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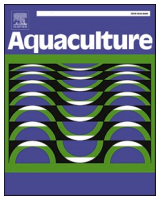

Are consumers in developing countries willing to pay for aquaculture food safety certification? Evidence from a field experiment in Nigeria

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ABSTRACT

Many developing countries face challenges in managing food safety risks associated with consumption of animal-source foods. Efforts to address these challenges increasingly recognize the role of certification in agri-food systems governance. Understanding consumers' willingness to pay (WTP) for food safety certification is fundamental to determining the appropriate design and implementation of programs to reduce the burden of foodborne illnesses in developing countries. To address this need, we implemented a framed field experiment with consumers of eight farm-raised African Catfish (*Clarias gariepinus*) products varying in certification status (safety certified versus uncertified) and product forms (live versus smoked) to examine their WTP for food safety certification in Nigeria. We applied a mixed-effects model to account for the hierarchical structure of the data with one participant entering multiple bids, and estimated a model with participant fixed effects as a robustness check. We found that consumers were willing to pay between 3.1% and 18.8% more for fish certified as safe compared to uncertified fish. Furthermore, there was an asymmetry in food safety certification valuation, with consumers paying significant premiums for high-value larger-sized certified live and smoked catfish, but not smaller-sized certified live and smoked catfish. The results are robust to a specification in which consumer fixed effects are included. Our findings suggest there exists consumer demand for certification programs to upgrade the food safety standards of higher-value fish products in Nigeria's domestic markets. Lower-value fish products typically consumed by lower-income consumers show less potential for certification. Alternative safety regulation is needed to ensure safety practices for low-end fish products.

1. Introduction

Fish are nutrient-rich foods that play a critical role in sustaining healthy diets and providing essential micro and macronutrients for human functioning and development. Global per capita annual fish consumption has more than tripled, from approximately 9.0 kg in 1961 to over 20.5 kg in 2018, and provides approximately 20% of animal protein intake on a global basis (FAO, 2020). Consumers in nations at all stages of development are advised to eat more fish because they are a rich source of multiple micronutrients and essential fatty acids (Thilsted et al., 2016; Uchida et al., 2017). Globally, fish consumption is projected to increase in both per capita and aggregate terms (Kobayashi et al., 2015; Chan et al., 2017; Chan et al., 2019). In recent years, aquaculture has surpassed capture fisheries in supplying seafood for direct human consumption; in 2018 aquaculture accounted for 52% of the global total (FAO, 2020).

The rapid growth of seafood production and consumption, particularly from aquaculture has, however, led to increased concern over food safety (Wessells and Anderson, 1995; Sapkota et al., 2008; Broughton and Walker, 2010; Okocha et al., 2018). Fish and fish products are high

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on the list of foods transmitting disease (Huss et al., 2000), a problem becoming increasingly serious with the expanding role of aquaculture. As is true with other confined animal feed operations, the use of antibiotics and other chemical inputs is common as stocking densities increase (Sapkota et al., 2008; Tacon and Metian, 2008; Anderson et al., 2018; Bailey and Tran, 2019). Additional health concerns may be introduced during handling and processing of a highly perishable commodity.

Certification programs designed to encourage effective seafood safety and sustainability practices, are an important mechanism to give consumers signals that certified products they purchase and consume are safe (Belton et al., 2011; Washington and Ababouch, 2011; Roheim et al., 2012). Voluntary certification standards are a market-based tool focusing on a broad set of good production practices and management guidelines. The success of such market-based interventions depends in large part on consumers' willingness to pay (WTP) price premiums (Ortega and Tschirley, 2017) and capacity of the market to transmit consumer demand signals along value chains to create incentives for producers, traders, and processors to improve food safety (Asche et al., 2015).

The existing academic and development literature on aquaculture certification standards focuses primarily on schemes initiated by actors in the Global North, for example, the Aquaculture Certification Council, the Aquaculture Stewardship Council (ASC), and the Global Partnership for Good Agricultural Practice. These programs address not only food safety but also broader concerns of social and environmental sustainability. Far less is known about certification programs developed in the Global South (Sun and van der Ven, 2020). The purpose of this article is to address this knowledge gap by measuring consumer WTP for African Catfish (*Clarias gariepinus*) certified for food safety through a voluntary certification program introduced by the Nigerian government.

Nigeria, which is the largest fish consumer and producer in sub-Saharan Africa (FAO, 2020), developed its fish farm and aquaculture certification program as "a market-based tool for minimizing negative impacts such as the risk of contamination by biological, chemical or physical food safety hazards and sources of pollutants which pose a potential hazard to human health" (DoFA, 2009). Other countries of the Global South also have initiated certification programs that encourage producers and processors to improve food safety and environmental stewardship to ensure public and environmental health and improve access to markets (Garcia Martinez et al., 2007; Anders and Caswell, 2009; Tran et al., 2011; Tran et al., 2013). The emergence of domestic, 'home-grown standards' meet dual goals of complying with export markets requirements and responding to increasing demand for safer fish in domestic markets resulting from food system transformation, increasing numbers of affluent consumers, and changes in consumer preferences (Sun and van der Ven, 2020). Understanding demand for certified products among consumers within producing countries can shed light on the extent to which voluntary certification can play a role in mitigating food safety hazards in low-income countries where the public health burden of foodborne disease is greatest.

While increasing foodborne illness incidences and environmental and social problems associated with aquaculture production and consumption have created demand for more effective regulation and adherence to sustainable production and manufacturing standards, governments in both developed and developing countries have limited capacity to respond. This context gives food companies and private parties incentives to participate and increase their roles in developing and implementing voluntary aquaculture food safety and sustainability certification standards (Bush et al., 2013; Tran et al., 2013). Although the popularity of transnational aquaculture certification standards developed in the Global North is rising, their effectiveness in regulating safety and sustainability in aquaculture practices is questioned (Bush et al., 2013; Tran et al., 2013; Osmundsen et al., 2020). Concerns are also raised about potentially adverse impacts of aquaculture certification programs on small-scale value chain actors in the Global South (Tran et al., 2013).

Existing studies reveal that consumers in high-income countries are willing to pay significant price premiums for certification/labelling of sustainably harvested wild fish (Wessells and Anderson, 1995; Onozaka and McFadden, 2011) and farmed fish (Roheim et al., 2012; Asche et al., 2021). The same is true for food safety certification. Consumers in Taiwan, for example, are willing to pay a high price premium of 46 to 53% for hypothetically safer seafood certified with HACCP standards (Jan et al., 2006). However, most studies assessing WTP for seafood safety and sustainability certification have focused in developed countries (e.g., US, EU and Japan) (Xuan, 2021), investigating consumer preferences for certified wild fish (Bronnmann and Asche, 2017). Little evidence exists on consumers' WTP for aquaculture certification in both developed and developing country markets.

This study examines consumer's WTP for African Catfish aquaculture certification standards developed by the Nigerian government using an incentive-compatible Becker-DeGroot-Marschak (BDM) approach. We asked consumers to bid on different fish products, with and without certification for food safety. By varying several other attributes at the same time as food safety certification status, we aim to mitigate bias due to salience that may arise when elicitation focuses on one specific attribute. In the case of food safety, this salience bias may be compounded by social-desirability bias (providing a response that the participant sees as the 'correct' one, in the eyes of society). Our study contributes to the literature on consumer willingness to pay for food safety certification in low-income settings. Our findings confirm that consumers in Nigeria are willing to pay a price premium in the range of 3.1%–18.8% for farm-raised catfish certified as safe. Consumers' willingness to pay varied with the type of fish product offered (live versus smoked) and product size (small to large fish), with a higher premium for smoked fish and larger fish products. The analysis with fixed effects model shows that the results are robust. We conclude that, at least for higher-value fish products, there is potential for voluntary certification to play a role in providing Nigerian consumers with greater confidence about the safety of the fish products they consume.

2. Background

With structural changes in aquatic food and fish systems over the last four decades, more than 52% of fish for human consumption is now from aquaculture, and increasing demand for fish will be met by aquaculture growth. Ensuring aquaculture food safety is a critical enabling condition for improving nutrition security, ending hunger and poverty, and promoting human health and well-being. In response to limited capacity and ineffective public management, volunteer certification programs have emerged as an increasingly important approach to aquaculture governance, guiding private and public actors in making sustainable and safe fish production and consumption choices (Bush et al., 2013). Certification schemes address environmental, social, and economic sustainability issues. Transnational certification schemes have been developed primarily by actors in the Global North. However, actors in the Global South are beginning to develop their own certification schemes to regulate aquaculture safety and sustainability in their own countries.

Since 2010, aquaculture has become the fastest growing sub-sector in Nigeria's agricultural economy (Wuyep and Rampedi, 2018). Food safety concerns as well as environmental and social issues associated with aquaculture have motivated the public sector in Nigeria to develop and implement a certification scheme to give consumers confidence that their purchases are safe. Although Nigeria's fish farm and aquaculture certification program was designed to improve compliance with standards in export markets, most farmed fish in Nigeria are destined for domestic markets (DoFA, 2009; FAO, 2020). Fish accounted for 35% of consumption expenditure for animal protein in Nigeria in 2015 (Liverpool-Tasie et al., 2021). Demand for fish in Nigeria has been increasing faster than domestic supply. Consequently, the country depended on

45% of fish imports for domestic consumption in 2013 (FAO, 2018). Smoked fish is the most common fish product consumed in Nigeria. Smoked fish products, if not appropriately handled, may present potential safety hazards to consumers ranging from food poisoning, bacterial infection, bacterial and fungal growth on fish, polycyclic aromatic hydrocarbon and heavy metal contaminations (Hg, Pb, Cd, Cr) (Adeyeye et al., 2016). Smoked catfish prepared using traditional methods may pose elevated cancer risks to consumers (Tongo et al., 2017). Smoked fish with small size is likely associated with traditionally smoking methods handled by low resource operators.

The government increasingly recognizes the need to regulate aquaculture production activities to ensure the supply of quality and safe fish products. In consultation with local stakeholders, including farmers, research institutes, universities, policymakers at federal and state levels, the voluntary aquaculture certification program was developed in 2009. Certification guidelines were reviewed by stakeholders in 2015, and the revised standards were published in 2017.

The aim of aquaculture certification in Nigeria is to enhance product quality, guarantee traceability, and prepare fish value chain actors to meet market requirements. Products eligible for certification include fresh fish and smoked fish. To obtain aquaculture facilities and/or product certification, the applicant or organization must submit an application to the Federal Department of Fisheries and Aquaculture (FDFA), after which the FDFA provides a copy of the Aquaculture Certification Guideline to the organization for compliance and completion of relevant forms. These forms are then returned to the FDFA and an inspection team with representatives from the Aquaculture Division, Fish Quality Assurance Division, Fish Disease Management Division, and the Aquatic Resource Division is dispatched to the site for assessment. The total certification cost includes the cost of inspection of about 300,000 Naira (US$789.5) and an annual certification fee of 10,000 Naira (US$26.3).[1] Compliance is reaffirmed through annual inspection visits.

3. Choice experiment design and data

The experiment was conducted from October to November 2019 in Nigeria's domestic fish markets. The decision to conduct the experiment at the points of purchase of fish was made (a) to ensure subjects are in a familiar environment and (b) because of a greater ability to target the population of interest (Lusk and Hudson, 2004). The research protocol was reviewed by the Institutional Review Board (IRB) of the International Food Policy Research Institute and approved on 9th November 2019 before implementation. Prior to commencement of experiment, a pre-analysis plan was registered at https://aspredicted.org/rj2mu.pdf on September 27th 2019.

A random sample of 200 urban consumers were selected in Lagos State by using a multi-stage sampling procedure. In the first stage, Lagos State was selected because: i) it is the most populous state and largest urban area in Nigeria; ii) it is popular in fish production and consumption, with the presence of certified aquaculture producers. In the second stage, four Local Government Areas (LGA), namely Ikeja, Ikorodu, Badagry, and Ojo, were selected to represent major fish markets in Lagos State. Except for Ikorodu, where two markets were selected, we selected one market within each LGA. The markets included Ajina, Sabo, Agbara (along the Badagry Expressway), Ipodo, and Okoko. The research team then visited market administrators to explain the purpose of the study, to introduce the field team of 10 trained enumerators, and to identify suitable places to set up the experiment. The experiment was pre-tested before actual implementation. In the third stage, every second consumer in each of the selected markets was approached, before making his or her intended purchase, and asked to participate in the experiment. Two-thirds of the consumers who were approached agreed to participate. The remaining one-third declined and were replaced by recruiting the second consumer after the one declining. The main reasons for replacements were that participants in a rush could not wait for 30 min—the amount of time an experiment session took.

Upon consenting, a participant received an endowment of 1500 Naira (≈ 4US$) in the form of a cash token as the show-up remuneration. Participants were informed that the money was theirs to keep and that they could use the money to buy fish during the market exercise if they so wished, but that they were under no obligation to do so. The show-up remuneration was about twice the price of 1 kg live catfish, consistent with previous studies (De Groote et al., 2016).

Consumers' WTP was elicited for eight catfish products varying in certification status (certified/safety labelled versus uncertified/non-safety labelled), size (250 g versus 500 g for smoked fish; and 500 g versus 1000 g for live fish), and form (smoked versus live). Specifically, the eight products include (1) uncertified, 500 g, live; (2) uncertified, live, 1000 g; (3) certified, live, large, 1000 g; (4) certified, live, medium, 500 g; (5) uncertified, smoked, medium, 500 g; (6) certified, smoked, medium, 500 g; (7) uncertified, smoked, small, 250 g; (8) certified, smoked, small, 250 g.[2] The motivation for the choice of product forms is that catfish is mostly bought live or smoked in Nigeria. Eliciting participants' valuation of uncertified products allows us to control for contextual factors that may influence their bids for both uncertified and certified products, and focus on differences in WTP across products, rather than levels. This approach is typical in studies that assess consumer valuation of particular product attributes (see for example, Bi et al., 2016; Chege et al., 2019 for the case of conventional and improved nutritious flour). Certified fish was obtained from producers approved as adhering to criteria and guidelines for certification of aquaculture animal products developed by the Nigerian government (DoFA, 2009). A list of certified producers in Lagos State was obtained from the federal government and cross checked with the state department. A validation exercise followed this to confirm that farmers had proof of aquaculture certification provided by the government. Uncertified fish was obtained from the local market.[3] All original packaging information was removed from the products prior to the study to control for any reaction individuals might have to the packaging.[4] Smoked fish was displayed in clear freezer bags while the live fish were kept in clean containers.

Ten trained enumerators, working in pairs of two, then described each product one at a time. Enumerators read aloud the information provided on the label for certified fish which were written by our team; no additional information was given. The label described the production method and explained that the product had been certified for food safety and environmental sustainability by the government through the National Agency for Food and Drug Administration and Control. For the uncertified fish, participants were informed that the fish had been obtained from a local market in Lagos State, that the production method was unknown to us, and that it had not been certified for food safety or environmental sustainability.

After describing the fish product, enumerators displayed it on the table for the participant to visually inspect. Participants were allowed to ask questions related to the fish products or the experiment. The BDM mechanism (Becker et al. 1964), a widely used experimental auction

[1] Central Bank of Nigeria exchange rate, one USD equals to 380 Naira from August 2020 to May 2021 https://www.cbn.gov.ng/rates/exchratebycurrency.asp.

[2] The decision to use 250 g and 500 g for the smoked fish was because larger sizes of smoked catfish were unavailable in the market at the time of the study. Smoked catfish was mostly sold within the range of 250-500 g. It would, therefore, have been logistically difficult to source for 1000 g smoked catfish.

[3] Obtaining uncertified fish from the local fish traders helped avoid creating the perception that we were competing with the traders.

[4] This is a standard procedure in experiments examining willingness to pay. See for example, Dillaway et al. (2011). We do not expect this procedure to distort the understanding of the fish offered through the experiment.

method, was used to elicit the participant's WTP through an opportunity to buy one of the fish products offered. Each participant was informed that depending on his or her choices and random chance, they may end up purchasing the fish product offered, or not. The enumerators explained that they were part of a research team, not salespersons, but that they could sell the participant some fish as part of the study.

Although individuals bid for all eight fish products (that is, we implemented a 4-by-2 design – 4 types of fish products each with or without certification), only one of these products could be purchased. The procedure was as follows. Before the study began, we *ex ante* assigned participants a unique identification number ranging from one to 200. Each participant was then randomly assigned one of the eight fish products to determine the product that would be sold at the end of the market exercise. We, therefore, prepared 200 "fish product cards"—one for each participant. Each card was put in a separate envelope, which was then sealed, and the unique identification number indicated on top.[5] A similar procedure was followed to prepare "fish price cards", indicating the selected fish product's selling price. Data on consumers' bids were gathered using pre-designed recording sheets which, for each consumer, carried the same identification number as that on the sealed envelopes for fish product card and fish product card. At the end of the experiment, the "product envelope" was opened first to determine the selected product for selling. Then, the "price envelope" was opened second to determine the price. The participant's highest bid (the maximum amount they were willing to pay for the selected fish product) was then compared with the randomly drawn price in the sealed envelope. If his or her bid met or exceeded the random price in the envelope, he or she actually paid the amount of money equal to the random price and received the fish product.

At the end of the market exercise, a post-experiment survey module was administered. The survey collected data about demographic characteristics, consumption and expenditure, knowledge about food safety, brand purchase preferences, and trust.[6]

Several biases can affect WTP estimates elicited through experimental auctions if not adequately addressed by the experimental design (Norwood and Lusk, 2011). Order effects are a form of bias that can arise due to the order in which items are presented to consumers. To avoid bias due to order effects, we randomized the order in which fish products were presented. Social-desirability bias might occur if people are induced to indicate greater preference towards goods with "normative" attributes such as food safety certification (Norwood and Lusk, 2011).[7] This can exist especially if participants intend to share the food product purchased with family members because the benefits from purchasing the fish extend beyond the individual to the family (Norwood and Lusk, 2011). In that case, experimental subjects bid higher for goods with normative attributes than they would normally be willing to pay for them, due to the knowledge that their behaviour is being observed (Ifft et al., 2012).

To minimize social-desirability bias and any bias arising through the salience of certified fish in the context of the experiment, we conduct a real as opposed to hypothetical experiment. This means that if a participant over-bids to please the experimenter, they incur a real cost for this behaviour because they must buy the product that, to them, is personally less desirable, if the auction of that product is selected (Norwood and Lusk, 2011). In addition, since several different attributes are varied, rather than only certification status, the value participants assign to certification is not immediately obvious to the experimenter – low valuation of a large piece of certified fish could arise, for example, from the participant's preference for a smaller piece. We also believe that randomizing the order in which the products were presented to the consumer helps to address attenuation bias by reducing the tendency for certified fish to always follow uncertified fish, or vice versa.

We also addressed the game form misperception problem, which may arise if individuals misunderstand the structure of the WTP elicitation method. First, the real experiment with fish was preceded by a warm-up exercise that elicited WTP for candies using the same method. Second, participants were asked three basic questions related to the experiment to assess their understanding of the market exercise (see online supplementary appendix A for the questions). If the participant failed to answer any of the three questions correctly, the enumerator explained the market exercise again. Therefore, the enumerators only proceeded when all three questions were answered correctly.

To minimize the tendency for unexpected cash to inflate bids through "house money effects", because participants received a cash token which they had not budgeted for, we used a cheap talk script (Carlsson et al., 2005; List and Price, 2016). The cheap talk was given after explaining the market exercise, and just before the participant started bidding. The cheap talk script was also important to address attenuation bias discussed earlier. At the same time, respondents selecting zero as the maximum price answered a follow-up question to identify true zeros from zeros protesting against paying a premium for certified fish (Moon et al., 2007).

In multiple-product round auctions, purchasing a product in one session may decrease WTP in subsequent sessions since the participant subsequently has less to spend (e.g., (Dillaway et al., 2011). This issue is particularly problematic if a participant has already purchased the same or a very similar product in a previous session. Our design avoids this problem arising between alternative types of fish products, as only the outcome for one of the products (determined through a random draw) was implemented. Since candy and fish are very different products, WTP for fish is unlikely to be affected by the warm-up exercise outcome through a substitution effect. To avoid the cash outlay by those who purchase candy meaningfully affecting WTP for fish, the possible prices for candy were limited to a maximum of 25 Naira.

Table 1 presents summary statistics describing the study participants. Most study participants were women, and the average age of the participants was 39 years. Eighty-seven percent had completed at least secondary education. Households consumed 3.2 kg of fish and 1.9 kg of other types of meat weekly, on average. With the average household size estimated at five, annual fish and meat consumption of the study participants were at 33.28 kg/per capita and 19.76 kg/per capita, respectively. Annual fish consumption reported by the study participants was 77% higher than annual consumption (18.8 kg/per capita) estimated for the southern states of Nigeria using the World Bank survey data in 2015 (Liverpool-Tasie et al., 2021). Most of the respondents correctly identified at least one reason why fish can be unsafe for consumption, with 78% indicating sanitation, hygiene, and poor handling of fish related concerns.[8] Study participants were generally aware of some of the risks associated with consumption of unsafe fish; 80% indicated foodborne illnesses. Most participants indicated that they thought about the potential for purchased fish in the market to be unsafe for consumption;

[5] One alternative to our approach would be to select the product and price in front of the participant. Undoubtedly, this approach may increase the participant's trust in the procedure. However, it may also considerably increase the amount of time required to complete the market exercise. Therefore, we decided to select the product and price beforehand to minimize participants and enumerator fatigue and to ensure that the selection was genuinely randomized in a way that could easily be replicated.

[6] The experimental and survey data are described in greater detail in Shikuku et al. (2020).

[7] According to Lusk and Norwood (2006), a good has normative implications if it generates positive or negative externalities.

[8] Construction of knowledge score based on a knowledge exam is increasingly popular in economics (see for example, Kondylis et al., 2016; Shikuku, 2019). We administered a knowledge "exam" comprising questions about reasons fish in the market can be unsafe to eat, the risks associated with eating unsafe fish, and ways to protect oneself from eating contaminated fish. Knowledge score was then computed as the sum of all correct responses.

Table 1
Summary statistics of study participants.

Variable	Description	Mean	SD	Frequency
Panel A: *Binary variables*				
Sex	1 = participant is female; 0 = otherwise.	0.83		164
Education	1 = participant has education above secondary; 0 = otherwise.	0.87		173
Salaried	1 = participant's main occupation is salaried employment; 0 = otherwise.	0.04		7
Market type	1 = type of market is roadside; 0 = otherwise.	0.40		80
Panel B: *Continuous variables*				
Age	Age of the respondent (years).	39.28	10.46	
Household size	Number of people residing in household.	4.89	1.96	
Infants	Number of household members below 5 years old.	0.74	0.94	
per capita *fish consumption*	Total fish consumption by household in past seven days (kg) divided by household size.	3.24	2.48	
per capita *meat consumption*	Total meat consumption (excluding fish) by household in past seven days (kg) divided by household size.	1.86	1.73	
Knowledge	Knowledge score about food safety including the reasons fish in the market can be unsafe to eat, the risks associated with eating unsafe fish, and ways to protect oneself from eating contaminated fish.	0.96	0.79	
Preference for brand purchase	A score measured on a scale of one [not important at all] to 10 [very important], indicating the extent to which a participant considers branding or labelling when buying appliances such as radio, television, and fridge.	9.00	1.83	
Trust	A score measured on a scale of one [no trust at all] to 10 [complete trust]) indicating the extent to which a participant trusts in government certification agency.	6.57	3.25	
Number of observations		198		

only 17% indicated they never thought about food safety when buying fish, and 67% said they worried that the consumption of unsafe fish would make them or their family members sick. Use of branding or labelling to assess product quality was very high. When asked to indicate on a scale of one (not important at all) to 10 (very important), the extent to which they consider branding or labelling when buying appliances such as radio, TV, and fridge, participants rated nine, on average. Use of this type of information has previously been shown to be an important determinant of consumers' willingness to pay for food safety certification (e.g., Ifft et al., 2012). The average rating for trust in government certification agencies was 6.3 out of 10, respectively, indicating moderate trust.

4. Empirical estimation approach

4.1. Main estimation approach

We begin by conducting non-parametric tests of equality of bid-distributions using the Kolmogorov-Smirnov test We then examine the effect of safety and environmental sustainability labelling on WTP by estimating Eq. 1.

$$y_{ijm} = \alpha + \sum_{j=1}^{7} \beta_j Product_{ijm} + \gamma_i x_{ijm} + \delta_i O_{ijm} + M_m + E_m + \varepsilon_{ijm} \quad (1)$$

where y_{ijm} measures consumer i's bid for the fish product j in market m; $product_{ijm}$ is a vector of dummy variables for the fish products. To avoid dummy variable trap, we include seven dummy variables representing seven fish products with the uncertified, live, medium-sized (500 g) catfish product as the comparison (base) group. We test the null hypothesis that β_is are individually statistically different from zero because a change in bid can move in either direction. WTP may vary among consumers in systematic ways, which can be analysed by including a vector x_{ijm} of consumer characteristics, as described in Table 1 (Lusk et al., 2004; Dillaway et al., 2011; Ifft et al., 2012; De Groote et al., 2016). In addition, we control for order effects, market fixed effects, and enumerator fixed effects denoted by M_m, E_m, and O_{ijm} respectively. ε_{ijm} is an error term.

A key feature of the data is that each individual participant provided one bid per product, for the eight products. Bids are in this sense nested within upper level units (individual participants) with the potential of by-participant variation and can, therefore, not be regarded as independent from each other. Furthermore, the data structure may also include by-product variation in bids due to product-specific idiosyncrasies. Therefore, Eq. 1 was estimated using a mixed-effects model (Raudenbush and Bryk, 2002) characterized as containing both fixed effects (for product type, market, and enumerator) and random effects (for participants). To understand how much of the total variance is attributed to individuals, we check the intraclass correlation (ICC) at the individual level, that is, the correlation between WTP bids by the same individual for the different products.

4.2. Alternative specification

We investigate the robustness of our estimates by estimating Eq. 2 using a fixed effects model as follows:

$$y_{ijm} = \sum_{j=1}^{7} \beta_j product_{ijm} + \alpha_i + u_{im} \quad (2)$$

where α_i is the intercept for each individual consumer capturing individual fixed effects, and u_{im} is the error term. In the fixed effects model, u_{im} is assumed to be independently and identically distributed (iid) with mean zero and variance σ_u^2. The rest of the variables are as defined in Eq. (1).

Next, we conduct a test for the presence of social-desirability bias. Salience of certification is likely to be highest when elicitation of WTP for a certified product is elicited immediately after WTP for the same, but uncertified product. Social-desirability bias may also arise due to the salience of the side-by-side comparison of the uncertified vs. certified product. We therefore construct a dummy variable equal to one if a certified product was presented immediately after an uncertified product of the same size and form, and zero otherwise. We then perform a *t*-test of differences in means of consumers' WTP between these two groups.

5. Results

5.1. Comparison with market prices

Comparing participants' bids for uncertified fish against market prices for these items, we see that participants bid systematically higher than the market price for the lowest-value product offered, and systematically higher for the highest-value product. While mean bid for 1000 g of uncertified live catfish was statistically indistinguishable from the prevailing market price, bids for the small portions of uncertified live

and smoked catfish were 13% and 7% above their respective market prices, and the mean bid for the large portion of uncertified smoked catfish was 20% below its market value (Table A1). We hypothesize that bids for lower-value items may have been inflated by a desire to "win" something through the auction, but that this motivation was too weak to affect higher-value items. Consumers may not have wished to purchase as much as 500 g of smoked fish, which tends to be purchased in smaller quantities.

As the factors driving these differences between participants' bids and market prices affect are expected to apply to both certified and uncertified fish, we focus on the differences in consumers' WTP for certified versus uncertified fish in the following analysis.

5.2. Willingness to pay for fish food safety certification

Study participants were willing to pay 452 Naira (USD 1.19), on average, for 500 g uncertified live catfish (Fig. 1). This increased marginally (≈3.1%) to 466 Naira (USD 1.23) for 500 g certified live catfish. Participants' WTP for 1000 g live catfish increased, on average, from 793 Naira (USD 2.09) for uncertified fish to 850 Naira (USD 2.24) for safety certified fish, corresponding to a 7.1% increase. For 250 g smoked fish, participants were willing to pay 856 Naira (USD 2.25), on average, for uncertified fish and 898 Naira (USD 2.36) for certified fish, corresponding to a 4.8% increase. Participants' WTP was highest for 500 g certified smoked catfish; participants indicated they would pay1,511 Naira (USD 3.98) for the certified fish compared to 1271 Naira (USD 3.34) for uncertified fish, representing a 18.8% increase in WTP. These results suggest an asymmetry in the valuation for certification of low vs. high value and live vs. smoked fish products, with higher premiums for larger-sized than smaller-sized live catfish and higher premiums for smoked versus live fish.

Fig. 2 presents bids distributions for the eight fish products. As shown, the bid distribution for certified fish stochastically dominates that of uncertified fish across all sizes and forms of fish products. Results of the Kolmogorov-Smirnov test for equality of distributions indicate a significant difference ($p < 0.01$) in bid distribution between certified 500 g smoked fish and the uncertified fish of the same size; bid distributions for other certified versus uncertified fish types do not differ statistically.

Table 2 presents the results of regression analysis to assess the determinants of WTP. Results shown in column 1 are for the mixed effects model, and those in column 2 are for the fixed effects model. While the R-squared in Table 2 (previously Table 4) seem low, these are similar to those reported in other studies (e.g., De Groote et al., 2011; 2016; Bi et al., 2016) and in some cases higher.

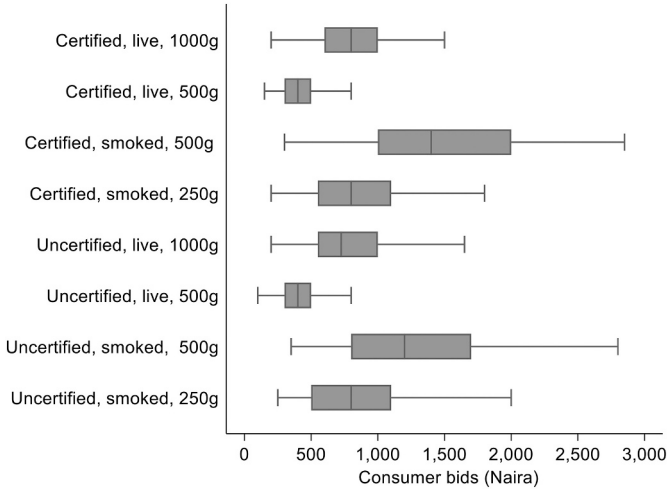

Fig. 1. Consumers' willingness to pay for certified/uncertified fish safety standards.

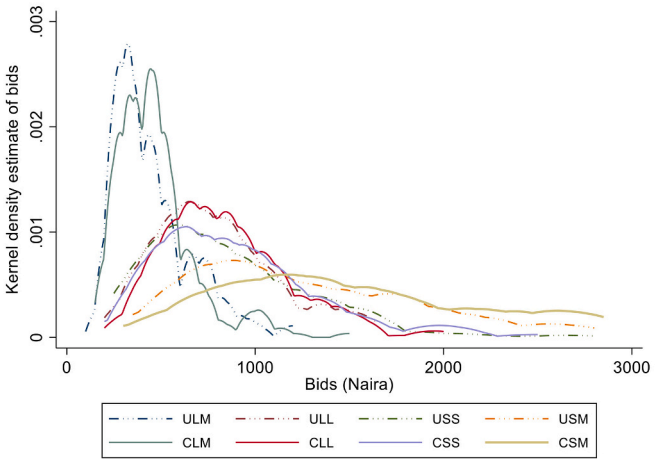

Fig. 2. Distribution of bids.
Notes: ULM = Uncertified, live, 500 g catfish; ULL = Uncertified, live, 1 kg catfish; USS=Uncertified, smoked, 250 g catfish; USM = Uncertified, smoked, 500 g catfish; CLM = Certified, live, 500 g catfish; CLL = Certified, live, 1 kg catfish; CSS=Certified, smoked, 500 g catfish; CSM = Certified, smoked, 1 kg catfish.
Kolmogorov-Smirnov test for equality of distribution:
ULM = CLM (p-value = 0.327).
ULL = CLL (p-value = 0.711).
USS=CSS (p-value = 0.711).
USM = CSM (p-value = 0.004).

Table 2
Determinants of willingness to pay for fish/seafood safety certification.

Variable	Mixed effects	Fixed effects
	(1)	(2)
Constant (base: Uncertified, live, 500 g)	422.89*** (167.60)	451.75*** (21.44)
Uncertified, live, 1000 g (ULL)	341.41*** (17.88)	341.50*** (30.33)
Certified, live, large, 1000 g (CLL)	393.94*** (20.96)	397.75*** (30.33)
Certified, live, medium, 500 g (CLM)	11.62 (15.53)	14.00 (30.33)
Uncertified, smoked, medium, 500 g (USM)	821.21*** (37.87)	819.25*** (30.33)
Certified, smoked, medium, 500 g (CSM)	1060.86*** (44.39)	1058.75*** (30.33)
Uncertified, smoked, small, 250 g (USS)	403.79*** (26.58)	404.50*** (30.33)
Certified, smoked, small, 250 g (CSS)	444.19*** (28.57)	446.00*** (30.33)
Additional controls	Yes	No
Market dummies	Yes	No
Enumerator dummies	Yes	No
σ_u		325.31
σ_e		303.26
ρ		0.54
Number of observations	1584	1600
Number of consumers	198	200
R^2 within		0.59
R^2 overall		0.38
Wald χ^2	1275.66***	284.06***
ULL = CLL (p-value)	0.006***	0.064*
USS=CSS (p-value)	0.137	0.171
USM = CSM (p-value)	0.000***	0.000***

Notes: Dependent variable measures consumers' submitted bids. Robust standard errors are reported. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Results of the mixed effects model suggest positive and significant premiums for safety certification of larger-sized and high value fish products. The model generates qualitatively similar results to those in Fig. 1. Specifically, we find a 7.1% increase in WTP for certification of 1000 g live catfish, significant at 1% level. We further find 21.1% increase in WTP for 500 g smoked fish, significant at 1% level. Tests

comparing coefficients between certified and uncertified fish products in the mixed effects model indicate that WTP for safety certification is statistically significant at the 1% level for the 1000 g live catfish and the 500 g smoked catfish. We cannot, however, reject the null hypothesis that WTP for certification of either 250 g of smoked or a 500 g live catfish is statistically equivalent to zero. These results seem to confirm the asymmetry that exists in the valuation of safety certified fish.

Table 3 presents the standard deviations of the random effects. The standard deviations for coefficients on product type are in all cases (except for the uncertified 500 g live catfish) almost equal to or greater than four standard errors from zero. This suggests that there exists significant individual-to-individual variation in the slope coefficients for product types. These results are supported by a likelihood-ratio test ($p = 0.000$) which shows that an intercept and slope model performs better than an intercept only model suggesting that adding random slopes brought significant improvement. Results of the ICC (0.56 for the parsimonious model and 0.52 when we control for additional covariates) show that conditional on the fixed-effects covariates, WTP bids are highly correlated for the same individual participant. We estimate that individual random effects compose approximately 52–56% of the total residual variance.

5.3. Robustness checks

We failed to reject the null hypothesis that social-desirability bias is absent (Table 4). Fixed effects regression results (Column 2 in Table 2) are very close to those of the mixed effects model, suggesting that our results are robust to this alternative specification.

6. Discussion

Our study shows that consumers in Lagos, Nigeria, are willing to pay a premium of between 7.1% for live and large (1000 g) and 22.1% for smoked and medium (500 g) farm-raised catfish certified for food safety. Results are robust to different model specifications. These estimates of WTP are consistent with the range of consumer WTP for ecolabel certification and nutrition claims in developed countries. For example, in a recent study (Menozzi et al., 2020), premiums for pangasius and salmon with nutrition and health claims in Italy were estimated at 17.1% and 21.1%. WTP for white fish (rainbow trout, pangasius and tilapia) certified by the Aquaculture Stewardship Council in Germany varied from 6 to 9% (Asche et al., 2021).

Noteworthy, our analysis shows evidence of asymmetry of WTP for fish safety certification in Nigeria by product type. Live fish has a low margin of WTP for safety certification, regardless of product size. For example, WTP for certified live fish were at 3.1% and 7.1% for 500 g and 1000 g, respectively. Certified smoked fish had a WTP range of 4.8% (for small, 250 g) to 18.8% (for large fish, 500 g). Smoked fish has higher unit prices and is more nutrient dense compared to live fish (Akintola et al., 2013). A possible explanation for the asymmetry in valuation for food safety certified smoked and live fish could be that although both commodities may have been produced in the same way, the process of smoking fish adds an additional layer of uncertainty about the safety of the finished product. We further observed that consumers' WTP for fish food safety was higher for larger-sized than smaller-sized fish, both live and smoked. Small-sized catfish is mostly bought by consumers at the base of pyramid with less purchasing power whereas large-sized catfish is mostly targeted for medium and high-income consumers with greater effective demand. This may also be traceable to ethnic diversity of the fish consumers. Consumers in the southwest Nigeria have higher disposition to smaller-sized fish because each household member can eat their own 'whole' fish and the family head can be served two fish if they are small rather than having to divide a large fish among many people. This contrast with the attitude of an average consumer from the southeast with disposition for bigger-sized fish that are cut into smaller bits prior to serving. Qualitative evidence showed that small-sized fish ($\leq$250*g*) occupy the largest share of the Nigeria's domestic market. Our analysis of the mediating effect of wealth on consumers' WTP, however, showed no significant effect. This finding is line with general outlook for an average Nigerian regard to food choice and has not been mediated by factor of wealth.

Our research findings provide useful information to value chain actors in developing effective production and marketing strategies. For instance, certification schemes can be used as a product differentiation strategy and as a risk management tool by retailers and producers to expand market shares and increase profitability. Asymmetry in the valuation of fish food safety suggests the possibility of market segmentation happening because of adoption of volunteer certification schemes. If volunteer aquaculture certification is promoted to improve food safety and environmental sustainability, it is likely to create product differentiation strategies and generate heterogeneous welfare effects on consumers. Consumers with a certain profile (affluent consumers with higher income, proxy by wealth level) might show significant demand for safety certification (Uchida 2014). The result is an expansion in the market share for high quality and shrinkage of the low-quality market share. Certified products' market shares increase at the expense of non-certified products (Roheim et al., 2018). This will raise an ethical issue of who are winners and losers of voluntary and market-based certification schemes. Our experiment design does not allow us to evaluate this question. Further studies investigate this research question.

Consumer WTP for live catfish reflects increasing concerns regarding use of antibiotics and forbidden chemicals by fish farmers (Sapkota et al., 2008; Olatoye and Basiru, 2013). Even more striking, our study found that WTP for large-sized smoked catfish was more than three times higher than for other catfish products. This finding reflects consumer concern regarding not only possible contamination during grow-out but even greater concern about safety risks introduced at different points along the value chain, particularly during post-harvest handling and processing stages. Smoked fish may be contaminated with carcinogenic chemicals if poorly processed (Tongo et al., 2017). This finding strongly suggests that effective food safety certification requires enforcement along the value chain. A certification scheme focused at the producer level alone is not adequate.

An important implication of our data for food policy is that a trusted government certification system could create incentives for (1) producers to avoid using antibiotics and other harmful chemical inputs, (2) fish processors to exert more care in smoking or preparation of fish and other products, and (3) improved post-harvest handling in general. To this finding, we must add a caveat: our data reflect an asymmetry in consumer WTP for catfish food safety with lower price premiums for small compared to large catfish, and live versus smoked catfish. This finding has implications for the way food safety certification programs are designed, and implies that studies that fail to recognize differentiation in consumers' WTP for fish products are likely to mask the true

Table 3
Standard deviations for coefficients on product type.

Random effects parameters	Mixed effects model without additional controls		Mixed effects model with additional controls	
	Standard deviation estimate	Robust standard error	Standard deviation estimate	Robust standard error
ULL	132.72	30.61	131.37	31.60
USM	266.38	39.71	267.88	40.59
USS	446.48	29.74	447.49	30.27
CLM	72.39	35.48	64.74	39.25
CLL	141.15	38.65	135.75	40.99
CSS	297.26	32.90	298.51	33.08
CSM	524.21	30.10	525.48	30.55
Constant	177.99	15.84	165.97	15.23
Residual	157.61	16.05	158.68	16.20

Table 4
Test for social-desirability bias.

Type of fish product	Bid for certified fish product minus bid for uncertified fish product					
	Whole sample	Social-desirability dummy = 1	Social-desirability dummy = 0	Difference	*t*-value	*p*-value
Live and medium sized	21.25 (16.97)	53.13 (57.28)	16.35 (17.53)	36.78	−0.737	0.463
N	120	16	104			
Live and large sized	68.28 (23.96)	173.53 (56.74)	52.30 (26.20)	121.23	−1.711	0.090*
N	129	17	112			
Smoked and medium sized	16.79 (35.57)	−6.82 (69.26)	21.56 (40.35)	28.38	0.298	0.766
N	131	22	109			
Smoked and large sized	280.00 (28.50)	275.86 (55.30)	281.08 (32.89)	5.22	0.074	0.941
N	140	29	111			

Notes: In parentheses are standard errors clustered at participant level.

WTP. This being said, targeted certification programs may not be advantageous to all farmers if premiums are absent for products catering to poorer consumers, such as small-sized catfish for live markets, and risks leaving poor consumers vulnerable to unregulated fish products and therefore at greater risk of consuming unsafe food.

One important caveat should be considered when interpreting the results of this study. We recognize that the sample for our study differs on several dimensions from the Nigerian population as a whole e.g., as described by Liverpool-Tasie et al. (2021). While the study provides important insights about the demand for fish food safety certification among consumers with characteristics like those of the participants in the experiment, we acknowledge the limitation of the study in terms of external validity of our findings. Still, our study is among the very few that shed light on demand for food safety in developing countries' domestic markets.

A second caveat is that a lack of familiarity with food safety certification among the study population may lead them to express a willingness to pay for certification that differs from their longer-term demand for this attribute. The direction of this potential bias is not clear. On one hand, learning about food safety certification may lead to concerns about the safety of uncertified food, thus lowering its value in consumers' eyes and biasing WTP for certification upward. On the other, consumers who are unfamiliar with certification may be skeptical that it means anything at all. We therefore caution that the results presented should be interpreted as indicative of the initial WTP for food safety certification of farmed fish in a population to whom this concept has recently been introduced.

7. Conclusions

Certification has gained more popularity as a market-based governance form to regulate food safety, environment, and social sustainability problems in agri-food production and consumption. While a dozen certification schemes have been developed by actors both in developed and developing countries, consumers' willingness to pay for price premiums to create incentives for producers to apply safe and sustainable production practices and guidelines is limitedly investigated. This evidence is remarkably scant in developing countries' domestic market contexts. In this study, we implemented a framed field experiment with catfish consumers in Nigeria to examine their WTP for food safety certification initiated by the Nigerian government. Our findings show that consumers were willing to pay 3.1%–18.8% higher for safety certified fish relative to uncertified fish. Furthermore, there was an asymmetry in food safety certification valuation with significant WTP premiums for larger-sized and smoked catfish but not smaller-sized live and smaller-sized smoked catfish.

Through these findings, we call for policy interventions to encourage implementing aquaculture safety certification as a market-based intervention to enhance food safety while supporting sustainable aquaculture development to meet increasing fish demand in developing countries in Africa and Asia. The literature on willingness to pay for certification primarily focuses on sustainability attributes. However, our research focuses on food safety attributes in a developing country context; consumers would care more about their real risks such as illness to them and their family members. Future research studies that disentangle WTP for environmental sustainability from WTP for food safety are needed.

It is critical to create effective mechanisms for premiums from certification schemes to transmit along aquaculture chains from retailers to producers to create incentives for safe and sustainable production practices. This requires the modernization of fish value chain structures and governance. There is need for further research in Nigeria and elsewhere on the extent to which price premiums observed in the markets can be transferred back to aquaculture producers to incentivize adoption of on-farm food safety practices. Similar research needs to occur on fish handling and processing. Improving governance and coordination along the value chain is vital to ensure aquaculture food safety issues are prioritized by actors and to create mechanisms for price premiums to producers and processors (Tran et al., 2013). Recent evidence in a related context of food quality, but focused on milk, shows that alignment of incentives along the value chain is crucial for increasing adoption of on-farm quality improvement practices by farmers (Treurniet, 2021). Finally, in this paper we investigate certification scheme as a mechanism for increasing revenues via price premiums. A follow-up study is needed to assess impacts of certification scheme on aquaculture producers and value chain actors, to determine the cost effectiveness of certification adoption.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A

Appendix Table A.1
t-test of differences between market prices and bids submitted by study participants.

Type of fish product	Market price	Mean bid	*t*-value	*p*-value
Uncertified, live, 500 g	400	452	3.490	0.001
Uncertified, live, 1000 g	800	793	−0.299	0.765
Uncertified, smoked, 250 g	800	856	1.850	0.066
Uncertified, smoked, 500 g	1600	1271	−7.741	0.000

A.1. Detailed description of the steps followed in the certification process

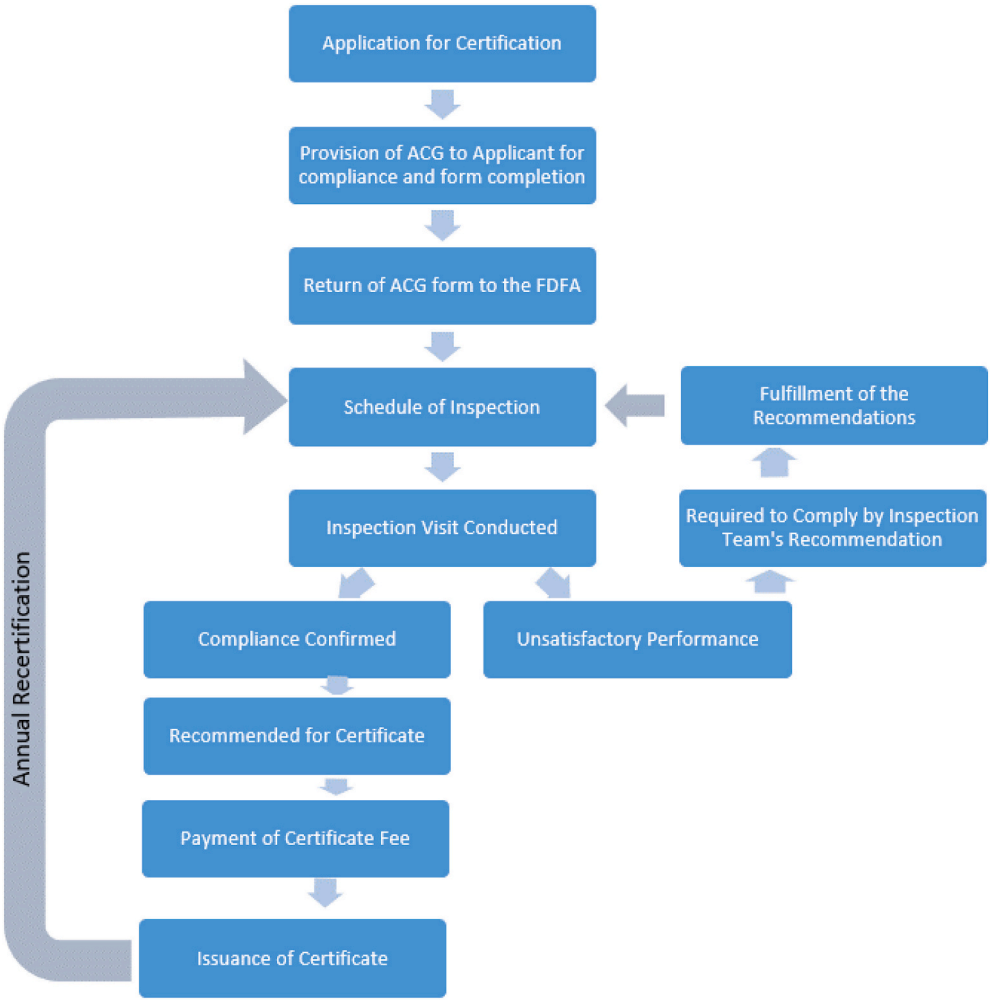

Fig. A1. Procedure for Aquaculture Certification in Nigeria (Federal Department of Fisheries and Aquaculture-FDFA).

A.2. Cheap talk script

The experience from previous similar studies is that people often respond in one way but act differently in practice. It is particularly common that one states a higher willingness to pay than what one actually is willing to pay for the product from traders in the market when they are provided money they did not have before and therefore had not budgeted for. We believe this is due to the fact that one does not really consider how big an impact an extra cost actually has to the family budget. It is easy to be generous when one is not buying from a real trader in the market and has extra money they did not have before and therefore had not budgeted for. In today's market activity, try to think whether you are really willing to pay the amount of money we will ask you for the fish that will be offered for sale. Try to imagine that this amount of money is no longer available to finance other purchases once you pay for the fish.

Above all else, we want you to be happy with your decisions no matter which price card is drawn – it is therefore very important that you give the most honest response at which price you would be willing to buy the fish products we will offer. Let us give you some examples to show some potential consequences of mismatches between the money that you indicate to us and the actual outcome following the draw of the actual price card:

First, please note that any price could be drawn between [0–800 for live fish] / [0–2800 for smoked fish], so it is important to think carefully about each decision.

Example 1: You have said you are willing to pay 100 Naira, but actually you would prefer to pay 300. Then, a 200 Naira price card is drawn. When the 200 Naira card is drawn, you will not be allowed to buy the fish product and therefore you will miss an opportunity to buy the fish product for your family, even though you really would have preferred to pay 300 Naira.

Example 2: You have said you are willing to pay 300 Naira, but actually you would prefer to pay 100 Naira. Then, a 200 Naira price card is drawn. When the 200 Naira card is drawn, you will be forced to pay 200 Naira and buy the fish product, even though you really would have preferred to pay 100 Naira."

So –again- it is therefore very important that you give the most honest response at which price you would be willing to buy the fish that we will offer for sale.

References

Anders, S.M., Caswell, J.A., 2009. Standards as barriers versus standards as catalysts: assessing the impact of HACCP implementation on U.S. seafood imports. Am. J. Agric. Econ. 91, 310–321.

Anderson, J.L., Asche, F., Garlock, T., 2018. Globalization and commoditization: the transformation of the seafood market. J. Commod. Mark. 12, 2–8.

Asche, F., Larsen, T.A., Smith, M.D., Sogn-Grundvåg, G., Young, J.A., 2015. Pricing of eco-labels with retailer heterogeneity. Food Policy 53, 82–93.

Asche, F., Bronnmann, J., Cojocaru, A.L., 2021. The value of responsibly farmed fish: a hedonic price study of ASC-certified whitefish. Ecol. Econ. 188.

Bailey, C., Tran, N., 2019. Aquatic CAFOs: aquaculture and the future of seafood production. In: Winders, B., Ransom, E. (Eds.), Global Meat: Social and Environmental Consequences of the Expanding Meat Industry. The MIT Press, Cambridge, MA, pp. 55–74.

Belton, B., Haque, M.M., Little, D.C., Sinh, L.X., 2011. Certifying catfish in Vietnam and Bangladesh: who will make the grade and will it matter? Food Policy 36, 289–299.

Bi, X., House, L., Gao, Z., 2016. Impacts of nutrition information on choices of fresh seafood among parents. Mar. Resour. Econ. 31, 355–372.

Bronnmann, J., Asche, F., 2017. Sustainable seafood from aquaculture and wild fisheries: insights from a discrete choice experiment in Germany. Ecol. Econ. 142, 113–119.

Broughton, E.I., Walker, D.G., 2010. Policies and practices for aquaculture food safety in China. Food Policy 35, 471–478.

Bush, S.R., Belton, B., Hall, D., Vandergeest, P., Murray, F.J., Ponte, S., Kusumawati, R., 2013. Certify Sustainable Aquaculture? Science 341, 1067–1068.

Carlsson, F., Frykblom, P., Johan Lagerkvist, C., 2005. Using cheap talk as a test of validity in choice experiments. Econ. Lett. 89, 147–152.

Chan, C.Y., Tran, N., Dao, C.D., Sulser, T.B., Phillips, M.J., Batka, M., Preston, N., 2017. *Fish to 2050* in the ASEAN Region. Penang, Malaysia. International Food Policy Research Institute (IFPRI), WorldFish and Washington DC, USA (Working Paper: 2017-01).

Chan, C.Y., Tran, N., Pethiyagoda, S., Crissman, C.C., Sulser, T.B., Phillips, M.J., 2019. Prospects and challenges of fish for food security in Africa. Global Food Security 20, 17–25.

Chege, C.G.K., Sibiko, K.W., Wanyama, R., Jager, M., Birachi, E., 2019. Are consumers at the base of the pyramid willing to pay for nutritious foods? Food Policy 87.

De Groote, H., Narrod, C., Kimenju, S.C., Bett, C., Scott, R.P.B., Tiongco, M.M., Gitonga, Z.M., 2016. Measuring rural consumers' willingness to pay for quality labels using experimental auctions: the case of aflatoxin-free maize in Kenya. Agric. Econ. 47, 33–45.

Dillaway, R., Messer, K.D., Bernard, J.C., Kaiser, H.M., 2011. Do consumer responses to media food safety information last? Applied Economic Perspectives and Policy 33, 363–383.

DoFA, 2009. Criteria and Guidelines for Certification of Aquaculture Animal Products. Abuja, Nigeria. Department of Fisheries and Aquaculture, Federal Ministry of Agriculture and Rural Development.

FAO, 2018. The State of World Fisheries and Aquaculture. Meeting the Sustainable Development Goals, Rome.

FAO, 2020. The State of World Fisheries and Aquaculture 2020.

Garcia Martinez, M., Fearne, A., Caswell, J.A., Henson, S., 2007. Co-regulation as a possible model for food safety governance: opportunities for public–private partnerships. Food Policy 32, 299–314.

Huss, H.H., Reilly, A., Embarek, P.K.B., 2000. Prevention and control of hazards in seafood. Food Control 11, 149–156.

Ifft, J., Roland-Holst, D., Zilberman, D., 2012. Consumer valuation of safety-labeled free-range chicken: results of a field experiment in Hanoi. Agric. Econ. 43, 607–620.

Jan, M.-S., Fu, T.-T., Liao, D.S., 2006. Willingness to pay for Haccp on seafood in Taiwan. Aquaculture Economics & Management 10, 33–46.

Kobayashi, M., Msangi, S., Batka, M., Vannuccini, S., Dey, M.M., Anderson, J.L., 2015. Fish to 2030: the role and opportunity for aquaculture. Aquaculture Economics & Management 19, 282–300.

Kondylis, F., Mueller, V., Sheriff, G., Zhu, S., 2016. Do female instructors reduce gender Bias in diffusion of sustainable land management techniques? Experimental evidence from Mozambique. World Dev. 78, 436–449.

List, J.A., Price, M.K., 2016. The use of field experiments in environmental and resource economics. Rev. Environ. Econ. Policy 10, 206–225.

Liverpool-Tasie, L.S.O., Sanou, A., Reardon, T., Belton, B., 2021. Demand for imported versus domestic fish in Nigeria. J. Agric. Econ. 72 (3), 782–804.

Lusk, J.L., Hudson, D., 2004. Willingness-to-pay estimates and their relevance to agribusiness decision making. Rev. Agric. Econ. 26, 152–169.

Menozzi, D., Nguyen, T.T., Sogari, G., Taskov, D., Lucas, S., Castro-Rial, J.L.S., Mora, C., 2020. Consumers' preferences and willingness to pay for fish products with health and environmental labels: evidence from five European countries. Nutrients 12.

Moon, W., Balasubramanian, S.K., Rimal, A., 2007. Willingness to pay (WTP) a premium for non-GM foods versus willingness to accept (WTA) a discount for GM foods. J. Agric. Resour. Econ. 32, 363–382.

Norwood, F.B., Lusk, J.L., 2011. Social desirability Bias in real, hypothetical, and inferred valuation experiments. Am. J. Agric. Econ. 93 (2), 528–534.

Okocha, R.C., Olatoye, I.O., Adedeji, O.B., 2018. Food safety impacts of antimicrobial use and their residues in aquaculture. Public Health Rev. 39, 21.

Olatoye, I.O., Basiru, A., 2013. Antibiotic usage and oxytetracycline residue in African catfish (Clarias gariepinus in Ibadan, Nigeria). World Journal of Fish and Marine Sciences 5, 302–309.

Onozaka, Y., McFadden, D.T., 2011. Does local labeling complement or compete with other sustainable labels? A conjoint analysis of direct and joint values for fresh produce claim. Am. J. Agric. Econ. 93, 693–706.

Ortega, D.L., Tschirley, D.L., 2017. Demand for food safety in emerging and developing countries. Journal of Agribusiness in Developing and Emerging Economies 7, 21–34.

Osmundsen, T.C., Amundsen, V.S., Alexander, K.A., Asche, F., Bailey, J., Finstad, B., Salgado, H., 2020. The operationalisation of sustainability: sustainable aquaculture production as defined by certification schemes. Glob. Environ. Chang. 60.

Roheim, C.A., Sudhakaran, P.O., Durham, C.A., 2012. Certification of shrimp and Salmon for best aquaculture practices: assessing consumer preferences in Rhode Island. Aquaculture Economics & Management 16, 266–286.

Sapkota, A., Sapkota, A.R., Kucharski, M., Burke, J., McKenzie, S., Walker, P., Lawrence, R., 2008. Aquaculture practices and potential human health risks: current knowledge and future priorities. Environ. Int. 34, 1215–1226.

Shikuku, K.M., 2019. Information exchange links, knowledge exposure, and adoption of agricultural technologies in northern Uganda. World Dev. 115, 94–106.

Shikuku, K.M., Tran, N., Pincus, L., Hoffmann, V., Lagerkvist, C.J., Akintola, S.L., Muliro, J., 2020. Experimental and survey-based data on willingness to pay for seafood safety and environmental sustainability certification in Nigeria. Data Brief 30, 105540.

Sun, Y., van der Ven, H., 2020. Swimming in their own direction: explaining domestic variation in homegrown sustainability governance for aquaculture in Asia. Ecol. Econ. 167.

Tacon, A.G.J., Metian, M., 2008. Aquaculture feed and food safety. Ann. N. Y. Acad. Sci. 1140, 50–59.

Thilsted, S.H., Thorne-Lyman, A., Webb, P., Bogard, J.R., Subasinghe, R., Phillips, M.J., Allison, E.H., 2016. Sustaining healthy diets: the role of capture fisheries and aquaculture for improving nutrition in the post-2015 era. Food Policy 61, 126–131.

Tongo, I., Ogbeide, O., Ezemonye, L., 2017. Human health risk assessment of polycyclic aromatic hydrocarbons (PAHs) in smoked fish species from markets in southern Nigeria. Toxicol. Rep. 4, 55–61.

Tran, N., Wilson, N.L.W., Anders, S., 2011. Standard harmonization as chasing zero (tolerance limits): the impact of veterinary drug residue standards on crustacean imports in the EU, Japan, and North America. Am. J. Agric. Econ. 94, 496–502.

Tran, N., Bailey, C., Wilson, N., Phillips, M., 2013. Governance of global value chains in response to food safety and certification standards: the case of shrimp from Vietnam. World Dev. 45, 325–336.

Treurniet, M., 2021. The potency of quality incentives: evidence from the Indonesian dairy value chain. Am. J. Agric. Econ. 135 (5), 1661–1678. https://doi.org/10.1111/ajae.12176.

Uchida, H., Roheim, C.A., Johnston, R.J., 2017. Balancing the health risks and benefits of seafood: how does available guidance affect consumer choices? Am. J. Agric. Econ. 99, 1056–1077.

Washington, S., Ababouch, L., 2011. Private standards and certification in fisheries and aquaculture. FAO Fisheries and Aquaculture Technicla Paper 553, 203p.

Wessells, C.R., Anderson, J.G., 1995. Consumer willingness to pay for seafood safety assurances. J. Consum. Aff. 29, 85–107.

Wuyep, S., Rampedi, I., 2018. Urban Fish Farming in Jos, Nigeria: Contributions towards Employment Opportunities, Income Generation, and Poverty Alleviation for Improved Livelihoods. Agriculture 8.

Xuan, B.B., 2021. Consumer preference for eco-labelled aquaculture products in Vietnam. Aquaculture 532.