

Implications of Ice Use on Consumers' Willingness to Pay for Fresh Fish

Findings from Experimental Auctions in Hadramawt Fish Markets

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Key Findings

An experimental auction conducted with 426 fresh fish consumers in Mukalla and Qusayir fish markets in Yemen reveals the following key findings:

- There is a modest price premium of 77 YER per fish for fish that is sold on ice compared with fish not sold on ice, across the sample.
- Compared with the sample average, the price premium in Mukalla is more than two times higher, with a difference of 162 YER per fish between fish sold on ice and not.
- There is no price premium for fish on ice in Qusayir.
- More than 60 percent of shoppers in both markets have positive perceptions about the use of ice to improve fish quality.
- The use of ice is not the most important consideration when shoppers are making their purchasing decisions, rather, the price of fish is deemed most important.
- The price premium appears to be too low to incentivize retailers to offer fish on ice to shoppers, considering high costs of ice.

Fish is highly perishable and requires an uninterrupted cold chain to maintain both observable, organoleptic quality characteristics and food safety, which is not directly observable. Yet the use of ice by artisanal fishers and fish retailers in coastal markets for fresh fish is limited in Hadramawt Governorate—the center of Yemen's artisanal fisheries in the Gulf of Aden (Belton et al., 2026). While increased use of ice by fishers and retailers could improve fish quality and safety in consumer markets, rigorous evidence is lacking on consumers' perceptions about the use of ice and their willingness to purchase fish placed on ice.

In the context of Yemen, and Hadramawt Governorate specifically, ice is mainly used on larger boats that go on multi-day fishing trips, while fishers with small boats tend not to use ice because their daily fishing trips are short and the cost of ice is high (Belton and Bahurmiz, 2026; Darwish et al., 2026). As such, using ice in coastal fish markets may be a negative signal of quality to shoppers, who may perceive fish that is not placed on ice as fresh (today's) catch and fish on ice as less fresh (that is, caught a few days ago and landed by larger boats) (Belton and Bahurmiz, 2026).

We conducted an experimental auction with 426 shoppers in two coastal markets for fresh fish, Mukalla and Qusayir, to understand consumer preferences and attitudes toward ice use and measure their willingness to pay a price premium for fresh fish that is sold on ice. We present the main findings of the study in this project note.

Study setting and approach

The target participants for experimental auctions were individual shoppers (that is, consumers) in fresh fish markets, who were purchasing fish for own-household consumption. We elicited shoppers' willingness to pay (WTP) with incentive-compatible auctions using the Becker-DeGroot-Marschak (BDM) mechanism (Becker et al., 1964). BDM auctions provide revealed preference estimates because participants bid real money and have the opportunity to purchase the fish after their bid.

In Mukalla and Qusayir, fish is normally caught early in the morning and sold fresh within several hours in local fish markets near landing sites. Each day of the experimental auction, we obtained freshly caught striped bonito in the morning and displayed it on one fish stand in each market in two different ways: (1) whole fish was placed on a common



Figure 1. Two fish displays: Fish on ice and fish not on ice

market-stand surface, such as on tiles, and (2) whole fish was placed in a well-drained container with shaved ice. Both fish displays included striped bonito from the same catch and of the same size and appearance, and the only difference between the two fish displays was the use of ice. Striped bonito is a commonly consumed mid-priced fish species (Jovanovic et al., 2026), and we selected it for the study because it was important to work with whole fish for which supply would be stable throughout the duration of the experiment (striped bonito was in peak season at the time of the study).

We conducted experimental auctions and surveys with the participating shoppers in the morning immediately after striped bonito was landed and placed on the two displays. We provided recruited shoppers with a fixed cash amount at the beginning of the experiment to remove potential liquidity constraints that could limit their participation and bias their bids. Before asking participants to bid for fish, we explained the goals and procedures of BDM auctions, including that the offer participants place will be real and will bind them to purchase the fish. To ensure that they understood the process well, we also conducted one

practice round using a small packet of shelf-stable pasteurized milk, which is a familiar item to all consumers.

In the auction, we asked each participant to place two separate bids, one for each fish display (ice and no ice). The shoppers' stated bid was then compared to a price that they randomly drew from an envelope. The envelope included 40 pieces of paper that represented a symmetrical range of prices from the market price for striped bonito (for example, if the market price for a whole fish was 4,000 YER, the prices in the envelope ranged from 3,000 to 5,000 YER in increments of 100 YER). Moreover, prices in the envelope were linked to each fish display—20 for fish on ice and 20 for fish not on ice.¹ Respondents made only one random draw each and were able to buy only one fish. If the bid was less than the envelope price, the participant could not buy the fish. If the bid was higher or equal to the envelope price, the participant purchased the fish (either ice or no ice fish) at the envelope price. Immediately after the auction, we surveyed the shoppers. The survey asked questions about their demographic characteristics and perceptions about the use of ice in local fish markets.

The experiment was implemented for six days in each market in January 2026. We ensured that the experimental setup was uniform between the two markets and across days.

Willingness to pay

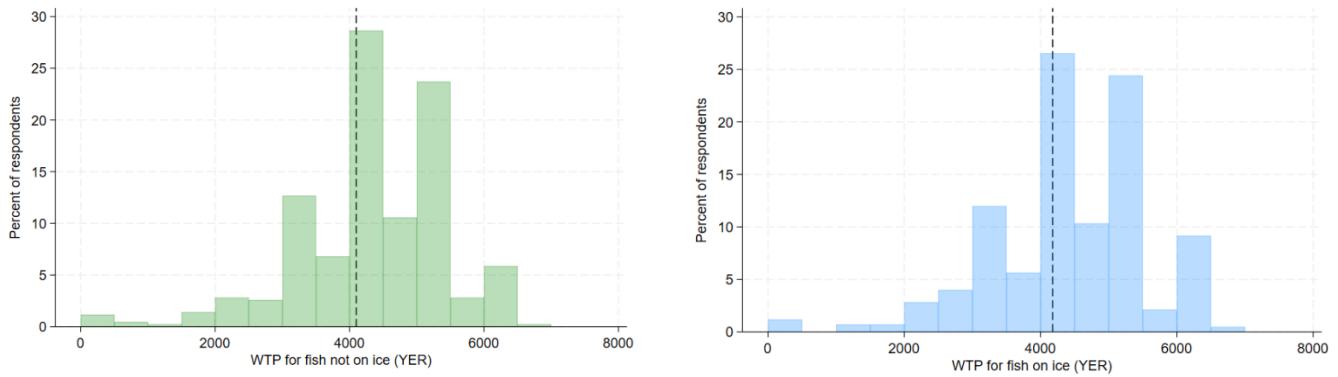
The overall average willingness to pay (WTP) for a fresh striped bonito in our sample is 4,139 YER.² Figure 2 shows the distribution of respondents' WTP for fish not sold on ice (left) and fish sold on ice (right). The average WTP for the fish not sold on ice is 4,100 YER, and most bids fell in the 3,000–5,000 YER range (about 82 percent): the largest share of respondents (around 28 percent) bid exactly 4,000 YER, while about 24 percent bid 5,000 YER, and about 12 percent bid 3,000 YER.

We observe a similar pattern for the fish sold on ice, with 79 percent of bids falling in the same range of 3,000–5,000 YER. Almost 27 percent of consumers bid 4,000 YER, while 24 percent bid 5,000 YER and 12 percent bid 3,000 YER. However, we note that a slightly higher percent of respondents were willing to pay more than 6,000 YER for fish sold on ice (about 10 percent) than for fish that is not sold on ice (6 percent). Therefore, while the two distributions appear similar, the average WTP for fish sold on ice is 77 YER higher than the average WTP for fish not sold on ice.

¹ For example, a piece of paper in the envelope stated “fish on ice, 3,500 YER” or “fish not on ice, 3,500 YER.”

² The market prices for fresh whole striped bonito ranged between 5,500 and 6,500 YER in Mukalla and between 4,000 and 5,000 YER in Qusayir. Striped bonito was not available for purchase from other retailers in Qusayir market on two days of the experiment.

Figure 2. Distribution of respondents' WTP for fish not on ice (left) and WTP for fish on ice (right) (YER)



Note: Number of respondents is 426. Dashed line represents mean WTP of 4,100 YER (left) and 4,177 YER (right). At the time of the study, 1 USD = 1,600 YER.

Table 1 shows average WTP for fresh striped bonito in the two markets where we conducted the experiments. The overall average WTP for a whole fish (on ice and not on ice) in Mukalla is higher than the average WTP for fish in Qusayir, although this difference is not statistically significant. A similar pattern is observed for fish not sold on ice: the average WTP in Mukalla is only 71 YER higher than the average WTP in Qusayir.

We observe the highest average WTP of 4,298 YER for fish sold on ice in Mukalla, which is significantly higher than both the average WTP for fish on ice in Qusayir and average WTP for fish not on ice in Mukalla. In Qusayir, we do not find any significant differences between consumers' average WTP for fish on ice and not on ice.

Table 1. Willingness to pay for fish on ice and not on ice in studied markets (YER)

	Mukalla	Qusayir	Difference between markets
Total bids for fish	4,217	4,063	154
<i>Bids for fish not on ice</i>	4,136	4,065	71
<i>Bids for fish on ice</i>	4,298	4,060	238**
<i>Bid difference between fish on ice and not on ice</i>	162***	5	
Number of participants	210	216	

Note: At the time of the study, 1 USD = 1,600 YER. Asterisks represent statistical significance between two means based on a *t*-test: *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.1$.

We use fixed effects regression analysis that controls for respondent-specific observable and unobservable characteristics to determine whether or not there is a price premium for fish that is sold on ice. Overall, regression analysis confirms our results in Figure 2 and Table 1.

Results in column (1) of Table 2 confirm that the difference of 77 YER between the WTP for fish on ice and not on ice (also highlighted in Figure 2) is statistically significant, indicating the existence of a modest price premium for icing fish in these markets. According to column (2) of Table 2, the consumers in Mukalla are willing to pay a premium of about 162 YER for a whole fish sold on ice, while consumers in Qusayir do not place any premium on fish on ice, compared with the normal presentation of fish in this market—that is, without ice.

Table 2. Consumers' WTP for fish on ice and not on ice (YER), BDM auction

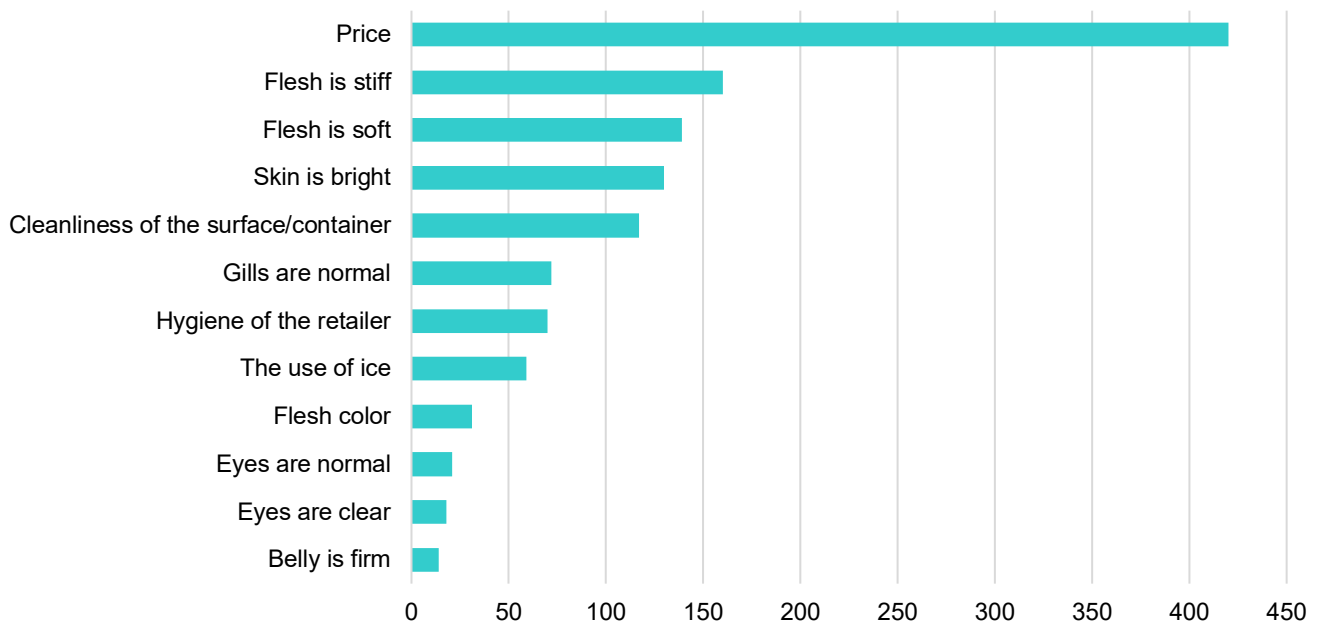
Variables	(1) WTP for fish (both markets)	(2) WTP for fish (Mukalla)	(3) WTP for fish (Qusayir)
Fish is sold on ice (yes = 1)	77.5** (36.6)	161.9*** (53.5)	-4.6 (49.6)
Constant	4,100.0*** (18.3)	4,136.2*** (26.7)	4,064.8*** (24.8)
Number of consumers	426	210	216

Note: At the time of the study, 1 USD = 1,600 YER. Robust standard errors are included in parentheses. Asterisks indicate statistical significance levels of coefficient estimates: *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.1$.

Determinants of purchase decisions

As part of our survey, we asked the respondents to report the three most important factors influencing their decisions about purchasing fresh fish in general. Figure 3 shows that, as expected, for 420 of the 426 consumers price is the main factor affecting their purchasing decisions. Only 59 consumers considered the use of ice, and as such it is the eighth most important factor.

Other factors influencing purchasing decisions are observable fish characteristics that relate to fish freshness (such as firmness and color of flesh) and handling practices as a potential indicator of food safety (such as cleanliness of surface or container and hygiene of the retailer). Temperature and smell of fish are considered less frequently.

Figure 3. Main factors considered when purchasing fresh fish

Note: Based on 1,278 responses, since each respondent indicated three main reasons. We do not show factors that registered fewer than 10 responses: skin is dull, fish is cold, eyes are sunken, belly is burst, smell is fresh, fattiness, fish is warm, smell is musty, gills are faded, and eyes are cloudy.

To better understand which observable factors of freshness affect participants' WTP for fish sold on ice versus not sold on ice, we asked them to report the reasons behind their auction bids for each display.

Using these data from the participants, we estimated separate regressions for WTP for fish on ice and not on ice to examine potential differences in the correlations with common visual indicators of freshness by controlling for participant-specific characteristics such as household income and education level. Table 3 confirms that good appearance of the fish skin, flesh, eyes, and gills positively affect participants' WTP for both fish on ice and not on ice. Significance levels and coefficient estimates (indicating the strengths of correlations) are similar, suggesting that freshness indicators are the main factor affecting shoppers' valuation of fish rather than whether fish is placed on ice or the bare market stand surface. The coefficient estimates for the four statistically significant freshness indicators are almost always higher in the regression for participants' WTP for fish on ice than that for fish not on ice, suggesting that these observable factors matter more for shoppers' valuation of fish when it is displayed on ice. As the freshness of the fish was identical for the two displays of our experiment by design, this finding can be explained by general perceptions about fish sold on ice, as discussed in the next section.

Table 3. Estimated effects of freshness indicators on WTP for fish displayed on ice and not on ice

	WTP for fish	
	Not on ice	On ice
Fish skin is bright (0 = no, 1 = yes).	0.222*** (0.085)	0.241*** (0.070)
Fish flesh is firm (0 = no, 1 = yes).	0.180*** (0.058)	0.183*** (0.053)
Fish eyes are bright and bulging (0 = no, 1 = yes).	0.110* (0.064)	0.127* (0.069)
Fish gills are red (0 = no, 1 = yes).	0.210** (0.091)	0.185** (0.090)
Market location (0 = Mukalla, 1 = Qusayir)	-0.574 (0.462)	-0.469 (0.465)
Number of consumers	426	426

Note: The WTP variables enter the regression in logarithms. Control variables include participants' reported household income per capita, household size, and age all in logarithms; participants' gender and basic education level; and days of the experiment. Asterisks indicate statistical significance levels of coefficient estimates: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Robust standard errors are reported in parenthesis.

Perceptions about the use of ice

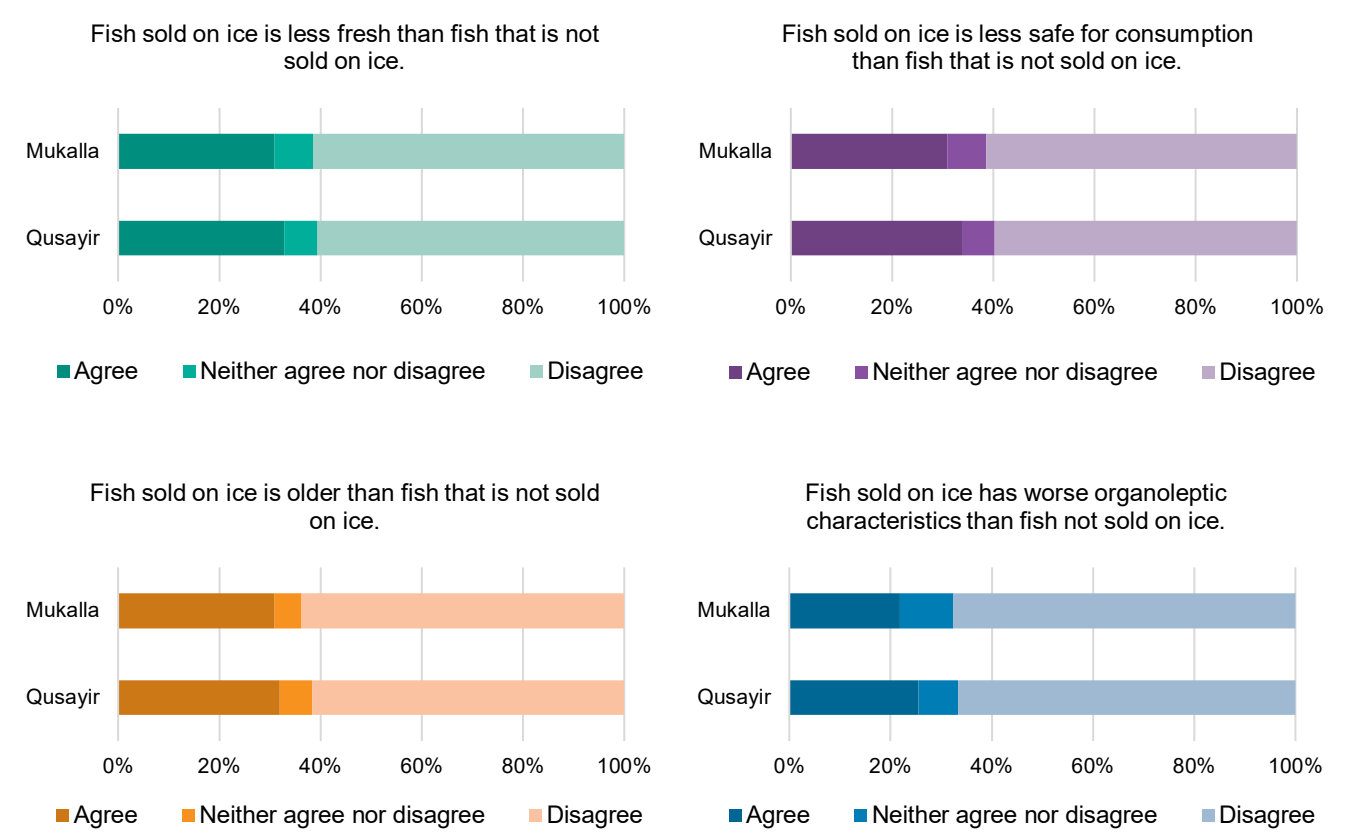
Although consumers do not prioritize the use of ice when deciding whether or not to purchase fresh fish but rather appear to base their purchase decisions on observable quality characteristics, the majority of them do not have negative perceptions about the use of ice. Following the auction, we asked participants to state their general perceptions about the use of ice by market retailers and its relation to fish quality. We read four statements that framed the use of ice negatively, and asked participants to agree or disagree: (1) Fish sold on ice is less fresh than fish that is not sold on ice; (2) Fish sold on ice is less safe for consumption than fish that is not sold on ice; (3) Fish sold on ice is older than fish that is not sold on ice; and (4) Fish sold on ice has worse organoleptic characteristics (such as smell, taste, color, firmness of flesh) compared with fish that is not sold on ice. We instructed the respondents not to use our fish stand as an example when answering these four questions; rather we asked them to have in mind the same market for fresh fish on a typical day.

Figure 4 shows that consumers' perception of ice use is not as negative as conjectured by fish retailers in similar markets (Belton and Bahurmiz, 2026). Our survey results show that more than 60 percent of respondents in Mukalla and Qusayir have positive perceptions about the use of ice for upholding fish

quality. Respondents in Qusayir have slightly more negative perceptions about the use of ice compared with consumers in Mukalla.

We note that the highest share of “agree” responses is for the “Fish sold on ice is less safe for consumption than fish that is not sold on ice” statement (31 percent in Mukalla, 34 percent in Qusayir), while the lowest share of “agree” statements is associated with the “Fish sold on ice has worse organoleptic characteristics (such as smell, taste, color, firmness of flesh) compared to fish that is not sold on ice” statement (22 percent in Mukalla, 26 percent in Qusayir). These responses suggest that when it comes to the use of ice, consumers are more concerned about the implications for unobservable quality (that is, food safety) rather than observable quality.

Figure 4. Consumers’ perceptions about the use of ice



Conclusions

We implemented incentive-compatible experimental auctions, using the BDM mechanism, to elicit consumers’ WTP for fresh striped bonito sold with and without ice in Mukalla and Qusayir, two coastal markets of Hadramawt. We standardized the experimental setup across markets and implementation days, to ensure that the only differences in the consumers’ WTP were associated with the use of ice. We targeted individual fish buyers who were purchasing fresh fish for household consumption, and we provided them with a fixed participation fee to avoid any potential liquidity constraints that might affect their bids. This approach allowed us to determine actual consumers’ WTP, since they bid real money and could actually purchase fish based on their bids. We complemented the experimental auction with a survey to understand consumers’ perceptions about the use of ice and which observable and unobservable fish quality attributes influence their purchasing decisions.

Our results from the experimental auction indicate that fish sold on ice is not undervalued compared to the fish that is not sold on ice. We find that there is a modest price premium of 77 YER for fish sold on ice across the sample. This premium is higher in Mukalla, where the participating consumers are willing to pay about 162 YER more for fish on ice. In Qusayir, however, we did not find a statistically significant difference between participants' WTP for fish on ice and not on ice, suggesting that there may be no price premium for fish sold in ice.

Compared to the cost of ice needed to run a fish stand (about 2,500 YER/day), the price premium of 77 YER per fish is low as the retailer would have to sell 33 whole fish to break even (or, about 15 whole fish in Mukalla market, where the price premium is 162 YER per fish). Thus, at the current cost of ice, the price of fish would inevitably have to increase if the retailers started putting fish on ice in Mukalla and Qusayir markets. Bearing in mind that price remains a dominant consideration in shoppers' fish purchasing decisions, there seems to be no economic incentive for retailers to start using ice in local fish markets near landing sites. Our findings therefore highlight that encouraging increased use of ice would require reducing its price. As outlined by Belton and Bahurmiz (2025), the main challenges faced by ice manufacturers are frequent machinery breakdowns and lack of access to reliable, low-cost energy sources. As such, there is potential to decrease the cost of ice through investments that would ensure better access to energy and provide more efficient machines to ice manufacturers.

We also find that the majority of consumers do not perceive the use of ice negatively and that, in addition to price, they base their purchasing decisions on organoleptic characteristics of fish. These results indicate that there is potential to improve consumer perceptions about the use of ice by retailers through awareness campaigns that emphasize the importance of ice in preserving fish quality and safety. Moreover, gradual introduction of ice, such as by using two fish displays in one fish stand—with fish on ice placed next to fish on a bare surface as in our study—could help accustom shoppers to ice use in these markets. Such an approach would allow fish buyers to examine and compare organoleptic characteristics of fish from the two displays and potentially help them understand the benefits of using ice maintain fish freshness.

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