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La percepción del consumidor y su relación en la innovación de productos agrobiotecnológicos

Consumer perception and its relationship with innovation in agricultural biotechnology products

Percepção do consumidor e sua relação com a inovação de produtos agrobiotecnológicos

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Resumen

El presente estudio tiene como objetivo analizar la relación entre la percepción del consumidor y la innovación en productos agrobiotecnológicos, tomando como caso de estudio el inoculante multiespecies Inocrep®, desarrollado por investigadores de la Benemérita Universidad Autónoma de Puebla. A partir de un enfoque cuantitativo, correlacional y transversal, se aplicó un cuestionario estructurado a una muestra no probabilística a 20 agricultores del estado de Puebla, México, dentro del segundo semestre de 2024. La investigación se basó en el modelo de Innovación Percibida por el Consumidor (IPC) de Lowe y Alpert (2015), evaluando dimensiones como novedad *per se*, ventaja relativa, relevancia, riesgo, actitudes hedónica y utilitaria, intención de compra, complejidad y novedad tecnológica para conocer la percepción del consumidor con respecto al nuevo producto agrobiotecnológico. Los resultados muestran una correlación positiva entre las dimensiones y la innovación percibida, destacando como factores clave la relevancia del

producto, la percepción del riesgo, la ventaja relativa y la novedad tecnológica. Se concluye que la percepción del consumidor es un elemento fundamental en la adopción de innovaciones agrobiotecnológicas y para las estrategias de desarrollo y comercialización.

Palabras clave: percepción, consumidor, innovación, producto, agrobiotecnología.

Abstract

The objective of this study is to analyze the relationship between consumer perception and innovation in agrobiotechnology products, using the multi-species inoculant Inocrep®, developed by researchers at the Benemérita Universidad Autónoma de Puebla, as a case study. Using a quantitative, correlational, and cross-sectional approach, a structured questionnaire was administered to a non-probabilistic sample of 20 farmers in the state of Puebla, Mexico, during the second half of 2024. The research was based on Lowe and Alpert's (2015) Consumer Perceived Innovation (CPI) model, evaluating dimensions such as novelty per se, relative advantage, relevance, risk, hedonic and utilitarian attitudes, purchase intention, complexity, and technological novelty to understand consumer perception of the new agrobiotechnology product. The results show a positive correlation between the dimensions and perceived innovation, highlighting as key factors the relevance of the product, the perception of risk, relative advantage, and technological novelty. It is concluded that consumer perception is a fundamental element in the adoption of agrobiotechnological innovations and for development and marketing strategies.

Keywords: perception, consumer, innovation, product, agrobiotechnology.

Resumo

O presente estudo tem como objetivo analisar a relação entre a percepção do consumidor e a inovação em produtos agrobiotecnológicos, tomando como estudo de caso o inoculante multiespécies Inocrep®, desenvolvido por pesquisadores da Benemérita Universidad Autónoma de Puebla. Com base em uma abordagem quantitativa, correlacional e transversal, um questionário estruturado foi aplicado a uma amostra não probabilística de 20 agricultores no estado de Puebla, México, no segundo semestre de 2024. A pesquisa foi baseada no modelo de Inovação Percebida pelo Consumidor (IPC) de Lowe e Alpert (2015), avaliando dimensões como novidade per se, vantagem relativa, relevância, risco, atitudes hedônicas e utilitárias, intenção de compra, complexidade e novidade tecnológica para entender as

percepções do consumidor em relação ao novo produto agrobiotecnológico. Os resultados mostram uma correlação positiva entre as dimensões e a inovação percebida, destacando a relevância do produto, a percepção de risco, a vantagem relativa e a novidade tecnológica como fatores-chave. Conclui-se que a percepção do consumidor é um elemento fundamental na adoção de inovações agrobiotecnológicas e nas estratégias de desenvolvimento e comercialização.

Palavras-chave: percepção, consumidor, inovação, produto, agrobiotecnologia.

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Introduction

Today's agriculture faces significant challenges such as climate change, resource scarcity, and the need to produce food sustainably. In this context, agrobiotechnology emerges as a key alternative, combining biotechnology with agriculture to improve crops, reduce environmental impact, and increase productivity (Chekol & Gebreyohannes, 2018).

However, the success of these innovations depends not only on their technical development, but also on how they are perceived by consumers. Consumer perception is a fundamental factor in the adoption of new products, as it directly influences their purchasing decision (Solomon, 2008). Therefore, understanding how farmers perceive an agrobiotech product can help improve its market acceptance.

The Consumer Perceived Innovation (CPI) model, proposed by Lowe and Alpert (2015), allows us to analyze this perception through different dimensions, such as novelty, relative advantage, relevance, perceived risk, and purchase intention. Its application constitutes a theoretical and methodological tool for evaluating user perceptions of innovative products.

This study aims to analyze the relationship between consumer perception and the perceived innovation of the product Inocrep —a multispecies inoculant developed by the technology-based microenterprise Yoliza® ', which is comprised of researchers from the Benemérita Universidad Autónoma de Puebla—using the IPC model as an analytical framework. The results of this research seek to provide useful information for designing strategies that promote the adoption of agrobiotechnological innovations in Mexico.

Consumer perception

Previously, consumers were assumed to act as rational agents, making decisions based solely on utility maximization and price analysis (Boada, Boada, & Morocho, 2023). It is essential to consider that consumer behavior is the analysis of the processes that occur when an individual or group chooses, acquires, uses, or discards products, services, ideas, or experiences to satisfy their needs and desires (Solomon, 2008).

The concept of consumer perception emerged as an expansion of the study of psychology applied to consumer behavior, especially in the areas of marketing and consumer psychology (Schiffman & Kanuk, 2010). Today, this term has been broadened to encompass the way consumers interpret not only goods and services, but also brands, companies, and their practices in ethical and social terms (Gil Hernández, Torres Estrada, & López Torres, 2013).

According to Schiffman & Kanuk (2010)Perception is "the process by which an individual selects, organizes, and interprets stimuli to form a meaningful and coherent image of the world." (p. 157). In other words, people act and respond according to their perceptions of reality and not according to an objective reality, so perception plays a crucial role in consumer behavior (Peter & Olson, 2006).

It is important to clarify that not all information coming from the environment is captured by the individual since of the large amount of data and stimuli that a person receives simultaneously, they will only pay attention to some and discard the rest, because, for some, the most important thing will be the technical characteristics, while others will prioritize economic, aesthetic aspects or the brand image (Jaén, 2016).

It should be noted that neuromarketing is the discipline that combines knowledge of neuroscience, psychology and marketing to understand how consumers make decisions and react to advertising stimuli, products or brands, with the aim of studying the brain and emotional responses of consumers to optimize marketing strategies and improve the effectiveness of advertising campaigns (Zaltman, 2003).

Understanding how people react emotionally to a product, an advertisement, or a purchasing environment helps companies design experiences that generate lasting emotional connections (Agyekum, Haifeng, & Agyeiwaa, 2015). Lindström (2008)He highlighted that brands that manage to connect emotionally with their customers are more likely to retain them.

In short, consumer perception has developed from the intersection of several disciplines, especially psychology, marketing , and advertising. As markets became more competitive, companies recognized that success depended not only on the objective quality of their products, but also on how consumers perceived them, which has led to an increasingly sophisticated approach to perception management through *branding* , experience design, and neuromarketing. (Ismajli, Ziberi, & Metushi, 2022).

Consumer perception of organic farming

Currently, the gradual increase in concern for health care and environmental protection has encouraged the development of more sustainable and ecological agricultural practices worldwide (Santos-Campelo, 2015). Giving rise to the emergence of the segment of ecological consumers, who show greater sensitivity towards personal well-being, healthy eating and conservation of the natural environment (Gómez-Racines, López-Luna, & Mazabel-Quintana, 2021).

Consumer perception regarding sustainable products has undergone a significant change, motivated by the growing concern for environmental issues and healthy lifestyles, therefore, organic and ecological products have acquired greater acceptance, since their consumption is perceived as a way to contribute to the care of the planet (Aguilar, 2017; Gómez-Racines, López-Luna, & Mazabel-Quintana, 2021) . In addition, Santos- Campelo (2015)It indicates that the knowledge that consumers have about this type of products directly influences their attitudes and, consequently, their purchasing behavior.

Because they are beginning to value and differentiate the origin of products more consciously, giving preference to those identified as organic because they are free of chemicals and less harmful to the environment (Arriaga-Latasa, 2014). This situation has driven the need to change cultivation methods and techniques, with the aim of reducing the negative effects on the environment and moving towards more sustainable agriculture, helping to ensure food security in various countries (International Food Policy Research Institute & Food and Agriculture Organization of the United Nations , 2009).

Innovation

Over time, innovation has become increasingly important for both businesses and organizations (Valdés García, Triana Velásquez, & Boza Valle, 2019). Therefore, in a globalized and dynamic world, innovation has become a fundamental factor, acting as the main driver of economic growth and business competitiveness (Doğan, 2016). For Martiniano (2012), One way to face the challenges of a capitalist, neoliberal and globalized society is through the promotion of creativity and innovation for the generation of wealth.

However, in an environment also characterized by accelerated technological advancement and the challenge of climate change, innovation has ceased to be merely a competitive advantage and has become an essential tool for adapting and achieving corporate success (Akis, 2015). In this context, Núñez, Bernedo, Aguado, and González (2023)pointed out that innovation is a key component of business strategies aimed at achieving high profit margins and meeting organizational objectives.

Within the literature, there are multiple definitions of innovation and a large number of theories that address this phenomenon, but the etymology of the term innovate comes from the Latin *innovare* , which translates as to change or modify something by incorporating novelties, that is, the action of introducing a change (Medina Salgado & Espinosa Espíndola, 1994). The Organization for Economic Cooperation and Development (OECD) (2018), in its Oslo Manual, 4th edition, defined innovation as a new or improved product, process, that differs significantly from the unit's previous products or processes and that has been made available to potential users.

Following this same approach, the Spanish Foundation for Technological Innovation and the Ministry of Science, Technology and Environment (CITMA) define innovation as a scientific, technological, organizational, financial, or commercial activity aimed at generating products, technological processes, or services that introduce unique innovations or significant improvements compared to existing alternatives, highlighting their intrinsic relationship with inventions (Valdés García et al., 2019).

For example, Freeman (1982)explained that innovation is the process of integrating existing technology (inventions) to create or improve a product, process, or system. Kochetkov (2023) defines innovation as a transformation in social action that involves changes in the social, economic, behavioral, and institutional spheres.

Considering the above, the analysis of definitions and concepts suggests that innovation is a fundamental process for any organization, transforming ideas and knowledge, both internal and external, into changes that are valued by the market and society for the benefits they provide (Serrano Leyva, Díaz Pompa, & Feria Velázquez, 2022). This means that knowledge becomes the medium, change becomes the process, and value creation becomes part of the ultimate goal of innovation (Fundación Cotec para la Innovación Tecnológica, 2010).

Likewise, research and development (R&D) activities, as well as patents, have become an important indicator of competitiveness and innovation (Akis, 2015). Michael Porter (2007)stated that companies achieve competitive advantage by incorporating innovation through the integration of new technologies and the development of new activities, such as product design, process implementation, marketing strategies , or alternative training methods.

Similarly, the Committee on Research, Technological Development and Energy, European Parliament (1996), in the report "Green Paper on Innovation" stated that innovation fulfils several key functions in favour of improving the environment, that is, it acts as the engine that drives companies to pursue ambitious long-term goals, while promoting the renewal of industrial structures and favouring the emergence of new sectors in the economy and ecology.

Thus, when a company or organization adopts innovation as a goal and recognizes a strategic opportunity, it anticipates that this process will lead to the development of a competitive advantage, in addition to facilitating the participation of small and medium-sized enterprises that could be excluded from the innovative environment by not finding a value proposition (Morales & León, 2013).

Agrobiotechnology

Agrobiotechnology is a branch of biotechnology dedicated to agriculture, whose main purpose is to improve the production, sustainability, and quality of crops and agri-food systems. This discipline combines knowledge of biology, genetics, microbiology, and technology to develop innovative alternatives to address current challenges in agriculture (Gallo-Meagher & Fulford, 2003).

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The word "agrobiotechnology" derives from the fusion of two fundamental terms: agriculture and biotechnology, linking its origin to the development of modern biotechnology and its direct implementation in agriculture. In this sense, for KC and Lamichhane (2021), biotechnology is defined as "the application of comprehensive scientific techniques aimed at modifying and optimizing the characteristics of various plants, animals, and microorganisms with economic relevance" (p. 85).

Among the many applications are the use of microorganisms in agriculture, food processing, forestry, environmental protection, and medicine. However, it wasn't until 1919 that Karl Ereky coined the term biotechnology to describe the science and methods that enable the production of goods from raw materials using living organisms (Gupta, Sengupta, Prakash, & Tripathy, 2017).

Therefore, biotechnology is fundamentally based on the use of living organisms and their components, such as cells, enzymes and proteins, with the aim of developing innovative products or improving existing processes, combining scientific and engineering principles (Chekol & Gebreyohannes , 2018). It has also contributed significantly to agriculture, facilitating the creation of genetically modified crops resistant to pests and unfavorable environmental conditions, such as drought (Bentahar, Abada, & Ykhlef, 2023).

Agrobiotechnology, also known as green biotechnology, fundamentally aims to improve crop resistance, enhance plant nutritional content, and accelerate plant growth. These are considered key elements in addressing food needs and combating food shortages (Rivera, 2006). This branch of biotechnology benefits environmental, social, and economic sustainability (Momoh, 2016).—Furthermore, it plays a key role in the economic competitiveness of developing countries, as a strategic tool to promote sustainable agriculture among small producers, driving economic growth at local and global levels (Bentahar et al., 2023).

However, its implementation faces challenges such as the need for adequate regulation, public acceptance and ethical aspects related to genetically modified crops, making it necessary to ensure that its benefits are maximized and its risks are minimized.

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Inoculant

The use of inoculants dates back to 1896, when a product called Nitragin® was patented . (Bashan, 1998)Today, demand for these products has increased due to global population growth, greater environmental awareness, the implementation of regulations protecting the environment, and the growing preference for organic products (Malusá, Sas-Paszt, & Ciesielska, 2012). However, only a small proportion of agricultural land uses inoculants containing plant growth-promoting rhizobacteria (PGPR) to treat crops (García-Fraile, Menéndez, & Rivas, 2015).

Inoculants are essentially biological products containing beneficial microorganisms (bacteria or fungi) designed to improve plant growth and health by facilitating processes such as nitrogen fixation, nutrient solubilization, and protection against pathogens (Bashan, 1998). This is why their use is essential in modern agriculture, as they promote more sustainable practices by reducing dependence on chemical fertilizers and pesticides, thus contributing to environmental conservation (Bashan, De-Bashan, Prabhu, & Hernández, 2013).

Despite their benefits, their adoption is still limited, as only a small percentage of agricultural land uses inoculants, suggesting the need for further research, dissemination, and policies that encourage their use in agricultural production systems (Vassilev et al., 2015). In Mexico, as in other developing countries, agricultural innovation that could guarantee higher crop yields is still in its infancy, and efforts to bring these technologies to Mexican farmers have been hampered by the lack of a strong connection between research centers and companies that are part of the agricultural market (Dutrénit & Vera-Cruz, 2018).

Spin -*off* companies in Mexican agriculture

Entrepreneurship is being fostered in Latin American universities due to the economic benefits generated for both the university and participating researchers (Maldonado-Sada, Caballero-Rico, & Ruvalcaba-Sánchez, 2019). In Mexico, the creation and development of technology-based companies such as *spin- offs* has gained relevance. However, the response to the creation of these types of companies has not been as expected because technological projects originating from universities require financing from large corporations. (Merritt-Tapia, 2012).

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Specifically, for universities in Mexico to develop *spin-off companies* , they must create technological and scientific products that meet the needs of specific markets (Torres-Vargas & Jasso-Villazul, 2019). According to the OECD, *spin- offs* are defined as companies created by researchers from universities or public sector organizations (OCDE, 2001).

In this national context and in line with the research topic, the company Yoliza, founded in 2020 and originally from Puebla, Mexico, is a university *spin-off dedicated to the development and commercialization of* agrobiotech products . Currently, this technology-based microenterprise has a main product called Inocrep , which consists of a multi-species inoculant that stimulates plant growth through the use of microorganisms (Gordillo-Ibarra & Muñoz-Morales, 2023).

This innovation is protected by a patent registered by the Benemérita Universidad Autónoma de Puebla (BUAP) in Mexico under number MX340596, granted in 2016 by the Mexican Institute of Industrial Property (IMPI) (Muñoz-Rojas et al., 2016). However, the registration of the product's trade name, Inocrep , was officially established in 2020. The main purpose of this formulation is to satisfy the demand for affordable, economical, ecological and highly efficient agricultural inputs, offering an excellent cost-benefit ratio.

Inocrep has a direct impact on the agricultural sector, as it is an agrobiotechnological development created from the combination of six nitrogen-fixing bacterial strains, which coexist in a formulation that promotes greater rooting in crops such as corn, beans, potatoes and tomatoes, among others (Báez-Rogelio, Morales-García, Quintero-Hernández, & Muñoz-Rojas, 2016). In addition, it contributes to soil bioremediation by using beneficial bacteria, reducing dependence on chemical fertilizers and improving crop yield in terms of size and production, with an application of only 250 ml per hectare (Morales-García, Sánchez-Navarrete, Romero-Navarro, & Rivera-Urbalejo, 2022). These characteristics of Inocrep can be appreciated in the following technical sheet (see Figure 1).

One of the biggest challenges facing this development is getting farmers to recognize and value its benefits, as they are often reluctant to adopt agricultural technologies that deviate from traditional methods of applying chemical fertilizers.

Figure 1 . *Inocrep technical sheet*

DESCRIPCIÓN DEL PRODUCTO

Datos técnicos y comerciales del producto

INOCREP

Inoculante de semillas y potencializador de crecimiento y enraizamiento de plantas.
Concentrado líquido
(Producto Registrado)

Principio activo

Inoculante multiespecies compuesto por seis cepas de bacterias diferentes, que estimula el enraizamiento y crecimiento de las plantas.

Ingredientes activos

Azospirillum brasilense Sp7
Burkholderia unamae MTl 641
Pseudomonas putida KT2440
Sphingomonas sp. OF 178
Gluconoacetobacter diazotrophicus PAl 5
Bradyrhizobium sp. MS22

Información general

La formulación promueve el crecimiento de plantas de maíz y otras de interés agrícola, las bacterias se adhieren y coloniza las plantas mediante sus propias capacidades. Su diversidad microbiana fue seleccionada para desempeñar las siguientes actividades en el suelo:

- ✓ Potencializar el crecimiento de plantas.
- ✓ Estimula el enraizamiento.
- ✓ Favorece el cuidado del ambiente.
- ✓ Mejora la calidad de la producción y asegura el potencial rendimiento en los cultivos.
- ✓ Inhibe el desarrollo de patógenos.
- ✓ Ahorro por disminución de fertilizantes químicos y eliminación de fungicidas para tratamiento de semillas.

Instrucciones de manejo y uso

La aplicación de INOCREP se puede llevar acabo directamente a la planta, plántulas o a las semillas; remojo de las semillas antes de la siembra y empapado de semillas o plantas de semillero después de la siembra.

DOSIS (ml/ha)	GRANO/HORTALIZA
250ml	Maíz, Frijol, Papa y Jitomate

Modo de aplicación

Empapar las semillas con el inoculante antes de sembrarlas.

Cuidados y contraindicaciones

1. Este producto no interfiere en el uso de abonos y fertilizantes.
2. No exponer este producto a la luz directa del sol.
3. Almacenar y manejar en un lugar fresco y a la sobra a 4°C en refrigeración.
4. Debido a que este producto contiene bacterias benéficas, deberá evitarse el uso de bactericidas.

Primeros auxilios

En caso de contacto con la piel lave con abundante agua y jabón, si hay contacto con los ojos lávese con abundante agua.

MICROBST YOLIZA S. R. L. de C. V.

Fountain: Inocrep Instructions (Microbst) Yoliza , 2020). All rights reserved.

Methodological Framework

To address this research, a quantitative correlational approach was used to contrast relationships and a descriptive sociodemographic approach was used to characterize the study. A cross-sectional design was used, as the data were collected at a single point in time and was not experimental, as the independent variable was not manipulated. Methods used included deductive methods, which proceed from the general to the specific; analytical methods, which break down a whole into its parts for study; and synthetic methods, which allow for a simplified and coherent explanation of the analyzed phenomena.

The study population consisted of farmers located within an approximate radius of the municipality of Puebla. The selected sample was a non-probabilistic convenience sample with an average of 20 farmers with prior use of Inocrep® in 2024 and a confidence interval (CI) of 0.95. Respondents were subsequently contacted electronically to administer and complete the survey. Participant data was obtained through the company Yoliza , but they were notified beforehand that their data (email and phone number) would be used for this study.

For data collection, a questionnaire was used consisting first of 5 descriptive questions about the study subject and then of 10 dimensions (perceived novelty, relative advantage, technological novelty, hedonic attitude, utilitarian attitude, purchase intention, perceived complexity, perceived relevance, perceived risk and innovation) from which 36 items are derived, using the 5-point Likert scale, where 5 is totally agree and 1 is totally disagree, to respond to the dependent variable innovation of agrobiotechnological products through the independent variable perception of innovation by the consumer. This questionnaire was applied through the Google Forms platform during the second half of 2024, with n = 20 surveys sent and having n = 20 responses.

The study subjects were farmers contacted via email and WhatsApp with a brief explanation of the purpose of the study. Their consent was obtained before applying the questionnaire through the online platform, Google Forms . The data were analyzed using IBM SPSS Statistics software , v. 25 and Microsoft Excel, a descriptive analysis was performed to characterize the sample and a correlation analysis using the Spearman Correlation Coefficient (rho) statistical method and significance criteria ($\alpha = 0.05$) to evaluate the relationship between the variables of interest.

At the same time, innovation has become a key factor for business competitiveness, and understanding consumer perceptions of innovative products or services is essential. Therefore, the CPI model, proposed by Lowe and Alpert in 2015, is presented as a robust theoretical and methodological tool for measuring how consumers perceive and value innovation in a product or service.

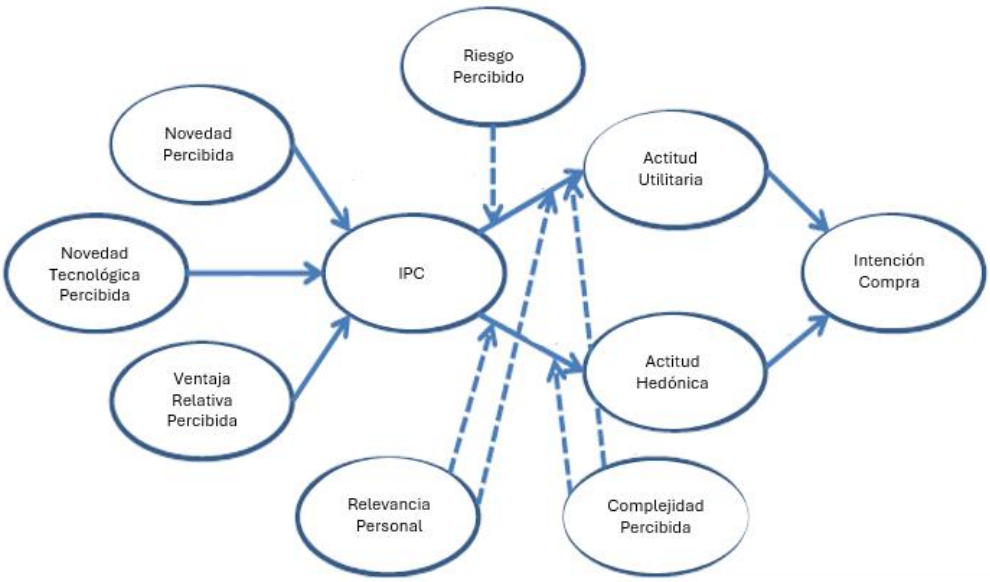
This model is especially relevant because it not only focuses on the objective characteristics of innovation but also considers consumer subjectivity, that is, how they interpret and value the innovation. This is crucial, as consumer perceptions can differ significantly from the company's innovation intentions, directly impacting market acceptance and success.

The IPC model consists of nine dimensions that assess aspects such as perception of novelty, perception of technological novelty, perception of relative advantage, personal relevance, perceived risk, utilitarian and hedonic attitudes, and purchase intention. These dimensions provide a comprehensive view of consumer perception, facilitating the identification of strengths and weaknesses in a company's innovation strategy (see Figure 2).

Lowe and Alpert model has been empirically validated in various contexts. An example of this is the study by Hasan et al. (2021) to understand consumer trust and loyalty towards voice and artificial intelligence devices. It has also been applied to understand consumer satisfaction with mobile app payment services (Chen et al., 2019), guaranteeing its reliability and applicability in different industries and markets. Its use in this research will allow obtaining precise quantitative data, which contributes to a better understanding of consumer preferences and expectations.

In summary, the Consumer Perceived Innovation (CPI) model is a suitable choice for this research due to its comprehensive approach, solid theoretical foundation, and ability to effectively measure consumer perceptions of innovation. Its application will provide valuable evidence for strategic decision-making in the fields of innovation and marketing.

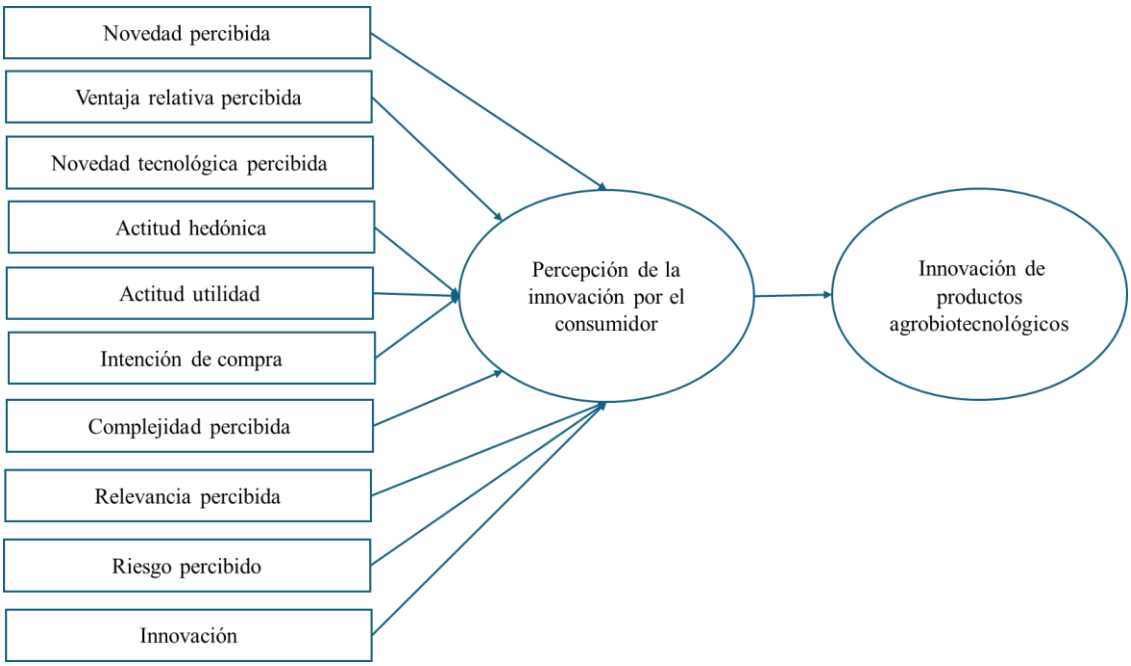
Figure 2. Consumer-perceived innovation model



Note: Adapted from Consumer Perceptions of Innovation (p. 8) by Lowe and Alpert (2015), Technovation (https://doi.org/10.1016/j.technovation.2015.02.001). All rights reserved.

For this research, the IPC model was adapted to obtain satisfactory results, taking as reference the dimensions proposed by Lowe and Alpert (2015)The *items* were modified for the study to highlight the characteristics of the Inocrep product . The "innovation" dimension was incorporated into this model to understand the perception of an invention as a new product and its relevance to the market. Figure 3 shows the complete model of consumer perception of innovation, with the 10 dimensions used in this study.

Figure 3. Model of consumer perception of innovation used in the research.



Source: Own elaboration, modified from the Lowe and Alpert CPI model (2015). All rights reserved.

In each dimension, the following constructs were made according to the proposed model: perceived novelty (4 items), relative advantage (4 items), technological novelty (2 items), hedonic attitude (4 items), utilitarian attitude (4 items), purchase intention (4 items), perceived complexity (3 items), perceived relevance (3 items), perceived risk (4 items), and innovation (4 items), having a total of 36 items, properly designed to respond to the general and specific hypotheses of this research. It is considered pertinent to mention that the instrument used to evaluate the perception of innovation of the Inocrep product presents a high internal consistency, with a Cronbach's alpha coefficient value (α) of 0.967 without redundancy between the items, see Table 1. This result is considered reliable according to

Pelegrín et al. (2016), who indicate that values between 0.70 and 0.90 are acceptable, see Table 2.

Table 1. Cronbach's alpha of the study instrument.

Reliability statistics	
Cronbach's alpha	Number of elements
.967	36

Source: prepared by the authors based on the survey results.

Table 2. Classification of Cronbach's alpha coefficient

Cronbach's alpha ranges
Very low reliability: $\alpha \leq 0.30$
Low reliability: $0.30 < \alpha \leq 0.60$
Moderate reliability: $0.60 < \alpha \leq 0.75$
High reliability: $0.75 < \alpha \leq 0.90$
Very high reliability: $\alpha > 0.90$.

Note: Adapted from the design and validation of a questionnaire for determining educational needs in patients (p. 81), by Pelegrín et al., 2016, Mexican Journal of Pharmaceutical Sciences. All rights reserved.

HG: There is a positive and direct relationship between consumer perception and innovation in agrobiotech products .

1HE. There is a positive and direct relationship between the perception of novelty and innovation of agrobiotechnological products .

2HE. There is a positive and direct relationship between perceived relative advantage and innovation in agrobiotech products .

3HE. There is a positive and direct relationship between perceived technological novelty and the innovation of agrobiotechnological products .

4HE. There is a positive and direct relationship between hedonic attitude and innovation of agrobiotechnological products .

5HE. There is a positive and direct relationship between the utilitarian attitude and the innovation of agrobiotechnological products .

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6HE. There is a positive and direct relationship between purchase intention and innovation of agrobiotechnological products .

7HE. There is a positive and direct relationship between perceived product complexity and innovation in agrobiotech products .

8HE. There is a positive and direct relationship between perceived product relevance and agrobiotech product innovation .

9HE. There is a positive and direct relationship between the perceived risk of the product and the innovation of agrobiotechnological products .

Results

According to the information obtained, the data were processed through the correlation of the variables with the Spearman coefficient, coefficient of determination and its statistical significance, to determine and understand the impact of the 10 dimensions on the dependent variable innovation of agrobiotechnological products , see table 3:

Table 1. Interpretation of results

Objectives and hypotheses	Results	Comments
O1: Determine the relationship between the perception of novelty and innovation of agrobiotechnological products . 1HE: There is a positive and direct relationship between the perception of novelty and the innovation of agrobiotechnological products .	ρ = .566 (mean) r^2 = .320 (~32%) p = .007: significant	agrobiotech product innovation can be explained by consumers' perceptions of novelty. The correlation between the variables is moderately positive, so hypothesis 1 is accepted, with a positive association between perceived novelty and agrobiotech product innovation . P = .007.
O2: Determine the relationship between perceived relative advantage and innovation in agrobiotechnological products . 2HE: There is a positive and direct relationship between perceived relative advantage and innovation of agrobiotechnological products	ρ = .734 (large) $r^2 \approx .538$ (~54%) p < .001: significant	agrobiotech product innovation can be explained by the relative advantage perceived by consumers. The correlation between the variables is highly positive, and hypothesis 2 is accepted, as there is a positive association. The p value is <.001.
O3: Determine the relationship between perceived technological novelty and innovation of agrobiotechnological products .	ρ = .704 $r^2 \approx .495$ (~50%) p < .001	agrobiotech product innovation can be explained by technological novelty perceived by consumers. The correlation between the variables is highly positive, so hypothesis 3 is accepted,

3HE: There is a positive and direct relationship between perceived technological novelty and the innovation of agrobiotechnological products .		as there is a positive association. P < .001.
O4: Determine the relationship between hedonic attitude and innovation of agrobiotechnological products . 4HE: There is a positive and direct relationship between hedonic attitude and innovation of agrobiotechnological products .	ρ = .676 (mean) $r^2 \approx .456$ (~46%) p = .001	agrobiotech product innovation can be explained by consumers' hedonic attitudes. The correlation between the variables is positive, so hypothesis 4 is accepted, as there is a positive association between the two. P = .001.
O5: Determine the relationship between utilitarian attitude and innovation of agrobiotechnological products . 5HE: There is a positive and direct relationship between the utilitarian attitude and the innovation of agrobiotechnological products .	ρ = .599 $r^2 \approx .358$ (~36%) p = .004	agrobiotech product innovation can be explained by consumers' utilitarian attitudes. The correlation between the variables is positive, so hypothesis 5 is accepted, as there is a positive association between the two. P = .004.
O6: Determine the relationship between purchase intention and	ρ = .631 (mean) $r^2 \approx .398$ (~40%) p = .002	agrobiotech product innovation can be explained by consumer purchase

innovation of agrobiotechnological products . 6HE: There is a positive and direct relationship between the purchase intention and the innovation of agrobiotechnological products .		intentions. The correlation between the variables is positive, so hypothesis 6 is accepted, as there is a positive association between the two. P=.002.
O7: Determine the relationship between perceived product complexity and innovation in agrobiotechnological products . 7HE: There is a positive and direct relationship between perceived product complexity and innovation in agrobiotechnological products .	$\rho = .622$ (mean) $r^2 \approx .386$ (~39%) $p = .003$	agrobiotech product innovation can be explained by consumers' perceived product complexity. The correlation between the variables is positive, so hypothesis 7 is accepted, as there is a positive association between the two. P=.003.
O8: Determine the relationship between perceived product relevance and innovation of agrobiotechnological products . 8HE: There is a positive and direct relationship between perceived product relevance and innovation in agrobiotech products .	$\rho = .774$ $r^2 \approx .599$ (~60%) $p = .003$	agrobiotech product innovation can be explained by consumers' perceived relevance of the product. The correlation between the variables is highly positive; therefore, hypothesis 8 is accepted, as there is a positive association between the two. P = .003.

O9: Determine the relationship between perceived risk and innovation of agrobiotechnological products . 9HE: There is a positive and direct relationship between the perceived risk of the product and the innovation of agrobiotechnological products .	$\rho = .747$ $r^2 \approx .558$ (~56%) $p < .001$	Fifty -six percent of the variability in agrobiotech product innovation can be explained by consumer-perceived risk. The correlation between the variables is highly positive; therefore, hypothesis 9 is accepted, as there is a positive association between the two. $P < .001$.

Source : prepared by the author based on results and data processed in Microsoft Excel and IBM SPSS Statistics software , v. 25.

Discussion

Regarding the contrast with the results obtained, the following statements are reached using innovation theory and the relatively emerging concept of consumer perception of innovation proposed in this study as a basis . Data from four dimensions with high positive correlation figures are prioritized according to the Spearman method:

Perceived relevance (0.774), understood as the sole attention to the need or problem through the solution. When perceived relevance is low, consumers are less likely to develop a favorable attitude toward the product, reducing their likelihood of consumption (Lowe & Alpert, 2015). Therefore, increasing the perception of personal relevance is key to fostering an associative connection between the consumer and Inocrep. Similarly, perceived risk, with a value of 0.747, proves to be a correlative factor in the acceptance of innovations, especially in contexts such as the behavior of farmers in Puebla, Mexico. This indicator reflects a high level of uncertainty about possible losses, which influences the willingness to adopt new technologies or products. As Cunningham points out (1967), perceived risk is a critical barrier to the acceptance of innovations, and its negative impact intensifies when the innovation is more radical. Therefore, understanding and managing this risk is essential for designing strategies that foster trust and reduce resistance to change in productive sectors.

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Regarding perceived relative advantage, with a value of 0.734, it reflects the perception of superiority that consumers attribute to the benefits of an innovative product compared to existing alternatives on the market. This perception not only drives product adoption but also contributes to reducing information asymmetries, facilitating more informed decisions by consumers. As Rogers states (1983), relative advantage is perhaps the most important of the characteristics that determine the adoption rate of an innovation, highlighting its crucial role in the success of new proposals. Therefore, clearly and convincingly communicating this advantage is essential to accelerate product acceptance in competitive markets.

Finally, perceived technological novelty, with a value of 0.704, reflects users' perceptions of the degree of technical innovation incorporated in a product or solution and its ability to efficiently address a specific need or problem. In the agrobiotechnology field, this perception is fundamental, as the technologies applied often involve a high level of scientific complexity. As Lin and Chen point out (2006), the perception of technological novelty directly influences consumer attitudes toward innovations, especially when they involve a high degree of technical or scientific complexity, as is the case with biotechnology. Therefore, ensuring that producers understand and value this technological novelty is key to encouraging its adoption and fully leveraging its transformative potential in the agricultural sector.

In conclusion, to maximize innovation in agrobiotech products, companies should prioritize the creation of products that are perceived as relevant, safe, and with clear advantages over alternatives, as these factors explain most of the variability in innovation (54-60%). Complementing this with efforts to highlight technological novelty and foster positive emotions (hedonic attitude) can strengthen the impact. However, factors such as the perception of novelty, complexity, or utilitarian attitude, although relevant, play a secondary role.

Conclusions

According to the data obtained and the methodology used, the research question on the relationship between consumer perception and innovation of agrobiotechnological products is answered , achieving the general objective of the research by determining that there is a positive relationship between consumer perception and innovation of agrobiotechnological products .

The 9 specific working hypotheses were tested, where 2HE, 3HE, 8HE and 9HE stood out, yielding high positive results, demonstrating that the relative advantage, technological novelty, relevance and perceived risks of the Inocrep product are significantly associated with the perception that consumers have about agrobiotechnological products and therefore there is a relationship between the variables.

The remaining hypotheses 1HE, 4HE, 5HE, 6HE, and 7HE were also accepted, although with lesser relationships; that is, their relationship is on average positive compared to hypotheses 2HE, 3HE, 8HE, and 9HE. In particular, it was found that the following dimensions: utilitarian attitude, hedonic attitude, purchase intention, and perceived product complexity moderately influence perceived innovation. This suggests that these elements are relevant, but not the predominant factors in the perception of innovation of the agrobiotech product studied.

These findings offer important insights for companies of this nature seeking to improve the acceptance of innovative products such as inoculants. Furthermore, to encourage greater adoption, it is essential to reinforce the perception of competitive advantage, highlight the product's relevance, and minimize the risks perceived by consumers.

Limitations and recommendations:

Individual r^2 values (ranging from 32% to 60%) indicate that no single factor fully explains innovation, accounting for between 40% and 68% of the variability. This suggests that innovation in agrobiotechnology is a complex phenomenon influenced by multiple factors, such as regulations, costs, scientific advances, and market dynamics.

Recommendations

It would be pertinent to conduct longitudinal studies to assess how consumer perception evolves over time and whether the factors influencing perceived innovation change with prolonged product use. It would also be useful to analyze the impact of neuromarketing-based strategies on improving the acceptance of innovative products in the agrobiotechnology sector .

A multivariate model combining these factors (e.g., multiple regression) could provide a more complete view of how they interact and their combined impact. For example, perceived relevance could be correlated with perceived relative advantage, and both could influence purchase intention.

Finally, innovation in agrobiotech products like Inocrep can be fostered by proper management of consumer perception. Understanding and optimizing the factors that influence innovation perception will allow companies to improve product adoption, strengthening their market positioning and contributing to the development of more sustainable and efficient agriculture.

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