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## COVID-19 and Beef Consumption in Mexico

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### Abstract

This study evaluated Mexican consumers' perceptions of the association between COVID-19 transmission and food consumption and assessed changes in their preferences for beef product attributes before and during the pandemic. Data were collected through two online consumer surveys (n = 2,020). Nearly half of the respondents (48.2%) perceived high/medium risks of being infected with COVID-19 through food. Results indicated a reduction in the ratings (i.e., preferences) of sensory and organoleptic attributes (freshness, flavor, and color) and food safety before and during the pandemic. Conversely, there was an increase in the ratings of extrinsic and production-related characteristics (organic labeling, production system, and traceability).

**Keywords:** preferences, perceptions, COVID-19

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## Introduction

Since the beginning of the pandemic, COVID-19 has been associated with the meat supply chain, as the earliest cases of COVID-19 were linked to a food market in Wuhan City, China, where wild animals were being sold (Maxmen, 2021). In the United States, COVID-19 outbreaks in meatpacking plants received extensive news media coverage. By July 2020, it was estimated that livestock plants were associated with a large number of COVID-19 cases and clusters in rural areas (Taylor, Boulos, and Almond, 2020). China imposed testing requirements for meat imports as well and reportedly found coronavirus on the surface of meat packaging samples from several countries (He and Mu, 2021).

While some studies have reported certain short-term modifications in meat consumption and increased demand for plant-based protein, it is too early to tell whether the pandemic will result in long-term changes in consumers' preferences for meat products (Master, 2020). However, there is some evidence that past public health crises, including the Avian Health Influenza in 2013 and the 2019 African Swine Flu in Asia, had long-term adverse effects on consumers' demand for poultry and pork, respectively, because of food safety concerns (Zhou et al., 2016; Pan, 2019).

Similarly, Bovine Spongiform Encephalopathy (BSE) outbreaks in the United Kingdom and Canada during the 1980s and 1990s led to a long-term reduction in beef sales and heightened risk perceptions of consuming beef (Burton, Young, and Cromb, 1999). While previous health crises have been regionally localized, COVID-19 is a pandemic, and thus, it might affect consumers' preferences globally. Several studies have been conducted to study food consumption habits during the pandemic, but they have focused primarily on developed countries (BfR, 2020; McFadden et al., 2021).

No evidence links food consumption with COVID-19 transmission, and major international agencies have provided guidance to clarify this misconception and allay consumers' concerns. However, widespread rumors, misconceptions, and confusion persist (Mardones et al., 2020; World Health Organization, 2020). This study's objective was to evaluate Mexican consumers' perceptions of the potential association between COVID-19 transmission and food consumption. Further, the study also assessed changes in consumers' preferences for beef products' attributes using data collected before the pandemic (December 2019–February 2020) and during the pandemic (December 2020).

Mexico is located in the southern portion of North America and has a population of approximately 130 million. Although the country is still classified as a developing upper-middle country, it is among the 15 largest economies globally and the second-largest in Latin America (World Bank, 2020). It was estimated that the Mexican economy contracted by 8.2% in 2020. The United States Department of Agriculture (USDA) also reported decreased beef and pork consumption in Mexico, attributable largely to a decrease in households' income because of the pandemic (USDA Foreign Agricultural Service, 2020). Less is known about the potential effect on food consumption habits of changes in consumers' food safety concerns because of COVID-19. The first case of COVID-19 was detected in Mexico on February 27, 2020. Overall, the country has experienced two

pandemic waves—the first with a peak in mid-July 2020 and the second in mid-January 2021. As of October 1, 2021, the country reported the fourth-highest number of deaths attributable to COVID-19 globally (more than 277,000). The Mexican government's COVID-19 response to the pandemic has been controversial as, for example, its president indicated initially that the pandemic's potential effects on people's health were less severe than the evidence suggested (Ibarra-Nava et al., 2020).

## Material and Methods

The study data were obtained from two Qualtrics online surveys of 2,020 Mexican consumers. The first survey ( $n = 1,000$ ) was carried out before the pandemic (December 2019–February 2020), while the second ( $n = 1,020$ ) was conducted in December 2020 during the pandemic. The surveys were designed to collect data from a representative sample of Mexican meat consumers. Respondents were required to be 18 years old and those responsible for (or who help with) meat purchases in the household. Both surveys collected information on socioeconomic demographic characteristics, meat consumption habits, and perceptions of the importance of various meat products' attributes. The question about attributes asked respondents to evaluate the significance of 13 product characteristics when purchasing beef. The questions were answered on a 5-point Likert scale that ranged from 1 = “least important” to 5 = “most important.” The attributes considered included freshness, flavor, color, tenderness, juiciness, food safety, price, preparation ease, product leanness, country of origin, traceability, organic labeling, and production system.

The second survey also included two questions about the relation between COVID-19 and food consumption: i) What do you think are the risks of being infected with the coronavirus (COVID-19) through food? and ii) What do you think are the risks of being infected with the coronavirus (COVID-19) through the consumption of meats from the following countries: Mexico, United States, Canada, and Nicaragua? These questions were adapted from the Corona-Monitor study conducted in Germany by the German Federal Institute for Risk Assessment (BfR, 2020). The countries named in the second question are the leading providers of beef products to Mexico, as the original project's emphasis was on beef demand (UN Comtrade, 2019). In both cases, the following choices were possible answers: there is no risk, low risk, medium risk, high risk, and I don't know.

Three types of statistical analyses were conducted. First, summary statistics of the variables of the sociodemographic characteristics were calculated. Second, Chi-square tests were used to evaluate the association between risk perceptions of COVID-19 contamination through food and sociodemographic characteristics and the association between risk perceptions of COVID-19 contamination through meats and country of origin. Finally, linear regression models were used to assess changes in consumers' perceptions of beef product attributes in the periods before and during the pandemic. Two versions of the linear regression models were estimated. The first version used the attributes importance rating as the dependent variable ( $y$ ) and a dummy indicating the survey period (0 = Pre-pandemic, 1 = Pandemic) as explanatory variable ( $d$ ) (unadjusted model):

$$y = \alpha + \gamma d + u, \quad (1)$$

where  $\alpha$  is the model intercept,  $\gamma$  is the coefficient measuring the change in average attribute ratings during the pandemic relative to the prepandemic period, and  $u$  is an error term. The second version also had the attribute importance rating as the dependent variable. As explanatory variables, it included the dummy indicating the survey period ( $d$ ) as well as respondents' age, household size, gender dummy, location dummy (urban vs. rural), a dummy for the presence of children, education level, and income group (adjusted model):

$$y = \tilde{\alpha} + \tilde{\gamma} d + \beta' x + \tilde{u}, \quad (2)$$

where  $\tilde{\alpha}$  is the model intercept,  $\tilde{\gamma}$  is the coefficient measuring the change in average ratings during the pandemic relative to the prepandemic period after controlling for the vector of characteristics  $x$  (with associated vector of coefficients  $\beta$ ), and  $\tilde{u}$  is an error term.

Our analyses were based on Lancaster's (1966) consumer demand theory. According to Lancaster, consumers have preferences for products' attributes; thus, each good represents a bundle of attributes. Accordingly, we evaluated the link between the COVID-19 health crisis and consumers' perceived importance of food attributes.

After observations with missing values for the primary outcomes of interest (risk perceptions and beef attributes importance) were eliminated, 814 observations from the first survey and 1,020 from the second survey were available for statistical analyses.

## Results

Most of the survey participants were female (59%), had a professional level of education (70.3%), lived in a household with children (75%), and lived in urban areas (93%). The respondents' mean age was 34 years, and the average household had approximately four members (see Table 1). The respondents' median monthly household income was between 8,000–12,999 Pesos (400–650 USD). The comparison of the sociodemographic characteristics among samples reflected certain differences in their composition, the most considerable of which were in education and income. The sample collected before the pandemic had a higher proportion of professional individuals (76.4% before, 65% during the pandemic) and a higher proportion of households with higher income levels (e.g., 19.66% of the pre-pandemic sample had incomes higher than 30,000 pesos, while only 10% in the pandemic sample had this income level).

How do the samples compare to the general population of Mexican consumers? Individuals in the samples were older and more educated than the average person in the Mexican population (see Table 1). The samples also had more female respondents and more urban dwellers. However, some of these differences are expected because the survey target was not the general Mexican population but the population of meat shoppers, which is likely to include more females and older individuals with higher education levels. Further, using an online survey likely resulted in a sample with a higher proportion of urban individuals relative to the general population. With respect to income,

the sample in the second survey was designed to have the same income composition as that observed in the population (National Institute of Statistics and Geography, 2018) (see Table 1).

**Table 1.** Consumers' Sociodemographic Characteristics

Characteristics	Both Samples	Before Pandemic (Dec. 2019)	During Pandemic (Dec. 2020)	INEGI (2018)
Total observations	1,834	814	1020	
	Mean (standard deviation)			
Age	33.94 (9.79)	34.53 (9.78)	33.48 (9.79)	27
Household size	3.94 (1.65)	4.00 (1.56)	3.89 (1.73)	3.6
	Category percentage (%)			
Gender				
Male	41	44	38	48.9
Female	59	56	62	51.1
Location				
Urban	93	93	93	85.2
Rural	7	7	7	14.8
Household with children				
Yes	75	77	73	
No	25	23	27	
Education				
Middle school or below	5.4	4.1	6.5	44.8
High school	24.3	19.5	28.1	23.2
Professional (technicians, BS, graduate degree)	70.3	76.4	65.4	32
Monthly household income				
Under 3,000 pesos	7.1	3.8	9.7	10
3,000–4,999 pesos	8.9	7.9	9.7	10
5,000–7,999 pesos	10.7	11.6	10.0	10
8,000–12,999 pesos	23.9	16.1	30.2	30
13,000–19,999 pesos	20.2	20.4	20.0	20
20,000–30,000 pesos	14.9	20.6	10.3	10
More than 30,000 pesos	14.3	19.7	10.1	10
Food budget spent on beef				
Less than 20%	24.0	26.6	21.9	
20%–less than 40%	42.4	41.8	42.9	
40%–60%	23.9	23.1	24.6	
More than 60%	9.7	8.5	10.6	

**Table 1.** Continued

<b>Characteristics</b>	<b>Both Samples</b>	<b>Before Pandemic (Dec. 2019)</b>	<b>During Pandemic (Dec. 2020)</b>	<b>INEGI (2018)</b>
Total observations	1,834	814	1,020	
Frequency of purchase of beef products				
Daily	20.5	19.4	21.3	
Weekly	64.3	65.3	63.4	
Biweekly	12.4	13.4	11.6	
Monthly	1.8	1.5	2.1	
Less than once a month	1.0	0.4	1.6	

Nearly half of the respondents (48.2%) perceived high/medium risks of getting infected by COVID-19 through food, 43.6% indicated that there were low or no risks, and 8.2% indicated that they did not know about the risk of contracting the disease (see Table 2). The Chi-squared test results suggest consumers' risk perceptions were associated with age, the presence of children in the household, and income ( $p < 0.05$ ) but not with gender, location of residence, or education. The proportion of individuals who indicated the risk of COVID-19 infection was high/medium was higher among younger individuals, individuals living in households with children, and lower-income individuals. For example, more than half of the individuals in the 18–34 age group (53.4%) perceived a medium or high risk of COVID-19 infection, compared to 40.9% and 35.1% in the 35–54 and 55–higher age groups, respectively.

**Table 2.** Risk of Being Contaminated with COVID-19 through Food Consumption by Sociodemographic Groups

Characteristics	Total Sample <i>n</i> (%)	Risk Preferences					<i>P</i> -value <sup>a</sup>
		I Don't Know	No-Risk	Low Risk	Medium Risk	High Risk	
n (%)							
Total	1.020 (100.0)	84 (8.2)	175 (17.2)	269 (26.4)	295 (28.9)	197 (19.3)	< 0.001
Age group							
18–34 years	616 (60.4)	54 (8.8)	84 (13.6)	149 (24.2)	197 (32.1)	132 (21.4)	
35–54 years	367 (36.0)	27 (7.4)	79 (21.5)	111 (30.3)	89 (24.3)	61 (16.6)	
55 years and older	37 (3.6)	3 (8.1)	12 (32.4)	9 (24.3)	9 (24.3)	4 (10.8)	0.6685
Gender							
Female	628 (61.6)	52 (8.3)	104 (16.6)	158 (25.2)	187 (29.8)	127 (20.2)	
Male	392 (38.4)	32 (8.2)	71 (18.1)	111 (28.3)	108 (27.6)	70 (17.9)	0.1426
Location							
Rural	75 (7.4)	10 (13.3)	16 (21.3)	12 (16.0)	21 (28.0)	16 (21.3)	
Urban	945 (92.6)	74 (7.8)	159 (16.8)	257 (27.2)	274 (29.0)	181 (19.2)	0.2114
Education							
Middle school or below	66 (6.5)	5 (7.6)	7 (10.6)	15 (22.7)	21 (31.8)	18 (27.3)	
High school	287 (28.1)	22 (7.7)	46 (16.0)	67 (23.4)	97 (33.8)	55 (19.2)	
Professional (technicians, BS, graduate degree)	667 (65.4)	57 (8.6)	122 (18.3)	187 (28.0)	177 (26.5)	124 (18.6)	0.004
Household with children							
No	274 (26.9)	32 (11.7)	54 (19.7)	73 (26.6)	80 (29.2)	35 (12.7)	
Yes	746 (73.1)	52 (7.0)	121 (16.2)	196 (26.3)	215 (28.8)	162 (21.7)	< 0.001
Household income							
Under 5,000 pesos	198 (19.4)	20 (10.1)	33 (16.7)	43 (21.7)	63 (31.8)	39 (19.7)	
5,000–12,999 pesos	410 (40.2)	31 (7.6)	59 (14.4)	92 (22.4)	136 (33.2)	92 (22.4)	
More than 13,000 pesos	412 (40.4)	33 (8.0)	83 (20.2)	134 (32.5)	96 (23.3)	66 (16.0)	

Note: <sup>a</sup>  $\chi^2$  test of proportions



Perceived risks of COVID-19 infection through meat consumption were found to be associated with the country of origin ( $p < 0.05$ ) (see Table 3). Nicaragua was the country of origin about which respondents knew the least, as 18.2% indicated they did not know about the risk of contamination with COVID-19 by consuming meat from this country. On the other hand, the United States was the country of origin with the highest percentage of individuals who indicated that the risk of contamination was medium or high (45.7%), followed by Nicaragua (42.5%), Mexico (41.8%), and Canada (38%). Statistically significant differences in the mean value of the attribute importance ratings for the prepandemic and pandemic periods were found in 7 of the 13 beef products attributes considered ( $p < 0.05$ ) (see Table 4). Freshness, flavor, color, and food safety experience had lower ratings during the pandemic than the prepandemic period. In contrast, traceability, organic labeling, and production system experienced increased average ratings. The results were similar after controlling for the sociodemographic characteristics of the respondents. The robustness of these analyses was also evaluated by estimating ordered probit models instead of linear regression models. The ordered probit model estimated coefficients were similar to those obtained using the linear regression model (see Table 5).

**Table 3.** Risk of Being Contaminated with COVID-19 through Meat Consumption by Country

Category	Mexico	United States	Canada	Nicaragua	<i>P</i> -value <sup>a</sup>
	n (%)				
I don't know	100 (9.8)	112 (11.2)	132 (13.1)	183 (18.2)	< 0.001
No risk	237 (23.3)	193 (19.2)	204 (20.3)	174 (17.4)	
Low risk	255 (25.1)	239 (23.8)	288 (28.6)	220 (21.9)	
Medium risk	281 (27.6)	246 (24.5)	260 (25.8)	230 (22.9)	
High risk	144 (14.2)	213 (21.2)	122 (12.1)	196 (19.5)	
Total (n)	1,017	1,003	1,006	1,003	

Note: <sup>a</sup>  $\chi^2$  test of proportions

**Table 4.** Relative Importance of Beef Products' Attributes

Attribute	Before Pandemic (Dec. 2019– Feb. 2020)	Pandemic (Dec. 2020)	Change in Importance Rating (Pandemic—Before Pandemic)			
	Mean (Std. deviation)	Mean (Std. deviation)	Unadjusted Model (Std. Error)	<i>P</i> - value	Model 1 <sup>a</sup> (Std. Error)	<i>P</i> - value
Freshness	4.75 (0.72)	4.65 (0.86)	-0.099** (0.037)	0.0075	-0.096** (0.038)	0.0116
Flavor	4.67 (0.75)	4.55 (0.95)	-0.126** (0.040)	0.0016	-0.093** (0.040)	0.0200
Color	4.56 (0.79)	4.44 (0.98)	-0.117** (0.042)	0.0050	-0.118** (0.043)	0.0061
Tenderness	4.52 (0.86)	4.47 (0.93)	-0.048 (0.042)	0.2526	-0.021 (0.042)	0.6212

Table 4. Continued

Attribute	Before Pandemic (Dec. 2019–Feb. 2020)	Pandemic (Dec. 2020)	Change in Importance Rating (Pandemic—Before Pandemic)			
	Mean (Std. deviation)	Mean (Std. deviation)	Unadjusted Model (Std. Error)	P- value	Model 1 <sup>a</sup> (Std. Error)	P- value
Juiciness	4.46 (0.86)	4.46 (0.95)	0.005 (0.043)	0.9048	0.032 (0.044)	0.4590
Food safety	4.46 (0.92)	4.34 (1.01)	-0.116** (0.046)	0.0108	-0.108** (0.047)	0.0209
Price	4.00 (1.08)	4.00 (1.20)	-0.001 (0.054)	0.9852	-0.037 (0.056)	0.5058
Preparation ease	3.95 (1.05)	4.03 (1.10)	0.083 (0.051)	0.1035	0.092* (0.051)	0.0708
Product leanness	3.84 (1.09)	3.77 (1.18)	-0.069 (0.054)	0.2004	-0.022 (0.054)	0.6896
Country of origin	3.80 (1.18)	3.80 (1.23)	0.004 (0.057)	0.9314	0.020 (0.058)	0.7292
Traceability	3.75 (1.14)	3.87 (1.15)	0.120** (0.054)	0.0255	0.129** (0.055)	0.0203
Organic labeling	3.73 (1.18)	3.91 (1.17)	0.180** (0.055)	0.0011	0.191** (0.057)	0.0008
Production system	3.70 (1.17)	3.88 (1.17)	0.179** (0.055)	0.0012	0.179** (0.056)	0.0015

Notes: <sup>a</sup> The estimated change values correspond to the parameters of regression models with importance rating as the dependent variable and a dummy indicating the survey period (0 = Pre-pandemic, 1 = Pandemic) (Unadjusted Model column) as explanatory variable. Estimated changes displayed under Model 1 correspond to regression models that also include as explanatory variables: age, household size, gender dummy, location dummy (urban vs. rural), dummy for presence of children, education level, and income group.

**Table 5.** Relative Importance of Beef Products' Attributes (Ordered Probit Model Results)

Attribute	Before Pandemic (Dec, 2019–Feb. 2020)	Pandemic (Dec. 2020)	Ordered Model Coefficient (Pandemic Dummy)			
	Mean (Std. deviation)	Mean (Std. deviation)	Unadjusted Model <sup>a</sup> (Std. Error)	P- value	Model 1 <sup>a</sup> (Std. Error)	P- value
Freshness	4.75 (0.72)	4.65 (0.86)	-0.124* (0.065)	0.0570	-0.135* (0.069)	0.0510
Flavor	4.67 (0.75)	4.55 (0.95)	-0.132** (0.062)	0.0340	-0.081 (0.065)	0.2170
Color	4.56 (0.79)	4.44 (0.98)	-0.098* (0.057)	0.0870	-0.106* (0.060)	0.0760
Tenderness	4.52 (0.86)	4.47 (0.93)	-0.038 (0.058)	0.5120	-0.002 (0.060)	0.9670
Juiciness	4.46 (0.86)	4.46 (0.95)	0.066 (0.056)	0.2390	0.105* (0.059)	0.0740
Food safety	4.46 (0.92)	4.34 (1.01)	-0.122** (0.056)	0.0300	-0.118** (0.059)	0.0460
Price	4.00 (1.08)	4.00 (1.20)	0.026 (0.053)	0.6230	-0.011 (0.055)	0.8410
Preparation ease	3.95 (1.05)	4.03 (1.10)	0.108** (0.052)	0.0680	0.115** (0.054)	0.0330
Product leanness	3.84 (1.09)	3.77 (1.18)	-0.051 (0.051)	0.3160	-0.014 (0.054)	0.7920
Country of origin	3.80 (1.18)	3.80 (1.23)	0.031 (0.051)	0.5450	0.043 (0.053)	0.8100
Traceability	3.75 (1.14)	3.87 (1.15)	0.136*** (0.051)	0.0080	0.142*** (0.053)	0.0080
Organic labeling	3.73 (1.18)	3.91 (1.17)	0.188*** (0.051)	0.0000	0.196*** (0.054)	0.0000
Production system	3.70 (1.17)	3.88 (1.17)	0.186*** (0.051)	0.0000	0.184*** (0.053)	0.0010

Note: <sup>a</sup> The reported parameters come from estimated ordered probit models with importance rating as the dependent variable and a dummy indicating the survey period (0 = Pre-pandemic, 1 = Pandemic) (Unadjusted Model column) as explanatory variable. Estimated parameters displayed under Model 1 correspond to ordered probit models that also include as explanatory variables: age, household size, gender dummy, location dummy (urban vs. rural), dummy for presence of children, education level, and income group.

## Discussion

Although there has been much discussion about the effects of the COVID-19 pandemic on food market demand and supply components, it is too early to tell whether the pandemic will have long-term effects on these issues. Multiple factors including prices, income, and consumers' perceptions of food attributes affect consumers' demand. While several institutions collect and report data on food products' quantities and prices and consumers' income, data on consumers' perceptions of food quality attributes are not readily available. Thus, this study focused on consumer concerns and perceptions of COVID-19 and meat consumption.

A substantial fraction of the sample (approximately 50%) was found to believe the risk of contracting COVID-19 through food consumption was medium or high. According to the World Health Organization (2020), there is no evidence that people can be infected with COVID-19 through food consumption; however, this concern still appears to be prevalent among Mexican consumers. A review of the Mexican government COVID-19 website did not show any information related to this issue either in the "Frequent Questions" or "Myths and Realities" sections. A Google search using "alimentos" (food) and "COVID" and "Mexico" identified multiple sources with information mainly related to food production, distribution, prices, and diet quality; however, only a few discussed the association (or lack thereof) between food consumption and COVID-19 infection (Secretariat of Health of Mexican Federal Government, 2020). Therefore, it appears that few efforts have been invested in educating the public about the risks of contracting COVID-19 through food consumption. In the United States, the nation's public health protection agency, the Centers for Disease Control and Prevention (CDC), has generated and communicated food safety information related to COVID-19 to the public through its website (CDC, 2020). Similarly, U.S. industry groups have made various efforts to inform the public about the safety of food consumption during the pandemic (e.g. ["Beef. It's What's for Dinner," n.d.]). These efforts can be used as guides for food safety communication campaigns in Mexico.

Since the pandemic's beginning, the German Federal Institute for Risk Assessment (BfR) has been surveying the German population on several aspects of the COVID-19 health emergency, including the perceived risks of becoming infected with coronavirus via food (BfR, 2020). In the first survey conducted in March 2020, 34% of respondents indicated that the risk of contamination through food was medium or high, compared to 29% in December 2020. Another study conducted in Kenya in April 2020 found that 33.5% of the survey respondents identified food consumption as a potential source of coronavirus infection (Carpio et al., 2020). In the United States, a survey found that, on average, consumers' level of concern about COVID-19 transmission through food was below 3 on a 1 to 5 scale (1 = very concerned, 3 = neither unconcerned nor concerned, and 5 = very concerned) (McFadden et al., 2021). In contrast, a study in the Arab region from April to June 2020 found that nearly 70% of the respondents were concerned about eating food that contained the virus (Faour-Klingbeil et al., 2021). The differences in these findings may reflect differences in the studies' context (e.g., the pandemic situation when the surveys were conducted and trust in institutions) and methods. Overall, Mexican consumers' perceptions of the risks of contracting COVID-19 through food consumption were high relative to other countries, even nearly a year into the pandemic (Carpio et al., 2020).

The proportion of survey respondents who indicated that the risk of COVID-19 transmission from meat consumption was medium/high was lower than the proportion who indicated medium/high risk of COVID-19 infection from food consumption in general. For example, 41.8% of survey respondents perceived that the risk of COVID-19 transmission from consuming Mexican meats was medium/high, compared to 48.2% who perceived that the risks from food were medium/high, reflecting heterogeneity in consumers' perceptions of risk depending on the type of food. A study in the United States found heterogeneity in concerns about COVID-19 infection from different food groups as well. U.S. consumers were more concerned about COVID-19 transmission from meats, fruits, and vegetables relative to breads and grains (McFadden et al., 2021).

The survey results also reflected risk perceptions heterogeneity associated with the foods' country of origin and consumers' sociodemographic characteristics. With respect to the country of origin, Mexican consumers perceived that the risk of COVID-19 transmission from consuming domestic meat is lower or equal relative to the risk of COVID-19 from consuming imported meat products (see Table 3). Still, the perceptions of the risk of contracting COVID-19 from meat consumption are high relative to other countries (Carpio et al., 2020). These differences in risk perceptions may be associated with two factors: First, consumers' perceptions or knowledge about food safety protocols and institutions in the countries of origin (for example, low trust or knowledge about food safety in Nicaragua, a relatively new source of meat imports in Mexico), and second, consumers' perceptions about the COVID-19 situation in each country of origin. Around the time the survey was conducted, the number of accumulated total COVID-19 cases reported per 1 million individuals in the United States was approximately four times (42,000) higher than the numbers reported in Canada and Mexico (approximately 10,000 and 9,000, respectively [Our World in Data, 2020]).

With respect to the association between risk perceptions of COVID-19 and sociodemographic characteristics, this study's findings are consistent with research from the United States and the Arab countries that reported a negative association between risk concerns and the respondents' age (Faour-Klingbeil et al., 2021; McFadden et al., 2021), in which, younger respondents were found to be more concerned about COVID-19 transmission from food. However, the results in the association with other sociodemographic characteristics differed. The study in the United States found that females were less concerned about COVID-19 contamination from food than males and that the level of concern increased with education but not with income. In the study conducted in Arab countries, COVID-19 transmission from food was not associated with other sociodemographic characteristics, including gender, education, marital status, household income, and residence location.

In contrast, this study found evidence of a positive association between risk perceptions of COVID-19 transmission from food and children's presence in the household and income. Differences in findings are not uncommon in studies about food safety risk perceptions, as they are likely to be context-specific. Nonetheless, these findings may be helpful in designing food safety information campaigns. For example, this information can be used to design campaigns that target groups of households and individuals more concerned about COVID-19 transmission from food (e.g., younger individuals, households with children, and low-income households).

The comparison of beef attribute importance ratings before and during the pandemic (see Table 4) provides clues to the pandemic's potential long-term impact. The results indicated a decrease overall in the ratings of sensory and organoleptic attributes (freshness, flavor, and color) and remarkably, food safety. In contrast, there was an increase in the ratings related to extrinsic and production-related attributes (organic labeling, the production system, and traceability). Still, the magnitude of all the changes observed in the attribute importance ratings was small (less than 5% in absolute value), and sensory and organoleptic attributes had the highest scores.

Given the COVID-19 health crisis and consumers' high levels of risk perceptions about COVID-19 transmission through food, it was expected that importance ratings of food safety would have increased relative to other attributes. However, the mean value of the food safety ratings decreased, and the ranking of importance did not change overall (before and after was the sixth attribute most valued). It is possible that consumers believe that the risk of COVID-19 contamination through food is only temporary, and the industry may not be able to do a great deal to reduce these risks.

On the other hand, the increase in the importance of production-related attributes (organic labels and traceability) appears to be consistent with the long-term rise in demand for extrinsic and credence meat attributes in the region overall, which seems to have continued even during the pandemic (Rojas, Stuardo, and Benavides, 2005; Castillo and Carpio, 2019; Forbes Mexico, 2021; Estévez-Moreno, Miranda-de la-Lama, and Miguel Pacheco, 2022). Further, the increase in the ratings for organic labels may be explained by consumers' perception that organic products are healthier than conventional products (Pew Research Center, 2016). Although related to food safety, the improved ratings in the traceability attribute may also capture consumers' increased interest in knowing more about production systems. Some research that evaluated the pandemic's effect on the food value chain in Latin America, including Mexico, found evidence of increased participation of producers selling food directly to consumers, which may have increased their interest in knowing more about food production systems. Thus, changes in the importance of the whole domain of attributes may reflect both long-term changes in consumer preferences and COVID-19-related impacts; however, data limitations do not allow us to separate these two effects.

## Conclusions

Even a year into the pandemic, Mexican consumers reported high levels of perceived risks of COVID-19 transmission through food consumption in general and meats in particular, in domestic and imported products. Remarkably, consumers' ratings of food safety as an important attribute of meat products decreased slightly during the pandemic, which suggests that consumers' concerns over COVID-19 contamination through food consumption might not have long-term consequences in consumer demand. On the other hand, the increase in importance during the pandemic of credence attributes, including organic labels and production systems, suggests that COVID-19 may have affected preferences for other meat attributes or, at the minimum, that the pandemic did not affect long-term trends in the evolution of consumers' preferences for meat attributes.

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