Evaluating the Impacts of Labeling on Consumers' Demand for Sour Milk: Evidence from Experimental Auctions in Senegal

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I. Introduction

Millions of poor and vulnerable households in low- and middle-income countries lack consistent access to safe and nutritious foods (Shephard, 2008). Consuming unsafe food creates foodborne diseases that affect about 600 million people worldwide, leading to 480,000 deaths per year, with an estimated economic cost of around $115 billion annually (Henson et al., 2023). Moreover, consumption of unsafe foods is linked to many negative long-term health effects which in turn reduce economic growth (Bhargava et al., 2001; Shephard, 2008; Wild & Gong, 2010).

In many developing countries, informal markets dominate the food sector, largely operating outside formal regulatory frameworks. This lack of oversight can lead to compromised food safety and mislead consumers through inadequate or absent product labeling. In Sub-Saharan Africa, nearly 80% of consumers purchase food in informal markets (Henson et al., 2023). These informal markets are characterized by numerous small-scale traders and processors who typically operate without formal business registration, thereby making enforcement and monitoring of food safety standards difficult and expensive (Grace, 2015; Hoffmann et al., 2019). Given the unobservability of many food safety attributes, actors in such informal markets have little to no incentive to invest in food safety. This creates asymmetric information where traders and processors have more information about the quality of the product than consumers. Evidence show that less informed consumers tend to underestimate the risks associated with unsafe food (Liu & Niyongira, 2017). This further gives rise to a "lemons market" in which products of questionable quality and safety dominate the food system (Akerlof, 1978). The case of Senegal dairy value chain provide a notable case of an informal urban market that raises food safety concerns. Thus, we aim to answer the following research question: How does labeling information about milk origin (produced from

milk powder versus produced from fresh milk) and food safety (milk tested for microbial contamination versus untested milk) impact consumer's demand for sour milk?

Milk and milk products are a rich source of calcium, which is essential for children to build strong bones and meets the nutritional needs of adults due to its easily digestible nutrients (Drewnowski, 2010; Kourkouta Lambrini et al., 2020; Muehlhoff et al., 2013). There is evidence that yogurt consumption benefits malnourished children and daily consumption of sour milk for six months improves cholesterol ratios in women (Kießling et al., 2002; Solis et al., 2002). The increase in milk consumption has been significant over the past two decade, driven by economic growth and rising income levels, which is mirrored in other developing regions as evidenced by the growing dairy demand in urban China (Ortega et al., 2012). Dakar, as the capital of Senegal, stands as the most significant market for dairy products in the country due to its largest population in the country, the relatively high purchasing power of a segment of its consumers, a longstanding habit of consuming manufactured products, and the absence of intra-urban livestock (Duteurtre & Corniaux, 2018). This urban setting primarily drives the demand for dairy, where the consumption habits are shaped by the accessibility and economic decisions. In urban and peri-urban neighborhoods of Dakar, small-scale milk processors, who produce sour milk – locally known as *soow* – which is recognized for its health-promoting properties, often do not adhere to Good Manufacturing Practices (GMP) or clear labeling standards (Leone et al., 2022). Sour milk is traditionally made through spontaneous cow's milk fermentation or by adding beneficial microorganisms. The spontaneous fermentation process involves boiling, cooling, and fermentation in wooden bowls – known as *lahal* – that retain microbial cultures from previous cycles, kickstarting the fermentation of the next batch, also known as the "last batch practice"(Groenenboom et al., 2019).

However, despite the nutritional value of sour milk, contamination can still occur (Fernández et al., 2015). The most common practice among small-scale traditional milk processors is the last batch practice, and has been found not to conform to Good Manufacturing Practices (GMPs) or Good Hygiene Practices (GHPs) (Leone et al., 2022). This approach results in uncontrolled fermentation due to its reliance on back-slopping, potentially exposing the milk and its fermented products to contamination by human pathogens of public health concern (Brouti & Goudiaby, 2021; Leone et al., 2022). Furthermore, a lack of fundamental practices such as proper hygiene, cleanliness, and basic tools can contribute to the supply of unsafe milk (Belli et al., 2013).

While a regulated Soow market exists in Senegal, catering to high-end stores, the vast majority of urban and peri-urban consumers purchase Soow from small-scale informal processors, called *Neex Soow,* literally translated as "tasty sour milk". These processors are small, unregistered businesses that operate without a license or any training in food processing, food safety, or business practices. Their production process entails solely purchasing imported powdered milk in bulk (as Senegal does not produce enough milk to meet its domestic demand), mixing it with water, fermenting it overnight with locally purchased ferments or using the last batch practice, and selling the sour milk the following morning (Ferrari, 2017). The transformation process at the point of sale frequently involves using large plastic basins and small artisanal wooden beaters to mix and homogenize the sour milk (Broutin et al., 2000). Often, Neex Soow have small retail kiosks located in lower-income neighborhoods and cater to limited-resource consumers. There is evidence to suggest that the level of contaminants in this sort of artisanal-produced sour milk can be higher than in fresh milk (Koussou et al., 2007). This issue of contamination is critical as shown in studies across other regions where consumers have expressed willingness to pay premiums for milk with reduced aflatoxin levels, indicating a significant concern about milk safety (Abedullah et al.,

2023). This is particularly relevant because of health risks associated with informal food markets in Africa from contamination and adulteration of food products (Kariuki & Hoffmann, 2022). Habiyaremye et al. (2023) have demonstrated that consumers were willing to pay a higher price for safe and high-quality milk, and the provision of quality-related information positively influences their willingness to do so. Earlier research has revealed that consumers were more inclined to pay a premium when provided with quality-related attributes and were even more willing to do so when presented with positive quality-related information (Banerji et al., 2018; Ruggeri et al., 2021). Given the substantial price difference between Neex Soow and other processing units, it becomes crucial to accurately gauge urban consumers' genuine willingness to pay for various milk types. This is particularly important when considering that Neex Soow processors manipulate milk powder during reconditioning of the product which makes it more susceptible to contamination from poor handling and fermentation practices, yet they maintain a significant market share. Given the unobservability of many food safety attributes and misconceptions about sour milk composition, producers and other informal processors in these informal markets have little to no incentive to invest in food safety and proper labeling.

Additionally, Senegal has become reliant on milk powder imports since the early 2000s - increasing imports to almost double the local production (Corniaux et al., 2012). A sudden surge in global milk powder prices arose in the mid 2000s which led to the government temporarily suppressing value-added tax (VAT) and customs duties on milk powder imports (Ngom et al., 2019). However, while these measures aimed to address short-term consumer affordability, they inadvertently had adverse effects on the local dairy value chain. This unintended consequence contributed to the ongoing significant imbalance between milk powder imports and locally produced milk. It also contributed to the prevalent use of powdered milk by Neex Soow and bigger

dairy processing firms, as the domestic dairy sector faced challenges to compete with imported milk powder, thus hindering its growth. Specifically, milk powder reconstituted with vegetable fats, has become a pivotal component in Senegal's dairy consumption, now ranking as the second most imported commodity after rice (Missohou, 2020). Despite evidence showing a preference from consumers for fresh local dairy products, there still exists consumer misconceptions about product composition, which hinder them from assigning a higher value to local milk-based products (Lefèvre, 2014).

Primary fieldwork observations have further highlighted another issue contributing to the substantial imbalance between milk powder imports and local milk production that is also consistent with existing literature: misleading advertising and a lack of proper labeling. Reconstituted milk powders with vegetable fats and other products such as re-engrained sweetened condensed milk are up to 30% cheaper than the dairy products they replace (Duteurtre & Corniaux, 2018). However, the vegetable origin of these products is often only mentioned on the packaging, leading to possible consumer confusion between genuine dairy products and those made from substitute ingredients. In some instances, poor labeling practices contribute to this confusion, such as milk powder sold in unlabeled transparent bags or locally made yogurts that do not specify the type of raw materials used. Such misleading practices and deficient labeling are not only deceptive but also potentially harmful, promoting misinformation about product origins and ingredients (Duteurtre & Corniaux, 2018). Perfect examples to that are Neex Soow processors who often use *'caille-lait*' (milk-curdling) tablets purchased from pharmacies or retailers to expedite fermentation, adding a bit of the previous day's curdled milk which in excessive use sometimes leads to severe intoxications during ceremonies (Broutin et al., 2000). While the trade in dairy substitutes allows many consumers in Sub-Saharan Africa to access cheaper products resembling

dairy, it often results in product name deceptions and origin ambiguities. The lack of clear composition indication can lead to unfair practices towards consumers and competitors who adhere to norms, posing a challenge that needs addressing to ensure consumer safety and market fairness. Findings from previous research indicates consumers' difficulties in distinguishing between available milk types and the misleading characteristics of powder-based products (Lefèvre, 2014).

Building on the existing research base, our study investigates the linkages between food safety concerns, milk origins and consumer preferences in the dairy sector. Prior literature extensively discusses safety concerns within informal markets in developing countries, particularly focusing on the consumer demand for safer food and the prevalence of milk powder in the sub-Saharan dairy market. However, few studies have simultaneously investigated the impact of both origin and safety on consumer willingness-to-pay , especially within the urban markets of Senegal where these factors are deeply intertwined. Our research contributes to filling the gap by looking at both aspects separately, and combined. One similar study conducted in Mali relied on hypothetical WTP assessments. Our approach not only corroborates the existing findings from Mali regarding consumer preferences for transparency and safety certifications but also advances the literature by assessing revealed preferences. This enhancement provides a more reliable basis for policy recommendations aimed at improving food safety standards and market transparency in developing urban markets.

We conducted an experimental auction in four urban food market in Dakar, Senegal where we assessed consumer demand for four variations of Soow: 1) labeled imported; 2) labeled imported and tested for microbial contamination 3) labeled local and; 4) labeled local and tested for microbial contamination. Utilizing the Becker-DeGroot-Marschak (BDM) mechanism to conduct experimental auctions, we accurately measure the participants' willingness-to-pay (WTP) for each

labeled milk product variant, revealing distinct consumer preferences. Our empirical investigation analyze consumer preferences for dairy products across four major markets in Dakar, involving 801 participants. The study reveals a higher willingness to pay for dairy products that were both safety-tested and locally sourced, on average. Specifically, consumers are willing to pay 524 CFA (0.86 USD) for locally sourced and tested milk, compared to 415 CFA (0.68 USD) for local but untested milk. Consumers are willing to pay 336 CFA (0.55 USD) for imported and untested milk versus 446 CFA (0.73 USD) for imported and tested milk. Regression analysis across two models—with and without demographic controls—consistently showed significant premiums for all tested milks over untested, emphasizing the value placed on safety. Notably, local and tested sour milk recorded the highest premium (187.52 CFA and 189.70 CFA across the two models, respectively), highlighting the preference for products that guarantee both local sourcing and safety. We also conduct a heterogeneity analysis to further highlighted demographic influences. The findings show that factors such as gender and education level do not significantly modify willingness to pay, despite magnitude results showing women and educated respondents having different price sensitivities. These findings underscore the importance of product safety and origin in consumer decisions within informal markets and illustrate the potential impact of enhanced labeling and safety standards on consumer trust and market dynamics.

The remainder of the paper is organized to guide the reader through a comprehensive analysis of our findings and their implications. Following this introduction, we delve into a detailed background section, setting the stage by discussing the existing studies on food safety in informal markets and the efficacy of consumer information as well as the specific case of Senegal informal dairy system. In Section 3, we then describe our data collection process and experimental design. Methodology will be discussed in depth in section 4, discussing our empirical model. Section 5

details the results and discussion of our findings where we present a detailed analysis of the consumer preferences elicited through our auction experiments, supported by statistical evidence. Finally, we conclude with a synthesis of our findings, outlining their implications for policymakers and markets' stakeholders, and propose strategies for improving food safety and market transparency.

II. Data

Sample Preparation and Testing

This study was conducted in collaboration with the Senegalese Food Technology Institute (*Institut de Technologie Alimentaire*, ITA), the national authority in food science. ITA prepared two batches of 65 liters of sour milk, differentiated by the origin of the milk used. The first batch was produced exclusively from imported milk powder, henceforth referred to as "imported milk." The second batch used only locally sourced milk, referred to as "local milk."

To assess the safety of these sour milk batches, ITA conducted microbiological testing on two 300-gram samples from each batch. Tests were aimed at detecting five types of pathogenic bacteria: *E. coli*, *Salmonella*, *Enterobacter*, *Staphylococcus aureus*, and *Listeria*. These bacteria were selected as proxies for the overall safety of the milk.

Following testing, each product was packaged into small 250-gram plastic cups by ITA lab technicians to simulate a typical market quantity sold by both formal and informal vendors. These cups were then labeled in four distinct ways: "*imported*", "*imported and tested by ITA*", "*local*", and "*local and tested by ITA*". It is important to note that all products were tested by ITA and guaranteed as suitable for consumption by ITA. However, for the purpose of our study and to assess a potential price premium that consumers are willing to pay for safer milk, this information was not shared with participants until the end of the survey.

Market Setup and Survey Implementation

The field research was conducted in four major markets within the urban and peri-urban areas of Dakar: *Castors*, *Guediawaye*, *Sandaga*, and *Colobane*. These markets were selected to capture a diverse sample of consumers and were approached sequentially, not simultaneously. At each location, four kiosks were established in collaboration with local vendors.

A team of eight enumerators, divided into pairs, managed the survey and auction process. Each pair of enumerators was tasked with inviting every third marketgoer to participate in the study. If the individuals agreed, they were guided to the vendor's shop where the survey and auctions were conducted.

In total, 801 individuals participated in the study. Participants were surveyed on a range of socio-economic and demographic characteristics, their personal and household consumption of sour milk, and their awareness of safety risks associated with milk processing. Additionally, preferences for local versus imported milk were assessed.

We employed the Becker-DeGroot-Marschak (BDM) incentivized demand revealing auction mechanism to gauge participants' true willingness-to-pay for each labeled milk product (Becker et al., 1964). To familiarize participants with the auction process, two practice rounds were conducted using a cookie and a pen, respectively. Participants were instructed to bid the maximum amount they would be willing to pay for each item. An envelope containing varied prices was then presented, from which participants drew one price. If their bid was less than the drawn price, they could not purchase the item; if it was equal to or greater, they could potentially purchase the item at the drawn price, conditional on this item being the randomly selected item for purchase.

For the auctions for sour milk, Participants were asked to bid separately on each of the sour milk products in the following order: "*imported*", "*imported and tested by ITA*", "*local*", and "*local and*

tested by ITA". Envelope prices ranged from 50 CFA (0.082 USD) to 600 CFA (0.98 USD), by multiples of 50. Participants were told about the price range before the draw. We chose this price range due to similar products in the current market having prices ranging from 150 CFA (0.33 USD) to 500 CFA (0.82 USD) which allows participants to have an idea of the prices they were bidding against while still being free to choose any number outside the proposed prices. They were made aware that if they bid below 50 CFA, they would have no chances of winning the item, which would confirm that they were not willing to pay for the product. On the other hand, if they bid higher than 600 CFA, then they were guaranteed to win the item if that product was randomly chosen to be purchased but at a high price. At the end of the four bidding rounds for each sour milk item, one of the products was randomly selected for purchase. Participants who won their bid purchased the item. This method guaranteed that participants bid their true willingness to pay.

III. Methodology

Empirical Model

Our study employs a linear regression model to investigate consumer willingness to pay (WTP) for differently labeled sour milk in informal markets. The model is specified as follows:

$$(1)\ WTP_{ir} = \beta_0 + \beta_1 TI_{ir} + \beta_2 NL_{ir} + \beta_3 TL_{ir} + \beta_4 X_{ir} + a_r + \varepsilon_{ir}$$

where:

WTP_{ir} represents the willingness to pay for each type of labeled milk for individual i in market r. TI_{ir} is a binary variable indicating whether the milk is imported and tested for safety. NL_{ir} is a binary variable indicating whether the milk is locally sourced but not tested for safety. TL_{ir} is a binary variable indicating whether the milk is locally sourced and tested for safety. The imported and untested is our baseline category. X_{ir} is a vector of control variables. a_r captures fixed effects for each market, controlling for unobserved market specific factors. ϵ_{ir} is the error term.

Our model is designed to assess how different labeling strategies regarding the safety and origin of milk affect consumer behavior in markets where formal regulations may be lacking or enforcement is weak. Each label type is hypothesized to have a distinct influence on WTP, reflecting consumer preferences for product safety and local versus imported goods. Market fixed effects are included to account for varying market characteristics that might influence overall consumer behavior.

Hypotheses

We formulate the following hypotheses to guide our empirical investigation:

$\beta_1 = 0$: Local milk tested for safety does not have a different WTP compared to the baseline category (imported and untested milk).

$\beta_2 = 0$: Imported milk tested for safety does not have a different WTP compared to the baseline category.

$\beta_3 = 0$: Local milk not tested for safety does not have a different WTP compared to the baseline category.

Additional hypotheses examine combined effects to assess broader preferences:

$\beta_1 + \beta_3 = \beta_0 + \beta_2$: There is no difference in the combined WTP for local milk (both tested and untested) compared to imported milk (both tested and untested).

$\beta_1 + \beta_2 = \beta_0 + \beta_3$: There is no difference in the combined WTP for tested milk (both local and imported) compared to untested milk (both imported and local).

IV. Results and Discussions

Descriptive Statistics

Table 1 presents the summary statistics for the variables of interest in our analysis of consumer willingness to pay (WTP) for sour milk, demographic characteristics, and market behaviors of 801 respondents in informal markets.

[Insert Table 1 here]

Willingness-to-Pay (WTP) variables

The mean Willingness-to-Pay (WTP) for imported, untested (NI) sour milk is 336 CFA (0.55 USD). This relatively lower average compared to the other WTPs suggests lower consumer interest in imported milk with no safety certification. Additionally, the distribution's wide range, from 0 to 1100 CFA (1.80 USD), indicates variability in consumer trust or valuation of imported products that do not have any safety assurance. For imported, tested sour milk (TI), we showcase a higher mean WTP of 446 CFA (0.73 USD), reflecting increased consumer valuation for safety testing among imported products. The broad range from 0 CFA up to 2000 CFA (3.27 USD) and a higher median of 500 CFA (0.82 USD) demonstrate a higher preference placed by consumers on safety features. With an average WTP of 415 CFA (0.68 USD), the local, untested sour milk category (NL) shows a preference over imported, untested milk, yet is lower than the WTP for imported, tested sour milk. The range extending to 2000 CFA and a median below the mean suggest a skewed distribution, where a small segment of the participant highly values local origin. It is still interested to note that both the mean and median willingness-to-pay for local, untested milk was lower than the willingness-to-pay for imported, tested milk, suggesting higher interest for safety first. For local, tested sour milk, we notice the highest mean WTP at 524 CFA (0.86 USD), signaling strong consumer preference for locally produced and safety-tested milk. The maximum WTP of 2500 CFA (4.09) illustrates the same situation as the imported, tested product. Here, some consumers are willing to pay a significant premium for products combining local sourcing with safety

assurance. The median of 500 CFA , however, seems to suggest that most consumers in our sample are willing to pay the same amount for safety certification, regardless of the milk origin.

To compare the differences in demand for origin and safety, we first looked at the difference in willingness-to-pay between imported and local sour milk. In Figures 1 and 2, we show the distribution of willingness-to-pay across 2 groups. The first group (see Figure 1) shows the willingness-to-pay for imported sour milk which includes both imported and untested milk as well as imported and tested milk. The second group (see Figure 2) shows the willingness-to-pay for local sour milk which includes both local and untested milk as well as local and tested milk. Interestingly, we notice a sharp peak at 500 CFA for both imported and local milk. However, while there is a higher density of consumer willing to pay 500 CFA for local milk than imported milk, we find a smaller spread at higher WTP values in the local milk distribution compared to the imported milk one, potentially suggesting that fewer people are willing to pay higher amounts for local sour milk.

[Insert Figure 1 and Figure 2 here]

Secondly, we looked at the difference in willingness-to-pay between tested and untested sour milk. In Figures 3 and 4, we also show the distribution of willingness-to-pay across 2 groups. The first group (see Figure 3) shows the willingness-to-pay for tested sour milk which includes both imported and tested milk as well as local and tested milk. We look at the willingness-to-pay for untested milk by including imported and untested as well as local and untested sour milk (see Figure 4). Similarly to Figure 2, Figure 3 shows a significant peak at 500 CFA, suggesting that a majority of respondent had a strong preference for this price point. The distribution in Figure 4 is more surprising, however, showing two prominent peaks; one around 250 CFA and another at 500 CFA. This dual peak might suggest that there is a divide in the market with two significant

segments – those looking for cheaper options and those willing to pay a higher-ranged price. Comparing Figures 1 and 2, we find again a higher density for one group, namely the tested sour milk group but a smaller spread at higher values in that group compared to the untested sour milk group. This distribution is a bit surprising and would need further analysis.

[Insert Figure 3 and Figure 4 here]

Demographic Information

The average age is 37 years and there is a wide age range of respondents from 18 to 76 years. Additionally, with the study taking place in the capital city of Dakar, it is not surprising to notice the high percentage (89.3%) of respondents had some level of formal schooling which suggests a well- informed sample. An average of 4 children per respondent underlines the role of family considerations in food purchase decisions, potentially prioritizing safety and nutritional value.

We then notice high awareness levels of milk origin (85.8%) and contamination concerns (70.8%) indicating a well-informed consumer base. This awareness is crucial for understanding the consumer demand for tested milk products and locally sourced milk. The strong preference for local milk (78.72% prefer local sour milk) aligns with the observed higher WTP for local, tested products, potentially emphasizing a community-level trust in local food sources.

The average expenditure of 198 CFA (0.31 USD) on 250g of milk, coupled with a widespread purchasing from informal processors (69.8%), highlights the significant role of informal markets in daily consumer habits.

Regression results

Impact of labeling on consumer demand

The regression results presented in Table 2 provide clarifications regarding consumer preferences for milk labeling in informal markets. The analysis was conducted with two models: Column (1) without demographic controls and Column (2) with controls included.

[Insert Table 2 here]

Labeling Effects on WTP

Both the model with control and the one without control indicate that consumers are willing to pay a significant premium for imported milk that has been tested for safety. The coefficients are 109.59 (Column 1) and 108.06 (Column 2), with p-values indicating statistical significance at the one percent level. The consistency of this premium across both models suggests a robust preference for safety assurances in imported milk, underscoring the importance of safety certification in influencing consumer behavior.

For Local, Untested Milk, we show a significant premium as well, with coefficients of 79.10 in Column (1) and 85.87 in Column (2), which are both statistically significant at the one percent level. The increase in the coefficient when controls are added suggests that certain demographic factors might slightly amplify the preference for local milk, even when it is not safety tested.

Demonstrating the highest premium among all categories, the coefficients for local, tested milk are 187.52 in Column (1) and 189.70 in Column (2), also significant at the one percent level. This clearly highlights the strong consumer preference for local milk products that also offer safety assurances, reflecting a deep-rooted trust and value placed on local sourcing combined with product safety.

In Column (2) showing the impact of additional control variables, the negative coefficient for age (-2.01) suggests that older respondents tend to value labeled milk slightly less than younger ones,

perhaps due to different health priorities, such as decreased consumption in dairy product, or fixed consumption habits.

Demographic and Socio-economic Controls

Education does not significantly impact WTP, indicating that formal schooling does not necessarily translate into higher valuation of labeled milk. Marital status shows a non-significant positive effect, suggesting that being married might influence purchasing decisions but not decisively so. The roles of gender and being the main breadwinner show non-significant effects on WTP. This indicates that these factors do not play a major role in determining how much more consumers are willing to pay for labeled milk.

Awareness and Preferences

Awareness of milk origins and contamination concerns does not significantly affect WTP. This might imply that while awareness is high, it does not necessarily lead to higher WTP unless coupled with tangible safety certifications.

Heterogeneity responses to milk product labeling information

In expanding our analysis of consumers' willingness to pay for milk products, we explore the variations from individual demographic characteristics. Building on our original regression model, we propose three prolonged models as follows:

Gender Interactions:

$$(2)\ WTP_{ir} = \beta_0 + \beta_1 TI_{ir} + \beta_2 NL_{ir} + \beta_3 TL_{ir} + \beta_4 Female_i + \beta_5 (TI_{ir} * Female_i) + \beta_6 (NL_{ir} * Female_i) + \beta_7 (TL_{ir} * Female_i) + \beta_8 X_{ir} + a_r + \varepsilon_{ir}$$

Education Level Interactions:

$$(3)\ WTP_{ir} = \beta_0 + \beta_1 TI_{ir} + \beta_2 NL_{ir} + \beta_3 TL_{ir} + \beta_4 Education_i + \beta_5 (TI_{ir} * Education_i) + \beta_6 (NL_{ir} * Education_i) + \beta_7 (TL_{ir} * Education_i) + \beta_8 X_{ir} + a_r + \varepsilon_{ir}$$

Breadwinner Status interactions:

$$(4)\ WTP_{ir} = \beta_0 + \beta_1 TI_{ir} + \beta_2 NL_{ir} + \beta_3 TL_{ir} + \beta_4 Breadwinner_i + \beta_5 (TI_{ir} * Breadwinner_i) + \beta_6 (NL_{ir} * Breadwinner_i) + \beta_7 (TL_{ir} * Breadwinner_i) + \beta_8 X_{ir} + a_r + \varepsilon_{ir}$$

where:

$Female_i$ is a binary variable indicating whether the respondent is female;

$Education_i$ is a binary variable indicating whether the respondent has some level of formal schooling;

$Breadwinner_i$ is a binary variable indicating whether the respondent is the main breadwinner of the household.

Our findings reveal notable heterogeneity in the willingness to pay (WTP) for milk safety across various demographic characteristics. Specifically, we investigate the differential impacts of gender, education level, and breadwinner status on WTP for imported tested, local untested, and local tested milk. Table 3 describes the individual and interaction coefficients for our three chosen categories.

[Insert Table 3 here]

Gender Differences

Column (1) presents the interaction effects between product testing and the respondent's gender. While women showcase a base willingness to pay a premium for safety-tested milk, the negative interaction terms for WTP imported, tested * Female (-6.60, $p > 0.05$), WTP local, untested * Female (-6.01, $p > 0.1$), and WTP local, tested * Female (-23.27, $p > 0.05$), although not

statistically significant, could suggest a marginally lower incremental WTP for safe milk products among women compared to men. We could speculate that while safety is valued, other unobserved factors may influence women's purchasing decisions, such as household budget constraints or risk perceptions.

Education Level

Column (2) examines the role of education in influencing WTP. The main effect of having any formal schooling is not statistically significant (-10.87, $p > 0.05$), suggesting that education alone does not significantly alter the baseline WTP. However, the interactions of education with WTP imported, tested (16.11, $p > 0.05$) and WTP local, tested (39.69, $p > 0.05$) are positive, although not significant at conventional levels. This may imply a potential trend where educated respondents may value tested milk more than uneducated ones, likely reflecting a greater awareness of health and safety benefits.

Breadwinner Status

Finally, column (3) delves into the effects of being the household breadwinner. The coefficient for WTP imported, tested * Respondent is household breadwinner (2.01, $p > 0.05$) and WTP local, untested * Respondent is household breadwinner (2.27, $p > 0.05$) are both positive but statistically insignificant, which could potentially indicate a slight propensity for breadwinners to pay more for tested milk. The interaction term for WTP local, tested * respondent is household breadwinner (20.13, $p > 0.05$) is positive and larger in magnitude, and it could suggest that the breadwinner's WTP for local tested milk could be higher compared to non-breadwinners, reflecting the additional responsibility of ensuring household health and safety.

V. Conclusion

In this paper, we explore the impacts of providing labeling information about products' safety and origin on consumer's demand for different products within urban Senegal's dairy markets. Our findings confirm that on average, urban consumers have a higher demand for local milk and for milk deemed as safe, and an even higher demand for the milk product combining both. This confirms the need for actors of the dairy value chain, as well as traders and vendors in informal markets to act with transparency to nurture a level of trust with consumers. The importance of trust and loyalty in the dairy sector, particularly within informal markets, cannot be overstressed. It significantly impacts consumer and trader behavior, shaping decisions about long-term consumer loyalty (Blackmore et al., 2022; Wei & Minjie, 2010). Clark et al. (2018) emphasize the role of credible signaling in assuring quality along supply chains, which is critical in environments plagued by information asymmetry.

In conclusion, our study aims to inform stakeholders along the value chain as well as decision makers to develop clear food safety regulations and quality assurance mechanisms in informal markets. These measures could help rectify the prevalent information asymmetry that not only hinders consumer choice but also perpetuates a market for lower-quality goods. Policies aimed at improving transparency in labeling and increasing consumer awareness about food safety standards could foster greater trust in small-scale dairy processors, thereby enhancing their competitiveness even in the regulated markets. Given the substantial role of informal markets in food supply in Sub-Saharan Africa, there is a case for formalization through policy interventions that focus on enhancing food safety and labeling standards. Initiatives could include training for small-scale processors in good fermenting practices, hygiene standards, and the benefits of compliance with food safety regulations. Furthermore, establishing a more comprehensive regulatory framework that enforces rigorous testing and accurate labeling could mitigate risks

associated with foodborne diseases, thereby protecting consumer health. By aligning consumer preferences with policy actions, we can foster a safer, more transparent, and more equitable food market in urban Senegal and potentially across similar markets globally.

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Table1. Descriptive Statistics

	Mean	Standard Deviation	Median	Min	Max
WTP for imported, untested sour milk (CFA)	336	205	300	0	1100
WTP for imported, tested sour milk (CFA)	446	270	500	0	2000
WTP for local, untested sour milk (CFA)	415	277	325	0	2000
WTP for local, tested sour milk (CFA)	524	312	500	0	2500
Age of the respondent (years)	37	13	35	18	76
Respondent has any level of formal schooling (%)	89.3	30.9			
Number of children	4	2	3	1	19
The respondent is female (%)	48.2	50.0			
Respondent is main breadwinner (%)	40.1	49.0			
Respondent has heard of local vs. imported sour milk before survey (%)	85.8	35.0			
Respondent has heard of contamination and safety concerns in milk production (%)	70.8	45.5			
Respondent prefers local sour milk	78.72	40.95			
Amount spent on 250g of informally processed milk (Neex Soow) - CFA	198	76	200	0	500
Respondent purchases sour milk from informal processor (Neex Soow) - %	69.8	46.0			
Observations	801				

Note: Median, ,Minimum, and Maximum of binary variables were omitted for clarity. WTP = willingness-to-pay.

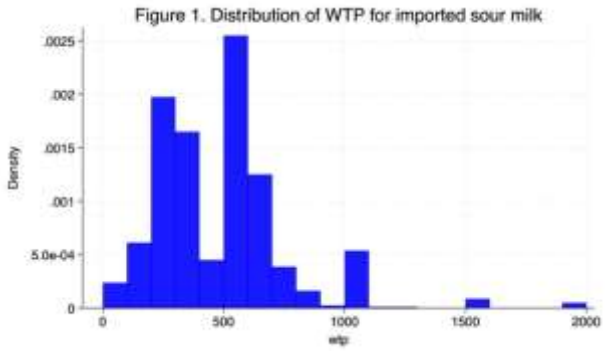
Figure 1. Distribution of WTP for imported sour milk
Density
.0025
.002
.0015
.001
5.0e-04
0
0
500
1000
1500
2000
wtp

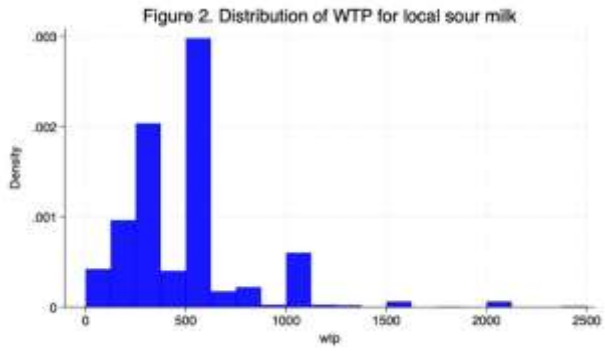
Figure 2. Distribution of WTP for local sour milk
Density
.003
.002
.001
0
0
500
1000
1500
2000
2500
wtp

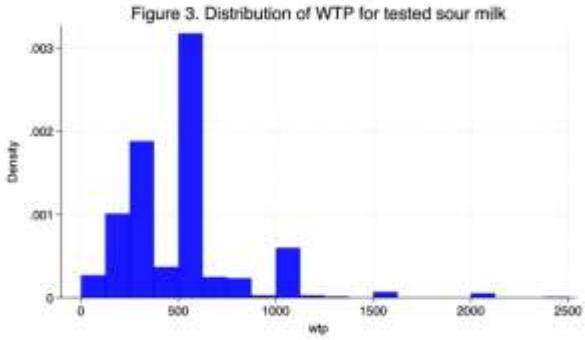
Figure 3. Distribution of WTP for tested sour milk
Density
.003
.002
.001
0
0
500
1000
1500
2000
2500
wtp

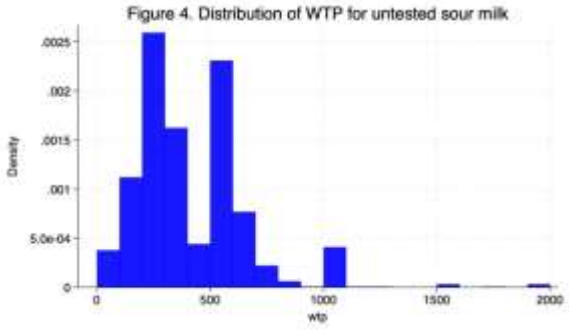
Figure 4. Distribution of WTP for untested sour milk
Density
.0025
.002
.0015
.001
5.0e-04
0
0
500
1000
1500
2000
wtp

Table2. Impact of labeling on Consumer Demand for sour milk

	No controls	With controls
Outcome variable: WTP	(1)	(2)
Label is imported, tested	109.59***	108.06***
	(6.62)	(6.95)
Label is local, untested	79.10***	85.87***
	(8.00)	(9.25)
Label is local, tested	187.52***	189.70***
	(10.09)	(11.14)
Age of the respondent		-2.01*
		(0.85)
Respondent has any level of formal schooling		-10.87
		(29.65)
Respondent is married		22.25
		(21.34)
The respondent is female		10.74
		(21.11)
Respondent is main breadwinner		0.31
		(19.38)
Respondent has heard of local vs. imported sour milk before survey		36.43
		(29.37)
Respondent has heard of contamination and safety concerns in milk production		-2.24
		(20.14)
Constant	336.04***	376.79***
	(7.29)	(52.93)
p-value TI=NL	0.000	0.000
p-value NL=TL	0.000	0.000
p-value TI=TL	0.000	0.000
Observations	3191	2673

Note: Robust standard errors shown in parentheses, and are clustered at the individual-level. ***, **, and * indicate statistical significance at the 1, 5, and 10 percent critical level, respectively.

Table3. Heterogeneity tests with Gender, education, and whether respondent is the breadwinner

Outcome Variable: WTP	Respondent is Female (1)	Respondent has some level of schooling (2)	Respondent is household breadwinner (3)
Label is Imported, tested	111.25***	93.66***	107.27***
	(9.94)	(20.39)	(9.25)
Female	19.72		
	(19.76)		
Label is Imported, tested * Female	-6.60		
	(13.87)		
Label is Local, untested	88.78***	104.93***	84.96***
	(13.41)	(26.79)	(13.20)
Label is Local, untested * Female	-6.01		
	(18.47)		
Label is Local, tested	200.91***	154.23***	181.58***
	(15.47)	(29.63)	(14.46)
Label is Local, tested * Female	-23.27		
	(22.27)		
The respondent is female		10.74	10.75
		(21.13)	(21.13)
Age of the respondent	-2.01*	-2.01*	-2.01*
	(0.85)	(0.85)	(0.85)
Respondent has any level of formal schooling	-10.87		-10.87
	(29.66)		(29.66)
Respondent is married	22.23	22.24	22.23
	(21.35)	(21.35)	(21.35)
Respondent is main breadwinner	0.29	0.30	
	(19.39)	(19.39)	
Respondent has heard of local vs. imported sour milk before survey	36.42	36.43	36.42
	(29.38)	(29.38)	(29.38)
Respondent has heard of contamination and safety concerns in milk production	-2.24	-2.24	-2.24
	(20.15)	(20.15)	(20.15)
Respondent has any level of formal schooling		-19.48	
		(28.40)	
Label is Imported, tested * Respondent has any level of formal schooling		16.11	
		(21.67)	
Label is Local, untested * Respondent has any level of formal schooling		-21.33	
		(28.54)	
Label is Local, tested * Respondent has any level of formal schooling		39.69	
		(31.94)	
Respondent is household breadwinner			-5.81
			(17.87)
Label is Imported, tested * Respondent is household breadwinner			2.01
			(13.95)
Label is Local, untested * Respondent is household breadwinner			2.27
			(17.84)
Label is Local, tested * Respondent is household breadwinner			20.13
			(22.63)
Constant	372.48***	384.51***	379.26***
	(52.67)	(51.98)	(53.33)
Observations	2673	2673	2673

Note: Note: Robust standard errors shown in parentheses, and are clustered at the individual-level. ***, **, and * indicate statistical significance at the 1, 5, and 10 percent critical level, respectively.