Establishing Linkages between Consumer Fish Knowledge and Demand for Fillet Attributes in Brazilian Supermarkets

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Seafood supply chains, from farmers to supermarkets selling direct to consumers, must understand consumer demand for product attributes to ensure production and availability of desired products. Tilapia and tambaqui, the two most important farmed fish species in the Brazilian market, are studied to provide insight into consumer demand for fish fillet attributes. Consumers' willingness to pay (WTP) was estimated while taking consumer demographics into account for each of the five Brazilian regions. A random parameters logit model was used to analyze data from discrete choice experiments conducted in-person at supermarket seafood counters. On average, Brazilian fish fillet consumers prefer tilapia to tambaqui, and fresh to frozen. Preferences for fillet attributes were found to be related to knowledge about fish. This study is the first known analysis of national seafood preferences considering factors such as product form, species, and familiarity with fish and fish products in multiple geographic regions of Brazil.

Keywords: food industry management; random parameters logit; willingness to pay; seafood preferences; Brazil fish demand

JEL: Q11; Q22; C93

Introduction

Global aquaculture production increased by over 560 percent from 1990 through 2018 at an annual rate of 7% and continues to drive growth in global seafood production (FAO, 2020). In 2018, capture fisheries produced 96.4 million metric tons of seafood compared to 114.5 million metric tons from aquaculture. In 2011 aquaculture produced more protein than beef for the first time, and in 2013 people consumed more fish from aquaculture than from capture fisheries in the world (Matias, 2013). Globally, fish is the largest animal protein source. Consequently, many countries are investing in and improving their aquaculture supply chain, including Brazil (Flores & Pedroza Filho, 2013; Carvalho Filho, 2018). A strong growth trend in aquaculture has been observed in Brazil with official data indicating 133% production growth in farmed fish between 2009 and 2013 (MPA, 2013; Carvalho Filho, 2014), and production reaching 547,163 metric tons of fish in 2017, according to the Brazilian Institute of Geography and Statistics (IBGE) (Carvalho Filho, 2018).

There is potential for growth and development of aquaculture markets in Brazil due to a deficit in the fisheries trade balance, which has increased in recent years due to increased imports (see Figure 1). Growth in domestic fish consumption, estimated at 4 kg per capita per year in 2005 and at 14.5 kg in 2013 (Scorvo Filho, 2014), is explained not only by the increase in national farmed fish production, but also by imports mainly from Norway, China, and Chile (Flores & Pedroza Filho, 2014). Understanding preferences for fish products in Brazilian markets is essential to inform the development of fish production and associated processing and retailing of fish products. However, presently data on Brazilian consumers' knowledge of the fish market and preferences for various product characteristics is limited. Past studies examined meat demand for Brazilian consumers, but few studies focus on seafood demand (Hoffmann, 2007; Carvalho et al., 2008; Carbonari & Silva, 2012; Flores et al., 2014). Santana and Ribeiro (2008) found inelastic

seafood demand, with fish being a complementary good for chicken and beef, and a substitute good for pork. Lopes et al. (2016) studied the factors that influence fish consumption for different regions in Brazil by interviewing more than one thousand people and found that most of the population prefers beef and poultry over fish. In addition, they found low yet increasing seafood consumption among the respondents, which they posited was mainly due to a lack of seafood products and a low level of information on the benefits of seafood consumption. Some dated demand studies for seafood focused on specific regions in Brazil (Teixeira et al., 2006; Almeida et al., 2003). Using a very large survey of families' budgets, Sonoda et al. (2012) conducted a study on how consumption of seafood differs between the North and South regions in Brazil. Consumers with higher income levels from the South region buy seafood in supermarkets, but in the North, they tended to buy from open markets and small fish stores. Pincinato and Gasalla (2010) tested the hypothesis that the demand for seafood is elastic using time-series data from the Sao Paulo city seafood wholesale market from 1968 to 2007. The authors failed to reject the hypothesis that demand for seafood is elastic for most species analyzed.

Past studies have employed varying methodologies to explain what factors influence the demand for seafood in different parts of the world (Asche et al., 2001; Ligeon et al., 2007; Sakai et al., 2010; Xu et al., 2012; Yip et al., 2017; Zander and Feucht, 2018; Hilger et al., 2019; Vitale et al., 2020). In terms of willingness to pay (WTP) estimation for fresh versus frozen fish products, some studies have found consumer preference for fresh fish in regions like Hawaii (Davidson et al., 2012) and Germany (Bronnmann & Hoffmann, 2018). Other studies have addressed the importance of consumer knowledge on the WTP estimates for seafood (Xu et al., 2012; Yip et al., 2017; Zander and Feucht, 2018). Using the concept of subjective knowledge, which is the individual self-assessment of the knowledge about a topic, Zander and Feucht (2018) did not find

a relationship between the lack of knowledge and the lack of interest and preference (low WTP) for sustainable fish in Europe.

There are no relevant economic studies in Brazil of the impact of variables such as species, processed form (fresh/frozen), and fish knowledge on consumers' fish selections. This article is the first study to analyze the impact of factors like product price, consumers' demographics, and product attributes such as species and processing of fish in the Brazilian market for tilapia and tambaqui, the two most important farmed fish species in Brazil (Carvalho Filho, 2018; Flores & Pedroza Filho, 2019). This study provides important product and market information for managers of fish farms and the seafood processing industry for both species through testing the following hypotheses:

- Brazilian consumers exhibit heterogeneous preferences for fish species and processed forms;
- WTP for species and product form vary across regions of Brazil; and
- Fish knowledge has an impact on the stated preferences/demand of consumers.

Materials and methods

Random utility theory (RUT) is used to model consumer demand for the fish attributes of species and fillet form; choice data is analyzed through a random utility model (McFadden, 1973). This analysis employs an attribute-based method based on Lancastrian consumer theory (Lancaster, 1966). Fundamentally, the utility of a product can be separated into the contribution of different attributes to their utilities. Since the researcher has incomplete information, the consumer's utility is a random variable (Manski, 1977). Estimation of WTP from choice experiment derived data relies on the properties of RUT in which decision maker *n*, faced with a set of choices, selects an alternative that reveals information about their underlying preferences (Greene, 2012). Therefore,

the model is derived from utility-maximization behavior where alternative *j* is selected from a set of *J* possibilities in a series of choice scenarios indexed by *k* (Train, 2003). Utility is specified as:

$$U_{njk} = V_{njk} + \varepsilon_{njk} \,, \tag{1}$$

where V_{njk} is the deterministic part of the utility according to the attributes of alternative *j* and ε_{njk} is a random term that is independent and identically distributed (iid) Type 1 Gumbel distributed over all alternatives and choice scenarios. Decision-maker *n* chooses alternative *j* if and only if $U_{njk} > U_{nik}, \forall\, j \neq i$. The probability of selecting *j* was outlined by Train (2003) as $Prob(V_{njk} + \varepsilon_{njk} > V_{nik} + \varepsilon_{nik}; \forall\, j \neq i;\ \forall\, i \in D;\ \forall\, n)$, where *D* is the total set of alternatives available to the participant (Boxall & Adamowicz, 2002). Adamowicz and Swait (2011) show that, since the random term ε_{njk} is iid across the *j* alternatives with an extreme value distribution, the probability is given by the standard logit:

$$L_{njk} = Prob(j\ is\ chosen) = \frac{e^{\theta V_{njk}}}{\sum_i e^{\theta V_{nik}}}, \tag{2}$$

where θ is a scale parameter, which is inversely related to the variance of the error term. If the deterministic part is assumed to be linear in parameters, equation (2) describes a multinomial logit model (MNL). However, this assumes homogeneous preferences which are unlikely, necessitating a specification that allows for preference heterogeneity (Olynk et al., 2010; McKendree et al., 2013). Thus, the random parameters logit (RPL) model (Train, 2003), also known as mixed logit is used to allow for heterogeneity in respondent's preferences. In the RPL, an individual's preference for fish attributes is allowed to deviate from the population mean, which means that the coefficient vector for individual *n* is $\beta_n = \bar{\beta} + \sigma\mu_n$, where $\bar{\beta}$ is the population mean, σ is a diagonal matrix of coefficient standard deviations and μ_n is a vector of independent standard normal deviates (Lusk et al., 2003). The random utility of individual *n* is:

$$U_{njk} = V_{njk} + [u_{nj} + \varepsilon_{njk}]\,, \tag{3}$$

where V_{njk} is the systematic part of the utility function, u_{nj} is an error that is distributed normally over individuals and alternatives (but not choice scenarios), and ε_{njk} is the random term that is iid over all consumers, alternatives, and choice scenarios (Olynk et al., 2010).

According to Train (2003), the RPL probability is obtained by integrating a weighted average of the MNL probability, $L_{njk}(\beta_n)$, where β_n is the unobserved coefficient vector for each *n* and varies in the population with weights distributed according to density $f(\beta_n|\rho^*)$, where ρ^* denotes the (true) parameters of this distribution. The unconditional probability is defined as:

$$Q_{njk}(\rho^*) = \int_{-\infty}^{\infty} \left(\frac{e^{V_{njk}(\beta_n)}}{\sum_i e^{V_{nik}(\beta_n)}}\right) f(\beta_n|\rho^*)\, d(\beta_n) \tag{4}$$

where Q_{njk} is the unconditional probability for alternative *j* that person *n* chooses in scenario *k*, and the dependence of V_{njk} on β_n is addressed below. Choices are independent over scenarios, so the probability of person *n*'s observed sequence of choices conditional on β_n, is the product of standard logits $\prod_{k=1}^{K} L_{njk}(\beta_n)$. The integral is approximated to get the following simulated unconditional probability for observed sequence of choices that person *n* makes: β_n

$$\hat{Q}_{njks}(\rho^*) = \frac{1}{R}\sum_{r=1}^{R} \prod_{k=1}^{K} \left(\frac{e^{V_{njk}(\beta_n^r(\rho^*))}}{\sum_i e^{V_{nik}(\beta_n^r(\rho^*))}}\right) \tag{5}$$

where $\beta_n^r(\rho^*)$ is the *r*-th draw of β_n from the conditional distribution $f(\beta_n|\rho^*)$. The simulated log likelihood objective that is maximized to obtain the parameter estimates, ρ, is:

$$\log\mathcal{L}(\rho) = \sum_{i=1}^{n} \log\left[\frac{1}{R}\sum_{r=1}^{R} \prod_{k=1}^{K} \left(\frac{e^{V_{njk}(\beta_n^r(\rho))}}{\sum_i e^{V_{nik}(\beta_n^r(\rho))}}\right)\right] \tag{6}$$

The parameters of the distribution of the β_n are estimated in a model for demand for fish fillets employing attributes of fish species (tilapia or tambaqui), product form (fresh or frozen

fillet), and the price. The simulated unconditional probability is calculated as in (5) using a sample size of one thousand (R = 1,000). The model for the systematic part is specified as:

$$V_{njk}(\beta_n) = \beta_{n0} OptOut_k + \beta_{n1} Price_{jk} + \beta_{n2} tilapia_{jk} + \beta_{n3} fresh_{jk} \ , \quad (7)$$

where n denotes the individual, j denotes the alternative, k denotes the choice scenario, $Price$ is the price of the fillet, and $OptOut$ is a constant that describes the disutility of not having the fish product in the consumer's choice scenario (Johnson et al., 2000). The variable $tilapia$ is an effects-coded term which represents the species of fish from which the fillet was obtained, and $fresh$ is an effects-coded term which represents the choice between fresh and frozen forms. All variables, except price, were assumed to be normally distributed. In effects coding, instead of a dummy variable that values 0 or 1, the attributes take a value of 1 when applicable, a value of -1 when the base category applies, and zero otherwise (Tonsor et al., 2009). Thus, the "left out" category is not incorporated into the intercept as in traditional dummy variable estimation (Lusk et al., 2003). Effects coding was used instead of dummy variables to avoid confounding effects of attribute levels with the opting-out option (when the consumer does not choose either of the fish fillet options presented).

The WTP for attribute m can be calculated as the negative of the ratio of the coefficient of the attribute and the coefficient of price (Adamowicz et al., 1994):

$$WTP_m = -2 \times \left(\frac{\beta_m}{\beta_1}\right), \quad (8)$$

where β_m represents the estimated coefficient on the attribute m, and β_1 is the estimated coefficient on price. Following Lusk et al. (2003), the numerator is multiplied by 2 due to effects coding. Estimation of the RPL was done in NLOGIT 5.0 (Econometric Software Inc., Plainview, NY, USA).

To allow the analysis of variability in the WTP estimations, the procedure uses parametric bootstrapping to calculate 95% confidence intervals for coefficients. Using the variance-covariance matrix and means estimated from the RPL, simulations of WTP estimate observations were drawn for each variable from a normal distribution a thousand times (Krinsky & Robb, 1986).

In addition, a complete combinatorial method (Poe et al., 2005) was used to determine if the WTP distribution calculated was different between regions. Calculation of confidence intervals and the complete combinatorial method were both completed using Matlab (MathWorks, Novi, MI, USA).

The data to estimate the parameters were collected from 1,352 fish consumer surveys administered in person at seafood counters in supermarkets of a representative city in each of the five Brazilian Regions. The selected cities within each region were Manaus in the North, Curitiba in the South, Sao Paulo in the Southeast, Recife in the Northeast, and Brasilia in the Midwest. The surveys were administered in February 2019 in supermarkets in at least three different neighborhoods in each city, facilitating reaching consumers with varying demographics and household income levels. The survey instrument included questions about sociodemographic attributes, fish consumption, fish knowledge and the choice experiment for tilapia and tambaqui fillets. The complete questionnaire used is presented in Appendix A.

To determine choice scenarios, an experimental design was developed using the SAS OPTEX maximizing D-efficiency[1] (Lusk & Norwood, 2005) considering two fish species (tilapia and tambaqui), two product forms (fresh and frozen) and four price levels for the fillet in kg (US$ 6.25, US$ 7.00, US$ 8.00 and US$ 8.75).[2] The maximum D-efficiency was 85.51, resulting in 13 choice scenarios. However, four scenarios were disregarded, in keeping with the suggestion of Hensher and Barnard (1990) to remove choice sets that contribute no useful information (i.e. choices with the same attributes but higher prices do not need to be asked, since the consumer will prefer the same attributes at the lowest price) resulting in nine choice scenarios in the questionnaire. In addition to the two purchase options presented in each scenario, the consumer

[1] D-efficiency maximization can be thought of as minimization of the variance of coefficient estimates in a linear model. The criterion is scaled to range from 0 to 100, where a balanced orthogonal design with optimum efficiency corresponds to 100 (Kuhfeld et al., 1994).

[2] Originally, the questions about price were done in Real, the Brazilian currency. At the time when this document was written R$ 1.00 equaled US$ 0.25.

being interviewed had a choice of not purchasing either option, which is represented by the OptOut variable in Equation (7).

The surveys were administered using tablet computers in front of the fish counter of each store with pictures of each choice presented on the tablet to consumers. To be selected to participate, customers had to indicate that someone in their family consumes fish. Before launching the country-wide data collection, a pretest of the questionnaire was administered in Piracicaba, a different city from the other five, to verify that the questions, the required survey time, and the planned approach would work in the actual retail supermarket data collection setting.

The results are presented by region, and Table 1 shows the summary statistics of the demographics for respondents. The distributions of age, income, and education are similar across the five regions. A high concentration of individuals between 31 and 60 years old, in the third level of monthly family income (between US$ 502 and US$ 2,160), and with educational attainment of at least a high school level completed is observed. In addition, the total number of people and the presence of a child under 12 years old living in the household is also approximately the same in the five Brazilian regions. According to the Brazilian Institute of Geography and Statistics (IBGE) females comprise 51.5% of Brazilians. There is some noticeable variation by region of the proportion of respondents who were female, ranging from 43% in the South and North to 62% in the Northeast and Southeast.

Results

Fish consumption patterns

There were differences in fish consumption documented in respondents from different regions of Brazil (Table 2). The Midwest and South regions showed the strongest preferences for freshwater

fish among the regions although the highest percentage of the respondents is indifferent to this characteristic (39.9% in the South and 44.2% in the Midwest); in addition, a higher percentage of respondents preferred wild-caught fish (over farmed fish) in every region of the country. More than three quarters of respondents in each region bought fish regularly in supermarkets. Besides supermarkets, specialty fish stores and farmers' markets were also reported as frequented by respondents. Fish fillet and fresh (as opposed to frozen) are the most popular forms reported by respondents. Table 2 summarizes monthly expenditures on fish and finds that they are similar across regions in Brazil, with spending of US$ 300 for all kinds of food and about US$ 40 for fish. On average, respondents (who were all fish consumers) spent about 13% of their food budget on fish.

Knowledge about fish species

Table 3 presents summary statistics for questions that assessed the fish knowledge of the survey respondents by asking respondents to identify pictures of some of the important fish species in the Brazilian market. For whole fish pictures, consumers were more familiar with tilapia, pintado, and salmon, which are species that are traditionally found in Brazilian markets. Pirarucu and tambaqui are native species from Amazon Rivers, and the population of North Region, that has most of its area in the Amazon Forest, is more familiar to those species. Pirarucu and tambaqui were less often correctly identified by consumers from fillet pictures. Besides being native species from the North Region, fillet forms of both species are not traditional, and some processing facilities are just starting to supply them.

Knowledge about species that are farmed or wild-caught was also assessed. In general, respondents knew that tilapia is farmed, and that sardine is wild-caught. Other species can come

from both sources of production, and consumers were generally unsure about how they are sourced. Saint Peter fillet was a name created as a marketing strategy for tilapia fillet for some states in the South and Southeast Regions (Kubitza, 2010). Approximately 10% of respondents knew that Saint Peter and tilapia are the same; more consumers were aware that the two names refer to the same fish in the South and Southeast regions where this marketing strategy was most commonly used.

Estimating monetary valuation of fish fillet attributes

The coefficients estimated in the RPL model and the mean WTP estimates are presented in Table 4. All parameters in the model were found to be statistically significant. The coefficients were used to calculate the WTP estimates and associated confidence intervals. For all regions except Midwest, the random parameters have statistically significant standard deviations, indicating heterogeneous preferences for species and the fillet form. The mean WTP estimates cannot be interpreted as being representative of the whole sample, since the model presented statistically significant diagonal elements in the Cholesky matrix, which indicates the presence of preference heterogeneity (McKendree et al., 2013). Results from the combinatorial method proposed by Poe et al. (2005) show that the estimated distributions of WTP for fillets by species (tilapia and tambaqui) and form (fresh versus frozen) were not statistically different across regions.

Consumers are, on average, willing to pay more for tilapia and fresh fillets than tambaqui or frozen fish. For tilapia, the lowest WTP is found in Northeast where consumers are willing to pay a premium of US$ 1.64 to purchase one kilo of tilapia instead of tambaqui on average. On the other hand, Southeast and Midwest have the highest WTP premium for tilapia of almost US$ 4.

Overall the results indicate a preference for tilapia especially in regions where tambaqui does not have a mature market.

Freshness appears to be the most important attribute for consumers in Brazil. In the Southeast, for example, consumers are willing to pay a premium above the average price across the choice experiment of US$ 7.50 for fresh fillet. Even in the Northeast where the WTP is lowest for freshness, the premium value of US$ 5.50 per kilo represents a strong preference for this attribute. According to IBGE, the monthly per capita income in 2018 in the state where Recife is the capital (Northeast) was US$ 218, and for Sao Paulo (Southeast) it was US$ 475. This result suggests the possibility that freshness may be more highly valued by consumers with higher incomes.

Table 5 presents percentiles of the distribution of estimated individual-specific WTP for attributes studied. In the Midwest and North regions more than 10% of respondents were estimated to pay more than US$ 15 to have tilapia instead of tambaqui. The preference for freshness is even stronger, and in the Northeast and Midwest regions more than 95% had a positive estimated individual-level WTP premium for the fresh variable. In the South, Southeast, and North regions, three quarters of consumers were willing to pay more than US$ 10 to have the fresh product (rather than frozen).

Demand for attributes across respondents with varying characteristics

Individual-specific consumer WTP for fish fillet attributes was investigated with respect to consumers reporting varying levels of fish consumption, with varying levels of fish knowledge, and from households with different sociodemographic characteristics. Table 6 highlights some consumer characteristics that associated with having individual WTP estimates that were in the

extreme high (top 10%) and low (bottom 10%) ends of the distribution. Table 6 shows that consumers who prefer tambaqui were more able to identify this species in the survey. About half of subjects (from the entire sample) identified tambaqui from a picture (Table 3), whereas about 86% of consumers that preferred tambaqui knew how to identify it, depending on the region. This result is an indication that knowledge about tambaqui is important to its preference. Tilapia is better known than tambaqui for most Brazilian consumers, and some consumers may have chosen it in the choice experiment because they have not tried tambaqui before. Respondents that preferred tambaqui had higher reported levels of fish consumption, providing further evidence that familiarity/knowledge is related to purchasing preferences**.**

Consumers that prefer more tilapia in the South and Southeast regions more often (correctly) reported that a Saint Peter fillet was a tilapia fillet. These regions are where this marketing strategy was applied, and knowing that a higher quality fillet like Saint Peter is tilapia, influences the species choice. In addition, in most regions, consumers with a higher purchase frequency of fish fillet also prefer tilapia fillet, the most common fish fillet in Brazilian markets. This suggests the importance of product availability in retail fish outlets.

A lower preference for freshness is related with characteristics like a lower number of children in the home, higher income level, higher educational level, and older age. In Brazil, people with low income and low educational levels generally patronize street markets, fishmongers, and direct sales (i.e., by fishermen or fish farmers), where fishes are sold principally fresh. As a consequence, the benefit of convenience probably influences the preferences of people with higher income and educational levels for frozen fish. Consumers with lower WTP for fresh fish buy more in supermarkets and less in open markets and small fish stores. Those demographic characteristics are associated with consumers that prefer convenience in their food preparation. Frozen fish is

easier to store at home than fresh. In addition, consumers with a stronger preference for fresh fish are more able to identify a picture of a tilapia fillet in the questionnaire, providing evidence of a relationship between better fish knowledge and increased preference for fresh fillet.

Discussion

The sample of Brazilian fish consumers studied, on average, preferred tilapia to tambaqui and fresh to frozen fish fillets. A variety of shopping outlets were reported, in addition to supermarkets, indicating that fish processors have diverse market outlets for selling fish products to consumers. Results suggest strong relationships between fish knowledge and species selection preferences, indicating the potential that improved shopper knowledge or awareness of fish availability may shape future demand. The preference for freshness is very strong, relative to frozen fillets, with almost all respondents in the survey indicating a positive WTP premium for fresh relative to frozen. The strong preference for fresh versus frozen product points towards the potential for supply chain management to enable supermarkets to offer fresh product to those consumers demanding it. The preference for fresh fish found in this article is in accord with the literature for other regions like Hawaii (Davidson et al., 2012) and Germany (Bronnmann & Hoffmann, 2018). Consumers who purchased fish fillet frequently preferred tilapia, suggesting that retail fish outlets may want to focus their filleted inventory on tilapia.

Understanding preferences of Brazilian consumers in different regions for different fish species and product forms can inform decisions relating to fish production, product forms and product availability. This work is novel because there has not been a national study of seafood preferences considering factors such as product form, species, and fish knowledge in Brazil. Seafood supply chains, from fish farmers to supermarkets selling direct to consumers, must

understand consumer demand for fish product attributes to ensure production and availability of desired products. The improved knowledge regarding consumer preference for tilapia and tambaqui can be used by farmers and the processing industry for production planning, as well as by wholesale and retail sellers for supply chain planning.

A number of limitations are acknowledged in this analysis, including the relatively limited number of fish species in the WTP analysis and the relatively small sample of consumers studied. The survey was conducted in supermarkets of only one city in each region and the choice experiment considered only the fillet form of each species. The single form of fish (fillet) and surveying in a city supermarket setting provide insights into the demands of shoppers in such retail settings; however, there is also ample need for future research to understand the fish buying habits of other segments of the Brazilian population. Shopping behaviors such as multiple purchasers by household, frequenting different retail market types, and/or shopping by residents outside of metropolitan areas are all aspects to consider for future study that would be important to improve understanding of Brazilian fish consumers. Despite the limitations, this study provides information for the government and private institutions working on aquaculture in Brazil. The results suggest strong relationships between fish knowledge and species selection preferences. While Brazil has many native fish species that could be farmed, some of these are unfamiliar to much of the population. Given these findings, government and food industry managers may have an opportunity, and in particular those seeking to develop the non-traditional fish marketplace in various regions of Brazil, to invest in education and advertising to inform shoppers of options available.

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Appendix A - Questionnaire

Enumerator_____ Date/Time_____ City _____ Supermarket_____ Fish day: □ Yes □ No

This survey should take no more than 7 minutes to complete. You must be at least 18 years of age and be a resident of this city to participate. Your participation in this study is voluntary and your responses to the questionnaire will be treated as confidential. Your name is not required anywhere and all survey data will be combined to ensure the anonymity of your individual responses.

1) **What is your gender? □ a) M □ b) F**

2) **How old are you? _____**

3) **Does your family eat fish?**
   □ a) YES
   □ b) NO (Give reason _____) Terminate interview

4) **Can you identify each species in the pics?**

	tilapia	tambaqui	pirarucu	salmon	Pintado (catfish)	Don't know
						
						
						
						
						

Did the consumer change any answer in this question? □ yes □ no

5) Could you identify the fillet of each species in the pics?

	tilapia	tambaqui	pirarucu	salmon
				
				
				
				

Did the consumer change any answer in this question? □ yes □ no

Which option of fish would you buy? (Use a picture of each to show the interviewed)

Question	Option A	Option B	Option C
6)	Tilapia Frozen US$ 8.00	Tilapia Fresh US$ 8.75	If these were the only fish options available, I would not buy fish at this time.
7)	Tilapia Frozen US$ 8.75	Tambaqui Frozen US$ 7.00	If these were the only fish options available, I would not buy fish at this time.
8)	Tilapia Frozen US$ 6.25	Tambaqui Fresh US$ 6.25	If these were the only fish options available, I would not buy fish at this time.
9)	Tilapia Fresh US$ 8.00	Tambaqui Frozen US$ 8.00	If these were the only fish options available, I would not buy fish at this time.
10)	Tilapia Fresh US$ 8.75	Tambaqui Fresh US$ 8.75	If these were the only fish options available, I would not buy fish at this time.
11)	Tambaqui Frozen US$ 8.00	Tilapia Frozen US$ 6.25	If these were the only fish options available, I would not buy fish at this time.
12)	Tambaqui Frozen US$ 7.00	Tilapia Fresh US$ 8.00	If these were the only fish options available, I would not buy fish at this time.

13)	Tambaqui Fresh US$ 8.75	Tilapia Frozen US$ 8.00	If these were the only fish options available, I would not buy fish at this time.
14)	Tambaqui Fresh US$ 7.00	Tilapia Fresh US$ 6.25	If these were the only fish options available, I would not buy fish at this time.

15) How many people live in your home? _____

16) How many people under 12 years old live in your home? _____

17) On average, how much is spent on food in a month for the whole family? _____

18) On average, how much is spent on fish in a month for the whole family? _____

19) Where do you usually buy fish? (please check all that apply)

□ a) Supermarket
□ b) Fish store
□ c) Butcher shop
□ d) Farmers market
□ e) City market
□ f) Direct from fishers / fish farmers
□ g) Other (please specify) _____

20) Which of these forms of fish do you usually buy?

	Never	**Occasionally**	**At least once a month**	**Every 15 days**	**At least once a week**	**At least twice a week**	**Daily**
	Processing						
Fillet							
Strips							
Chunk							
Whole fish							
Canned							
	Conservation						
Fresh							
Frozen							
Salted							
Cooked							

21) Which of these types of fish do you prefer the most?

□ a) Fresh water
□ b) Sea / Salt water
□ c) Indifferent

22) If you can choose between two fishes from the same species, do you prefer?

□ a) Farmed. Why? _____

□ b) Wild-caught. Why? _____

□ c) Indifferent

23) Do you know how these fishes are produced?

	Wild-caught	Farmed	Both	Do not know
□ a) Tilapia				
□ b) Tambaqui				
□ c) Salmon				
□ d) Sardine				
□ e) Pintado (catfish)				

24) Which one of the following do you prefer?

□ a) Saint Peter fillet

□ b) Tilapia fillet

□ c) Indifferent

□ d) They are the same

□ e) Do not like either/Did not eat both

□ f) I do not know one or both of these fillets

25) Which of these represents the total monthly family income?

□ a) Less than US$ 301

□ b) Between US$ 302 and US$ 501

□ c) Between US$ 502 and US$ 2,160

□ d) Between US$ 2,161 and US$ 2,815

□ e) More than US$ 2,816

26) What is your highest level of education?

□ a) No formal school

□ b) Primary school - incomplete

□ c) Primary school - complete

□ d) High school – incomplete

□ e) High school - complete

□ f) Bachelor - incomplete

□ g) Bachelor – complete

□ h) Graduate

Table 1. Demographics results for subjects participating in the consumer survey

	South (n=300)	Southeast (n=300)	Midwest (n=212)	Northeast (n=300)	North (n=240)
Percentage (%) of survey respondents					
Gender					
Female	42.6	60.5	46.2	62.0	42.9
Age					
Under 21	4.0	2.3	2.4	2.7	2.5
21-30	12.7	8.7	13.2	16.0	16.7
31-40	22.7	17.3	18.4	24.0	20.0
41-50	22.7	23.3	20.8	21.0	19.2
51-60	23.7	24.7	22.2	21.3	18.3
61-70	9.0	17.0	16.5	9.3	15.8
Above 70	5.3	6.7	6.6	5.7	7.5
Household income					
E (Less than US$ 301)	18.0	14.8	13.1	15.2	15.0
D (Between US$ 302 and US$ 501)	14.1	14.4	17.7	12.4	16.3
C (Between US$ 502 and US$ 2,160)	44.4	46.6	48.0	54.0	42.5
B (Between US$ 2,161 and US$ 2,815)	14.8	17.2	15.2	14.0	21.0
A (More than US$ 2,816)	8.8	6.9	6.1	4.4	5.2
Education					
no formal school	0.3	0.0	0.0	0.0	0.4
primary incomplete	5.0	4.1	5.9	4.8	5.1
primary complete	8.1	5.1	7.4	4.8	5.1
high school incomplete	2.4	3.4	4.4	3.5	3.0
high school complete	27.5	28.0	18.2	27.7	23.7
bachelor incomplete	10.1	15.4	13.3	13.2	13.6
bachelor complete	31.2	28.3	34.0	29.1	30.1
graduate	15.4	15.7	16.8	17.0	19.1
People at home					
Average (everyone)	3.3	3.4	3.3	3.4	3.3
Average (below 12 years old)	0.4	0.5	0.5	0.4	0.4

Table 2. Fish consumption characteristics for subjects participating in the survey

	South (n=300)	Southeast (n=300)	Midwest (n=212)	Northeast (n=300)	North (n=240)
Percentage (%) of survey respondents					
Fresh water-sea preference					
Fresh water	30.7	26.9	31.6	25.4	25.0
Sea / Saltwater	29.4	31.3	24.3	29.2	34.3
Indifferent	39.9	41.8	44.2	45.4	40.7
Fishery-aquaculture preference					
Farmed	6.1	7.5	10.2	6.9	6.4
Wild-caught	50.9	48.6	48.3	53.6	48.9
Indifferent	43.0	43.9	41.5	39.5	44.7
Where consumers bought fish					
Supermarket	78.0	77.3	76.9	80.7	80.8
Fish store	18.3	22.3	20.8	17.3	15.0
Butcher shop	1.3	0.3	0.5	1.0	0.0
Farmers' market	13.7	14.0	15.1	12.7	15.4
City market	5.0	7.0	7.6	6.7	5.4
Direct fishers/farmers	4.3	6.0	5.2	5.3	5.8
Other	6.7	5.7	6.1	4.0	5.0
Forms of fish purchased					
Fillet	83.6	87.8	83.9	85.3	83.9
Strips	26.6	28.6	26.8	28.1	30.6
Chunk	61.0	64.5	64.9	64.4	65.5
Whole fish	66.3	61.1	66.3	67.1	63.4
Canned	63.8	57.7	61.0	58.4	56.2
Fresh	93.8	93.2	95.1	95.9	92.8
Frozen	58.6	62.7	63.9	63.6	58.5
Salted	58.9	57.5	66.8	62.2	61.3
Cooked	69.6	68.7	74.9	70.1	66.8
Family expenses (US$/month)					
On food (average)	298.6	290.3	302.5	307.9	299.9
On fish (average)	40.4	36.3	38.7	43.7	39.9

Table 3. Fish knowledge of subjects participating in the survey

	South (n=300)	Southeast (n=300)	Midwest (n=212)	Northeast (n=300)	North (n=240)
Percentage (%) of survey respondents					
Is able to identify the species in a picture					
Tambaqui	45.6	47.5	48.5	50.5	52.3
Tilapia	63.8	60.8	64.3	62.3	59.8
Pintado (catfish)	67.5	66.9	70.5	70.4	66.0
Pirarucu	43.0	41.2	42.2	47.3	49.6
Salmon	69.0	58.5	53.1	59.1	57.6
Is able to identify the fillet in a picture					
Tambaqui	41.4	34.6	39.6	42.4	39.4
Tilapia	66.6	64.8	60.9	66.2	64.8
Pirarucu	52.2	47.8	46.9	54.6	49.2
Salmon	77.1	77.3	73.0	80.8	76.2
Knows if it is farmed or wild-caught					
Tilapia	43.5	42.7	45.4	42.4	46.4
Tambaqui	16.2	20.2	20.0	27.4	22.7
Salmon	9.3	12.7	12.7	13.9	11.1
Sardine	51.2	53.5	49.8	57.6	52.3
Pintado (catfish)	11.1	11.0	12.8	4.5	11.1
Saint Peter vs tilapia					
Knows that Saint Peter fillet is tilapia	12.1	11.0	9.8	8.7	9.8

Table 4. Parameters from correlated RPL and mean WTP estimates for tilapia and tambaqui fillet for five Brazilian Regions

	Variable	Coefficient (standard error)	Standard deviation (standard error)	Mean WTP (US$) [confidence interval]
South	OptOut	-8.73302***	5.24055***	-10.28
		(0.80158)	(0.45008)	[-11.36 , -9.38]
	Tilapia	1.17864***	2.91891***	2.78
		(0.18918)	(0.26404)	[1.82 , 3.90]
	Fresh	2.82335***	2.49630***	6.65
		(0.22967)	(0.22162)	[5.41 , 8.26]
	Price	-0.84956***		
		(0.08427)		
Southeast	OptOut	-6.30680***	6.23263***	-10.56
		(0.72321)	(0.67232)	[-12.17 , -9.30]
	Tilapia	1.19012***	2.59268***	3.99
		(0.18550)	(0.18181)	[2.66 , 5.74]
	Fresh	2.47430***	2.12634***	8.29
		(0.22380)	(0.18322)	[6.22 , 11.23]
	Price	-0.59728***		
		(0.07856)		
Midwest	OptOut	-3.76346***	0.11309	-8.38
		(0.54378)	(0.22723)	[-8.96 , -7.90]
	Tilapia	0.89627***	2.10174	3.99
		(0.18008)	(0.19162)	[2.32 , 6.42]
	Fresh	1.58539***	1.12601***	7.06
		(0.12287)	(0.11135)	[6.14 , 10.18]
	Price	-0.44924***		
		(0.07032)		
Northeast	Optout	-9.97463***	5.40616***	-10.79
		(0.86679)	(0.44401)	[-12.05 , -9.69]
	Tilapia	0.75772***	3.02082***	1.64
		(0.17830)	(0.25330)	[0.84 , 2.53]
	Fresh	2.54543***	1.81019***	5.51
		(0.18911)	(0.17221)	[4.54 , 6.77]
	Price	-0.92472***		
		(0.08848)		
North	OptOut	-8.93798***	6.17997***	-10.85
		(1.00014)	(0.69095)	[-12.45 , -9.69]
	Tilapia	1.04372***	4.49560***	2.53
		(0.27779)	(0.41376)	[1.21 , 4.12]
	Fresh	2.99109***	2.62738***	7.26
		(0.30071)	(0.27123)	[5.66 , 9.57]
	Price	-0.82408***		
		(0.10516)		

Notes: *** indicates significance at the 1% level.

Table 5. Percentiles of OptOut, tilapia and fresh WTP (US$/kg) distribution per Brazilian region

	Percentile						
	5%	**10%**	**25%**	**50%**	**75%**	**90%**	**95%**
South							
OptOut WTP	-16.05	-15.68	-15.14	-10.75	-7.54	-2.00	1.62
Tilapia WTP	-8.08	-6.29	-0.09	2.63	7.38	10.94	10.98
Fresh WTP	-0.41	1.06	3.46	5.91	10.46	14.19	14.24
Southeast							
OptOut WTP	-21.53	-20.14	-19.34	-15.19	-7.52	-0.02	7.47
Tilapia WTP	-12.94	-10.20	-0.75	4.98	8.84	13.21	14.15
Fresh WTP	-0.42	0.65	4.23	8.02	11.81	16.90	17.09
Midwest							
OptOut WTP	-8.78	-8.70	-8.52	-8.40	-8.24	-8.03	-8.03
Tilapia WTP	-11.12	-8.06	-1.38	3.10	9.19	16.80	16.85
Fresh WTP	0.57	1.52	3.96	6.71	9.74	12.94	13.39
Northeast							
OptOut WTP	-15.74	-15.27	-15.00	-13.06	-7.76	-3.03	-0.58
Tilapia WTP	-10.29	-7.83	-1.90	1.41	6.12	9.81	9.85
Fresh WTP	0.33	1.66	3.78	5.39	7.85	10.37	10.66
North							
OptOt WTP	-18.42	-17.46	-16.43	-11.75	-7.64	-0.72	2.61
Tilapia WTP	-15.37	-12.25	-2.82	3.63	11.82	15.12	15.23
Fresh WTP	-0.16	1.51	3.81	6.44	11.17	14.55	15.50

Table 6. Highlights of sociodemographic, fish consumption and fish knowledge variables for consumers with higher and lower preferences on fish attributes

Tilapia - lower than 10th percentile	Tilapia - higher than 90th percentile
South	
More able to identify the whole tambaqui picture (93%)	More aware that Saint Peter and tilapia fillet are the same (29%)
Higher average monthly consumption of fish (US$ 63)	Purchase more fish fillet at least occasionally (93%)
Southeast	
More able to identify the whole tambaqui picture (89%)	More aware that Saint Peter and tilapia fillet are the same (17%)
Higher average monthly consumption of fish (US$ 53)	Purchase more fish fillet at least occasionally (93%)
Midwest	
More able to identify the whole tambaqui picture (86%)	Higher presence in income classes D and E (45%)
Higher average monthly consumption of fish (US$ 72)	Purchase more fish fillet at least occasionally (95%)
Northeast	
More able to identify the whole tambaqui picture (93%)	Lower average monthly consumption of fish (US$ 28)
Purchase more whole fish at least occasionally (97%)	Purchase more fish fillet at least occasionally (96%)
North	
More able to identify the whole tambaqui picture (96%)	Fewer children at home on average (0.25)
Purchase more whole fish at least occasionally (91%)	Prefer more farmed fish (13%)

Fresh - lower than 10th percentile	Fresh – higher than 90th percentile
South	
Fewer children at home on average (0.25)	More able to identify the tilapia fillet picture (80%)
Buy more in supermarkets (90%)	Higher presence in income classes D and E (41%)
Southeast	
Fewer children at home on average (0.29)	Higher average monthly consumption on fish (US$ 50)
Buy less in farmers markets (0%)	Lower presence in income classes A and B (11%)
Midwest	
Prefer more farmed fish (18%)	Prefer more wild-caught fish (58%)
Higher presence in income classes A and B (48%)	Lower presence in income classes A and B (6%)
Northeast	
Prefer less freshwater fish (13%)	More able to identify the tilapia fillet picture (83%)
Higher presence in graduate educational level (40%)	Higher presence in income classes D and E (45%)
North	
More consumers are older than 40 years old (54%)	More able to identify the tilapia fillet picture (92%)
Prefer more sea/saltwater fish (50%)	Purchase more fish fillet at least occasionally (96%)

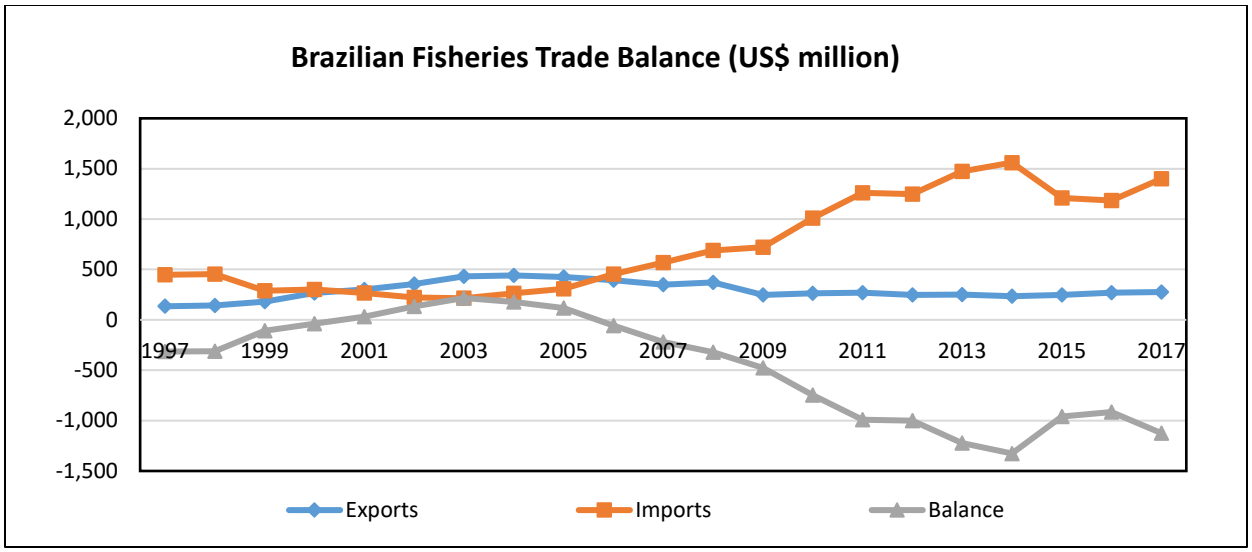

Figure 1. Fisheries trade balance (US$) – 1997-2017

Source: Brazilian Ministry of Fisheries and Aquaculture and Ministry of Industry, Foreign Trade and Services.