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Comments

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RESEARCH ARTICLE

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Mexican consumers' attitudes toward irradiated and imported apples

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Abstract

This study centers on analyzing Mexican consumers' willingness to pay (WTP) for imported US fresh apples subjected to irradiation, contrasting it with the more prevalent postharvest chemical treatments. We collect data using a survey tool in Qualtrics designed to explore the impact of information dissemination through two distinct narrative styles: scientific and layman. The study uses a between-subjects approach and apply the propensity score matching to address potential confounding factors across respondents' samples. We apply the generalized multinomial logit models in WTP space, taking into consideration respondent's certainty when answering to the choice experiment questions. Our findings reveal that respondents are willing to pay less for apples treated with irradiation compared to untreated ones but more than apples treated with chemicals. The WTP for irradiation increases when respondents receive information about this technology from both the scientific and layperson narrative styles. Similar to findings in previous studies, WTP for irradiated food is affected by gender, age, income, family size, and level of education. This study contributes to the

Abbreviations: ASC, alternative specific constant; DCE, discrete choice experiment; FAO, Food and Agricultural Organization; FTNS, food technology neophobia scale; GMNL, Generalized Multinomial Logit; IAEA, International Atomic Energy Agency; INEGI, National Institute of Statistics, Geography, and Informatics; JMP, John's Macintosh Project; MB, methyl bromide; PSM, propensity score matching; SAGARPA, Secretariat of Agriculture, Livestock, Rural Development, Fisheries and Food of Mexico; UN, United Nations; US, United States; WHO, World Health Organization; WTP, willingness to pay.

literature by identifying the key factors that strongly influence consumers' decisions to opt for irradiation-treated fresh fruits. These influential factors encompass information provision, social and demographic aspects, as well as the presence of country-of-origin labels. EconLit citations: C250, D820, Q160, Q180.

KEYWORDS

consumer behavior, generalized multinomial logit, information asymmetry, irradiated food, novel technologies

1 | INTRODUCTION

The agri-food industry must consistently meet consumers' expectations for top-quality foods while also addressing their expectations and perceptions regarding the technologies used to ensure that quality. Apples are a unique fresh produce, because they are harvested over a relatively short period, which—in the United States—spans from August to November. However, due to advancements in postharvest treatments, it is possible to store apples for a year or longer, ensuring consistent availability throughout the entire year. Nonetheless, apples share a common vulnerability with other fresh produce—they are susceptible to contamination in storage (e.g., insect infestation, pathogenic bacteria, viruses, and parasites). This could lead to substantial losses and increased probability of foodborne illnesses outbreaks. Therefore, to ensure year-round quality and safety of fresh apples, it is essential to meticulously apply postharvest treatments (Watkins, 2006, 2008).

This study investigates consumers' potential acceptance of irradiation as an alternative postharvest treatment method for fresh apples. This question holds significant importance because of the phasing out of methyl bromide (MB), a commonly employed treatment to prevent insect infestations. MB has been the standard treatment due to its insecticidal effectiveness. The decision to phase it out primarily stems from its adverse environmental impact, contributing to the depletion of the ozone layer (Johnson et al., 2012). Because the phase-out would trigger significant market disruptions, the Montreal Protocol and the US Clean Air Act recognize the need for critical use and quarantine/preshipment exemptions in the absence of technically and economically feasible alternatives (Johnson et al., 2012). Nevertheless, states like California ended these critical use exemptions, permitting MB only for quarantine/preshipment since December 2016 (California Department of Pesticide Regulation, 2017). As a result, there is an urgent need for the fresh fruit industry to identify and adopt alternatives to MB that are technically viable and economically feasible.

Irradiation has been a widely accepted food preservation technology since the 1920s (US Food and Drug Administration, 2018). Various international scientific organizations, including the International Atomic Energy Agency (IAEA), the World Health Organization (WHO), and the Food and Agricultural Organization (FAO) of the United Nations (UN) have conducted extensive evaluations and found no evidence that food irradiation poses an increased risk in terms of toxicity, microbiological safety, or nutritional quality for treated foods (Diehl, 1995). Despite the conclusive and consistent findings that irradiation poses no risk to human health, consumers generally resist accepting irradiated foods (Bruhn, 1998; Castell-Perez & Moreira, 2021). Some studies suggest that consumer acceptance has improved with more information on the comparative effects of irradiation versus status quo chemical treatments (Bruhn, 1998). Other studies still find that consumers perceive irradiation as harmful, dangerous, risky. The technology and its benefits remain in most instances largely unknown (Castell-Perez & Moreira, 2021).

This study's main objective is to estimate consumers' willingness to pay (WTP) in Mexico for apples treated with irradiation compared to more commonly used MB treatments to mitigate insect infestation in the context of the impending phase-out of MB and the urgent need to find feasible alternative treatments. In addition, this study includes estimations of the WTP for the zero probability of insect infestation and WTP estimates for the country of origin (Mexico vs. the United States). Further, the study considers the impact of the style of information transfer on the WTP by including three information treatments, building on Yang and Hobbs (2020).

The study contributes to the existing literature by estimating the WTP for using irradiation as an alternative to chemical applications in preserving fresh apples. It compares against the benefit of achieving zero probability of insect infestation through each treatment method. The study is the first of its kind in scope, focus, and size to be conducted in Mexico. It is worth noting that Mexico approves the use of irradiation for fruits they both export and import (Secretariat of Agriculture, Livestock, Rural Development, Fisheries and Food of Mexico [SAGARPA], 2015). This is relevant because Mexico is the primary export destination for apples grown in the United States, in particular, California (Karst, 2021).[1] The study also advances the understanding of how the presentation style of information impacts WTP for an alternative food technology. Further, this study uses the propensity score matching, a method not commonly utilized in the field of agricultural economics, to account for potential confounding factors associated with differences among samples of respondents.

2 | BACKGROUND

Research on consumers' preferences for using irradiation as a food preservation treatment, including meats, fruits, and vegetables has been conducted since the 1990s. These studies employ a variety of empirical methods, such as surveys, economic experiments, and various econometric modeling techniques, to assess consumers' reactions and WTP for irradiated foods (Bruhn, 1995, 1998; Malone, 1990; Resurrection et al., 1995). Through surveys, these studies found that the primary reason for consumers' initial unwillingness to pay for and consume irradiated foods was a lack of awareness about food irradiation, including its effects on the food and its benefits. However, consumers' sentiments quickly changed once they learned about the advantages of irradiation compared to traditional chemical treatments. Bruhn (1998) examined the evolution of consumers' attitudes toward irradiated foods relative to other food safety procedures, highlighting the influence of information. The results indicate that a significant proportion, ranging from 60% to 90% of consumers, prefer the advantages irradiation provides. The proportion increased to 99%, when consumers were provided with relevant information about their food samples.

Building on Bruhn's work (1998) subsequent studies like Gunes and Deniz Tekin (2006), Teisl et al. (2009), Galati et al. (2019), and Bearth and Siegrist (2019) investigated consumers' reactions to irradiated foods and how attitudes change when provided with information. They found that consumers who possessed a strong understanding of a specific technology tended to hold positive attitudes toward it. Furthermore, they observed a phenomenon known as the negative cross-informational effect, wherein increased knowledge about one technology resulted in more negative attitudes toward other technologies.

Other studies measuring consumers' WTP for irradiated food include Fox et al. (2002), Nayga (2003), Nayga et al. (2004), Rimal et al. (2004), and Nayga et al. (2005). Consistently, these studies found that either favorable or unfavorable descriptions of the use of irradiation on foods impacted consumers' WTP. Further, findings in some of these studies validate the positive correlation between consumers' WTP and the information on the potential benefits of food irradiation (Hinson et al., 1998; Nayga, 2003; Nayga et al., 2004, 2005). Another interesting finding is that those who think improper food handling contributes to food poisoning are more willing to pay a premium for irradiation, with some willing to pay up to twice as much (Rimal et al., 2004).

[1]The California Apple Commission has a permit to export irradiated apples to Mexico and is currently the only state with this permit.

Parlato et al. (2014) and Galati et al. (2019) examined Italian consumers' acceptance of irradiated foods and the key factors influencing their sentiments toward this technology. They found that the available information on how foods are treated, the irradiation technology, and its benefits were generally insufficient. They also identified the need to improve the availability and standardization of irradiation information. Respondents were mostly concerned about the perceived health risks, and their acceptance was affected by factors like age, monthly income, and geographical location.

The socioeconomic characteristics positively influencing the acceptance of irradiated foods were being female, having attained higher education, higher household income, having food irradiation knowledge, household exposure to raw meat and poultry, consumption of meats, and geographic location (Frenzen et al., 2001; Hinson et al., 1998). When including the country of origin and preferences for irradiated foods, studies found that consumers consistently preferred domestically produced irradiated foods (Holdershaw et al., 2013; Lim et al., 2013; Yeh et al., 2018). Yeh et al. (2018) related the persistent preference for domestic foods to the lack of trust in foreign information.

Yang and Hobbs (2020) investigated the impact of communication style (scientific vs. blog narrative) on consumers' WTP for biotechnology applications to fresh apples. They discovered that when information was presented in a layman's narrative style, consumers were less inclined to lower their price expectations for these apples. This suggests that conveying information in a more straightforward language is more effective when communicating with the general public, as it is easier to understand and more engaging, leading to a greater persuasion. D'Souza et al. (2021) examined how consumers' acceptance of irradiated foods is influenced by their perception of risk and trust in the information provided. They examined whether incorporating a metric representing consumer's concerns about information on irradiated foods could enhance the explanatory power of the estimates. Their findings demonstrated that the theory of planned behavior successfully predicted consumers' intentions regarding irradiated foods.

Bisht et al. (2021) conducted recent reviews on the effects of irradiation on fruits and vegetables. They found that, in general, studies have revealed positive effects of irradiation on the physical and nutritional properties of different fruits and vegetables, in addition to a significant reduction in microbial load during storage. However, despite these documented positives, consumers remain skeptical of this technology. A study showing a contrasting finding on the effects of irradiation on the food quality was Jia et al. (2022). They assessed the effects of irradiation on meat, and observed adverse effects on its nutritional value, pH levels, tenderness, water holding capacity, color, and flavor. These effects varied depending on the level of irradiation applied.

Our study builds on previous research by being the first to measure consumers' WTP for irradiated fresh apples, compared to the application of chemicals as a postharvest treatment, consider the provision of information under different narrative styles. In addition, the study investigates the effects of country of origin and probability of insect infestation.

3 | METHODS

3.1 | Experimental design and data description

The data was collected from an online survey of a nationwide sample of 2107 Mexican citizens, utilizing the Qualtrics^{XM} platform and consumer research panel during the period from June to September 2021. When using the Qualtrics^{XM} consumer research panel, one must be aware of the recruitment criteria used by this company. Qualtrics^{XM} defines its panel as convenience/nonprobability, that is, the panel's representativeness comes from a sample that is not a rigorous probability sample of the general population. There are no qualification requirements to enter the panel. As a result, the panel sample from Mexico exhibits skews overrepresenting higher income, higher levels of education, women, and middle-aged individuals. To address this issue, researchers requested Qualtrics^{XM}

FIGURE 1 Geographical distribution of survey responses.

to apply response quotas. In this study, the quotas were implemented to align the demographic distribution of age, gender, and income as closely as possible with the 2020 Mexican Census data.

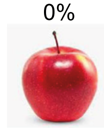
Figure 1 shows the geographic distribution of respondents throughout the country, indicating wide representation with expected clusters around urban centers. The survey's selection criteria required participation from individuals aged 18 and above who confirmed they were primarily responsible for grocery shopping in their households and had consumed fresh apples within the 3 months preceding the survey. This criterion was established to ensure that respondents were familiar with the product in question and had made purchasing decisions regarding it. It is important to note that due to these selection criteria and the composition of the Qualtrics research panel in Mexico, the sample of respondents for this study may not be a perfect representation of the Mexican population when compared to demographic data obtained from the National Institute of Statistics, Geography, and Informatics (INEGI, 2022). The survey instrument used was approved by Washington State University Institutional Review Board No. 18859.

This study uses a discrete choice experiment (DCE) to elicit respondents' WTP for fresh apples that have received different postharvest treatments (irradiation vs. chemical application), probability of insect infestation, and country of origin. Each respondent was presented with nine scenarios to mimic a grocery shopping experience for fresh apples. Table 1 and Figure 2 show that each scenario consisted of two purchase options, A and B, which differed in terms of the attributes of fresh apples (including postharvest treatment irradiation vs. chemical application vs. no treatment, probability of insect infestation 0 vs. 10%, and country of origin Mexico vs. the United States) and price in Mexican pesos per kilo (38.9, 46.9, and 54.9). In each scenario, respondents selected only one option among the three. They could choose either option A, B, or neither A nor B (labeled as option C in each scenario). The selected attributes and their levels reflect close consultation with food scientists and the fresh produce industry representatives in Mexico. The prices used were consistent with grocery store prices for fresh apples in Mexico during the time the study was conducted.

We used the JMP® software to generate a fractional factorial design with random combinations of attributes in each scenario. The JMP® software employs a two-step procedure using an algorithm taken from Kessels et al. (2011). The fractional factorial design minimized the number of scenarios, mitigating potential respondents' fatigue

TABLE 1 List of attributes and the set of possibilities for each attribute.

Attributes	Level A	Level B	Level C
Probability of finding an insect inside the apple	0	10	-
Postharvest treatment	Irradiation	Other postharvest chemical	No postharvest treatment
Country of origin	United States	Mexico	
Price (Mexican peso $/kg)	$38.9/kilo	$46.9/kilo	$54.9/kilo

Features	Option A	Option B	Option C
Probability of finding an insect inside the apple	0% 	10% 	Neither A nor B
Post-harvest treatment	No	Irradiation	
Country of origin	USA 	Mexico 	
Price (Mex$/kg)	54.9	46.9	
I would choose			

If you indicated that you would be willing to buy Product A or B, how certain are you of your answer in a scale of 1 to 10, where 1=Very Uncertain and 10=Very Certain

1	2	3	4	5	6	7	8	9	10
○	○	○	○	○	○	○	○	○	○

FIGURE 2 Hypothetical scenario survey questions.

while maximizing the D-efficiency. The D-efficiency measures how close to optimal is the experimental design. Its' values are a function of the number of observations in the design, the number of independent variables in the model, and the maximum standard error for prediction over the design observations. The best design has values close to 100 (US Department of Commerce, National Institute of Standards and Technology, 2012). In our study, the fractional factorial design ended with nine scenarios and a D-efficiency value of 92.

The study uses three treatments, following a between-subjects design, to test the information transfer style effects on the WTP for the different attributes. Treatment 1 is the control with no additional information on irradiation other than the definition. Treatment 2 presented additional information on irradiation, an extended definition, statements indicating the scientific community's support, and the benefits of irradiation. This information was a composite from websites of the WHO, FAO, and the IAEA (see Appendix A). Treatment 3 is the information on apple irradiation technology, provided by a mom blogger, with a hispanic name, who narrates her experiences when deciding to buy fresh fruits for her family and shares how she looked for information on what irradiation consists of and its benefits. Using a narrative style, we present how she interprets the information from WHO and other regulating agencies in Europe and the United States (see Appendix B).

Other questions in the survey asked respondents to rate on a 1–5 scale (1 = "not important," 5 = "extremely important") the importance of different external and eating characteristics of fresh apples when purchasing. The survey included questions on the frequency of fresh apple consumption, reasons for not consuming, who in the family consumes apples, the number of apples bought in the household, place of purchase, how are apples usually consumed, the importance of labels (e.g., private brand, grown in Mexico, free of pesticides), perceptions of new food technologies including measurement of food neophobia, knowledge of irradiation, and trusted sources of information.

To strengthen the causal inferences of the study, we employed the propensity score matching (PSM) procedure outlined in Perraillon et al. (2022). By applying PSM we adjusted for potentially confounding factors that may affect respondents' choices, which would result in biased results.[2] The variables selected as possible confounders are gender, income, family size, age, food neophobia, worked on a farm and knowledge of irradiation.[3] Given the multiple treatments, the chosen procedure uses inverse probability weightings. This approach allows for optimizing the balance and overlapping of the different treatments versus control regions in the matching samples. See Appendix C for a detailed explanation of the procedure used.

3.2 | Empirical specification

We utilize McFadden's (1974) random utility of consumer demand approach, where the utility derived from consuming a good reflects attributes of the good and not the good itself. If the consumer chooses i from a set of feasible choices A, then it must be that choice i provides at least the same utility as all other alternatives in the set. It follows that the flexible random utility formulation of the model where each individual n chooses alternative j feasible alternatives A in choice scenarios $t \in \{1,2, \ldots, T\}$, has the standard form of the utility given by

$$U_{njt} = \beta x_{njt} + \varepsilon_{njt}, \quad (1)$$

where β is a vector of utility weights, x_{njt} is a vector of observed attributes, and ε_{njt} is assumed to be distributed identically and is an independently extreme value. Rewriting Equation (1) as

$$U_{njt} = \beta_0 + \beta_n x_{njt} + \beta_p p_{jt} + \varepsilon_{njt}, \quad (2)$$

then the parameter vector, β_0 is the vector of alternative specific constant (ASC), which captures the marginal value of each option presented over the opt-out, β_n is the unobserved random coefficient vector for each consumer n's choice, and β_p is the coefficient estimate of price, which is assumed to be fixed for all individuals n, choices j and scenarios t. The estimate of individual WTP in preference space is obtained by dividing the bootstrapped coefficient estimates for each attribute by the price coefficient. The disadvantage of this approach is that assuming the effect of price is nonrandom implies homogeneous consumer preferences for price. One can assume a normal distribution for the price coefficient. However, the ratio of two normal distributions or a log-normal distribution to a normal distribution may generate ambiguous results.

A more general specification is the generalized multinomial logit (GMNL) (Fiebig et al., 2010). This specification, which nests several discrete choice models, has a utility in preference space restated as

$$U_{njt} = [\sigma_n \beta + \gamma \eta_n + (1 - \gamma)\sigma_n \eta_n] x_{njt} + \varepsilon_{njt}, \quad (3)$$

[2]This was done using the Stata -teffects ipwra- the inverse-probability-weighted regression adjustment module.

[3]These variables represent the typical demographic and knowledge metrics chosen based on their explanatory power and to ensure minimal correlation between variables. The resulting selected variables reflect covariates that resulted in the most balanced matched samples.

where σ_n is the individual specific scale variance, β is the mean attribute utility weight, η_n is a vector of individual specific utility weight deviations from the mean, and γ is a parameter between 0 and 1. This specification allows us to obtain the mixed logit model by restricting $\sigma_n = \sigma = 1$ and $\text{var}(\eta_n) = 0$. Fiebig et al. (2010) outlined two GMNL models, where:

1. GMNL-I: $\gamma = 1$. Therefore, $\beta_n = \sigma_n\beta + \eta_n$.
2. GMNL-II: $\gamma = 0$. Therefore, $\beta_n = \sigma_n(\beta + \eta_n)$.

This study estimated the parameter estimates for both GMNL-I and GMNL-II. The starting points used to estimate models included unrestricted estimates of the gamma (γ) parameters, which were all statistically different from zero and close to 1. We, therefore, chose the GMNL-I specification, where the variance of residual taste heterogeneity is invariant to the scale (Fiebig et al., 2010). The estimate of γ also confirms the existence of both the scale and taste heterogeneity in the data. Fiebig et al. (2010) raised the issue of using scaled versus unscaled ASC. This study estimates the models using scaled ASC as this outperformed the goodness of fit statistics from the unscaled ASC model.

Further, we extend the model by incorporating the measure of respondents' certainty to mitigate hypothetical bias. Each respondent indicates the level of certainty of their choices after each scenario in the DCE. The literature suggests that this technique can effectively eliminate bias inherent to the hypothetical nature of the DCE (Beck et al., 2013). This study uses a certainty scale of 1–10, with 1 = "extremely uncertain" and 10 = "extremely certain." We also re-code the data when the response indicated a certainty less or equal to 7, any choice option A or B was re-coded as none.[4] Different threshold levels are used throughout the literature, reflecting the distributional properties of the dataset being examined. For example, Ethier et al. (2000) use responses greater than seven on the certainty scale. Champ and Bishop (2001) use only responses greater than eight on the certainty scale. Champ et al. (1997) used only responses that indicated a certainty scale equal to 10. Beck et al.(2013) discuss that different approaches are used to include the certainty scale in the econometric specification used to analyze the DCE. Here, the certainty index is included as a probability weight placing more weight on the responses to choices with higher certainty. Another way is to introduce the certainty index in the degree of error of the respondent, under the assumption that the more certain, the more consistent the responses to the DCE are. In this study, we follow the approach of Kunwar et al. (2020) where the certainty scale is included in the scale parameter, as follows,

$$\sigma_n = \exp(\bar{\sigma} + \delta_1 \text{certain}_n + \delta_2 \text{uncertain}_n + \tau\varepsilon_{0n}), \tag{4}$$

where σ_n is the scale parameter, $\bar{\sigma}$ is a constant term, δ_1 and δ_2 are the parameter estimates associated with the certainty and uncertainty scale values and $\tau\varepsilon_{0n}$ is the error term. All estimations are conducted in Stata 17.0.

3.3 | Heterogeneity analyses

This study also includes a set of analyses to infer the presence of heterogeneity in the WTP across different groups for key respondents' demographic attributes. The attributes used are gender, income, number of children, age, family size, and education level. The subgroupings employed are gender = 1 if male and 0 otherwise; age = 1 if age < 30 and 0 otherwise; education = 1 if the education level is below postgraduate and 0 otherwise; income = 1 if income < 124,999 pesos/year and 0 otherwise; family size = 1 if the number of members ≤ 4, and 0 otherwise, and children = 1 if the number of children ≤ 4, and 0 otherwise. All groupings except for gender are made based on the median class of each sociodemographic attribute.

[4]The incorporation of the certainty scale was done in two stages. In the first stage when the response indicated a certainty less or equal to 7, any choice option A or B was re-coded as none. In the second stage, and to estimate Equation (4) below, we created dummy variables for the recorded data with the ≤4 for uncertain and ≥8 for certain.

4 | RESULTS AND DISCUSSIONS

Table 2 presents the demographic characteristics of respondents in the control and treatment groups and tests of the differences between these groups for both the matched and unmatched data. The unmatched data consists of a total of 2107 respondents, distributed as 703 in the control group, 703 in information treatment 2, and 701 in information treatment 3. After completing the PSM procedure, the dataset consists of a total of 1972 respondents, with 660 in the control group, 653 in information treatment 2, and 659 in information treatment 3. *p*-Values indicate that the matching method improved the balance in selected covariates between the two groups. In particular, before matching, the differences in respondents' education exceeded the 1% level of significance but was below the 5% level ($p = 0.04$). Following matching, the education's *p*-value increased ($p = 0.05$). Therefore, following matching the null hypothesis of equality between groups cannot be rejected at the 5% level for all attributes.

Table 2 also compares the sociodemographics of respondents with the Mexican population census. Our sample of respondents exhibits a higher proportion of females (64 relative to 51.2%), more years of education (16.9 relative to 9.7 years), and older individuals (34 relative to 29 years). In addition, survey respondents had more children (2.54 relative to 1.7) and significantly higher monthly income (76,114 compared to 28,381.46 Mexican pesos) (INEGI, 2022). These results indicate that the Qualtrics™ Mexican consumer research panel had a proclivity toward higher incomed residents, possibly due to the online nature of the panel.

Appendix D presents the rate of the importance of apple attributes when buying, for both the matched and unmatched data. Respondents rated the importance (on a 1–5 scale, 1 = *extremely not important*, 5 = *extremely important*). The matched versus unmatched results indicate evidence of some imbalance in the panels regarding the rating of importance respondents assigned to external quality apple attributes, and frequency of consumption where the *p*-values were 0.04 and 0.02, respectively. There was no improvement in the balance for those attributes in the matched panel. Ratings of importance assigned to phytonutrient content registered the highest scores ranging from 4.41 to 4.45 across the three survey versions. The second most important attribute was internal/eating quality apple attributes (including texture, firmness, juiciness, flavor, aroma, tartness, sweetness, and acid/sweet balance), ranging from 4.00 to 4.04. Last rated were appearance attributes (including exterior color, size, symmetrical shape, free of external appearance defects, and free of internal appearance defects) with a rating ranging from 3.67 to 3.75. These results contrast those of Carrillo-Rodríguez (2013) on fresh apples, Uddin et al. (2022), and Uddin et al. (2023) on fresh table grapes, who found that US respondents rated eating quality as the highest in importance, followed by external appearance, and lastly, phytonutrient content. In the United States, phytonutrient content is ranked as the least important factor, whereas in Mexico, it holds the top position in terms of importance. This indicates that consumers in different countries assign varying degrees of importance to different sets of attributes. This difference in prioritization may be influenced by contextual factors specific to each country.

Apples are purchased on average about 73 times per year, with approximately 0.88 kg on average per purchase occasion making 64.24 kg per year per household. Considering the average household size is 4, we calculate the average per capita consumption at 16 kg per year. This apple per capita consumption is higher than the 7 kg reported by Statista for 2021 (Statista, 2023). Over 64% of our respondents consumed fresh apples alone as snacks (Appendix D).

Appendix E presents the results of the ratings of the importance of various factors, for the matched and unmatched data, when deciding to purchase apples; on a 1–5 scale, 1 = *extremely not important*, 5 = *extremely important*. The *p*-values for the tests of differences across groups suggest no evidence of imbalance across any of these attributes. Respondents rated health and nutrition as the highest in importance when making apple purchase decisions, with a rate of 4.52–4.56. The religious, ethical, or cultural considerations were the least important, with a rate of 2.09–2.12. Price ranked 5th out of the 13 factors, including falling behind healthy and nutritious, taste good, produced in a family ranch, and use of sustainable agricultural practices. Produced in Mexico ranked 9th and produced with little pesticides (that could be a proxy for chemical use) was ranked 10th.

TABLE 2 Sociodemographic characteristics for each treatment sample of respondents, corrected with the propensity score-matching and compared with Mexican Census data.

	Nonmatched respondents (N = 2107)				Propensity score-matched respondents (N = 1972)				
	Information treatment 1—Control	Information treatment 2—Scientific	Information treatment 3—Blog	p-Value	Information treatment 1—Control	Information treatment 2—Scientific	Information treatment 3—Blog	p-Value	Mexico 2020 Census
N	703	703	701		660	653	659		
Gender									
Male	260 (37%)	246 (35%)	246 (35%)		248 (38%)	229 (35%)	235 (36%)		
Female	443 (63%)	457 (65%)	455 (65%)	0.68	412 (62%)	424 (65%)	424 (64%)	0.61	0.51
Education									
Avg. years of schooling	16.9	16.8	17	0.04	16.9	16.8	17	0.05	9.7
Incomplete high school	2 (0.3%)	6 (0.9%)	2 (0.3%)		2 (0.3%)	6 (0.9%)	2 (0.3%)		
Complete high school	14 (2%)	13 (2%)	22 (3%)		14 (2%)	13 (2%)	19 (3%)		
Preparatory school	117 (17%)	120 (17%)	112 (16%)		106 (16%)	99 (15%)	97 (15%)		
Higher technical or professional degree	53 (8%)	65 (9%)	5 (7%)		51 (8%)	58 (9%)	47 (7%)		
Bachelor's degree	440 (63%)	399 (57%)	398 (57%)		419 (64%)	384 (59%)	384 (58%)		
Postgraduate	77 (11%)	100 (14%)	116 (17%)		68 (10%)	93 (14%)	110 (17%)		
Number of children									
Avg. number of children	2.5	2.5	2.6	0.78	2.5	2.5	2.6	0.84	1.7
1	149 (21%)	150 (21%)	148 (21%)		139 (21%)	135 (21%)	137 (21%)		
2	215 (31%)	192 (27%)	194 (28%)		202 (31%)	179 (27%)	182 (28%)		
3	193 (28%)	216 (31%)	213 (30%)		188 (29%)	205 (31%)	202 (31)		
4	121 (17%)	123 (18%)	119 (17%)		107 (16%)	112 (17%)	111 (17%)		

TABLE 2 (Continued)

	Nonmatched respondents (N = 2107)				Propensity score-matched respondents (N = 1972)				
	Information treatment 1—Control	Information treatment 2—Scientific	Information treatment 3—Blog	p-Value	Information treatment 1—Control	Information treatment 2—Scientific	Information treatment 3—Blog	p-Value	Mexico 2020 Census
5	21 (3%)	18 (3%)	20 (3%)		20 (3%)	18 (3%)	20 (3%)		
6	2 (0.3%)	4 (0.6%)	7 (1%)		2 (0.3%)	4 (0.6%)	7 (1%)		
Family size									
Avg. size (number)	4	3.9	3.9	0.90	4	3.9	3.9	0.92	3.6
1	34 (5%)	39 (6%)	48 (7%)		29 (4%)	33 (5%)	43 (7%)		
2	65 (9%)	68 (10%)	69 (10%)		62 (9%)	63 (10%)	63 (10%)		
3	124 (18%)	136 (19%)	129 (18%)		117 (18%)	124 (19%)	123 (19%)		
4	217 (31%)	213 (30%)	206 (29%)		210 (32%)	206 (32%)	194 (30%)		
5	175 (25%)	167 (24%)	159 (23%)		160 (24%)	151 (23%)	152 (23%)		
6	88 (13%)	80 (11%)	90 (13%)		82 (12%)	76 (12%)	84 (13%)		
Household monthly income (Mexican pesos)									
Avg. monthly income (Mexican pesos)	78,402.77	79,017.99	72,520.84	0.12	76,817.68	78,548.75	72,976.77	0.09	28,381.46
Less than 4999	28 (4%)	34 (5%)	45 (6%)		27 (4%)	32 (5%)	43 (7%)		
5000–24,999	174 (25%)	171 (24%)	188 (27%)		168 (26%)	160 (25%)	173 (26%)		
25,000–49,999	91 (13%)	78 (11%)	69 (10%)		88 (13%)	73 (11%)	66 (10%)		
50,000–74,999	134 (19%)	134 (19%)	142 (20%)		126 (19%)	117 (18%)	134 (20%)		
75,000–99,999	53 (8%)	69 (10%)	67 (10%)		48 (7%)	66 (10%)	62 (10%)		
100,000–124,999	63 (9%)	54 (8%)	43 (6%)		58 (9%)	52 (8%)	40 (6%)		
125,000– 149,999	38 (5%)	27 (4%)	35 (5%)		34 (5%)	24 (4%)	35 (5%)		

(Continues)

TABLE 2 (Continued)

	Nonmatched respondents (N = 2107)				Propensity score-matched respondents (N = 1972)				
	Information treatment 1—Control	Information treatment 2—Scientific	Information treatment 3—Blog	p-Value	Information treatment 1—Control	Information treatment 2—Scientific	Information treatment 3—Blog	p-Value	Mexico 2020 Census
150,000–174,999	28 (4%)	47 (7%)	40 (6%)		25 (4%)	45 (7%)	39 (6%)		
175,000–199,999	33 (5%)	31 (4%)	29 (4%)		32 (5%)	31 (5%)	28 (4%)		
More than 200,000	61 (9%)	58 (8%)	43 (6%)		54 (8%)	53 (8%)	39 (6%)		
Avg. age (years)	34 (10%)	33 (10%)	34 (10%)	0.27	34.20 (10%)	33.31 (9%)	33.85 (9%)	0.44	29

Note: Percent values in parentheses. *p*-Values indicate test results of equality of groups with Pearson χ^2 tests for equality between groups for factor variables and Kruskal–Wallis test for equality between levels of variable group.

Source: https://www.inegi.org.mx/programas/ccpv/2020/

Appendix F shows the results of respondents' knowledge of farming and Postharvest treatment methods across control and treatments, for unmatched and matched samples. The *p*-values indicate evidence of imbalance across samples with regard to individuals who have worked on farms and who have received training in agriculture, with *p*-values of 0.01 and 0.02, respectively. This imbalance was generally unchanged after matching. Overall, respondents had the most extensive knowledge of conventional farming from a list of four agricultural methods, using a 1–5 scale where 1 = *have never heard*, and 5 = *expert in the technology*. The second largest knowledge was for organic farming, followed by using chemicals as a postharvest treatment and finally using irradiation as a postharvest treatment. This result coincides with the literature in that irradiation remains an unknown technology (Henson et al., 2008). In addition, Appendix F presents the results of respondents' familiarity with agricultural production methods. Responses show that 43% of respondents have worked in agriculture, 42% have worked on a farm, and 28% have training in agriculture.

The survey also asked respondents to rate how much they trust their sources of information for the foods they consume (see Appendix F). A scale of 1–5 was used, with 1 = strongly do not trust, and 5 = strongly trust. Results show that respondents assigned the highest ratings of trust to friends and family, followed by producer groups, consumer groups, government, and scientific groups. The media was the least trusted source of information. These results contrast with findings of a survey in the United States by the PEW Research Center in which respondents selected medical scientists and scientists as the group most likely to act in the public's best interests over the military, police officers, public school principals, religious leaders, journalists, business leaders, and elected officials (Kennedy et al., 2022).

Appendix G provides the assessment of respondents' willingness to accept new food technologies, for the matched dataset, using the food technology neophobia scale (FTNS), a psychometric measure developed by Cox and Evans (2008). Their study noted that the scale could range from 13 to 99, with higher scores indicating more neophobia. Using a sample of 294 individuals in Australia, they calculated an average score of 55, ranging from 21 to 88. Garrido et al. (2021) also used the scale on a sample of 102 panelists evaluating microwaved ready meals, recruited in Pullman, Washington. They found a FTNS score of 47.66, and values ranged from 24 to 68. Appendix G shows that the FTNS score for our sample of respondents is 55.37, with values that ranged from 26 to 78. Therefore, the Mexican consumers in our survey are as neophobic as the sample in Cox and Evans (2008) and more neophobic than the sample in Garrido et al. (2021).

4.1 | Generalized multinomial model (GMNL) results

The results of the GMNL model for each of the three information treatments are presented in Table 3. All models are estimated using the matched dataset. Across all models, except for the control, the coefficient estimates for the ASC are not statistically significant. In the control, the ASC coefficient for option A is positive and statistically significant. This indicates for this specific sample respondents favored option A over option B and the opt-out.

Across all information treatments respondents stated a price discount (negative WTP) for the use of chemical application as postharvest treatment compared to no treatment. The discount ranged from 169.10 to 190 pesos/kg. The discount increased with the provision of information, being the highest for respondents who were presented with the layman style explanation of irradiation. For the control sample, respondents indicated a willingness to discount 75.14 pesos/kg for irradiated apples compared to untreated ones. The discount was not statistically significant for individuals who were presented with information, in either style. This outcome suggests that respondents' WTP for irradiation when from negative to indifferent with respect to the no treatment. Also results imply that these individuals have a stronger aversion to the use of chemicals to prevent insect infestation compared to the use of irradiation.

Across all treatments, respondents indicated that they would pay a price premium for Mexican-grown apples compared to those imported from the United States. The premium increased with the provision of information

TABLE 3 Estimated parameters of GMNL-I model with scaled alternative specific constant to estimate the willingness to pay for different apple attributes under three information treatments.

Variable	Information treatment 1—Control Coefficient estimate	Std. error	Information treatment 2—Scientific Coefficient estimate	Std. error	Control versus scientific p-Value	Information treatment 3—Blog Coefficient estimate	Std. error	Control versus Blog p-Value
Mean								
Alternative specific constant—Option A	45.42*	−2.23	13.64	0.94	0.01	21.51	1.29	0.02
Alternative specific constant—Option B	6.99	−0.58	−0.47	0.04	0.22	−16.32	1.48	0.18
Postharv. treatment: Chem. application = 1, 0 ow	−169.10***	−4.22	−184.80***	4.07	0.00	−190.00***	3.89	0.00
Postharv. treatment: Irradiation = 1,0 ow	−75.14***	−3.99	−18.05	1.37	0.00	17.78	1.33	0.00
Country of origin: Mexico = 1, US = 0	126.70***	−3.72	140.10***	3.62	0.00	163.30***	3.62	0.00
Probability of insect infestation	−13.08***	−4.60	−15.94***	4.50	0.10	−17.03***	4.28	0.00
Standard deviation								
Alternative specific constant—Option A	65.43***	7.27	128.30***	4.06		92.75***	3.89	
Alternative specific constant—Option B	11.73	1.81	−4.39	0.25		−12.81	1.04	
Postharv. treatment: Chem. application = 1, 0 ow	94.77***	6.18	212.30***	3.98		202.80***	3.89	
Postharv. treatment: Irradiation = 1,0 ow	110.70***	6.71	−206.30***	4.16		−221.60***	4.01	
Country of origin: Mexico = 1, US = 0	103.20***	7.12	192.10***	4.13		−167.90***	3.99	
Probability of insect infestation	9.73***	7.18	−15.87***	4.26		−14.06***	4.10	

TABLE 3 (Continued)

Variable	Information treatment 1—Control Coefficient estimate	Std. error	Information treatment 2—Scientific Coefficient estimate	Std. error	Control versus scientific p-Value	Information treatment 3—Blog Coefficient estimate	Std. error	Control versus Blog p-Value
Heterogeneity: Certain	−0.675***	12.38	−0.69***	17.68		−0.70***	16.64	
Heterogeneity: Uncertain	−3.716***	18.38	−3.80***	17.13		−3.89***	17.44	
Scale heterogeneity (tau)	0.947***	−10.3	0.87***	7.98		0.85***	8.81	
Observations	17,814		17,631			17,793		
BIC	11,070		10,885.4			10,996.5		
AIC	10,961		10,768.7			10,879.7		
Log-likelihood	−5466.5		−5369.4			−5424.9		

Note: *, ** and*** indicate statistical significance at 10%, 5%, and 1% alpha levels, respectively. *p*-Values indicate results of Wald test for joint hypothesis $\beta_{control} = 0$, $\beta_{contol} = \beta_{treatment}$.
Abbreviations: AIC, Akaike information criterion; BIC, Bayesian information criterion.

being the highest for the group who were presented with the information using layman style. It is possible that the layman style induced side effects due to its author's hispanic name. Consequently, the WTP for Mexican-grown apples was the highest under treatment 3. Respondents also indicated their willingness to discount for a higher probability of finding insect damage in their apples. Again, this discount increased for the groups who were presented with information, being the highest for the group presented with the information in layman style.

Also, across all treatments, the standard deviation of the coefficient estimates for the attributes included were all statistically significant, indicating heterogeneity in the WTP across respondents. The tau (τ) parameter captures scale heterogeneity, and the positive and significant value suggests the presence of scale heterogeneity in the data. Both the "certain" and "uncertain" coefficients were negative and significant in their effect on the scale factor. This result suggests that respondents were stochastic if they indicate strong certainty or uncertainty about their choices.

Overall, findings imply that the information—regardless of its style—led to a more positive perception of irradiated fresh apples. Consumers went from requiring a negative WTP for irradiated apples with respect to untreated, to WTP for irradiated apples not statistically significant different from untreated. These results are aligned with previous literature indicating that positive information about irradiation led to higher WTP (Fox et al., 2002; Nayga, 2003; Nayga et al., 2004, 2005; Rimal et al., 2004). We acknowledge that part of this improvement may be influenced by the imbalance in the proportion of respondents who worked in a farm or who received training in agriculture, as reported in Appendix F. Despite our efforts applying the PSM, the imbalance remains, as evidenced by the higher proportion of individuals with farming experience or agricultural training in samples exposed to information in either style.

These results are also consistent with the findings of Yang and Hobbs (2020) that information reduces the discount to consume apples treated with a controversial technology. Yang and Hobbs (2020) similarly found that the layperson's blog information outperformed the scientific style. The results regarding WTP for chemical treatment versus irradiation are consistent with those of Bearth and Siegrist (2019), who found a strong negative cross-informational effect where increased knowledge of one technology leads to more negative attitudes toward other technologies. Regarding the country of origin, the results are also in line with authors

TABLE 4 Coefficient estimates of the GMNL-I model with scaled alternative specific constant, by sociodemographic groups.

	Coefficient estimates								
	Gender			Age			Education		
Variable	Male	Female	Male versus female p-Value	<30	≥30	<30 versus ≥30 p-Value	Below postgrad.	Postgrad	Below postgrad versus postgrad p-Value
Mean									
Alternative specific constant—Option A	171.30	95.14	0.20	192.40	97.05*	0.06	190.20	117.40	0.17
	(1.09)	(1.45)		(0.34)	(2.26)		(0.60)	(1.74)	
Alternative specific constant—Option B	51.67	22.87	0.44	−3.53	36.42	0.10	−0.58	38.27	0.34
	(0.95)	(0.80)		(0.03)	(1.83)		(0.01)	(1.32)	
Postharv. treatment: Chem. Application = 1, 0 ow	−269.60	−261.50*	0.08	−871.70	−164.80**	0.05	−460.80	−241.00*	0.07
	(1.26)	(2.00)		(0.41)	(2.85)		(0.70)	(2.24)	
Postharv. treatment: Irradiation = 1, 0 ow	−73.25	−123.30*	0.08	−407.80	−55.99**	0.04	−255.30	−78.65*	0.06
	(1.24)	(2.02)		(0.41)	(2.63)		(0.72)	(2.13)	
Country of origin: Mexico = 1, US = 0	237.70	194.70	0.11	745.20	119.10*	0.08	356.10	190.80*	0.10
	(1.15)	(1.84)		(0.40)	(2.41)		(0.67)	−2.02	
Probability of insect infestation	−22.15	−18.17*	0.06	−76.24	−12.22**	0.03	−33.03	−17.28*	0.05
	(1.34)	(2.13)		(0.42)	(3.17)		(0.74)	(2.40)	

TABLE 4 (Continued)

Variable	Coefficient estimates: Gender: Male	Female	Male versus female p-Value	Age: <30	≥30	<30 versus ≥30 p-Value	Education: Below postgrad.	Postgrad	Below postgrad versus postgrad p-Value
Standard deviation									
Alternative specific constant—Option A	0.59***	0.89***		−0.84***	−0.71***		0.88***	0.79***	
	(4.35)	(9.58)		(7.45)	(7.12)		(6.22)	(9.37)	
Alternative specific constant—Option B	0.01	0.09		0.09	0.00		−0.16	0.00	
	(0.06)	(0.61)		(0.52)	(0.03)		(0.57)	(0.04)	
Postharv. treatment: Chem. Application = 1, 0 ow	−1.13***	1.20***		0.96***	1.40***		−1.07***	1.22***	
	(7.54)	(9.01)		(6.21)	(10.64)		(4.84)	(10.72)	
Postharv. treatment: Irradiation = 1, 0 ow	−1.55***	−1.48***		1.38***	1.65***		−1.44***	−1.57***	
	(10.09)	(12.52)		(9.50)	(12.92)		(7.58)	(13.99)	
Country of origin: Mexico = 1, U.S. = 0	0.94***	−1.22***		1.25***	1.06***		1.47***	−0.99***	
	(7.30)	(12.41)		(11.22)	(9.37)		(9.27)	(9.91)	

(Continues)

TABLE 4 (Continued)

Variable	Coefficient estimates: Gender – Male	Gender – Female	Male versus female p-Value	Age – <30	Age – ≥30	<30 versus ≥30 p-Value	Education – Below postgrad.	Education – Postgrad	Below postgrad versus postgrad p-Value
Probability of insect infestation	−0.12***	−0.12***		0.09***	0.14***		−0.14***	−0.11***	
	(8.68)	(10.90)		(7.17)	(12.33)		(7.36)	(12.11)	
Heterogeneity: Constant	−5.05***	−5.12***		−6.51**	−4.53***		−5.61***	−5.01***	
	(6.58)	(10.48)		(2.68)	(13.42)		(4.06)	(11.51)	
Scale heterogeneity (tau)	1.22***	0.70***		0.52***	1.05***		0.95***	0.88***	
	(6.03)	(6.71)		(3.75)	(7.21)		(5.08)	(6.69)	
Observations	6696	11,118		6480	11,334		4671	13143	
BIC	4208.5	6949.4		4174.9	6915.8		2963.4	8170.9	
AIC	4113.2	6846.9		4080.0	6813.1		2873.1	8066.1	
Log-likelihood	−2042.6	−3409.5		−2026.0	−3392.6		−1422.5	−4019.1	

Variable	Coefficient estimates: Family size – Number ≤4	Family size – Number >4	Number ≤4 versus Number >4 p-Value	Number of children – Number ≤4	Number of children – Number >4	Number ≤4 versus Number >4 p-Value	Annual household income – <124,999 pesos/year	Annual household income – ≥124,999 pesos/year	<124,999 pesos/year versus ≥124,999 pesos/year p-Value
Mean									
Alternative specific constant—Option A	175.10	93.71	0.20	156.10	50.58	0.16	979.80	32.80	0.18
	(0.68)	(1.44)		(1.18)	(1.77)		(0.26)	(1.90)	
Alternative specific constant—Option B	37.06	25.01	0.40	50.12	17.51	0.19	247.00	11.03	0.33
	(0.45)	(0.85)		(0.87)	(1.18)		(0.24)	(1.08)	

TABLE 4 (Continued)

Variable	Coefficient estimates: Family size: Number ≤4	Family size: Number >4	Number ≤4 versus Number >4 p-Value	Number of children: Number ≤4	Number of children: Number >4	Number ≤4 versus Number >4 p-Value	Annual household income: <124,999 pesos/year	Annual household income: ≥124,999 pesos/year	<124,999 pesos/year versus ≥124,999 pesos/year p-Value
Postharv. treatment: Chem. Application = 1, 0 ow	−460.90	−261.60*	0.08	−419.90	−88.97**	0.10	−2073.60	−77.40***	0.06
	(0.81)	(2.01)		(1.46)	(2.58)		(0.27)	(3.30)	
Postharv. treatment: Irradiation = 1, 0 ow	−199.20	−122.70*	0.08	−191.70	−26.11*	0.10	−847.00	−20.46*	0.06
	(0.82)	(2.03)		(1.48)	(2.10)		(0.27)	(2.22)	
Country of origin: Mexico = 1, US = 0	326.40	194.10	0.12	317.20	57.58	0.14	1624.40	54.75*	0.09
	(0.77)	(1.84)		(1.39)	(1.86)		(0.27)	(2.42)	
Probability of insect infestation	−28.49	−17.95*	0.06	−29.59	−7.62**	0.08	−131.90	−7.74***	0.04
	(0.85)	(2.14)		(1.52)	(3.02)		(0.27)	(4.10)	
Standard deviation									
Alternative specific constant—Option A	0.99***	0.90***		0.86***	0.56**		0.76***	0.78***	
	(7.84)	(9.75)		(10.62)	(3.12)		(8.28)	(6.36)	
Alternative specific constant—Option B	0.04	0.09		0.018	0.02		−0.06	0.04	
	(0.20)	(0.61)		(0.15)	(0.07)		(0.53)	(0.15)	
Postharv. treatment: Chem. Application = 1, 0 ow	1.07***	−1.18***		−1.23***	1.09***		1.09***	1.33***	
	(5.36)	(9.26)		(10.49)	(5.57)		(8.30)	(7.99)	
Postharv. treatment: Irradiation = 1, 0 ow	1.68***	−1.50***		−1.55***	−1.42***		1.61***	−1.40***	
	(9.34)	(12.66)		(14.51)	(6.50)		(12.56)	(9.40)	

(Continues)

TABLE 4 (Continued)

Variable	Coefficient estimates: Family size: Number ≤4	Family size: Number >4	Number ≤4 versus Number >4 p-Value	Number of children: Number ≤4	Number of children: Number >4	Number ≤4 versus Number >4 p-Value	Annual household income: <124,999 pesos/year	Annual household income: ≥124,999 pesos/year	<124,999 pesos/year versus ≥124,999 pesos/year p-Value
Country of origin: Mexico = 1, US = 0	−1.26***	−1.20***		−1.22***	−0.83***		−1.24***	0.98***	
	(9.05)	(12.29)		(14.75)	(4.69)		(12.12)	(7.47)	
Probability of insect infestation	0.13***	0.12***		−0.12***	0.11***		−0.12***	−0.11***	
	(8.38)	(11.25)		(12.82)	−6.20		(11.53)	(7.87)	
Heterogeneity: Constant	−5.66***	−5.11***		−5.59***	−3.85***		−0.73***	1.22***	
	(4.66)	(10.50)		(8.25)	(10.34)		(6.95)	(4.96)	
Scale heterogeneity (tau)	0.86***	0.70***		0.57***	1.34***		−0.73***	1.22***	
	(6.51)	(6.35)		(6.09)	(5.87)		(6.95)	(4.96)	
Observations	5613	11,118		14,277	3537		11,037	6777	
BIC	3589.1	6948.7		8873.1	2255		6857.8	4306.5	
AIC	3496.3	6846.2		8767.2	2168.6		6755.5	4211	
Log-likelihood	−1734.1	−3409.1		−4369.6	−1070.3		−3363.7	−2091.5	

Note: Standard errors in parentheses. *, ** and *** indicate statistical significance at 10%, 5%, and 1% alpha levels, respectively. *p*-Values indicate results of Wald test for joint hypothesis $\beta_{group_1} = 0, \beta_{group1} = \beta_{group2}$. Estimated for different sociodemographic groups, each group was defined by the median class of each demographic group, except for gender. Group 1 refers to males, age < 30, income < 124,999 pesos/year, family size ≤ four members, number of children ≤ 4, and below postgraduate education. Group 2 refers to the counterpart of group 1: females, age ≥ 30, income ≥ 124,999 pesos/year, family size > 4 members, number of children > 4, and above postgraduate education.

like Yeh, Hartmann, & Hirsch (2018), who found that country of origin significantly impacts consumers' WTP, with a preference for domestically produced irradiated foods.

4.2 | Heterogeneity analyses

Table 4 presents the complete set of results for the GMML coefficient estimates for each sociodemographic subgroup: gender (male vs. female), age (younger vs. older than 30 years old), education (postgraduate attainment vs. education below the postgraduate level), family size (less or equal vs. more than four members in the household), presence of children in the household (less or equal to four children vs. more than four children), and income (annual household income less than 124,999 pesos vs. more or equal to 124,999 pesos). These groupings, except for gender, reflect separations by the median class of each demographic group.

We conducted Wald tests to assess differences in parameter estimates across the above-mentioned sociodemographic subgroups. We discuss only results that are statistically significant at the 10% level. The discount (negative WTP) for both chemical applications and irradiation was larger—compared to their counterparts—for the following sociodemographic subgroups: females, individuals equal and older than 30 years old, individuals with a postgraduate education, individuals in households with more than four members and whose income was equal or greater than 124,999 pesos/year. Individuals in households with more than four children were willing to discount more compared to their counterpart for chemical application but not for irradiation. For each sociodemographic group, the average discount required for chemical treatments was higher than for irradiation treatments.

These results suggest that individuals that are females, older, with postgraduate education, larger family size and higher income display a larger discount for chemical and irradiation compared to no postharvest treatment. Our results are consistent with findings in Nayga et al. (2005) and Malone (1990) which concluded that being female, having greater education, and having higher household income exhibited a more considerable aversion to irradiated foods than their counterpart. Of note, there is some ambiguity in the literature with regard to the effect of gender on the WTP for irradiated foods as Frenzen et al. (2001) and Hinson et al. (1998) found that the acceptance of irradiated foods was associated with being female, having greater education, and having a higher household income.

5 | CONCLUSIONS

This study focuses on a particular instance of consumer adoption related to an alternative food technology, irradiation. More precisely, we employ discrete choice methods to estimate the WTP of a sample of Mexican consumers for fresh apples treated with irradiation as opposed to the more prevalent chemical treatments used to control insect infestation during storage. We replicated the elicitation, dividing our pool of respondents into three groups. Each group received information about irradiation applications using distinct communication styles: one was presented with a scientific source and narrative style, another group received a layman's narrative, and third group served as the control, and received no additional information. PSM was used to adjust for potential confounding effects among the three groups of respondents. Further, we incorporate a measure of certainty to mitigate potential the hypothetical bias associated with responses to discrete choice scenarios in a survey setting.

The implications for the agribusiness industry emphasizes consumers' reluctance toward alternative food technologies. An interesting discovery is that the reluctance to irradiation was less pronounced compared to the use of chemicals to prevent insect infestation of fresh apples in storage. Another interesting finding is the role of information exposure in shaping respondents' WTP. Notably, the presentation of information using both scientific and layman narrative styles reduced the aversion to irradiation technology, changing it from a willingness to discount to a state of indifference with respect to the no postharvest treatment, when receiving information in both styles. Consistent with prior research, this study finds that the WTP for irradiated food is influenced by several demographic factors, income, age, family size, and level of education.

The findings of this study validate earlier research, which demonstrated that providing information about the advantages of alternative food technologies, such as irradiation, lead to positive changes in consumer's WTP. These results underscore the importance of a well-structured marketing communication campaign aimed at educating the public about the benefits and associated risks of irradiation with the goal of mitigating consumers' resistance. This campaign should highlight the advantages of irradiation, emphasizing its safety for consumers and its role in eliminating the need for chemical postharvest treatments. A limitation of the study is the small potential for generalization, as the sample of respondents in this study is not a perfect representation of the Mexican population. We acknowledge that our results are applicable to the specific group represented in our sample, higher income, higher educated, women, and middle-aged individuals. Further research should aim to gather a more representative sample of the Mexican population. This will provide a more precise insight into the perceptions held by the entire population regarding the various technologies used in the preservation of fresh fruits.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

Data are available on request and will be made publicly available in conformity with Journal publication requirements.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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