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Article

Analysis of the willingness to pay for antibiotic-free pork, a Choice Experiments approach

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Abstract:

Health issues and the production of differentiated foods influence the consumers' decisions and lead them to opt for products with particular organoleptic characteristics. The objective of this research was to estimate the preferences and willingness to pay for antibiotic-free pork in the municipality of Texcoco, State of Mexico, in order to determine the existence or absence of an incentive for the commercialization of antibiotic-free pork. The Discrete

Choice Method of Experiments was used. The attributes considered in the design were: color, fat content, and presence of antibiotics. A survey of 196 consumers was carried out for this purpose. The results were analyzed with the NLOGIT 4.0 software, using a mixed logit model. The most valued attribute was antibiotic content, which means that respondents would be willing to pay an additional premium of $30.65 MXN/kg for antibiotic-free pork. It was found that the higher the income and the higher the frequency of pork consumption, the greater the willingness to pay an additional premium for antibiotic-free meat. A WTP of $5.78 MXN was determined for meat with normal fat, and of $3.73 MXN for red meat. Pork consumers in the eastern part of the State of Mexico would be willing to pay an additional premium for antibiotic-free pork and for such quality aspects as fat content and color.

Keywords: Choice Experiments, Willingness to pay, Antibiotic-free meat, Mixed Logit, Differentiated products.

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Introduction

Until a few years ago, pork was considered harmful due to its high fat content and type, in addition to the diseases (e.g., cysticercosis) it caused due to poor farming practices[1]. However, current studies[2,3] have shown that this meat is among the meat products with the lowest fat content. Eating pork meat has several advantages, such as the fact that it provides good (monounsaturated) fats, multiple vitamins and minerals, and proteins of high biological value[3].

Pork is considered one of the three main red meats in the Mexican diet and is the second most consumed; therefore, it is important to analyze it[4]. Its consumption has increased consistently, with an estimated demand of 2.4 million tons (historical maximum growth of 2.5 % per year) by 2020[5].

In the same year (2020), consumers showed greater interest in healthier differentiated foods —such as organic, and free of chemicals, hormones, antibiotics, among others—, and pork was no exception. The reason is that the overuse of chemical substances is related to certain health problems. For example, in the case of antibiotics in the breeding and fattening of livestock, it can trigger such problems as antimicrobial resistance[6-11]; hence, the death of

both animals and humans from infectious causes, which are growing every year and have become a global risk[12].

The World Bank states that most antimicrobial use in many countries occurs in the agricultural sector, particularly in livestock. A study using antimicrobial sales data for broiler, livestock and swine systems in 41 countries with 2017 data projected antimicrobial sales at 93,309 t in 2017, and 104,079 t by 2030 (11.5 % increase), globally[13].

Therefore, the general objective of this research was to estimate the preferences and willingness to pay for antibiotic-free pork by consumers in the municipality of Texcoco, State of Mexico, using the method of Discrete Choice Experiments (DCE), in order to discover whether there is a price premium that encourages the marketing of this meat in the studied area.

The hypothesis suggests that pork consumers in Texcoco, State of Mexico, attach importance to antibiotic-free meat and would be willing to pay an additional sum for this product.

Material and methods

Description of the method

The DCE method is one of the so-called direct valuation methods and is mainly used to value non-market assets. According to Espinal and Gómez[14], the DCE method originates in the areas of mathematical psychology and statistics, and its theoretical basis is found in Lancaster's Consumer Theory, which indicates that an individual can decompose their utility into separable utilities of their attributes. The method has been applied to a variety of disciplines, most recently to the valuation of environmental assets. This method involves presenting respondents with a series of alternatives that include the attributes of the goods to be valued, at different levels, including the *status quo* (current state) and the attribute "price"; also, the variation in levels can be downward or upward, i.e., attributes can improve or worsen[15].

Certain studies use these direct valuation methods and provide a broader view of their advantages. For example, Espinal and Gómez[14] apply DCE to economically assess a building with historical and social value and highlight that, with the proposed changes (entailing an additional cost), the benefits outweigh the costs, justifying those potential changes. Gracia[16] finds that 2.74 euros is the maximum price that would be paid for 1 kg of

organic apples in Valle de Manubles. The attributes of organic tomatoes in Ecatepec, Mexico are assessed with DCE[17], and the most valued attribute is the product information (with a MWTP of $11.34). Melo[18] highlights such advantages as the internal and external validity of the method. Yangui[19] finds that "commitment to healthy food" and "orderly lifestyle" are most influential when rating extra virgin olive oil.

On the other hand, several authors[20-26] conducted studies using various methods to evaluate differentiated animal products, highlighting such attributes as safety, organic, antibiotic-free, and designation of origin, among others.

Melo *et al*[18] simplify the theoretical basis of DCE; they argue that it is based on the random utility developed by McFadden[27] and that it generates a relationship between the deterministic model and the statistical model of human behavior. Given that the method involves an econometric regression, it is necessary to determine two aspects: the utility function and the distribution assumption for the error term, which generally ends up entered as an additive term:

$$U_{ij} = V_{ij}\left(Z_{ij}S_iM_j\right) + \varepsilon_{ij} \qquad (2.1)$$

Where:
U_{ij}= utility function of the individual *i* for alternative *j;* V_{ij}= deterministic component of the indirect utility function for each alternative *j* of the choice set *C;* Z_{ij}= attributes of good*;* S_i= socioeconomic variables of the individual *i;* M_j= income of the individual *i.*

In other words, if alternative *m* offers a higher utility than any other alternative, the user *i* will prefer this alternative; in other words: if $U_m > U_{ij}\ \forall\ m \neq j$, where m and $j \in C$. The probability of choosing alternative *m* is expressed as follows:

$$\Pr(im) = \Pr\left[\left((U_{im}) > U_{ij}\right)\forall j \neq m\right] = \Pr[\left(V_{im} - V_{ij}\right) > \left(\varepsilon_{ij} - \varepsilon_{im}\right)] \qquad (2.2)$$

The observable component of utility (V_{ij}) can be expressed as a linear function of the explanatory variables:

$$V_{ij}=\alpha_j+\beta'Z+\gamma(T) + \delta'S \qquad (2.3)$$

Where:
α represents the specific constant for each alternative *j*; β, the vector of utility coefficients associated with the vector Z of explanatory variables (attributes); γ is the coefficient

associated with the price of alternative *j*, and δ is the vector of coefficients associated with the socio-economic variables.

Under the assumption that the error terms are independent and identically distributed with a Gumbel or extreme value type I distribution, the probability of choosing alternative *m* is usually expressed by a multinomial logit model (MLM) which includes both the attributes to be assessed and the characteristics of the individuals[27].

The MLM model assumes that the error terms are independent and identically distributed (IID) over alternatives and individuals; that is, irrelevant alternatives with non-zero probability are not affected by the introduction or elimination of additional alternatives in the choice set. However, the IID assumption is unlikely to hold if there is unobserved preference heterogeneity among respondents; therefore, the use of MNL may lead to biased estimates.

In order to avoid these limitations, the present research employed a Mixed Logit (MXL) or random parameter model:

$$P(ij) = \int \frac{exp(\beta' x_{ij})}{\sum_{j=1}^{J} exp(\beta' x_{ij})} f(\beta) d\beta \qquad (2.4)$$

Where P(*ij*) is the probability that individual *i* will choose the attribute *j* within the space of choice C*i*,

Experimental design

As suggested[28], the experimental design was carried out in the following order: selection of attributes, assignment of levels, choice of experimental design (combination of levels and attributes to be presented to respondents), construction of choice sets (cards), measurement of preferences (with the application of surveys), and estimation procedure (using a regression model such as logit, probit, conditional logit, etc.). In order to select the attributes most highly valued by pork consumers, a focus group questionnaire was carried out and applied in which the participants ranked the attributes they value most at the time of purchasing their pork. The questionnaire showed that the most important attributes are color, fat content, and price (not necessarily in that order). A support bibliographic consultation was also carried out[20,21,23,26,29,30], facilitating the selection of the product attributes (as well as the levels) included in the experimental design, which are shown in Table 1.

The "color" attribute may reflect the freshness and tenderness of the meat, characteristics explained by pH, age of the animal, species, diet, exercise, etc.[30]. The "fat content" is reflected in the marbling of the meat, which can give an idea of its juiciness and flavor (*ibid*).

Table 1: Attributes and levels of experimental design

	Attributes			
Levels	**Color**	**Fat content**	**Presence of antibiotics**	**Price**
	Pink (0)	*Status quo* (0)	*Status quo* (0)	*Status quo* (0)
	Red (1)	10% less (1)	Without antibiotics (1)	10% premium (1)
		15% less (2)		15% premium (2)
				20% premium (3)

(0)= *status quo*; (1)= improvement level 1; (2)= improvement level 2; (3)= improvement level 3; (4)= improvement level 4. "Premium"= surcharge.

The experimental design was based on a fractional factorial analysis using an orthogonal design in the SPSS® statistical package (IBM SPSS Statistics, 2015). This resulted in 16 sets of choices (cards), which were divided into two blocks of 8 cards each.

The data were recorded in a Excel panel and the variables were analyzed using a mixed logit model with the help of Nlogit© software (Nested Logit Model Ver. 4.0). The variables considered to obtain the explanatory model are described as follows: **NUM**: survey number, **BLOCK**: block, **CARD**: card, **ALT**: alternative (1, 2, or neither), **PINKC**: pink meat, **REDC**: red meat, **NF**: normal fat, **F10**: 10 % less fat, **F15**: 15 % less fat, **WANT**: with antibiotics, **WOANT**: without antibiotics, **PRICE**: price, **RESP**: response, **AGE**: age in years, **GEN**: male or female gender, **EDUC**: educational level (elementary, middle school, high school, university, master's degree, Ph.), **NFAM**: number of family members, **DEP**: number of dependents of the respondent, **INC**: average monthly income of respondent (according to INEGI decile), **PL**: place where the respondents normally buy their pork (butcher's shop, supermarket, street market, other), **CONS**: frequency of pork consumption per week (less than 1 time, 1 time, 2 times, 3 or more times).

For this research, dichotomous variables were used to determine the effects of the attributes, for example: for the variable PINKC, the dichotomous variable was 1 if the respondent's preference was pink meat, and 0 for other preferences.

Accordingly, Table 2 summarizes (as an example) some of the resulting codes that gave rise to the interpretation of the effects of attributes.

Table 2: Indicator variables (dummies) coded for card rating scenarios using the Discrete Choice Experiments method

Attributes		Color		Antibiotics	
Card	Alternative	PINK	RED	WITH	WITHOUT
1	1	0	1	0	1
1	2	1	0	1	0
1	3	0	0	0	0
2	1	1	0	0	1
2	2	0	1	1	0
2	3	0	0	0	0
3	1	1	0	1	0
3	2	0	1	0	1
3	3	0	0	0	0
9	1	0	1	0	1
9	2	1	0	1	0
9	3	0	0	0	0

Survey

The original plan was to apply the survey in person; however, due to the restrictions imposed by the COVID-19 pandemic, digital tools were used; for this purpose, the Google Forms® platform was utilized. The survey was conducted from January 22 to February 26, 2021 and was applied to consumers in the eastern part of the State of Mexico, which corresponds to the central region, characterized by being the main economic center of consumption and marketing of pork in Mexico; it is also an area with a high population density and ranks second in per capita income[31]. Social networks (Facebook® and WhatsApp®) were used to send the survey to people of legal age who consume pork and live in the study area.

The survey was divided into five sections: 1: introduction, 2: brief presentation of the product, 3: socioeconomic information questions, 4: rating questions (where choice cards were included), and 5: acknowledgment of the respondent's participation.

Because the population was large, consisting of more than 200,000 inhabitants (279,698 inhabitants in 2020)[32], the infinite population formula[33] was used to calculate the sample size:

$$N = \frac{Z^2 * p * q}{e^2}$$

Where:

N= sample size, Z= value of the standardized normal distribution (1.96) with a 95% confidence level, p= proportion of the population that would be willing to pay a premium

(0.5), q= proportion of the population that would be unwilling to pay a premium (0.5), e= sampling error (0.07). These data resulted in a sample size of 196.

Results

The characteristics of the interviewees were as follows: the average age was 35 yr old, with a preponderant age range of 31 to 40 yr; half of the interviewees were men, and half were women. The highest percentage (46 %) had completed university studies, and the average number of years of schooling was 16; in terms of the number of family members, 53 % of the sample has between 3 and 4 members (the highest percentage). 50 % of the respondents have between 0 and 1 dependent, 38 % have between 2 and 3 dependents, and 12 % have more than 4; their income most frequently ranges between $15,001.00 and $26,000.00 MXN (28 %), and 61 % have incomes below $15,000.00. 89 % of the consumers interviewed purchase their meat at the butcher's shop, and the highest proportion in frequency of consumption (58 %) is 1 to 2 times per week. Table 3 shows the results of the mixed logit model (MXLM).

Table 3: Results of the mixed Logit model

Variables	**Mixed Logit**	
	Coefficient	**P(|Z|>z)**
REDC	0.1638	0.0448
NF	0.2539	0.0172
WOANT	1.3457	0.0000
PRICE	-0.0439	0.0000
1_GEN1	-0.5604	0.0002
1_INC1	0.1189	0.0014
1_CONS1	0.5645	0.0000
2_GEN2	-0.6432	0.0000
2_INC2	0.1888	0.0000
2_CONS2	0.4439	0.0000
Log likelihood	-977.2509	
Xi square	684.3650	
Pseudo R-sqr	0.25934	
Adj Pseudo R-sqr	0.25500	
Nº of observations	1208	

The variables in the model that were statistically significant were as follows: REDC, NF, WOANT, PRICE, GEN, INC, and CONS.

In the selection of the best econometric model, the following criteria were considered: a) That the coefficients of the variables had the expected signs, b) That the coefficients of the independent variables were significant at an acceptable level of reliability, and c) That the logarithm of maximum likelihood of the model (log likelihood) was high[34-36].

The value of McFadden's pseudo R^2 is considered relevant (0.25). According to certain authors[18,34], a value of this test between 0.2 and 0.4 would be equivalent to an R^2 of 0.70-0.90 in ordinary least squares, indicating a good fit. Based on these results, the model representing the indirect utility function adopts the following form:

V_{ij}= 0.1638CROJO + 0.2539GN + 1.3457SANT -0.0439PREC -0.5604(1_GEN1) + 0.1189(1_ING1) + 0.5645(1_CONS1) -0.6432(2_GEN2) +0.1888(2_GEN2) +0.4439(2_ING2)

The interpretation of the results of the model in terms of money utilized the Marginal Willingness to Pay (MWTP), which indicates the willingness to pay by attribute. The formula for estimating the MWTP consists in dividing the coefficient of the attribute in question by the coefficient of the price attribute with a negative sign[14]. Table 4 summarizes the results. For example, the MWTP for red meat (REDC) was calculated as follows:

$$\text{MWTP} = -0.1638 * -0.0439^{-1} = 3.7312$$

Table 4: Marginal willingness to pay for each attribute (MWTP)

Attribute	MWTP by improvement level ($/kg/person)	Total ($)	%
Color	CROJO 3.7312	3.7312	9.3
Fat	GN 5.7836	5.7836	14.4
Antibiotics	SANT 30.6537	30.6537	76.3
Total		40.1685	100

Discussion

The results show that the most highly valued attribute was the content of antibiotics, which means that the interviewees are willing to pay an additional premium of $30.65/kg of antibiotic-free pork meat. Considering that, in average, a kilogram of pork steak costs $90.00, the interviewee would be willing to pay an additional 34 %; this figure is similar to that found

by other authors[20]. The interviewees would be willing to pay an additional $5.78 for pork meat with normal fat, i.e., a premium of 6 %. The attribute COLOR was also significant, and the interviewees would be willing to pay an extra $3.73 for red meat, which amounts to a premium of 4 %.

The fat content and the color are valued attributes that agree with the results of other papers[20,29].

The variables "income" and "frequency of consumption" were identified as having a positive influence on the WTP; in other words, the larger the income and the more frequent the consumption of pork meat, the greater the willingness to pay an additional premium for antibiotic-free pork meat. As for the gender, the negative sign indicates that women are more willing to pay an additional premium; this may be due to the fact that it is women who buy the groceries or cook at home[37]. Other authors[17,22,38] include such variables as "knowledge" of the attribute, which may have proven significant because the interviewees have a clearer notion of how much to pay for a product that they know[39-41]. Moreover, based on the results obtained by Valdés-Castro *et al*[17], it is recommended to address the interviews to housewives or to those in charge of buying the groceries at home, as they have more information and knowledge about the characteristics of the foods that they consume.

Unlike other studies[20,42], the variables education (or level of schooling) and age did not prove statistically significant; this may be due to bias generated by the modality of application of the survey, although there are not sufficient elements to support this statement.

Conclusions and implications

The results of this research confirm that pork consumers in the eastern part of the State of Mexico would be willing to pay a 34 % ($30.65) premium for antibiotic-free meat, reflecting a market for differentiated products for consumers concerned about purchasing healthier and more natural foods. It is expected that the establishment of public policies aimed at controlling the use of antimicrobials in the fattening process will generate benefits by making antibiotic-free meat available, as well as improvements in health due to a decrease in antibiotic resistance. The implementation of campaigns highlighting the benefits of consuming antibiotic- or hormone-free meat is suggested, and so is the implementation of a National Action Strategy against Antimicrobial Resistance. This research provides information about the willingness to pay and the positive utility of antibiotic-free meat consumption. It is recommended to complement the analysis by including production costs in order to facilitate the making of more accurate decisions by the producers, as well as to extend the study to a national level in order to compare results.

Acknowledgments and conflict of interest

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The authors declare that they have no conflict of interest.

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