evolved over the years from a focus on providing quantifiable financial information, to the focus of supporting management in decision-making, covering a broader scope such as: external information on markets, clients, competition in the industry, non-financial information related to production processes and a broader range of support mechanisms for decision-making.

Vargas & Saavedra (2022) in one of his main contributions to contingency theory, mentions that this approach is based on the premise that there is no universally appropriate accounting system that can be applied in the same way to all organizations and in any circumstance.

Another point of view is that of Mejía e Higuera (2015), who explain this premise as the non-existence of a single and best way to manage and configure the organizational structure, since this will depend on the environment in which the company operates.

From the perspective of the ASM, the theory of contingency establishes that the financial performance of the company is influenced by various contingent variables such as strategy, size, structure and organizational environment, technology and individual tasks, as well as variables related to the management, instrumentation, structure and development of the information system (Buckingham & Goodall, 2015).

In this sense, Zizlavsky (2014) analyzed the alignment of different variables, such as accounting control techniques and the impact on business performance. Therefore, ASM should not be based solely on one form of control, such as performance measurement, but in a number of systems of control that work together.

DeNisi & Murphy (2017) in their contribution to the same theory, argue that the structure of an organization depends to a large extent of technology and the environment, also mentioning that the effectiveness of management processes is a contingent factor that affects the structure organizational.

Business competitiveness is related to three elements: the first is national competitiveness, which implies factors such as macroeconomic stability, openness and trade with other countries, or the complexity of regulation for the business sector; the second element refers to regional capacity; A third element that explains the competitiveness of companies has to do with the company itself and its internal dynamics (Perez, 2018).

Business competitiveness is derived from competitive advantage that an organization has through its production processes and efficiency that are reflected in the quality and price of the product or services, maintaining an advantage over its competitors (Meraz, Pérez-Cruz, & Olague, 2021).

#### Variables

The technology variable was measured as follows:

- Technology as the set of scientific knowledge applied to improve products and/or services.

- The company's policy on the most advanced technologies in the market for the development of its products and/or services.
- Technology life cycle forecasts.

The innovation variable was based on what was proposed by Pérez (2020a; 2019) Cruz y Vázquez (2018) y Cruz (2017), and measured: the rate of new products or services in the company in comparison with its direct competitors.

The degree of differentiation between own innovations and those of its direct competitors; the success rate of new products in relation to that of its direct competitors and innovation as part of business culture (Cruz, 2014).

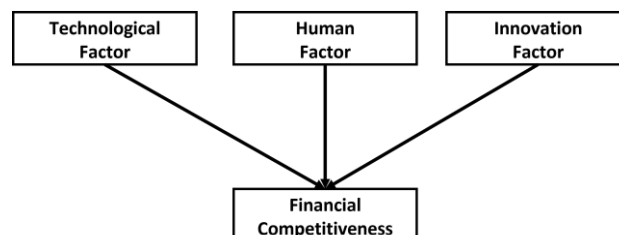
The human factor variable was based on what was proposed by Pérez-Cruz (2021) Licon-Michel y Pérez-Cruz (2018) Cruz (2014) and measured: emotional ties, lasting relationships, loyalty and effort.

To measure the dependent variable (competitiveness), financial results were considered based on three items: return on investment (ROI); profits and gross production sales.

Financial performance is a key variable within the contingent approach, since it will allow evaluating the degree of adjustment or coupling between the contingent variables and the organizational objectives.

Various studies have used competitiveness as a dependent variable, among others are: Demuner et. al. (2022), Pérez-Cruz (2020b), Matallana et. al. (2021), Esparza y Reyes (2019) González et. al. (2019) y Saavedra et. al. (2013).

Referring to the main objective of the work, which is to analyze the relationship between the use of scg and financial performance in MSMEs in Mexico, financial performance is considered as a dependent variable, and as independent variables: analysis (technology degree, degree of innovation) and with the dependent variable (financial competitiveness. The following figure illustrates the model addressed in this research:



**Figure 1** Research model

Source: Own Preparation

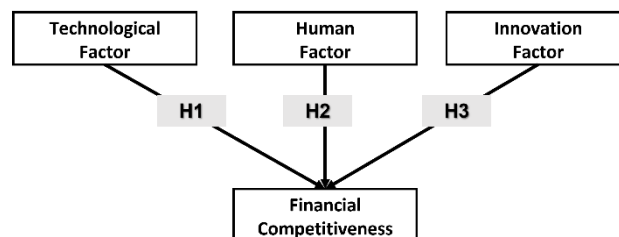
## Hypothesis

As hypotheses are presented:

H<sub>1</sub>: Competitiveness is positively related to the degree of technology of MSMEs.

H<sub>2</sub>: Competitiveness is positively related to the human factor practices of MSMEs.

H<sub>3</sub>: Competitiveness is positively related to the innovation practices of MSMEs.



**Figure 2** Hypothesis research

Source: Own Preparation

## Methodology

From the review of the literature that allowed the conceptual model, We now turn to the characterization of the model and the specific methodology that will be taken into account to carry out this research.

A The data used is described below, the model developed for the measurement of the influence of the categories of analysis (degree of technology, degree of innovation and human factor) with the dependent variable (competitives).

The research was of a quantitative type, since from this An analysis of the influence of the independent variables was carried out, on the dependent variable.

Regarding the calculation of the correlations between the variables, the licensed software spss 18 was used, which allowed obtaining the factor analysis study.

The Mipymes object study belong to the industrial, trade and service sectors. This selection of these companies as a case study allowed us to grant more validity to this research with the application of the factor analysis model.

## Results

To test the research hypotheses that relate each of the independent variables with the dependent variable, a principal component analysis was performed.

Principal component analysis represents a mathematical technique that does not require a statistical model to apply the probabilistic structure of the errors.

This analysis is applied when it is desired to know the relationship between elements of a population and it is suspected that said relationship is influenced in an unknown way by a set of variables or properties of the elements.

## Factorial analysis

To carry out this analysis it is necessary to know the correlations of the data matrix.

One of the validity requirements of the matrix is the high correlation of the independent variables, for which the determinant of said matrix is taken into account, which must be different from zero. In this case, a determinant of 2.33 was obtained.

The second step was the Kaiser-Meyer-Olkin (KMO) sampling adequacy, which was 0.843, which brings it closer to 1 and the analysis can continue.

The third step consisted of testing whether the correlation matrix is an identity matrix, for which the Bartlett sphericity test was used. In this case, the result was a significance of 0.000, so the results are accepted as valid (Carmona, 2014).

Another applied analysis was the Measure of Sampling Adequacy (MSA), which was observed through the diagonal of the antiimage.

	CO	TF	HF	IF
CO	0.882	-0.309	-0.172	-0.096
TF	0.031	0.821	-0.265	0.028
HF	-0.17	0.265	0.903	0.019
IF	-0.100	0.028	0.019	0.901

**Table 1** Diagonal of the antiimage

Source: Own elaboration based on STATA 14

This type of measurement makes it possible to individually compare all the variables. Here, 0 and 1 are taken as the minimum and maximum values respectively, the higher the MSA value being the better.

In the case of the antiimage correlation matrix, of the 4 variables, all presented values greater than 0.821. This provides another positive indicator of the validity of the matrix.

In this first phase of the factorial analysis, the analysis of relevance and validity of the data matrix is fulfilled, therefore, the matrix was integrated by technology, innovation and human factor ratios.

This coincides with the conceptual framework when affirming the incidence of the human factor for the development and innovation of companies. It also contradicts the theory of ICTs by observing that they have a lower incidence on the financial performance of MSMEs in Mexico.

## Correlation of the variables

Finally, the Pearson  $\chi^2$  test was applied, which allows measuring the discrepancy between an observed distribution and a theoretical one, which is called goodness of fit. This measure indicates the independence of two variables from each other according with Pérez-Cruz (2022).

The validity criterion is that the adjustment value is less than 0.05 in both distributions. The following values were obtained:



	CO	TF	HF	IF
CO	1.000			
TF	0.0904*	1.000		
HF	0.1599*	0.0167	1.000	
IF	0.1460*	0.0051	0.0957	1.000

Notes: CO=Competitives; TF Technological Factor; HF=Human Factor; IF=Innovation Factor.

Significance level: at 0.05\*;

**Table 2** Correlation of the variables

Source: Own elaboration based on STATA 14

### Linear regression

Once it has been verified that the dependent variables are correlated. Therefore, simple linear regressions were carried out with the aforementioned variables. The following table shows the summary of the results:

	Coef.	P valor
TF	0.0758	0.013*
IF	0.1141	0.004*
HF	0.0327	0.062**
Constant	0.7488	0.000***
R-cuadrada		0.065

Note: TF=technological factor; HF= human factor and IF= innovation factor.

Significance level: at 0.01\*\*\*; at 0.05\*\* and significant at 0.1\*;

**Table 3** Linear regressions

Source: Own elaboration based on STATA 14

In the previous table it can be seen that of the regression model, the one with the highest explanatory level was that of "innovation factor" with an *p value* significant at 0.01% (*pvalue*=0.00); followed by the variable "technological factor" with an *p value* significant at 0.05% (*pvalue*=0.013); and finally the variable of "humna factor" with a *p value* significant at 0.01% (*pvalue*=0.062).

### Conclusions

The objective of this research was to analyze the relationship between the use of resources and capabilities and financial performance in the Mipymes of the three sectors in Mexico.

If you start from the idea that the main objective of this work was not to develop a model with high predictive power but to analyze the main factors that affect on financial performance to determine the probability of financial success.

From this mode, the approach of theme result complex to the to intervene several combined and simultaneous factors, such as: the performance of the staff, innovation and product development practices, as well as the implementation of new technologies; however, even when these ítems keep a business logic to leverage organizational success, the main urdle involves determining the specific value or the marginal contribution that each factor has on performance financial.

Thus, an adequate model of financial performance demands the joint integration of these and other factors to determine a profile on the characteristics of these explanatory variables.

In this sense, it is important clarify that each factor is integrated by characteristics different in each organization, in relation to that the observation units meet or not information required.

One of the contributions of this research is the approach to the important aspects of contingent theory and its relationship with estimative variables.

For it was important to integrate the framework conceptual what would expose the principles and rules that govern the accounting technique nowadays, for know and understand the practical problems what are presented to meet financial information.

Finally, it is concluded that this empirical study, framed in the contingent approach, has been able to show that human and innovation factors explain to a greater extent their influence on financial performance. And that technology, while contributing to performance, conflicts when the human factor intervenes in the implementation of said technolodge. Thus constituting a sustainable competitive advantage for success business.

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## Antioxidant evaluation of food grade extracts obtained from soursop (*Annona muricata*) fruit

### Evaluación antioxidante de extractos grado alimenticio obtenidos a partir del fruto de guanábana (*Annona muricata*)

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#### Abstract

The soursop fruit (*Annona muricata*) is recognized as a source of carbohydrates, vitamins and minerals, although the presence of bioactive compounds such as acetogenins, alkaloids and phenolic compounds has also been reported, with recognized anticancer, antimicrobial and antioxidant activity. However, in the production chain of this fruit, one of the problems is the short post-harvest life of 4-9 days. For this reason, an alternative for the use of its bioactive compounds could be to obtain and use soursop extracts to improve the quality of food products. Based on the above, in the present experiment, the changes in firmness, color and weight of soursop fruits in their ripening stages were determined, as well as the amount of phenolic compounds and antioxidant activity by DPPH and ABTS methods of two different tissues (peel and pulp) at two different stages of maturity (physiological and consumption) using two types of solvents (70% food grade ethanol and water). The results showed that the extract obtained with a 70% ethanol solution from the peel of fruits at the consumption maturity stage presented significantly higher amounts of phenolic compounds, as well as the highest antioxidant activity. The results support that the peel of the fruit, which is preferably consumed or industrialized fresh, may represent a sustainable alternative for the utilization of the bioactive compounds of soursop as a preservative in food products.

Soursop, Antioxidant activity, Food Grade

#### Resumen

El fruto de guanábana (*Annona muricata*) es reconocido como fuente de carbohidratos, vitaminas y minerales, aunque también se ha reportado la presencia de compuestos bioactivos como acetogeninas, alcaloides y compuestos fenólicos, a estos se les reconoce actividad anticancerígena, antimicrobiana y antioxidante. No obstante, en la cadena productiva de este fruto, uno de los problemas es la corta vida postcosecha, siendo de 4-9 días. Por esa razón, una alternativa para el aprovechamiento de sus compuestos bioactivos, podría ser la obtención y utilización de extractos de guanábana para mejorar la calidad de los productos alimenticios. Con base en lo anterior, en el presente experimento se determinaron los cambios de firmeza, color y peso que presentan los frutos de guanábana en sus etapas de maduración, también se evaluó la cantidad de compuestos fenólicos y la actividad antioxidante por los métodos de DPPH y ABTS de dos diferentes tejidos (cáscara y pulpa) en dos diferentes etapas de madurez (fisiológica y de consumo) utilizando dos tipos de disolventes (etanol grado alimenticio al 70% y agua). Los resultados mostraron que el extracto que se obtuvo mediante una solución con etanol al 70%, a partir de la cáscara de frutos en etapa de madurez de consumo presentó significativamente la mayor cantidad de compuestos fenólicos, así como la mayor actividad antioxidante. Los resultados sustentan que la cáscara del fruto, el cual se consume o industrializa preferentemente en fresco, puede representar una alternativa sustentable para el aprovechamiento de los compuestos bioactivos de la guanábana como conservador de productos alimenticios.

Guanábana, Actividad antioxidante, Grado alimenticio

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## Introduction

Soursop fruit, nutritionally, is recognised as a source of carbohydrates, vitamins and minerals, although the presence of bioactive compounds such as acetogenins, alkaloids and phenolic compounds has also been reported, which are recognised as having anticancer, antimicrobial and antioxidant activity (Jiménez et al., 2014., p.44.). Regarding the production of this fruit, the largest production worldwide is attributed to Mexico and, at the national level, Nayarit ranks first in soursop production (SIAP-SAGARPA, 2019). However, in the production and distribution chain of this fruit, one of the problems is its short post-harvest life, which averages 4-9 days at a temperature of 15-20 °C (Berumen-Varela et al., 2019., p.271.).

On the other hand, it is estimated that annually one third of the food produced in the world is wasted, this waste is mainly attributed to factors such as environmental conditions, microbial spoilage, mechanical damage during transport and oxidative processes. In order to reduce the percentage of global food waste, each of the above-mentioned factors must be overcome. In terms of oxidative spoilage of food; oxidative stability has been improved through the strategy of using a wide variety of antioxidants of both synthetic and natural origin (Rangaraj et al., 2021., p.1). However, in recent years, the demand for natural antioxidants, mainly of plant origin, has grown in recent years due to increasing concern among consumers about the presence of toxicological effects of synthetic antioxidants (Falowo et al., 2014., p.177).

In response to the demands of finding natural resources with antioxidant activity and based on the agricultural production of the state of Nayarit, soursop is one of the fruits that could be used as a source of phytochemical compounds that improve the oxidative stability of foods. Therefore, it is necessary to explore different extraction methods and perform antioxidant evaluations on extracts obtained from soursop fruit.

## Theoretical framework

The soursop tree is an evergreen tree belonging to the Annonaceae family, native to Mexico, Central America, the West Indies and northern South America.

This plant produces oval or cone-shaped fruits with a dark green colour, characterised by a set of thorns with a shell-like appearance all over the skin. These fruits weigh between 0.5 and 4 kg. The pulp represents most of the fruit (approximately 80 %) and is white, juicy and has a sweet and sour taste. The soursop also contains black or brown seeds (127-170), which can measure 1.25 to 2 cm in length. Regarding the composition of the fruit, water (80 %) and carbohydrates (15-17 %) are the most abundant; it is also rich in vitamins C and A, and minerals such as calcium, iron and phosphorus. In addition, the presence of bioactive compounds such as acetogenins, alkaloids and phenolic compounds has been reported, which are recognised to have anticancer, antimicrobial and antioxidant properties (Jiménez et al., 2014, p.45; Leite-Neta et al., 2019, p.72; Berumen-Varela et al., 2019, p.270).

A nivel internacional México es el principal productor de guanábana. A nivel nacional, en el año 2018, el estado de Nayarit fue el principal productor del país, con una producción de 21,860.02 ton; seguido en menor escala por los estados de Colima con 2,933.31 ton, Michoacán con 2,395.80 ton, Guerrero con 1,070.66 ton y Veracruz con 511.06 ton (SIAP-SAGARPA, 2019).

In recent years, the soursop has been the most important member of the anonaceae family, due to the discovery of potential applications of its pulp at nutritional, medicinal and industrial levels. Currently, soursop is consumed as a whole fruit and its pulp is marketed natural or frozen for the preparation of aguas frescas, as well as for the production of ice cream, nectar, jellies, popsicles, liqueurs, jams, jellies, yoghurts and purees (Sanusi and Abu Bakar, 2018, p.393.). However, no references have been documented on the use of soursop extracts as additives in food products.

On the other hand, it is estimated that every year 33 % of the food produced in the world is wasted, this waste is mainly attributed to factors such as environmental conditions, microbial spoilage, mechanical damage during packaging or transport and oxidative processes (Rangaraj et al., 2021., p.1).

With regard to oxidative food spoilage, a clear example can be observed in meat and meat products. The second most relevant cause affecting the quality of meat and meat products are the oxidative processes of both lipids and proteins. The deterioration caused by these oxidative processes is reflected through the following phenomena; development of unpleasant odours and flavours caused by volatile oxidation products, changes in colouring caused by the oxidation of myoglobin, an increase in water loss due to dripping, and a decrease in nutrients due to protein denaturation. There is also a shortening of shelf life and the emergence of oxidation by-products with toxic effects for the consumer, which have been associated with diseases such as arteriosclerosis, neurodegenerative diseases and some types of cancer (Falowo et al., 2014., p.177.; Papuc et al., 2016., p.100.; Pellissery et al., 2019., p.318).

To counteract the oxidative deterioration of food products; the food industry has improved the oxidative stability of foods through the strategy of using a wide variety of antioxidants (Falowo et al., 2014., p.177). In terms of antioxidants, antioxidants are defined as compounds that can neutralise free radicals by accepting or donating electrons to eliminate an overload of oxygen-reactive substances (Bielli et al., 2015., p.212). Antioxidants can be of natural or synthetic origin. Synthetic antioxidants such as hydroxybutylbutylanisole, butylated hydroxytoluene, tertiary butyl hydroquinone and propyl gallate have been widely used in food products. However, in recent years, the demand for natural antioxidants, mainly of plant origin, has grown in recent years due to increasing concern among consumers about the presence of potential toxicological effects of synthetic antioxidants (Falowo et al., 2014., p.178).

The main source of bioactive substances with antioxidant role for humans are plants, therefore, different plant products have been evaluated as natural antioxidants to preserve and improve food quality. These natural antioxidants derived from the plant kingdom are extracted from different agricultural products such as fruits (grapes, pomegranate, date, tangerines, avocado, among others), vegetables (broccoli, potato, pumpkin, curry, among others), herbs and spices (tea, rosemary, oregano, nettle, cinnamon, mint, sage, thyme, ginger, clove, among others) using different methods and solvents (Falowo et al., 2014., p.180).

## Methodology

In a commercial soursop orchard located in the locality of Venustiano Carranza, Mpio. de Tepic, Nayarit (21° 30' N, 104° 54' W, 920 masl), 30 fruits were collected at physiological maturity stage. Subsequently, this raw material was transferred to the laboratory of the Specialised Unit for Food Quality and Natural Products of CENITT-UAN, where the weight, colour and firmness of the fruits were determined. Subsequently, 15 fruits were stored at room temperature until the fruits reached consumption maturity and 15 more fruits were stored at physiological maturity vacuum packed at a temperature of -20°C. For the fruits that reached eating maturity, the weight was determined, the peel was removed by hand and the peel weight was determined. These fruits were stored under vacuum wrapped in aluminium foil at a temperature of -20 °C until further analysis.

The weight was determined using a Torrey LEQ-5 scale. Surface firmness was determined using a SHIMPO digital penetrometer model FGV-50XY, which recorded the force necessary to cause a slight pressure on the surface of the fruit. The colour of the fruit peel was determined by a Minolta R-400 colorimeter. The extracts were obtained using two different solvents (70% food grade ethanol and water) for the peel and pulp of the fruit at two different stages of maturity (physiological maturity and consumption maturity).

To obtain the extracts, 3 g of sample were homogenised in a 50 mL Falcon tube with 15 mL of the solvent according to each treatment. After homogenisation, the tubes were centrifuged at 2500 rpm for three minutes and the liquid fraction was recovered in a ground-glass flask through Whatman filter paper no. 54. The resulting residue was treated again with 15 mL of the same solvent used, applying the same homogenisation and centrifugation conditions. The supernatant obtained was then added to the first one using the same filter paper. Once the extract was completely filtered, it was subjected to rotaevaporation of the solvent at a maximum temperature of 42 °C. The residue obtained was diluted in water and diluted in a solution. The residue obtained was diluted in 25 mL of water and kept refrigerated (4 °C) until further analysis.

From the extracts obtained, aliquots of the extracts were prepared with the following dilutions: 1:4 for pulp extracts and 1:10 for peel extracts in order to perform the following analyses under these conditions. First, the total content of phenolic compounds in the extracts was determined by the Folin-Ciocalteu method following the procedure described by Soong & Barlow (2004); where an aliquot of 200  $\mu\text{L}$  of the previous dilution of the extracts was mixed with 1000  $\mu\text{L}$  of 10 % Folin-Ciocalteu reagent and 800  $\mu\text{L}$  of 7.5 % sodium carbonate. They were left to stand in the dark for 30 minutes until a bluish colour was obtained and then the absorbance was read at 765 nm in a Unico spectrophotometer, mod UV-2150.

The concentration of phenolic compounds in each extract was calculated using a regression equation obtained from a standard curve of gallic acid with a concentration range of 5 to 100 mg gallic acid/L. The total amount of phenolic compounds expressed was calculated using a regression equation. The total amount of phenolic compounds was expressed as milligrams of gallic acid equivalents (GAE) per 100 grams of fresh matter.

Subsequently, each of the extracts was also tested for antioxidant activity equivalent to 6-hydroxy-2,5,7,8-tetramethylchroman-2-carboxylic acid (Trolox) by 2,2-diphenyl-1-picrylhydrazyl (DPPH) and 2,2-azinobis-3-ethylbenzothiazolin-6-sulphonic acid (ABTS) spectrophotometric methods.

To determine the inhibitory capacity of the extracts by the DPPH technique, a 0.1 mM DPPH solution in methanol was prepared according to the method described by Ganhão et al. (2010). Once the diluted extracts were prepared, 33  $\mu\text{L}$  of each sample was mixed with 2000  $\mu\text{L}$  of the DPPH free radical (initial absorbance  $\sim 1,200$ ), allowed to stand for 6 min in the dark and absorbance was measured at a wavelength of 517 nm. To express the results, a standard curve of Trolox was prepared at different concentrations (0.25, 0.5, 1, 1.5, and 2 mM). The antioxidant capacity was determined in Trolox equivalents and expressed in mM Trolox equivalents per gram of fresh fruit (mM Trolox/g fresh sample).

Finally, the in vitro antioxidant activity of the extracts was determined by testing for inhibition of the chromogenic ABTS+ radical measured by the method described by Re et al. (1999). The ABTS radical was generated by mixing 2,2-azinobis-3-ethylbenzothiazolin-6-sulphonic acid 7 mM with 2.45 mM potassium persulphate, which was allowed to stand for 15 hours at room temperature.

The radical was then diluted in ethanol to an initial absorbance of  $\sim 0.700$  at a wavelength of 734 nm. For the development of the technique, 10  $\mu\text{L}$  of each sample was mixed with 1000  $\mu\text{L}$  of the ABTS+ radical (ABS  $\sim 0.700$ ) and allowed to stand in the dark for 6 minutes to subsequently measure absorbance at a wavelength of 734 nm. To express the results, a standard curve of Trolox was prepared at different concentrations (0.25, 0.5, 1, 1.5, and 2 mM). The antioxidant capacity was established in Trolox equivalents and expressed in mM Trolox equivalents per gram of fresh fruit (mM Trolox/g fresh sample).

In the present project, a 2 x 2 x 2 x 2 factorial design was used for the analysis of the soursop extracts, the sources of variation of the factorial model being: two types of solvents (70 % food grade ethanol and water), two tissues from the soursop fruit (peel and pulp) and two stages of fruit maturity (physiological and consumption). All analytical techniques were performed in triplicate for each sample and each fruit was considered as a replicate.

The statistical analysis was carried out by processing the data of the individual variables, for which an analysis of variance was performed. The data of the quantitative variables were studied by descriptive statistics. In cases where significant differences were found ( $p < 0.05$ ), a comparison of means test was carried out using Tukey's test to contrast differences between treatments. For these analyses, the SAS programme for Windows version 9.0 was used.

## Results

Tables 1 and 2 show the quantitative values of colour (in CIE  $L^*a^*b^*C^*h^*$  scale), firmness and weight of soursop at physiological maturity and consumption maturity, respectively.



	L	a*	b*	C*	h*	Weight (kg)	Firmness (N)
Average	39.69	-7.01	16.73	18.73	116.92	1.28	31.73
S	4.07	5.25	3.69	4.17	2.58	0.45	8.30
CV (%)	10.25	74.89	22.09	22.29	2.21	35.46	26.17

L\*: Luminance; a\*: red/green co-ordinates; b\*: yellow-blue co-ordinates; C\*: Chroma; h\*: hue; S: standard deviation; CV: coefficient of variation; S: standard deviation.

**Table 1** Colour, weight and firmness values of guanábanas collected at physiological maturity

	L	a*	b*	C*	h*	Weight (kg)	Firmness (N)	TM (d)
Average	36.09	-3.61	13.50	14.10	104.05	1.39	3.68	7.00
S	4.14	2.47	2.89	3.24	8.25	0.23	1.42	2.49
CV (%)	11.48	-68.29	21.40	23.02	7.93	16.71	38.68	35.63

L\*: Luminosity; a\*: red/green coordinates; b\*: yellow-blue coordinates; C\*: Chroma; h\*: hue; S: standard deviation; CV: coefficient of variation; TM: ripening time. Regarding the composition of soursop fruits at eating maturity, the peel represented on average 13.25 % of the total weight of the fruit ( $159 \pm 34$  g).

**Table 2** Colour, weight and firmness values of soursops collected at eating maturity

Table 3 shows the amount of total phenolic compounds obtained from the different extracts.

Tissue	Solvent	Maturity	CFT
Pulp	Agua	Physiological	23.71 <sup>f</sup>
Pulp	Ethanol 70 %	Physiological	26.08 <sup>f</sup>
Shell	Agua	Physiological	46.12 <sup>d,e</sup>
Peel	Ethanol 70 %	Physiological	90.50 <sup>b</sup>
Pulp	Agua	Consumption	32.97 <sup>e,f</sup>
Pulp	Ethanol 70 %	Consumption	52.74 <sup>d</sup>
Peel	Agua	Consumption	72.56 <sup>c</sup>
Peel	Ethanol 70 %	Consumption	195.37 <sup>a</sup>
E.E.			3.67

S.E.: Standard error of the mean; CFT: Total phenolic compounds expressed in mg GAE/100 g fresh matter; Different literals per column denote significant statistical differences ( $p < 0.05$ ).

**Table 3** Total phenolic compounds determined by the FOLIN CIOCALTEU method

Table 4 shows the data obtained from the analyses of antioxidant activity obtained by the DPPH and ABTS methods, respectively.

Tissue	solvent	Maturity	DPPH	ABTS
Pulp	Agua	Physiological	0.25 <sup>e</sup>	0.28 <sup>d</sup>
Pulp	Ethanol 70 %	Physiological	0.24 <sup>e</sup>	0.26 <sup>d</sup>
Shell	Agua	Physiological	0.54 <sup>c,d</sup>	0.57 <sup>c,d</sup>
Peel	Ethanol 70 %	Physiological	1.06 <sup>b</sup>	1.02 <sup>b</sup>
Pulp	Agua	Consumption	0.39 <sup>d,e</sup>	0.42 <sup>c,d</sup>
Pulp	Ethanol 70 %	Consumption	0.61 <sup>c</sup>	0.73 <sup>b,c</sup>
Peel	Agua	Consumption	0.70 <sup>c</sup>	1.02 <sup>b</sup>
Peel	Ethanol 70 %	Consumption	2.26 <sup>a</sup>	2.46 <sup>a</sup>
E.E.			0.05	0.06

S.E.: Mean standard error; DPPH: Antioxidant activity expressed mg Trolox/g sample by DPPH method; ABTS: Antioxidant activity expressed mg Trolox/g sample by ABTS method; Different literals per column denote significant statistical differences ( $p < 0.05$ ).

**Table 4** Antioxidant activity obtained from soursop extracts by DPPH and ABTS methods

## Discussion and conclusions

A large variation in colour, firmness and weight variables can be observed in both soursops at eating maturity and those at physiological maturity, such variation among soursop fruits was also previously described by Terán-Erazo et al. (2019), and by Jiménez-Zurita, et al. (2019), who report a variation of more than 42 % for fruit weight, a variation of 28 % in chromaticity or even a variation of more than 71 % in fruit firmness.

On the other hand, the peel weight of the fruit at eating maturity represented 13.25 % of the total fruit weight. This value is up to 6 percentage points lower than that reported by other authors. Regarding the proportion of the peel compared to the whole fruit Terán-Erazo et al. (2019), reported a proportion of pulp, peel and seed weight of 73.2 %, 19.5 % and 7.3 % respectively. Similarly, Solís et al. (2010) evaluated soursop fruits from an area of Actopan, Veracruz, and determined that the proportions of pulp, peel and seed were 70.3 %, 18.8 % and 5.4 %, respectively.

During the consumption maturity process of the fruits, a slight decrease in the green colouring of the surface, as well as in the luminosity, could be observed, dropping from -7.01 to -3.61 for the a\* (red/green) coordinates and from 39.69 to 36.09 for the luminosity. The described phenomenon of change in fruit colouring at physiological maturity and eating maturity has been reported previously.

These changes are attributed to the rupture of chloroplasts, which causes the release of enzymes such as polyphenol oxidase and the degradation of chlorophyll during the last stage of ripening (Jiménez-Zurita et al., 2016., p.1160). Regarding the information provided by the different soursop fruit extracts, it is important to highlight that the extract that had a higher concentration of total phenolic compounds and greater antioxidant activity was the one obtained using 70 % ethanol solvent, from the peel of fruits at the consumption maturity stage.

This could be attributed to the softening of the fruit, which is caused by the enzymatic cellular deterioration that the fruit undergoes when they reach the consumption maturity stage, which could facilitate the extraction of secondary metabolites with antioxidant activity. This softening and cell deterioration was reflected in the firmness of the fruits studied, which went from 31.73 N at physiological maturity of the fruit to 3.68 when the fruit reached consumption maturity. It is worth mentioning that the firmness reported for soursop fruit at eating maturity is 8.3 N (Berumen-Varela et al., 2019., p.270).

The softening that occurs in the ripening process of soursop fruit is associated with the presence and action of different enzymes; among the enzymes that are most involved in this process are: Pectinmethyl esterase (PME) and pectolytic enzymes. PME is related to the degradation of pectic substances in the middle lamella of the cell, which is a component of the cell wall that acts as a cementing or binding agent between cells and can also control the movement of soluble materials. Regarding this enzyme; its activity has been quantified, indicating a considerable increase of this enzyme in short periods and presenting activity 23 times higher in the fruit at consumption maturity with respect to the fruit at physiological maturity (Jiménez-Zurita et al., 2016., p.1162.). It should be noted that some authors have suggested that the function of PME is to promote the de-esterification of galacturonans in order to allow the action of pectolytic enzymes (PGs). These PGs have been directly related to the softening of fruits with high ethylene production. PGs are pectolytic enzymes of which endo-PG (EC 3.2.1.15) and exo-PG (EC 3.2.1.67) have been identified; endo-PG catalyses the random hydrolytic cleavage of the  $\alpha$ -(1-4) bonds of galacturonans; exo-PG hydrolyses releasing galacturonic acid.

These enzymes have been described more extensively in fruits such as mango and durian. However, in soursop fruit, a sudden increase in the presence of these enzymes has been reported at the stage coinciding with the climacteric phase of the fruit. PGs promote the degradation of the middle lamella of parenchyma cells, resulting in softening of the fruit (Jiménez-Zurita et al., 2016., p.1163).

It is also important to mention that the extract obtained using 70% ethanol from the peel of fruits at the consumption maturity stage had 135.97 mg GAE per 100 g of fresh matter. However, this concentration is not similar to that obtained by Terán-Eraza et al. (2019), who had an average of 64.2 mg GAE g<sup>-1</sup> fresh weight. The discrepancy in the concentration of phenolic compounds in soursop fruits is reported by Coria-Telles et al. (2018, p.665.).

In conclusion, it is important to consider obtaining ethanolic extracts of soursop peel at consumption maturity as an alternative to take advantage of the bioactive compounds with antioxidant activity of a fruit that is highly perishable and that is preferably consumed fresh and the peel is discarded. It would also be interesting to use technologies such as ultrasound to compare the quantity of bioactive compounds extracted and their antioxidant activity with the conventional method.

It is also necessary to challenge ethanolic extracts of soursop peel at consumption maturity in food matrices, particularly in meat matrices, and it would be interesting to evaluate their antioxidant effect and their impact on the oxidative stability of meat.

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## Soursop fruit storage: Edible coating based on Hibiscus sabdariffa mucilage

### Almacenamiento de frutos de guanábana: Recubrimiento comestible a base de mucílago de Hibiscus sabdariffa

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#### Abstract

Soursop fruit (*Annona muricata* L.) is a crop of important economic value for the state of Nayarit, however, it has a fast ripening that causes a short shelf life. Several post-harvest handling techniques have been applied to reduce its metabolic processes, such as refrigeration, the use of 1-methylcyclopropane (1-MCP) and controlled and modified atmospheres. In recent years, polysaccharide-based coatings have been applied to fruits. The aim of this research was to evaluate the physicochemical changes of soursop fruits coated with hibiscus calyx mucilage (2%), stored at 22 °C and 15 °C. Weight loss, firmness, pH, total soluble solids, acidity and colour were evaluated. Results for coated fruits stored at 15 °C showed lower weight loss (6.4%), lower firmness (29.7 N), higher TSS concentration (10.4 °Bx) and lower acidity (0.38%) compared to uncoated fruits. Coating with hibiscus mucilage and storage at 15 °C for four days decreased fruit weight loss. It was also observed that storage under these conditions allows a lower concentration of total soluble solids and organic acids. The coatings did not intervene in the decrease of fruit peel colour. Key words: coating, mucilage, soursop, postharvest. Introduction Mexico is the world's leading producer of soursop, with a national production of 30, 790 T in 2019. In this sense, the state of Nayarit was the largest producer of soursop with 23,230 T (Servicio de Información Agroalimentaria y Pesquera [SIAP], 2020). Soursop production contributes to the economic growth of Nayarit; however, there is a problem in the handling of the fruit due to the high respiration rate and ethylene production leading to softening of the fruit, resulting in a short post-harvest shelf life (Balois-Morales et al., 2019). Nayarit does not have an adequate postharvest system, which leads to inadequate fruit handling during handling (Jiménez-Zurita et al., 2016), causing production losses (Tovar-Gómez et al., 2011). Therefore, there is interest in investigating postharvest technologies that allow prolonging shelf life while maintaining the nutritional quality of the fruit (Moreno-Hernández et al., 2014). As an alternative to improve postharvest handling and maintain the quality of fruit and vegetable products, the use of edible coatings has been implemented (Park et al., 2014). Edible coatings based on polysaccharides have gained importance because they create a modified atmosphere through a semi-permeable layer in the fruit that allows gas exchange, reducing metabolic processes and prolonging the postharvest life of the fruit (Solano-Doblado et al., 2018). Among the polysaccharides of interest, mucilages have been used due to their highly branched structure, complex polymeric and hydrocarbon nature that allows modifying the rheology of a solution (Dugarte et al., 2019). Coatings made from mucilage allow a decrease in weight loss, delay in the concentration of total soluble solids, as well as colour improvement (Zambrano et al., 2017). In the above context, hibiscus mucilage could be used as a material for the preparation of an edible coating to prolong the shelf life of fruits. With this in mind, the effect of hibiscus mucilage-based coating (2%) on physicochemical changes during postharvest storage was evaluated in this study.

#### Resumen

El fruto de guanábana (*Annona muricata* L.) es un cultivo de importante valor económico para el estado de Nayarit, sin embargo, presenta una maduración rápida que ocasiona una corta vida de anaquel. Para reducir sus procesos metabólicos se han aplicado diversas técnicas de manejo poscosecha, como la refrigeración, el uso de 1-metilciclopropano (1-MCP) y atmósferas controladas y modificadas. En los últimos años se han aplicado a las frutas recubrimientos a base de polisacáridos. El objetivo de esta investigación fue evaluar los cambios fisicoquímicos de frutos de guanábana recubiertos con mucílago de cáliz de hibisco (2%), almacenados a 22 °C y 15 °C. Se evaluó la pérdida de peso, firmeza, pH, sólidos solubles totales, acidez y color. Los resultados de los frutos recubiertos almacenados a 15 °C mostraron menor pérdida de peso (6,4%), menor firmeza (29,7 N), mayor concentración de SST (10,4 °Bx) y menor acidez (0,38%) en comparación con los frutos sin recubrir. El recubrimiento con mucílago de hibisco y el almacenamiento a 15 °C durante cuatro días redujeron la pérdida de peso de los frutos. También se observó que el almacenamiento en estas condiciones permite una menor concentración de sólidos solubles totales y ácidos orgánicos. Los recubrimientos no intervinieron en la disminución del color de la cáscara de los frutos. Palabras clave: recubrimiento, mucílago, guanábana, poscosecha. Introducción México es el primer productor mundial de guanábana, con una producción nacional de 30, 790 T en 2019. En este sentido, el estado de Nayarit fue el mayor productor de guanábana con 23, 230 T (Servicio de Información Agroalimentaria y Pesquera [SIAP], 2020). La producción de guanábana contribuye al crecimiento económico de Nayarit; sin embargo, existe un problema en el manejo de la fruta debido a la alta tasa de respiración y producción de etileno que conduce al ablandamiento de la fruta, lo que resulta en una corta vida de anaquel poscosecha (Balois-Morales et al., 2019). Nayarit no cuenta con un sistema de poscosecha adecuado, lo que conlleva a un manejo inadecuado de la fruta durante su manipulación (Jiménez-Zurita et al., 2016), ocasionando pérdidas en la producción (Tovar-Gómez et al., 2011). Por ello, existe interés en investigar tecnologías poscosecha que permitan prolongar la vida útil manteniendo la calidad nutricional del fruto (Moreno-Hernández et al., 2014). Como alternativa para mejorar el manejo poscosecha y mantener la calidad de los productos hortofrutícolas, se ha implementado el uso de recubrimientos comestibles (Park et al., 2014). Los recubrimientos comestibles a base de polisacáridos han cobrado importancia debido a que crean una atmósfera modificada a través de una capa semipermeable en el fruto que permite el intercambio gaseoso, reduciendo los procesos metabólicos y prolongando la vida poscosecha del fruto (Solano-Doblado et al., 2018). Entre los polisacáridos de interés, se han utilizado los mucílagos debido a su estructura altamente ramificada, naturaleza polimérica compleja e hidrocarbonada que permite modificar la reología de una solución (Dugarte et al., 2019). Los recubrimientos elaborados a partir de mucílagos permiten disminuir la pérdida de peso, retrasar la concentración de sólidos solubles totales, así como mejorar el color (Zambrano

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## Bibliographic Review

Polysaccharides and their use as coatings Films obtained from biopolymers are of great interest in the industry because they present the property of being biodegradable; in addition, if certain bioactive substances are added, the properties can be improved, as well as the controlled release of bioactive compounds that would allow prolonging the post-harvest life of the coated product (Raspo *et al.*, 2018).

Polysaccharides such as cellulose derivatives, chitosan, starches, pectins and mucilages have been reported as raw materials for preparing edible films and coatings that can be used as packaging material for food preservation (Cazón *et al.*, 2017). Edible coatings, based on polysaccharides, are an alternative for food packaging due to their biodegradability and low production cost, however, their hygroscopic nature and physical instability are important limitations (Rafieian *et al.*, 2014).

## Mucilage

Mucilages are complex carbohydrates made up of chains of L-arabinose, Dgalactose, L-rhamnose, D-xylose and galacturonic acid, the proportion of these monomers varies according to various factors such as variety, age, environmental conditions, extraction method, part of the plant, among other factors (Molina *et al.*, 2019). Research reports the use of mucilage from Nopal (*Opuntia ficus-indica*) and cactus (*Opuntia elatior* Mill) indicating that coatings made from this polysaccharide decrease weight loss, total soluble solids concentration, transpiration rate and respiration (Molina *et al.*, 2019; Zambrano *et al.*, 2017).

## Hibiscus mucilage (*Hibiscus sabdariffa* L)

Among the main plant sources from which polysaccharides can be extracted, hibiscus calyx (*Hibiscus sabdariffa* L.) is an excellent source of mucilage, hibiscus has been reported to have a high content of this polysaccharide, therefore, it can be used to make edible coatings applied to fruits and vegetables (Castañeda and Cáceres, 2014). However, hibiscus calyx mucilage has not been extensively studied, therefore, little is known about its effect as a coating on fruit and vegetable products.

## Method and tols

### Plant material

Soursop fruits harvested at physiological maturity were used. The harvest was carried out in a commercial orchard located in the ejido Venustiano Carranza in the municipality of Tepic, Nayarit (21° 32' 2.77" N, 104° 58' 37.73" W, 893 masl) (Jiménez-Zurita *et al.*, 2016) (Jiménez-Zurita *et al.*, 2016). The fruits were transported to the special analysis laboratory of the Food Technology Unit of the Autonomous University of Nayarit.

A selection of fruits was made by visually discarding those with physical, mechanical and phytopathological damage; subsequently, they were washed by immersion for 1 min with a solution of water with sodium hypochlorite at a concentration of 1 % (v/v) to avoid proliferation of harmful microorganisms, the fruits were left to dry at room temperature (25 °C) to apply the mucilage coating respectively.

### Preparation and application of the coating

A 2% solution of hibiscus calyx mucilage and water (w/v) was prepared. The solution was then heated at  $50 \pm 2$  °C for 30 min with constant stirring. The coating was applied to the fruits by dipping for one minute. After the fruits were coated and left in the open air at 25 °C to solidify the hibiscus calyx mucilage (2%), they were stored in climate chambers (ClimaCell®, CLC-B2V-M 404). Sample collection 1 g of pulp was mixed with 10 mL of distilled water using ULTRA-TURRAX T-25 IKA®.

This mixture was used for the quantification of pH, total soluble solids (TSS) concentration and titratable acidity. Variables evaluated Weight loss was determined by gravimetry using a digital balance (Scout Pro, OHAUS®). Colour was measured in the soursop peel using the parameters brightness (L), hue angle (°Hue) and chromaticity (C) with a colourimeter (Konica Minolta®). Loss of firmness was measured in two equatorial zones of the fruit using a penetrometer (Force Gauge model GY-4) with an 8 mm diameter probe. Pulp pH was measured with a potentiometer (Hanna Instruments HI22).

Total soluble solids (TSS) concentration was determined by placing an aliquot in a refractometer (Hanna HI 96801). Titratable acidity was determined according to the official method (AOAC, 2005) by volumetric titration.

### Experimental design

Treatments were established under a completely randomised design, with a  $2 \times 2$  factorial arrangement (two temperatures and two coating conditions). The fruits were grouped in four batches. The treatments (T) were: uncoated fruits (T1 and T3), coated fruits (T2 and T4). The fruits of T1 and T2 were stored for 6 days at 22 °C and 90% RH. T3 and T4 fruits were stored for 8 days (4 days at 15 °C, then 4 days at 22 °C and 90% RH).

### Results and discussion

#### Weight loss

Fruits stored at 22 °C showed an average daily mass loss of 3.9% (T1) and 4.2% (T2). At the end of eating maturity, the cumulative mass loss was 11.8% (T1) and 12.8% (T2), respectively. Soursop fruits stored at 15 °C showed a daily mass loss of 2.4% (T3) and 2.8% (T4). At the end of storage the cumulative mass loss was 9.8 (T3) and 11.4% (T4) (Figure 1 (a)). No significant statistical difference was found between treatments ( $P \geq 0.05$ ) (Figure 1 (a)). Valero and Serrano (2010) reported that fruit weight loss during postharvest handling is mainly due to transpiration and respiration.

Tovar-Gómez et al. (2011), reported that the use of coating and low temperatures decrease weight loss between 2.5 and 2.4% of soursop fruits coated with wax emulsions and 1-MCP. On the other hand, Jiménez-Zurita et al. (2017), observed that uncoated soursop fruits stored for seven days (four days at 15 °C and then three days at 22 °C), present a cumulative weight loss of 2.3% and 2.7%, respectively. The same authors reported cumulative mass losses of 6.7 and 7.1% in uncoated soursop fruits stored for six days at 22 °C. The results obtained in the present investigation showed a lower mass loss in T4 compared to T1 and T2 fruits.

#### Firmness

A gradual decrease in firmness was observed in fruit stored at 22 °C during storage, where values of 27.1 N (T1) and 22 N (T2) were recorded after six days of storage (Figure 1 (b)). The same behaviour was observed for fruit stored at 15 °C for 4 days, where firmness decreased to 24.8 N (T3) and 22.7 N (T4). According to the statistical analysis, significant differences ( $P \leq 0.05$ ) were observed in the treatments, where T1 and T3 showed higher firmness during storage (51.7 and 35.1 N) (Figure 1 (b)).

Loss of firmness in climacteric fruits such as soursop has been reported to be attributed to cell wall degradation due to the effects of enzymatic solubilisation and depolymerisation (Márquez et al., 2012). Montalvo-González et al. (2014), observed that the application of candelilla wax and beeswax to fruits stored at 25 °C reduced firmness by up to 9.4 N in soursop fruits.

The results obtained in this research were also higher than those reported by Márquez et al. (2012), who reported firmness values of 7.5 N at seven days after harvest. The pH of soursop pulp in fruits stored at 22 °C decreased during ripening from 5.7 (T1) and 5.4 (T2) to values of 4.3 and 4.2, respectively (Figure 1(c)).

Similar results were obtained for fruit stored at 15 °C for 4 days and subsequently transferred to 22 °C, where initial values were from 5.7 (T3) and 5.8 (T4) to 4.7(T3) and 4.5(T4), respectively. Statistically significant differences ( $P \leq 0.05$ ) were observed (Figure 1 (c)). The decrease in pH is related to the increase in acidity characteristic of soursop fruits (Jiménez-Zurita et al. 2016).

These results are in the range established by the Colombian Technical Standard for Commercialisation (NTCC) at physiological or commercial maturity, "soursop fruits must have a minimum pH of 3.38" (Instituto Colombiano de Normas Técnicas y Certificación [ICONTEC], 2003). Jiménez-Zurita et al. (2016) conducted a characterisation of soursop fruits in Tepic, Nayarit, at 26 °C, obtaining a pH of 3.6 at consumption maturity.

Villalba et al., (2006) conducted an investigation with soursop fruits from Colombia at eating maturity, reporting pH values of 3. Total soluble solids (TSS) The final TSS concentration in soursop fruits stored at 22 °C was 13.7 (T1) and 14.4 °Bx (T2), respectively (Figure 1 (d)). On the other hand, the final TSS concentration of fruits stored at 15 °C for four days was 10.75 and 11.95 °Bx (T3 and T4), respectively, showing significant differences in the treatments ( $P \leq 0.05$ ) (Figure 1 (d)). Yashoda et al. (2006), mention that the increase in TSS is attributed to the reduction of total sugars, starch and cellulose during ripening to monosaccharides that confer the texture and flavour characteristics of the fruit.

The reduction of these sugars is due to the high enzymatic activity of amylase and polygalacturonase, which results in an increase in total soluble solids during ripening (Nolasco-González et al., 2019). Montalvo-González et al. (2014), reported 18.6 °Bx 10 days after harvest using combinations of 1-MCP and wax emulsions in the preservation of soursop stored at 25 °C. These results are within the range of the NTCC, which states that "soursop fruits should be above 13 °Bx", which is the maturity indicator used for soursop fruits (ICONTEC, 2003)

Days of storage	0	2	2	4	6	8	10
Total soluble solids (°Brix)	0	5	10	15	20		
Days of storage	0	2	2	4	6	8	10
pH	2	3	4	5	6	7	
Firmness (N)	20	40	60	80	100		
Weight loss (%)	0	5	10	15	20		
T1 22 °C							
T2 22 °C							
T3 15 °C + 4 D							
T4 15 °C + 4 D							

Figure 1. Loss of mass (A), firmness (B), pH (C) and total soluble solids (D) in soursop fruit stored at 22 °C and 15 °C.

Each point represents the mean of six observations and its standard error. The dotted line indicates the end of refrigerated storage. Titratable acidity The concentration of organic acids increased during the storage period from 0.12 and 0.09% to 0.8 (T1) and 1.0% (T2) (Figure 2 (a)).

As for fruits stored for four days at 15 °C and transferred to 22 °C, lower concentration of organic acids was observed, where the initial concentration ranged from 0.1 and 0.17 % (T3 and T4) to 0.42 and 0.5 % (T3 and T4) at eating maturity, respectively. Statistically significant difference was observed between treatments ( $P \leq 0.05$ ) (Figure 2 (a)).

The increase in the concentration of organic acids has been reported by Tovar-Gómez et al. (2011), where they observed that titratable acidity in soursop fruits increases during the ripening process by decreasing pH levels and acidifying the pulp.

It has been reported that the acidity of soursop fruits decreases at the end of storage, so it can be inferred that organic acids are used as substrates in the respiration process (Etienne et al., 2013). Jiménez-Zurita et al. (2017) reported values of 0.88 and 0.96% in soursop fruits stored at 22 °C after eight days of storage, while Do Sacramento et al. (2003), in selections of soursop fruits ("Lisa", "Morada" and "Comum"), obtained values between 0.92 and 1.0% of titratable acidity at eating maturity. Colour ( $L * C * h$ ) The fruits stored at 22 °C (T1 and T2) showed a decrease in the colour parameters, where the average values at physiological maturity were characteristic of an opaque green with low luminosity (Luminosity= 44. 2 and 44, chromaticity= 16.3 and hue angle=109.5°), these values decreased to a very opaque green with a low lightness index at consumption maturity (lightness= 40.5 and 41.2, chromaticity= 9.2 and hue angle=80.89°) (Figure 2 (d)) (Figure 2 (d)).

This behaviour was similar in fruits stored for 4 days at 15 °C and then transferred to 22 °C, where a dull green colour was recorded in soursop fruits (Luminosity= 47.5 and 43, Chromaticity= 18. 5 and 15.1, hue angle=105 and 113.7°) which decreased to a less intense green at low light (Brightness= 40 and 34.8, Chromaticity= 11.3 and 5.9, hue angle=81.4 and 78.5) (Figure 2 (b)). Significant differences were observed in the evaluated treatments ( $P \leq 0.05$ ). T3 fruits showed higher lightness ( $L = 44.4$ ) and chromaticity ( $C = 15.8$ ); however, hue angle was higher in coated fruits (hue = 102.7). Nolasco-González et al. (2019), observed a decrease in the green colour of soursop fruits and suggest that annonaceae during the ripening process manifest variations in colour and brightness, as well as decrease in the green colour angle, the peel colouring transforms from dark green to a light yellowish green indicating that the chlorophyll has lost carotenoids which are the main contributors to the peel colouring. Lima et al. (2003) reported values of  $L = 50$ , hue = 118 and  $C = 24$  in uncoated soursop fruits stored at 23 °C.



Tovar-Gómez et al. (2011) reported brightness values of 43 and 45 in soursop fruits coated with wax and 1-MCP emulsions stored at  $13 \pm 2$  °C, observing from day 10 a dark skin that caused a decrease in brightness values (43.5).

The bright green colour of the fruits evaluated in this research decreased during ripening to a dull green with low lightness index due to darkening of the epidermis. Days of storage 0 2 4 6 8 10 Chromaticity (C) 0 5 10 15 20 25 Days of storage 0 2 4 6 8 10 Hue (°) 40 60 80 100 120 Titratable acidity (%) 0.0 0 0.2 0.4 0.6 0.8 0.8 1.0 1.2 1.4 1.6 1.6 1.8 T1 22 °C T2 22 °C T3 15 °C + 4 D at 22 °C T4 15 °C + 4 D at 22 °C Luminosity (L) 20 30 40 A 50 B C D Figure 2. Titratable acidity (A), Luminosity (B), Chromaticity (C) and °Hue (D) in soursop fruits stored at 22 °C and 15 °C. Each point represents the mean of six observations and its standard error.

The dotted line indicates the end of refrigerated storage. Conclusions Hibiscus mucilage coating and storage at 15 °C for four days decreased fruit weight loss. It was also observed that storage under these conditions allows a lower concentration of total soluble solids and organic acids. The coatings did not intervene in the decrease of the fruit peel colour.

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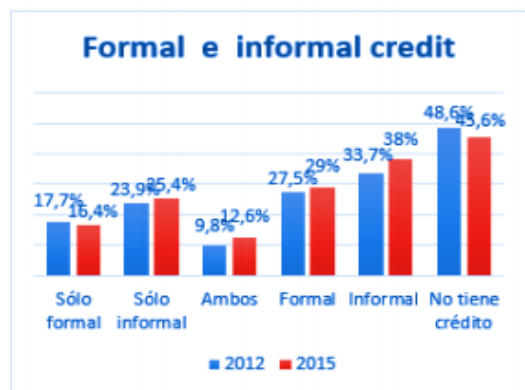
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