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Consumption frequencies, determinants, and habits of aquaculture species in Brazil

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Abstract

The Brazilian aquaculture sector faces many challenges involving internal consumption; Brazil's per capita fish consumption is lower than its production capacity. In this study, the dataset used the Pearson correlation coefficients and ordered logit models and their odd ratios to identify relationships and estimate the probabilities of the main determinants and barriers for fish purchasing on consumption frequency levels. A sample of 1509 participants was surveyed to examine Brazil's main consumption frequencies, determinants, and habits of aquaculture species. The study confirmed that aquaculture fishes are mainly consumed occasionally during Easter and supermarkets are the main retail channel. Tambaqui, tilapia, and white leg shrimp are the species mostly consumed amongst the sample. The results indicated that the highest probability for a consumer to increase their consumption frequency levels for tilapia is related to availability on shelves. Nutritional value is a significant determinant relating to the increased consumption frequency of grouper. Lack of desired species, not trusting the health quality of the product, and culinary options are essential determinants for consuming shrimp. Similarly, for catfish, high prices, variety in culinary options and difficulty in preparation are the main determinist affect consumption frequency levels. Also, the results indicated that income and education influence the probability of moving to a higher consumption frequency level of all species, except for tambaqui. The findings provide valuable information, especially for producers and organizations in terms of marketing and policy analysis. Marketing strategies and campaigns are recommended to promote the habit of eating fish throughout the year.

Keywords Aquaculture fishes · Consumption frequency · Consumer behaviour · Brazil · Proportional odds model

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Introduction

Growing demand, rising incomes, and population growth, amongst other factors have impacted the consumption and production expansion of fish and fish products in the world (Food and Agriculture Organization of the United Nations, 2018). The vast majority of the increase in seafood consumption in recent decades has been sustained by aquaculture, while food fish consumption output has grown from 9.0 to 20.2 kg per year from 1961 to 2015, respectively (FAO, 2018). However, consumption patterns, consumers health status, several behavioural, and socioeconomic elements of consumer behaviour and consumption habits involving seafood affect the sector's development (Erdoğan et al., 2011).

It should be noted that consumers hold various perceptions of a product or service, thus affecting consumption (Kurtuluş and Okum, 2010). Consumer behaviour and perception of fish and seafood products are influenced by several other factors, including but not limited to socioeconomic and behavioural factors, general habits, product quality, product choice, species, food choice habits and family preferences, health benefits, value, advertising, and packaging (Altintzoglou et al., 2011; Christenson et al., 2017; Erdoğan et al., 2011; Kurtuluş and Okum, 2010; Richter et al., 2017).

Based on Kinnucan and Wessells, (1997) review, it is confirmed that for aquaculture to be market-driven, it requires general marketing and consumer information and intimate knowledge on consumers' perceptions, wants, beliefs, attitudes, lifestyles, habits, and other factors that govern choice. Henceforth, in recent times, consumer-held perceptions of fish have obtained much attention. However, there are still several gaps between objective scientific proof and the consumer's subjective perceptions of fish (Verbeke et al., 2007). Thus, understanding consumers' perceptions play a central role in market development.

In terms of aquaculture, Brazil is categorically the primary producer of inland water capture and fish farming production in South America (Food and Agriculture Organization of the United Nations, 2018). The Brazilian aquaculture industry has a vast diversity of species, including tambaqui, tilapia, white leg shrimp, arapaima, grouper and catfish[1] (Flores et al., 2014). In fact, Brazilian fish farming production has been experiencing rapid fish production and stable long-term growth during the past years by cause of growth in aquaculture (Flores and Pedroza Filho, 2019); and in 2020, attained a growth rate of 5.9% at 802,930 tons in relation to the production level in 2018 (FAO, 2018; Flores and Filho, 2014; PEIXE BR, 2021). And significantly, as stated by PEIXE BR (2020, p. 5), "This growth rate was the highest amongst all animal proteins in the country."

Although Brazilian aquaculture production and consumption are growing, which presents the most significant potential to increase fish supplies (Barone et al., 2017), one of the market challenges confronting Brazilian aquaculture is internal consumption (PEIXE BR, 2019). In Brazil, fish consumption habits have been influenced in the past decades by several cultural and socioeconomic changes (Filho et al., 2020). The Federal government has been encouraging the consumption of fish through investments as a means to increase fish as a supply of protein for the population (Chong-Carrillo et al., 2018); the objective of the Brazilian government to promote the consumption and production of fish is to increase

[1] Tambaqui (Colossoma macropomum); tilapia: (Oreochromis Niloticus); whiteleg white leg shrimp (Litopenaeus vannamei); arapaima (Arapaima gigas); grouper (Epinephelus marginatus); catfish (Pseudoplatystoma corruscans).

Brazilian fish consumption to an average of 14 kg per year (FAO, 2020). However, regardless of its yearly growth in fish consumption, Brazil's per capita fish consumption is lower than its production capacity (PEIXE BR, 2019). Compared to the world, Brazil's domestic per capita fish consumption remains lower than 10 kg/year, whereas globally, the average is approximately 20 kg/year (PEIXE BR, 2019).

There are major inadequacies and a lack of studies of fish consumption and consumer perceptions analysis in the industry (Gaviglio et al., 2014). The PEIXE BR[2] CEO, Francisco Medeiros, confirmed that Brazilian fish farming has tremendous but unrealized potential. However, continuing research is required in developing fish consumption; in other words, research is necessary for aquaculture (PEIXE BR, 2019). In doing so, information on consumer attitudes is essential for future aquaculture product development (Gonçalves and Kaiser, 2011).

Moreover, research and marketing may be an additional barrier to aquaculture development due to insufficient institutional backing in these fields (Shang, 1985). Furthermore, from the perspective of marketing and consumer behaviour, it has been observed that there is a deficient volume of research on fish consumption (Temesi et al., 2020). As such, reliable marketing data in aquaculture lags far behind in the Brazilian aquaculture industry. Especially in Brazil, there is a requirement to demonstrate the developments and potential directions within the aquaculture sector.

Henceforth, the premise of this research is to explore consumers' consumption frequencies, main determinants, and habits of aquaculture species towards six distinguished farmed species in Brazil; tambaqui, tilapia, white leg shrimp, grouper, arapaima, and catfish. Knowledge of fish consumer behaviour is required to increase fish consumption. Thus, as a consequence of the shortage of fish consumer behaviour studies in Brazil, it is rather challenging to acquire reliable information (Filho et al., 2020). Therefore, to develop successful strategies to increase Brazilian aquaculture fish consumption, we must first understand the main determinants, habits and frequency affecting consumers 'consumption'.

To date, there are no papers to our knowledge that collectively examined these aquaculture species consumption frequencies, determinants, and habits extensively, covering all states of Brazil through an online survey methodology. Comparably, a study conducted in 2019 by Flores et al. (2021) analysed data from different choice experiments performed in person at supermarket seafood counters of five selected regions in Brazil. Thus, in the discussion section, a descriptive comparison of the findings of this present survey of 2020 and the previous related survey conducted in 2019 was evaluated to discover any consumption patterns as the two studies exhibit similar descriptive structures.

The main aims of this present study were (I) to investigate the relationships between the species of fish consumed and consumption frequency, the likeliness of fish choice, and barriers; (II) to examine, to what extent, if any, does socioeconomic status, education level, gender, and age of consumer influence fish consumptions; and (III) to explore possible strategies that can be implemented to increase consumption of the main fish farming products in Brazil. It is believed that the results of this research will assist stakeholders in the decision-making process regarding aquaculture species production, marketing and promotion, product diversity, and sales policies on both regional and national scales.

[2] PEIXE BR is The Brazilian Fish Farming Association.

Materials and methods

Two primary purposes of a survey methodology are to measure attitudes and opinions and achieve knowledge of a social problem. Market research increasingly uses surveys to seek information about the reactions of "real" people to current and projected products and services (Groves et al., 2011). The insights of this stakeholder [consumers] are essential in the development of the aquaculture sector. (Shang, 1985, p. 5), stated that "research into the economics of aquaculture plays a major role in aquaculture development. It provides a foundation, not just for decision-making amongst farmers, but also for devising public aquaculture policies". Aquaculture in an economy has several internal and external determining factors to the sector and the economy.

The survey methodological approach applied in this research allowed a nationwide investigation of "real" consumers regarding their consumption habits, attitudes, and behaviours of aquaculture species, as the methodological sample reach includes the entire country of Brazil. With such an approach and the customer-centred design objective of this research, the knowledge generated from the sample may have immense applicability to consumer behaviour for the entire population.

Primary data were gathered through an online survey by 1509 individuals with different socioeconomic backgrounds and are dispersed within the five central geographical regions (North, North-eastern, Midwestern, South-eastern, and South) in Brazil. Such non-probability sampling is commonly used since it is somehow convenient to execute (Fricker, 2017). Furthermore, Schonlau, Fricker and Elliott (2002) recommend keeping the internet survey in the field for a prolonged period to attain a high enough response level. In this case, the survey remained in circulation for 7 days before retraction for data analysis. Thus, data for this survey was collected in December 2020. The online survey was composed of three general categories: (I) questions regarding the respondent's socioeconomic characteristics, (II) introductory questions such as the preference for aquaculture species, and (III) questions on consumption behaviours, including aquaculture species' consumption frequency, habits, and determinants. The questionnaire applied is presented in Appendix.

Five commonly consumed fish species plus white leg shrimp were employed to explore consumption frequency. In this study, the ordered logit model was used, where the dependent variable is represented by consumption frequencies, measured using a five-point category scale and coded in descending order as described in the following: (0) never, (1) occasionally, (2) at least once a semester, (3) at least once a month, (4) at least once a week, (5) and 2 or more times a week. The independent variables in the model are according to the primary factors when choosing a species, the main barriers in purchasing fish, and the respondents' age, gender, income, education. Table 1 summarizes the variables used in the ordered logit model.

The methodology described here is according to (Aydin and Saracli, 2016). Ordered logit models are used when the dependent variable has more than two categories and an ordered structure. This model is similar to the multinomial logit model (Aydin and Saracli, 2016). However, the multinomial logit model is used when categories are nominal and have no ordered structure (Hosmer and Stanley, 2000). In this article, the aquaculture consumption frequency was analysed using the STATA software package through maximum likelihood. In addition, the validity of the model for each species was tested by the likelihood ratio test and pseudo R^2.

Table 1 Distribution of indices by variable

Variable	Index classes	Variable	Index classes
Consumption frequency levels by species	– Never = 0 – Occasionally = 1 – At least once per semester = 2 – At least once per month = 3 – At least once per week = 4 – 2 or more times per week = 5	Income status[a]	– Less than R $ 1254 = 1 – Between R $ 1255 and R $ 2004 = 2 – Between R $ 2005 and R $ 8640 = 3 – Between R $ 8641 and R $ 11,261 = 4 – More than R $ 11,261 = 5
Which of the options below do you consider the main difficulty for buying fish?	– High prices = 1 if the option was selected; = 0 otherwise – Lack of the desired species = 1 if the option was selected; = 0 otherwise – Difficulty in preparation = 1 if the option was selected; = 0 otherwise – Does not find the desired presentation = 1 if the option was selected; = 0 otherwise – Does not trust the health quality of the products = 1 if the option was selected; = 0 otherwise – Other = 1 if the option was selected; = 0 otherwise	Education level	– Illiterate = 1 – Elementary Education – Incomplete = 2 – Elementary School – Complete = 3 – High School – Incomplete = 4 – High School – Complete = 5 – Higher Education – Incomplete = 6 – Higher Education – Complete = 7 – Postgraduate = 8
What is the main factor that you consider when choosing a species of fish?	– Taste = 1 if the option was selected; = 0 otherwise – Price = 1 if the option was selected; = 0 otherwise – Nutritional Value = 1 if the option was selected; = 0 otherwise – Availability on shelves = 1 if the option was selected; = 0 otherwise – Culinary variation options = 1 if the option was selected; = 0 otherwise – Visual appearance of the product = 1 if the option was selected; = 0 otherwise – Other = 1 if the option was selected; = 0 otherwise	Gender of the consumer	– Male = 1 – Female = 0
	–	Age	– 18–77 (range)

[a]As of April 2021, 1 Brazilian Real is equal to 0.18 United States dollar.

Besides estimating the regular coefficients from the ordered logit model, the proportional odds model (POM) was used for category comparisons of the dependent variable. The POM, an ordered logistic regression model based on estimating the cumulative probabilities, was initially proposed by Walker and Duncan (1967) and later called POM by McCullagh (1980). Equation 1 shows how POM uses cumulated probabilities (Ananth and Kleinbaum, 1997):

$$\Pr\left(Y \le y_j|x\right) = \left[\frac{\exp\left(\alpha_j - x'\beta\right)}{1+\exp\left(\alpha_j - x'\beta\right)}\right] \quad \text{for j} = 0, 1, \ldots, 5. \tag{1}$$

where Y is the multinomial response variable with categorical outcomes j (consumption frequencies for each species) and x is the vector of covariates. Equation 1 can be written by taking the natural logarithm of the odds ratio of the model and re-expressed in logit form as follows:

$$\text{logit}\left(\Pi_j\right) = \log\left[\frac{\Pi_j}{1-\Pi_j}\right] \tag{2}$$

$$\log\left[\frac{\Pr\left(Y \le y_j|x\right)}{\Pr\left(Y > y_j|x\right)}\right] = \alpha_j - x'\beta \qquad \text{for j} = 0, 1, \ldots, 5. \tag{3}$$

where $\Pi_j = \Pr(Y \le y_j|x)$ is the cumulative probability of the event $(Y \le y_j|x)$, α_j are the unknown intercept parameters, and β is a vector of the regression coefficients corresponding to x. In the present study, it is estimated one vector β for each aquaculture species. The coefficients in vector β do not depend on j; therefore, Eq. 3 assumes that the relationship between x and Y is independent of j. According to McCullagh (1980), this is the assumption of identical log-odds ratios across the cut points, or the proportional odds assumption.

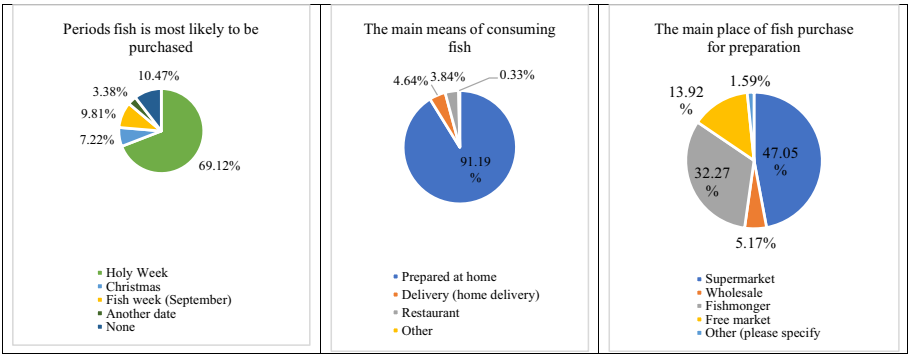
The survey further explored information on the type of fish consumers prefer, periods in which fish is most likely to be purchased, the main place of fish purchase for preparation, and the primary means of consuming fish. Basic descriptive statistics were used to summarize the general nature of the data attained (Billard and Diday, 2006; Fisher and Marshall, 2009; Ormrod and Leedy, 2010). The relationships between the consumers' socioeconomic characteristics, the difficulties when acquiring fish, the factors when choosing a species, and fish consumption frequencies were also analysed using the Pearson correlation coefficient. The threshold of interpretation values can range from negligible to very strong correlation (Schober et al., 2018), which can be inferred in measurements of effect sizes as small, medium, or large. Particularly, $r = 0.00$–0.29 is interpreted as small effects, $r = 0.30$–0.49 as medium effects, and $r = 0.50$–1.00 as large effects, where r is the Pearson correlation coefficient (Gignac and Szodorai, 2016; Hemphill, 2003; Lovakov and Agadullina, 2021).

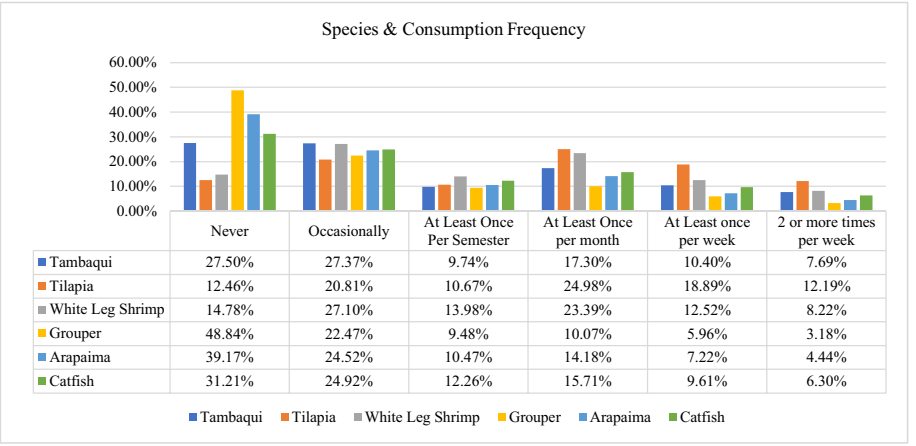
Results

The sociodemographic profile of the survey results and their sample percentages are shown in Table 2. As presented, the sample representation was fairly distributed along with each sociodemographic category. In addition, specific consumers' habits and

Table 2 Descriptive background characteristics

Gender	%	Regions	%	Education level	%
Male	48.05	South Region	19.88	Illiterate	0.20
Female	51.95	Southeast Region	19.88	Elementary education – incomplete	1.13
Age groups		Northeast Region	19.88	Elementary school – complete	1.86
Less than 18	0	North Region	19.95	High school – incomplete	2.85
18–24	26.24	Midwest Region	20.41	High school – complete	27.83
25–34	33.27	**Household members**		Higher education – incomplete	15.64
35–44	21.74	1–3 people	51.56	Higher education – complete	37.24
45–54	11.66	4–6 people	46.45	**Household income**	
55–64	5.63	7–9 people	1.79	Less than R$ 1.254	11.00
65 and over	1.46	10–20 people	0.20	Between R$ 1.255 e R$ 2.004	21.01
				Between R$ 2.005 e R$ 8.640	46.39
				Between R$ 8.641 e R$ 11.261	11.93
				More than R$ 11.261	9.68





	Never	Occasionally	At Least Once Per Semester	At Least Once per month	At Least once per week	2 or more times per week
Tambaqui	27.50%	27.37%	9.74%	17.30%	10.40%	7.69%
Tilapia	12.46%	20.81%	10.67%	24.98%	18.89%	12.19%
White Leg Shrimp	14.78%	27.10%	13.98%	23.39%	12.52%	8.22%
Grouper	48.84%	22.47%	9.48%	10.07%	5.96%	3.18%
Arapaima	39.17%	24.52%	10.47%	14.18%	7.22%	4.44%
Catfish	31.21%	24.92%	12.26%	15.71%	9.61%	6.30%

Fig. 1 Consumer fish consumption frequency, habits and preferences

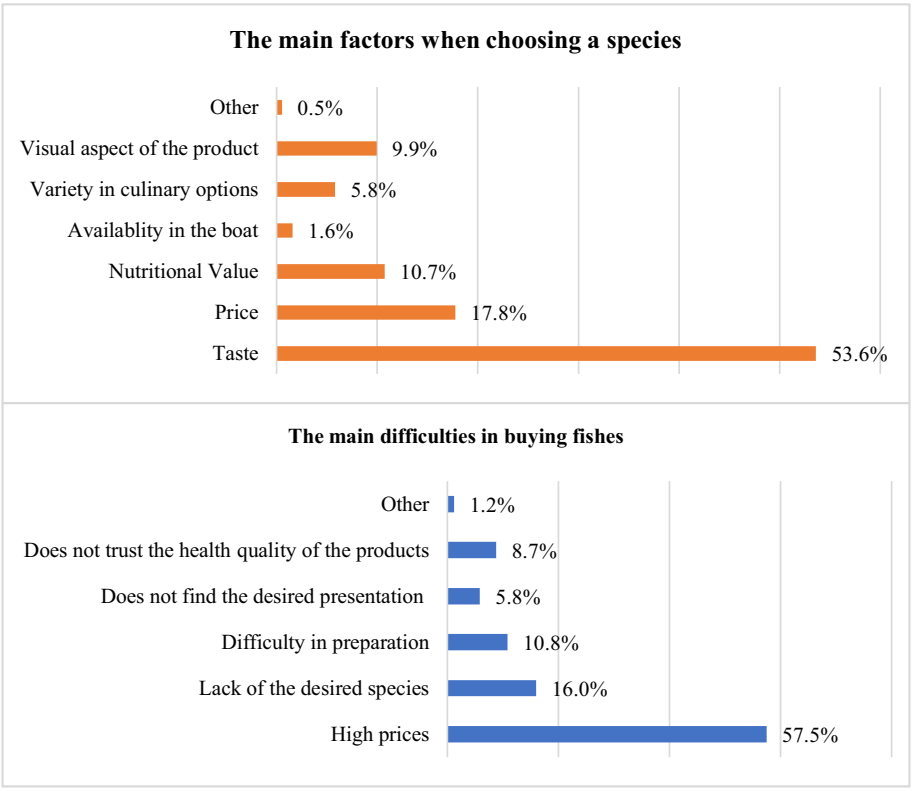


Fig. 2 Likeliness of choosing a species and main barriers to purchasing fishes, Survey 1, 2020

preferences are summarized in Fig. 1. In the 1990s, fish consumption has been given attention as concerns for health grew. Since then, the intention to consume fish in Brazil has been linked to health, weight control, and longevity, thus following an increased fish consumption desire (Chong-Carrillo et al., 2018; Kato and Freitas, 2015; Silveira et al., 2012). Nevertheless, in Brazil, there are still many barriers or limitations of fish consumption amongst the population, as previously mentioned, such as price, taste, preference for other meats, lack of access to convenience products (Kato and Freitas, 2015; Silveira et al., 2012).

Based on the information presented in Fig. 1, when fish is consumed, it is primarily consumed on an occasional basis as appose to throughout the year, given that 69.12% of respondents stated that they are more likely to purchase fish during Holy Week (Easter). Notably, fish is mainly prepared for household consumption (91.9) and the main places of fish purchased for preparation are supermarkets (47.05%).

Tilapia was reported as the species mostly consumed two or more times per week (12.19%), at least once per week (18.89%), and once per month (24.93%). However, tambaqui is more consumed occasionally and white leg shrimp was mostly consumed at least once per semester (13.98%). On the other hand, the species that was mostly never consumed by the respondents was grouper.

Figure 2 shows the main factors when choosing a species and the main difficulties in buying fish. More than half of consumers identified "taste" as the most important factor when choosing a species. In other words, greater intentions to consume aquaculture fishes frequently are led by the product's taste. Nevertheless, there is also an important influence of other factors, such as price, nutritional value, and visual aspects of the product. On the other hand, high prices were viewed as the principal barrier when buying fish. We can presume that high prices may be a determinant or barrier for consumption for the respondents who reported never consuming fish. However, the results showed that the other factors are comparatively weak barriers.

We tested the proposed relationships between the above variables. Table 3 presents the correlation coefficients between the frequency of consumption for each species and the variables generated from the difficulties in buying fish, the factors when choosing a species and demographic variables.

High prices were significantly negatively correlated with all species' consumption frequency, demonstrating values between −0.164 and − 0.085, which can be considered a small effect. Likewise, the lack of desired species and lack of the desired presentation were poorly correlated variables. All species in the category of difficulty in preparation and lack of trust pertaining to the products' health quality were not significant. When choosing a species, the factor of taste was poorly positively correlated with the consumption frequency presenting a significant relationship with white leg shrimp (0.079) and arapaima (0.069) and its consumption frequency. Also, price as a factor when choosing a species and consumption frequency was negatively correlated with all species. Consequently, the results reflect the fact that as price increases, consumption frequency decreases. The results for the demographic variables indicated that income and education variables were significantly correlated to the consumption frequency of all species.

In addition to the correlation coefficient, the present study further analysed the main determinants of fish consumption frequency in Brazil using the ordered logit model. The odds ratios are estimated to determine how many times the exogenous variables increase the probability of a consumer moving to a higher level of consumption frequency. This type of model permits the effective analysis of consumers' preferences (Cantillo et al., 2021). Table 4 summarizes the results.

The results from the ordered logistic regression showed that the coefficients relating to difficulties in buying were not significant for tambaqui, tilapia and arapaima consumption frequency. In terms of shrimp consumption levels, the probability of a consumer moving to a higher level because he/she thinks lack of desired species or not trusting the health quality of the product are the main difficulties buying seafood is, respectively, 3.1 and 1.5 times higher. Whereas for grouper, the probability of a consumer moving to a higher consumption level due to not trusting the health quality of the product is 0.4 times higher (i.e., 2.26 times less likely). In terms of catfish consumption levels, the variables such as high prices, difficulty in preparation and not trusting the health quality of the product presented a negative impact.

An increase in the consumption frequency level was not explained by variables taste and price as factors when choosing any species. For tilapia, the chances of a consumer that thinks availability on shelves is the main factor reaching a higher consumption level are 3.8 times higher. As for shrimp, grouper and catfish consumption levels, a consumer that indicated culinary options in the survey is, respectively, 3.4, 6.4 and 3.3 times more likely to move to a higher level.

Table 3 correlation coefficients between the frequency of consumption for each species and the variables generated from the difficulties in buying fish, the factors when choosing a species and demographic variables

Variables	**Consumption frequency of aquaculture species**					
Difficulties in buying fish	**Tambaqui**	**Tilapia**	**White leg shrimp**	**Grouper**	**Arapaima**	**Catfish**
High prices	−0.068**	−0.086**	−0.163***	−0.124***	−0.125***	−0.105***
Lack of the desired species	0.099***	0.083**	0.150***	0.110***	0.114***	0.098***
Difficulty in preparation	−0.003	0.021	0.044	0.028	0.114	0.000
Does not find the desired presentation	0.052*	0.062*	0.072**	0.064*	0.044	0.071**
Does not trust the health quality of the products	−0.046	−0.017	−0.001	−0.017	−0.003	−0.014
Factors when choosing a species						
Taste	0.048	0.005	0.079**	0.013	0.069**	0.014
Price	−0.077**	−0.059*	−0.149***	−0.079**	−0.086***	−0.074**
Nutritional Value	0.008	0.042	0.044	0.058*	0.011	0.029
Availability on shelves	−0.026	0.050*	−0.007	0.012	−0.022	0.010
Variety in culinary options	0.054*	0.039	0.059*	0.078**	0.024	0.064*
Visual aspect of the product	−0.022	0.034	0.008	−0.011	−0.019	0.019
Demographics						
Gender	0.048	0.028	0.054**	0.078**	0.074**	0.051**
Age	−0.031	0.013	−0.025	0.005	−0.068**	0.013
Income	0.077**	0.242***	0.293***	0.200***	0.108***	0.163***
Education	0.121***	0.197***	0.263***	0.221***	0.160***	0.177***

*Significant at 10% level of probability; **significant at 5% level of probability; ***significant at 1% level of probability

Table 4 Ordered logistic regression summary

Variables	Tambaqui		Tilapia		Shrimp		Grouper		Arapaima		Catfish	
Difficulties in buying fish	Coef.	Odds ratio	Coef.	Odds ratio	Coef.	Odds ratio	Coef.	Odds ratio	Coef.	Odds ratio	Coef.	Odds ratio
High prices	−0.031	0.970	0.409	1.505	0.483	1.621	−0.763	0.466	−0.237	0.789	−0.856*	0.425
Lack of desired species	0.381	1.464	0.746	2.108	1.143**	3.134	−0.241	0.786	0.349	1.417	−0.443	0.642
Difficulty in preparation	−0.006	0.994	0.442	1.556	0.691	1.996	−0.557	0.573	−0.027	0.974	−0.860*	0.423
Lack of desired presentation	0.328	1.389	0.719	2.052	0.897	2.452	−0.276	0.759	0.065	1.067	−0.434	0.648
Does not trust the health quality of the products	−0.212	0.809	0.160	1.174	0.385*	1.470	−0.813*	0.443	−0.088	0.916	−0.962*	0.382
Factors when choosing a species												
Taste	0.641	1.899	0.599	1.821	0.916	2.498	1.334	3.795	0.799	2.223	0.785	2.192
Price	0.447	1.564	0.454	1.574	0.448	1.565	1.176	3.242	0.539	1.715	0.641	1.899
Nutritional value	0.644	1.905	0.782	2.185	1.019	2.770	1.641*	5.162	0.805	2.236	0.929	2.532
Availability on shelves	0.407	1.502	1.323*	3.754	0.830	2.294	1.679*	5.361	0.325	1.384	0.950	2.586
Culinary options	0.971	2.641	0.845	2.327	1.212*	3.361	1.852**	6.375	0.950	2.586	1.194*	3.300
Visual aspect of the product	0.591	1.806	0.824	2.280	0.955	2.600	1.421	4.143	0.771	2.162	0.995	2.705
Demographics												
Income	0.036	1.037	0.333***	1.395	0.361***	1.435	0.214***	1.239	0.074	1.077	0.171***	1.187
Age	−0.010**	0.990	−0.008*	0.992	−0.014***	0.986	−0.006	0.993	−0.018***	0.983	−0.005	0.995
Gender	0.185**	1.203	0.071	1.074	0.187**	1.206	0.323***	1.382	0.317***	1.373	0.216**	1.240
Education	0.171***	1.187	0.176***	1.192	0.269***	1.309	0.242***	1.274	0.200***	1.221	0.188***	1.206
Prob > chi2	0.0000		0.0000		0.0000		0.0000		0.0000		0.0000	
Pseudo R^2	0.0121		0.0272		0.0496		0.0335		0.0207		0.0196	

*Significant at 10% level of probability; **significant at 5% level of probability; ***Significant at 1% level of probability

It is observed that demographic variables, especially education and income, significantly influenced fish consumption frequency. The ordered logistic regression model revealed a positive association between the consumption frequency of tilapia, shrimp, grouper and catfish and income status. A higher income status corresponds to an increased probability of achieving a higher frequency level of fish consumption amongst these species. As expected, a similar pattern is found for education level but for all species studied. On the other hand, negative associations were found between the consumption frequencies of tambaqui, tilapia, shrimp. and arapaima and age. Therefore, younger people are more likely to consume in a higher frequency these species than older people. From this model, men showed a higher chance of consuming tambaqui, shrimp, grouper, arapaima, and catfish more frequently.

Discussions

The survey conducted in 2019 by Flores et al. (2021), as mentioned in the introduction, aimed to obtain macro indicators on the national fish chain of five species[3] in Brazil using fish consumption and processing information. The researchers collected a sample consisting of 1352 Brazilian consumers over 18 years of age. Data for this research were collected in person at supermarket seafood counters. The sample was decently representative of the Brazilian population regarding age, gender, education, income, regions, consumers of fish, and household members. Comparing the main places fish was purchased for both surveys revealed that the majority of the respondents purchased fish at supermarkets.

The prior research of 2019 demonstrated that most respondents preferred fishes from the sea (50.3%), while only 7.28% preferred freshwater fishes. From our study surveyed in 2020, 44.93% of respondents preferred freshwater fishes, and 30.15% preferred fishes from the sea. The differences in results from both studies may be due to the differences in both surveys' administration. The survey in 2019 was conducted in person and was administered in supermarkets of one selected city per region, whereas the present survey was administered entirely online. According to the 2003 FAO fisheries report, supermarket expansions in the developing world have influenced and promoted a global transformation of food. Additionally, supermarkets in Brazil are directly engaged in promoting fish farming. Hence, although fish consumption is relatively low and less traditional than other animal proteins, the introduction of fresh seafood on supermarket counters has shown to receive highly positive consumer responses (FAO, 2003). Henceforth, we suggest future comparative studies regarding the preferences of freshwater and seawater fishes to help us better understand this behaviour and preference amongst fishes.

The first aim of the present study was to investigate relationships between the species of fish consumed, consumption frequency, barriers of consumption, and the likeliness of fish choice. Our results found that taste was the principal variable in choosing aquaculture fishes. Therefore, we suggest that efforts need to be geared towards

[3] Tambaqui, tilapia, catfish, arapaima, and salmon.

further enhancing consumers' familiarity, exposure, and acceptance to other aquaculture fishes' flavours (e.g., Amazonian species) by increasing their sensory awareness through promotion strategies such as free product samples. Consumer acceptance is extremely important for the marketplace success of aquaculture production (Vanhonacker et al., 2013).

On the other hand, high prices were the highest and most significant barrier when purchasing a species. Moreover, over the last 20 years, relative to other protein items, specifically beef, pork and poultry, fish, and fish commodities both in the domestic and export markets, detailed the highest increase in price (Yokoyama Sonoda, 2006). Thus, the willingness for consumers to pay a premium price for farmed fish is lacking. This is a critical aspect that should be addressed, primarily due to the adverse effects of the COVID pandemic and its effect on income for Brazilians. Therefore, we suggest introducing and applying consumer market segmentation and marketing strategies along with the appropriate product offerings and innovations ranging from budgeted or lower priced to premium offerings. In addition, fish farmers and retailers, principally supermarkets, could implement some initiatives to reduce the production and selling costs of fish. It concerns strategies such as technological innovation (e.g., automation in fish production and processing and genetic improvement of species), increased production scale (e.g., cooperatives or vertical integration), and reduced sales margins by supermarkets.

The findings from the present study supported that tilapia and white leg shrimp were the aquaculture species most consumed or purchased. Our results also corroborated findings from earlier works that confirmed tilapia is the most frequently consumed fish by the Brazilian population (Flores et al., 2021). *Furthermore, t*ilapia is the primary cultured species in Brazil (Lima et al., 2020); the nation has one of the fastest-growing tilapia industries in the Americas (Fitzsimmons, 2000), and it is also considered the most important species in Brazilian aquaculture (PEIXE BR, 2019). While, on the other hand, a small number of respondents consumed grouper, indicating room for improvement and revealing an opportunity for this marine species, which is currently starting to be farmed in Brazil (Mello, 2021). Thus, we suggest increased awareness of action strategies as an essential factor in influencing the consumption of this species.

Under the factor of taste, shrimp and arapaima are the only two species significantly related to consumption frequency; however, the probability of a consumer moving to a higher consumption frequency level is not significant. Conversely, all species were negatively significantly correlated with the factor of price when choosing a species and high prices as a difficulty in buying a fish with consumption frequency. However, the factor of high prices and price does not affect the probability of increasing or decreasing the consumption frequency levels of any species, except for catfish.

The second objective was to elaborate on the socioeconomic status, education level, gender, and age of consumer influence on fish consumption frequency by species. Consumer demographics are the main determinants contributing to the increase in fish consumption frequency. Although a small correlation with gender and age was found with the consumption frequency of selected species, higher values were found with consumption frequency of all aquaculture species and income and education, especially with tilapia, white leg shrimp, and grouper, which yielded the highest Pearson coefficient values. Based on this relevant relationship, we can conclude that income and education levels

have an effect on the consumption frequency, especially of tilapia, white leg shrimp and grouper species, more than the other species specified in this survey. The results corroborate the previous findings by Anater et al. (2021), through Spearman's correlation analysis, observed that consumers' demographic data (age, gender, and social class) significantly influenced fish consumption frequency in Brazil. Therefore, further comprehensive studies are required to assess the influence of socioeconomic and demographic determinants of fish consumption frequency.

As per Valenti and Moraes-Valenti (2010), the implementation of collective as well as individual marketing strategies in aquaculture are important to (I) increase current fish consumption, (II) introduce new or innovative products, (III) effective targeting, and (IV) need assessment of consumers (Valenti and Moraes-Valenti, 2010). In other words, for a profitable aquaculture business in market economies, effective product marketing is necessary (Tisdell, 2013). For example, salmon is the largest single fish commodity by value and a popular item in markets worldwide. The rapid demand for salmon mainly resulted from international marketing campaigns and advances in logistical and production technology and product innovation (Food and Agriculture Organization of the United Nations, 2018). Another example is canned tuna used to increase marketing to establish the item as an inexpensive and low-priced food fish product to its targeted modern consumer markets (Food and Agriculture Organization of the United Nations, 2018).

Therefore, the results of this work could be of interest to actors aiming to increase the consumption patterns of aquaculture species from seasonal consumption to traditional or year-round consumption. The season and fish consumption frequency are significant concerns. Respondents reported consuming fish principally on Easter. The results confirm previous findings by Anater et al. (2021) and Matos et al. (2019), in which the authors found that Brazilians eat fish mainly because of religion or during religious celebrations, particularly on Easter. Fish consumption in Brazil is highly traditional. During Easter, fish purchases are more abundant and fresher. This phenomenon also occurs in Mexico. Most Mexicans are Roman Catholics, and religion plays a significant role in their culture, traditions, and diet. As a result, fish consumption is significantly associated with the Easter, Roman Catholic Lenten seasons (Sabbagh, 2012; Staples, 2018). In essence, fish consumption patterns display seasonal variations as cultural/ritual factors influence the frequency of consumption. It is stated that seasonal influences have been recorded in numerous fields in consumer psychology (Spence, 2021). Seasonal variations also affect consumers' nutrition and food consumption (Kucukerdonmez and Rakıcıoglu, 2018; Ravaoarisoa et al., 2019). Some studies have identified a relevant relationship between a population's nutritional status and season (Ravaoarisoa et al., 2019).

We recommend firstly the reduction in seasonal marketing of aquaculture fishes and increase marketing campaigns throughout the year. Secondly, we suggest that further marketing, specifically consumer marketing research, can help explain the motivations consumers choose to eat fish primarily at Easter, despite the increasing availability of fish year-round. Assessing the reasons and effects of seasonal fish consumption can help us identify strategies to reverse the current beliefs and behaviours. Likewise, tailored advertisement campaigns on certain areas as price value, the health quality of the product, nutritional value, and techniques to prepare different species are important to increase consumers' awareness and attract their attention, which might positively impact fish consumption frequency.

Appendix 1 Online fish consumer questionnaire applied in Brazil

This interview should last approximately 10 minutes. You must be at least 18 years old to participate. Your participation in this study is voluntary and your responses will be confidential. Your name is not required. The database will be combined to ensure your responses remain anonymous.

Questions

1. In which municipality do you reside?? _____ State:_____

2. What is your gender □ **a**) M □ **b**) F

3. What is your age? _____

4. Which of the alternatives below represents the total family income?

□ **a**) Less than R$ 1.254; □ **b**) Between R$ 1.255 e R$ 2.004; □ **c**) Between R$ 2.005 e R$ 8.640; □ **d**) Between R$ 8.641 e R$ 11.261; □ **e**) More than R$ 11.261

5. What is your education level?

□ a) Illiterate; □ b) Elementary School – Incomplete; □ c) Elementary School – Complete; □ d) High School – Incomplete; □ e) High School – Complete; □ f) Higher Education – Incomplete; □ g) Higher Education – Complete; □ h) Graduate

6. How many people live in your home?

7. What is the family's monthly expenditure, on average, with food?

R$_____

8. Does your family consume fish?

□ **a**) YES

□ **b**) NO (Reason: _____) *END INTERVIEW - SCREEN OUT*

9. On average, how much is spent monthly on fish for the whole family? R$_____

10. What is the main place to buy fish for preparation?

□ a) Supermarket

□ b) Wholesale

□ c) Fishmonger

□ d) Free fair

□ e) Other (please specify) _____

11. What is the main means of fish consumption?

□ a) Prepared at home

□ b) Delivery (home delivery)

□ c) Restaurant

□ d) Other (please specify) _____

12. Which of these fish species options do you usually buy?

	Never	**Occasionally**	**At least once a semester**	**At least once a month**	**At least once per week**	**2 or more times a week**
Tambaqui						
Tilapia						
Shrimp						
Grouper						
Arapaima						
Catfish						

13. What is the main factor you consider when choosing a fish species?

□ a) Taste

□ b) Price

□ c) Nutritional value

□ d) Availability on the gondola

□ e) Culinary variation options

□ f) Visual appearance of the product

□ g) Other_____

14. Which of these types of fish do you prefer most?

□ a) Fresh water

□ b) from the sea

□ c) Indifferent

15. If you could choose between two fish of the same species, which type would you choose?

□ a) Aquaculture (Captive Breeding)
□ b) Fishing (Nature Extraction)
□ c) Indifferent
□ d) I don't know
16. In which of the following periods are you likely to buy more fish than usual?
□ a) Holy Week
□ b) Christmas
□ c) Fish Week (September)
□ d) Other date _____
□ e) None
17. Which of the options below do you consider the main difficulty in purchasing fish?
□ a) High prices
□ b) Lack of the desired species
□ c) Difficulty in preparation (e.g., presence of bones)
□ d) You can't find the desired presentation (e.g., filet, slices)
□ e) Does not trust the health quality of the products
□ f) Other. _____

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References

Altintzoglou T, Vanhonacker F, Verbeke W, Luten J (2011) Association of health involvement and attitudes towards eating fish on farmed and wild fish consumption in Belgium, Norway and Spain. *Aquaculture International* 19(3):475–488. https://doi.org/10.1007/s10499-010-9363-2

Ananth CV, Kleinbaum DG (1997) Regression models for ordinal responses: a review of methods and applications. Int J Epidemiol 26(6):1323–1333. https://doi.org/10.1093/ije/26.6.1323

Anater A, Thon BM, Montanha FP, Weber SH, Ribeiro DR, Pimpão CT (2021) Fish consumption and consumer awareness aspects of possible mycotoxin contamination in fish in Curitiba-PR, southern Brazil. Brazilian Journal of Environmental Sciences (Online) 56(3):541–549. https://doi.org/10.5327/Z217694781023

Aydin EAN, Saracli SKS (2016) Analysis of households' electricity consumption with ordered logit models: example of Turkey. International Journal of Humanities and Social Science Invention 5:73–84

Barone RSC, Lorenz EK, Sonoda DY, Cyrino JEP (2017) Fish and fishery products trade in Brazil, 2005 to 2015: a review of available data and trends. Sci Agric 74:417–424. https://doi.org/10.1590/1678-992x-2016-0300

Billard L, Diday E (2006) Descriptive statistics for interval-valued observations in the presence of rules. Comput Stat 21(2):187–210. https://doi.org/10.1007/s00180-006-0259-6

Cantillo J, Martín JC, Román C (2021) Determinants of fishery and aquaculture products consumption at home in the EU28. Food Qual Prefer 88:104085. https://doi.org/10.1016/j.foodqual.2020.104085

Chong-Carrillo O, Moraes-Valenti P, Vega-Villasante F, Chávez-Chong CO, Arencibia-Jorge R, Michán-Aguirre L (2018) Description of the scientific domain Macrobrachium through the analysis of the authors with higher productivity and higher H-index according to Scopus. Lat Am J Aquat Res 46(3):570–580. https://doi.org/10.3856/vol46-issue3-fulltext-10

Christenson JK, O'Kane GM, Farmery AK, McManus A (2017) The barriers and drivers of seafood consumption in Australia: a narrative literature review. Int J Consum Stud 41(3):299–311. https://doi.org/10.1111/ijcs.12342

Erdogan, B.E., Mol, S. and Cosansu, S., 2011. Factors influencing the consumption of seafood in Istanbul, Turkey. *Turkish Journal of Fisheries and Aquatic Sciences*, *11*(4). FAO, 2020. The state of world fisheries and aquaculture 2020. Food and Agriculture Organization of the United Nations https://doi.org/10.4060/ca9229en

Filho, M.X.P., Flores, R.M.V., Rocha, H.S., da Silva, H.J.T., Sonoda, D.Y., de Carvalho, V.B., de Oliveira, L. and Rodrigues, F.L.M., 2020. O mercado de peixes da piscicultura no Brasil: estudo do segmento de supermercados. Embrapa Pesca e Aquicultura-Boletim de Pesquisa e Desenvolvimento ***(INFOTECA-E)***

Fisher MJ, Marshall AP (2009) Understanding descriptive statistics. *Australian critical care* 22(2):93–97. https://doi.org/10.1016/j.aucc.2008.11.003

Fitzsimmons K (2000) Future trends of tilapia aquaculture in the Americas. Tilapia aquaculture in the Americas 2:252–264

Flores, R.M.V., Chicrala, P.M. and Soares, S.S., 2014. Avaliação das preferências dos consumidores de pescado do Estado do Tocantins através de pesquisa de campo realizada no seminário caiu na rede é lucro. *Embrapa Pesca e Aquicultura-Artigo em periódico indexado (ALICE)*. https://doi.org/10.14210/bjast.v18n1.p121-129

Flores RMV, Pedroza-Filho MX (2014) Is the internal market able to accommodate the strong growth projected for Brazilian aquaculture. J Agric Sci Technol 4:407–417

Flores RMV, Pedroza Filho MX (2019) Measuring the impact of fish farming on regional development of poor cities: a case study on Ceará state Brazil. *Journal of Applied Aquaculture* 31(4):356–366. https://doi.org/10.1080/10454438.2019.1600095

Flores RMV, Widmar NO, Quagrainie K, Preckel PV, Pedroza Filho MX (2021) Establishing linkages between consumer fish knowledge and demand for fillet attributes in Brazilian supermarkets. Journal of International Food & Agribusiness Marketing:1–21. https://doi.org/10.1080/08974438.2021.1900016

Food and Agriculture Organization of the United Nations, (2003). Report of the expert consultation on international fish trade. Rio de Janeiro, Brazil, 3-5 December 2003. (FAO Fisheries Report No. 744). Rome. https://www.fao.org/3/y5767e/y5767e05.htm

Food and agriculture Organization of the United Nations (Ed.), 2018. The state of world fisheries and aquaculture, Rome. https://www.fao.org/documents/card/en/c/I9540EN/

Food and Agriculture Organization of the United Nations (Ed.), 2020. Fishery and aquaculture country profiles. The Federative Republic of Brazil. Fisheries and Aquaculture Division. https://www.fao.org/fishery/facp/bra/en **(accessed 10.26.21)**

Fricker, R.D., 2017. Sampling methods for online surveys, in: the SAGE handbook of online research methods. SAGE publications ltd, 1 Oliver's yard, 55 City road London EC1Y 1SP, pp. 162–183. https://doi.org/10.4135/9781473957992.n10

Gaviglio A, Demartini E, Mauracher C, Pirani A (2014) Consumer perception of different species and presentation forms of fish: an empirical analysis in Italy. Food Qual Prefer 36:33–49. https://doi.org/10.1016/j.foodqual.2014.03.002

Gignac GE, Szodorai ET (2016) Effect size guidelines for individual differences researchers. Personal Individ Differ 102:74–78. https://doi.org/10.1016/j.paid.2016.06.069

Gonçalves AA, Kaiser C (2011) Value-added products from aquaculture: a global trend. World Aquaculture 42(4):48

Groves RM, Fowler FJ Jr, Couper MP, Lepkowski JM, Singer E, Tourangeau R (2011) Survey methodology, 2nd edn. John Wiley & Sons

Hemphill JF (2003) Interpreting the magnitudes of correlation coefficients. Am Psychol 58:78–79. https://doi.org/10.1037/0003-066X.58.1.78

Hosmer, D.W., Stanley, L., 2000. Introduction to the logistic regression model, applied logistic regression, Second ed. ed. John Wiley & Sons, Inc, New York

Kato, H.C.A. and Freitas, A.A., 2015. Panorama of the aquaculture expansion of aquaculture and the fish consumption in Brazil. Embrapa Pesca e Aquicultura-Artigo em periódico indexado (ALICE)

Kinnucan HW, Wessells CR (1997) Marketing research paradigms for aquaculture. Aquaculture Economics & Management 1(1-2):73–86. https://doi.org/10.1080/13657309709380204

Kucukerdonmez O, Rakıcıoglu N (2018) The effect of seasonal variations on food consumption, dietary habits, anthropometric measurements and serum vitamin levels of university students. Prog Nutr 20(2):165–175. https://doi.org/10.23751/pn.v20i2.5399

Kurtuluş K, Okumus A (2010) Consumers' price perceptions as a segmentation criteria: an emerging market case. İstanbul Üniversitesi İşletme Fakültesi Dergisi 39(1):21–34
Lima CAS, Machado Bussons MRF, de Oliveira AT, Aride PHR, de Almeida O'Sullivan FL, Pantoja-Lima J (2020) Socioeconomic and profitability analysis of tambaqui *Colossoma macropomum* fish farming in the state of Amazonas Brazil. *Aquaculture Economics & Management* 24(4):406–421. https://doi.org/10.1080/13657305.2020.1765895
Lovakov A, Agadullina ER (2021) Empirically derived guidelines for effect size interpretation in social psychology. Eur J Soc Psychol. https://doi.org/10.1002/ejsp.2752
Matos ÂP, Matos AC, Moecke EHS (2019) Polyunsaturated fatty acids and nutritional quality of five freshwater fish species cultivated in the western region of Santa Catarina Brazil. *Brazilian Journal of Food Technology* 22. https://doi.org/10.1590/1981-6723.19318
McCullagh P (1980) Regression models for ordinal data. J R Stat Soc Ser B Methodol 42(2):109–127. https://doi.org/10.1111/j.2517-6161.1980.tb01109.x
Mello, G.L., 2021. Produção de garoupas no Brasil: realidade e perspectivas. Aquaculture Brasil, 23, April/June 2021, pp. 78-79
Ormrod, J.E., Leedy, P.D., 2010. E. 2010. Practical research: planning and design. Ohio, Merrill Prentice Hall
PEIXE BR, 2021. Anuário 2021 Peixe BR da Piscicultura. https://www.peixebr.com.br/anuario-2021/
PEIXE BR, 2019. Anuário 2019 PEIXE BR da Piscicultura. https://www.peixebr.com.br/anuario-peixe-br-da-piscicultura-2019/
Ravaoarisoa L, Rakotonirina J, Randriamanantsaina L, Rakotomanga JDDM, Dramaix MW, Donnen P (2019) Food consumption and undernutrition variations among mothers during the post-harvest and lean seasons in Amoron'i mania region Madagascar. *BMC Public Health* 19(1):1–9. https://doi.org/10.1186/s12889-019-7333-9
Richter I, Thøgersen J, Klöckner CA (2017) Sustainable seafood consumption in action: relevant behaviors and their predictors. Sustainability 9(12):2313. https://doi.org/10.3390/su9122313
Sabbagh, S.M., 2012. Social factors affecting shark conservation on the Mesoamerican barrier reef: a case study of Belize (Doctoral dissertation, McGill University)
Schober P, Boer C, Schwarte LA (2018) Correlation coefficients: appropriate use and interpretation. Anesth Analg 126(5):1763–1768. https://doi.org/10.1213/ANE.0000000000002864
Shang YC (1985) Aquaculture economics: an overview. GeoJournal 10:299–305. https://doi.org/10.1007/BF00462130
Silveira, L.D.S., Abdallah, P.R., Hellebrandt, L., Barbosa, M.N. and Feijó, F.T., 2012. Análise socioeconômica do perfil dos consumidores de pescado no município de Rio Grande
Spence, C., 2021. Spence, C., 2021. Explaining seasonal patterns of food consumption. *International journal of gastronomy and food science*, p.100332.https://doi.org/10.1016/j.ijgfs.2021.100332
Staples, D., 2018. Mexican food and culture fact sheet. https://core.ac.uk/download/pdf/151303421.pdf
Temesi Á, Birch D, Plasek B, Eren BA, Lakner Z (2020) Perceived risk of fish consumption in a low fish consumption country. Foods 9(9):1284. https://doi.org/10.3390/foods9091284
Tisdell C (2013) Economics and marketing. In: Lucas JS, Southgate PC (eds) Aquaculture. Blackwell Publishing Ltd., West Susse, pp 252–267. https://doi.org/10.1002/9781118687932.ch12
Valenti WC, Moraes-Valenti P (2010) Production chain of aquaculture. World aquaculture 41(4):54
Vanhonacker, F., Pieniak, Z. and Verbeke, W., 2013. European consumer image of farmed fish, wild fish, seabass and seabream. *Aquaculture international*, *21*(5), pp.1017-1033. 21, 1017–1033. https://doi.org/10.1007/s10499-012-9609-2
Verbeke W, Sioen I, Brunsø K, De Henauw S, Van Camp J (2007) Consumer perception versus scientific evidence of farmed and wild fish: exploratory insights from Belgium. Aquac Int 15(2):121–136. https://doi.org/10.1007/s10499-007-9072-7
Walker SH, Duncan DB (1967) Estimation of the probability of an event as a function of several independent variables. Biometrika 54(1-2):167–179. https://doi.org/10.1093/biomet/54.1-2.167
Yokoyama Sonoda D (2006) Demanda por pescados no Brasil entre 2002 e 2003 (Doctoral). University de Sao Paulo, Brazil