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ORIGINAL ARTICLE

Social norms, nutrition messaging, and demand for biofortified staple crops: Evidence from a discrete choice experiment in Ethiopia

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Abstract

Biofortified maize offers a potential solution to combat micronutrient deficiencies in households, yet its adoption remains low. Realizing biofortification's benefits necessitates a shift in smallholder farmers' production and consumption behavior. Social norms can significantly influence societal behaviors and have the potential to trigger substantial changes. However, their role in promoting biofortification adoption remains underexplored. This study investigates the influence of nutrition information and social norm messaging on smallholder farmers' adoption of biofortified maize seeds in Ethiopia's highlands. We conducted an experiment with 2022 randomly selected households to evaluate the effectiveness of nutrition messages and social norm messaging on farmers' willingness to pay for biofortified maize seeds. Our results reveal that nutrition information alone significantly increases farmers' interest in purchasing biofortified maize seeds, highlighting the positive influence of information-based interventions on biofortified crop adoption. Conversely, social norm messaging on its own has a limited effect on demand. However, a combined approach demonstrates a stronger positive influence, suggesting a synergistic relationship between these interventions. These results underscore the critical role of disseminating clear information about the nutritional benefits of biofortified crops in fostering their adoption among smallholder farmers. Additionally, our study suggests that integrating social norm messaging with information-based interventions could be a highly effective strategy for promoting biofortified maize and similar nutrition-focused initiatives. This research offers valuable insights for policymakers and organizations aiming to improve nutritional outcomes through food-based approaches to agricultural development among smallholder farming communities.

KEYWORDS
biofortified maize, choice experiment, nutrition information, social norms, willingness to pay

JEL CLASSIFICATION
Q18, Q12, O15, J13, D13, C93

1 INTRODUCTION

Overcoming all forms of malnutrition worldwide is one of the most pressing challenges of our time. Malnutrition in children is especially harmful as it has long term and substantial negative impacts on the child's future. Globally it is estimated that childhood stunting, wasting, and underweight, which all are the manifestation of nutrient deficiencies, causes over 1 million deaths (GBD 2016 Risk Factors Collaborators, 2017). Malnutrition is also associated with lower cognitive ability in children (Grantham-McGregor & Ani, 2001; Kar et al., 2008; Liu et al., 2003). This in turn hampers future productivity (Siddiqui et al., 2020) restricting income-earning potential. The problem is especially acute for countries in the global south. For lower- and middle-income countries, the prevalence of stunting, wasting, and underweight is reported to be 29.1%, 6.3%, and 13.7%, respectively (Ssentongo et al., 2021).

Malnutrition arises from insufficient or excess intake of nutrients. In developing countries, however, inadequate food intake is observed most frequently (Bain et al., 2013). In these settings, biofortification has been recognized as an effective and cost-efficient intervention to deliver essential nutrients (Nuss & Tanumihardjo, 2011; Ruel & Alderman, 2013). For biofortification to be effective, the biofortified crops need to be consumed by the target population at scale. The scale up effort requires effective promotion strategy. This requires a clear understanding of crop characteristics or attributes that are considered by the target population in their decision process. This need is amplified for biofortified crops because the biofortification process sometimes alters certain characteristics of a crop, such as its color (Talsma et al., 2013). Moreover, since the key selling point of biofortification is its nutritional value, there is a need to understand how much the target population values the nutritional contents of a crop relative to other crop attributes and how one can increase this value. This article seeks to contribute to the effort to scaling up biofortification interventions by evaluating the effectiveness of two interventions: nutrition messaging and social norms messaging using Ethiopia as a case study.

Ethiopia, a country with a population of 112 million, faces a significant challenge in child malnutrition. Among its estimated 15.2 million children under five, stunting prevalence remains high at 34.4% (WHO, 2024). Wasting, another form of malnutrition, also affects this age group, with an estimated prevalence of 6.8% based on 2019 data (WHO, 2024).

Ethiopia is a predominantly rural country, with an estimated 77% of its population residing in rural areas in 2022 (World Bank, 2024). These rural residents are primarily smallholder farmers, responsible for producing a staggering 90%–95% of the nation's agricultural output (IFAD, 2024). This reliance on smallholder production creates a unique characteristic: these farmers often practice "semisubsistence farming." This means their decisions about what to grow and how much to produce are closely linked to their own consumption needs. In economic terms, this relationship is known as "nonseparability" and suggests that a significant portion of what they harvest is consumed by the farmers themselves (Allen, 2018; Dillon & Barrett, 2017). For instance, in 2018, over three-quarters (76.3%) of the maize produced by smallholder farmers in Ethiopia was used for own consumption (CSA, 2018). The link between what farmers produce and consume is expected to be even stronger in the study area due to limited access to markets, a common challenge faced by agrarian households in Sub-Saharan Africa (Sheahan & Barrett, 2017).

In smallholder production settings, the relationship between crop production and household nutrition outcomes has been extensively studied, with many studies demonstrating a direct and positive link. One such study conducted in rural Uganda found that crop diversification leads to an increase in household diet diversity and consumption (Tesfaye & Tirivayi, 2020). Another study in Ethiopia revealed that crop production decisions are linked to nutrition outcomes at the household level, with a stronger impact in areas with limited market access (Tesfaye, 2022). Similarly, a study that focused on maize-based farming systems in Tanzania found a positive link between household crop production decisions and diet diversity (Rajendran et al., 2017).

These results indicate that improving nutritional outcomes at the smallholder household level can be achieved by promoting nutrition-sensitive agricultural production and focusing on their production decisions. In our case, this can be achieved by encouraging the production of nutritionally enhanced crop varieties as an effective way to promote the consumption of food prepared from biofortified crops.

The study focuses on biofortified maize, because cereals (maize, sorghum, teff) form the bulk of the Ethiopian diet and are therefore good biofortification candidates. While these grains provide cheap energy, they lack key micronutrients and essential amino acids such as lysine

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and tryptophan (Hafebo et al., 2015; Nuss & Tanumihardjo, 2010). By enriching cereals with micronutrients, it is possible to improve nutrition without significantly disrupting the food system and diets.

It is also the most important and cheapest source of calorie intake in the country, providing 23% of per capita calorie intake (Berhane et al., 2012). Recognizing its potential, maize has been an ideal candidate for biofortification interventions in Ethiopia. It has been successfully biofortified with proteins (Asare-Marfo et al., 2013), and the resulting varieties have been promoted in Ethiopia since 2012 (Teklewold et al., 2015). There is strong interest by the government of Ethiopia to cover 10% of the total maize growing area with biofortified maize, which is more than 227 thousand hectares by the latest estimate (CSA, 2020). However, adoption is disappointingly low (Tessema et al., 2016).

The low adoption rate of biofortified maize in Ethiopia can be attributed to several reasons. Firstly, biofortification programs are relatively recent in Ethiopia (EPHI, 2022). Secondly, the availability of biofortified seed varieties is still limited, particularly in remote rural areas. This is due in part to the fact that the varieties are relatively new and have not yet been widely disseminated. Thirdly, lack of awareness is another reason why adoption is low. Many people in Ethiopia are not aware of the biofortified maize seed varieties. For instance, in the study sample only less than half of maize producers reported that they were aware of nutritionally enhanced maize varieties. In addition, awareness of the benefits of consuming food prepared from biofortified maize and how it can improve their nutrition is also limited. This lack of awareness makes it difficult to convince farmers to adopt the new varieties. This is consistent with studies in Sub-Saharan African countries where lack of awareness is a significant challenge for the adoption of biofortified crops by smallholder farmers (Msungu et al., 2022). Fourthly, institutional factors also influence the low adoption rate of biofortified maize in Ethiopia. A recent assessment showed that the absence of a designated organization to oversee and coordinate biofortification activities has limited the implementation of coordinated and collaborative efforts (EPHI, 2022). The intervention tested in this article contributes to address one of the key challenges–lack of awareness–for low adoption of the crop.

We conducted a behavioral choice experiment among 2022 smallholder households from 184 rural *kebeles* in the maize-producing highlands of Ethiopia to assess their willingness to pay (WTP) for biofortified maize. This large and rich dataset allows precise estimate of effect sizes and generalizability of results. We additionally examine the effects of two interventions: nutrition and normative messaging. In our experimental setup, assessing the effect entails comparing various groups exposed to different messaging interventions among themselves and in comparison to a control group.

Provision of nutrition information can effectively stimulate healthy consumption by altering the information set on which people base their decision, though evidence is relatively sparse for low and middle income countries (Bonaccio et al., 2013; Chege et al.,2019; Donato et al., 2020; Miller & Cassady, 2015; Shimokawa, 2013). Similarly, social norm treatments have been effectively used to nudge consumers towards healthier choices (Bucher et al., 2016; Higgs et al., 2019; Lehner et al., 2015; Lycett et al., 2017). Social norms have long been recognized to influence individual behavior (Fehr & Falk, 2002; Lindbeck et al., 1999; Moffitt, 1983). Pointing people at social norms can motivate conformity (Cialdini, 2008) due to the two psychological phenomena of "herd behavior" and the "bandwagon effect (Corneo & Jeanne, 1997)." People tend to make social comparisons and evaluate their own performance, possessions, and wellbeing not in absolute terms, but relative to others (Smith et al., 2012). In addition, descriptive norms often function as shortcuts (i.e., heuristic cues) in the decision-making process and thereby influence behavior (Cialdini, 2008).

Our contribution to the existing literature on the effect of information interventions on food choice is twofold. First, we leveraged the link between production and consumption decisions in the context of improving nutritional outcome of smallholder farmers. Despite the abundance of interventions aimed at improving smallholder farmers' food choices, a crucial aspect is often neglected: the production decision-making process (Chege et al., 2019). This gap is addressed by a limited number of studies that integrate agricultural production into their nutritional interventions (De Groote et al., 2014; Donato et al., 2020; Hotz et al., 2012). For example, Hotz et al. (2012) compared training intensity for biofortified sweet potato adoption in Mozambique. Donato et al. (2020) investigated the impact of information and storage tools on feeding food prepared from biofortified maize to young children in Ethiopia (though their focus was postharvest utilization). Our study complements these efforts by examining farmers' willingness to pay for biofortified seeds, a critical step before planting. Unlike De Groote et al. (2014) who explored the observational association between extension participation and adoption, we employ a choice experiment to directly assess the effect of information interventions on this willingness to pay.

Second, this is one of the first articles to look at shifting social norms in the domain of agriculture. The economic literature has long recognized the effect of social norms on people's behavior (Bagwell & Bernheim, 1996; Bernheim, 1994; Leibenstein, 1950) and continues to be a topic of study in recent years (Acemoglu & Jackson, 2017; Bursztyn et al., 2020). This growing literature has found that the willingness to confirm to social norms has strong effects on a range of behaviors (Bursztyn & Jensen, 2017). However, in the agricultural domain, people's tendency to follow norms has not been exploited in encouraging the adoption of technologies. We explore to what extent normative messaging is effective in stimulating demand for agricultural technology. In addition, we assess if there is a complementarity between normative messaging and information interventions in encouraging adoption of new crops. Since the two interventions can be combined cost-effectively, our result would be useful in designing messaging campaigns.

The results indicate that farmers are willing to pay a premium for biofortification. However, without messaging treatments, this premium is not enough to compensate for their dislike of the color of biofortified maize, which is yellow whereas commonly consumed maize is white. Both treatments had a statistically significant positive effect on the WTP for biofortification, though the effect of the social norm treatment was too small to compensate the negative effect of the yellow color of the maize. The two treatments are found to be complementary and have synergistic effects indicating that combining the health message with a social norm treatment is more effective in stimulating demand for biofortification.

The rest of the article is structured as follows. Section 2 briefly describes the conceptual framework of the study and how it fits into the food system. Section 2 describes the experimental design, the treatment, the data source, and the methods used to analyze the data. Section 3 presents the theoretical foundation of the experiment and describes the empirical strategy. Section 4 presents the results of the experiment. Section 5 discusses the results and section 6 concludes the article with policy implications.

2 | RESEARCH DESIGN AND DATA COLLECTION

2.1 | Experimental design

We conducted a discrete choice experiment (DCE) to answer the research questions. Choice experiments are based on Lancasterian consumer theory that goods and services are essentially bundles of various attributes, and the value of a good or service to a consumer is determined by the relative importance of these attributes (Lancaster, 1966). In the experiment, participants were asked to choose between hypothetical alternatives and there were no real consequences associated with the choice. As such, responses may differ from real-world behavior (Hensher et al., 2015). To reduce the potential bias, choice sets were framed in a way that closely reflects actual purchase decisions of farmers and an opt out option was included. In this set up, participants are informed that if they do not prefer either of the two alternatives, they have the option of choosing neither. Thus, though the results should be used with caution, DCE are still useful and they allow researchers to gain an understanding of people's preferences (Louviere et al., 2010).

Based on the pilot survey and objective of the article, we considered five attributes – seed price, producers' price, nutritional value, source of seed, and color. Though there are other interesting crop attributes, we limited the attributes to five thus improving the quality of our data by reducing the cognitive burden on respondents. Therefore, the choice of these attributes was guided by an extensive literature review, experts' opinion, and the results of a pilot testing the experimental design. Each attribute has various levels, which we selected to reflect actual situations respondents experience in the market. However, not all combinations of attributes are feasible in practice: as indicated before white biofortified maize is not yet available. We conducted a pilot-test to see whether the attributes included were relevant and whether the levels for each attribute were plausible and understandable. The test results showed that respondents pay attention to the proposed attributes and the attribute levels make sense from their perspective. Table 1 shows the final set of attributes and their respective levels.

The D-optimal approach of fractional factorial was used to design the experiment with the help of SAS software (Kuhfeld, 2010). This design approach generates choice sets that allow the estimation of all main and key interaction effects. It reduces the predicted standard errors of parameter estimates and gives unbiased estimates (Carlsson & Martinsson, 2003; Hoyos, 2010; Rose et al., 2008). Using D-optimal design, we generated 48 choice sets using random selection without replacement. To promote response efficiency and reduce cognitive effort for respondents, the choice sets were optimally divided into six equal blocks of eight choice sets using SAS macros to ensure orthogonality between the blocking factor and all of the attributes of all alternatives (Kuhfeld, 2010). Each choice set consisted of two maize seed types (Options 1 and 2) and a no-buy option (Option 3). Inclusion of the no-buy option has been recommended by previous literature (Hoefkens et al., 2012; Louviere et al., 2000), as it reflects real market choices, where consumers can decide not to purchase maize seed. Table 2 presents a sample choice set. The design has a maximum between attributes covariance of .04, suggesting a highly optimal and balanced orthogonal design.

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TABLE 1 Attributes and attribute levels for the choice experiment.

Attributes	Description	Levels considered
Seed price	Price of 1 kg of maize seed in Ethiopian birr.	Three levels (24, 35, 47)
Product price	Selling price of 1 kg of maize in Ethiopian birr.	Three levels (7.00, 8.25, 9.50)
Origin of the seed	Source of the seed	Four levels (Other farmers, private traders, government, NGOs)
Bio-fortification status	Whether or not the maize is bio-fortified	Two levels (bio-fortified, not bio-fortified)
Color of the grain	The color of the maize grain.	Two levels (yellow, white)

TABLE 2 Example choice set.

Block 1 Question 1	Option 1	Option 2	Option 3
Seed price (ETB/kg)	35.00	47.00	Neither of the two
Product price (ETB/kg)	9.50	8.25	
Biofortification status	Biofortified	Non-biofortified	
Source of the seed	Government	Other farmers	
Color of the maize	White	Yellow	

2.2 | The treatments

The study employs a between-subjects design, which incorporates explicit treatment and control groups. It evaluates three treatment groups against a designated control group and each other. Participants were randomly assigned to four groups: Group one received nutrition information, Group two received normative messaging, Group three received both nutrition information and normative messaging, while the fourth group served as the control, receiving neither the nutrition information nor the normative messaging. Unlike the within-subjects design, which examines pre- and post-treatment, our article centers on comparing outcomes across distinct groups exposed to varied messaging interventions. While our experiment deviates from a within-subjects design format, the randomized assignment and inclusion of a control group allow us to gauge the effectiveness of our interventions.

The nutrition information treatment involved informing participants about the benefits of consuming food produced from nutritionally enhanced maize. The information in the message came from a guide by the International Maize and Wheat Improvement Center (CIMMYT) (Teklewold et al., 2015) promoting nutritionally enhanced maize in Ethiopia, and it was also informed by an Ethiopian Public Health Institute nutritionist.[1]. The exact text of the message is:

> "*Consumption of nutritionally enhanced maize leads to better growth in children for whom maize is the major food staple. This is because nutritionally enhanced maize provides more high-quality protein for the human body than conventional maize.*"

The social norm treatment involved informing participants that consumption of foods prepared from nutritionally enhanced maize is both common and socially desirable among their peers. Studies have demonstrated that behaviorally informed interventions induce substantial behavior change in rural settings with regards to adopting pro-poor technologies (Benhassine et al., 2015; Donato et al., 2020; Hummel & Maedche, 2019) and influencing people food choices (Bucher et al., 2016; Lehner et al., 2015; Lycett et al., 2017). More importantly, studies show that knowledge about what others who are close to the target population are doing can be leveraged to promote new technologies (Bandiera & Rasul, 2006; BenYishay & Mobarak, 2019; Krishnan & Patnam, 2014). In the economics literature, the tendency to follow norms has been used to explain a wide range of phenomena ranging from prosocial behavior (Bénabou & Tirole, 2006; Tabellini, 2008) to development and evolution of culture (Bernheim, 1994; Bisin & Verdier, 2001) to conspicuous consumption (Bagwell & Bernheim, 1996) to educational effort (Bursztyn et al., 2019). Social pressure or social image concern has also been exploited to design effective rule and punishment structures (Acemoglu & Jackson, 2017). In economics, social image concern or status is studied under the utility maximization framework. It is usually introduced into the utility function and assumed that apart from deriving utility directly from consumption, individuals also derive

[1] Personal communication

utility from their public image, which itself depends on their behavior or actions (Bernheim, 1994; Bursztyn & Jensen, 2017). The literature also highlights that the need to conform to social norms is so strong that people are willing to incur costs or forgo benefits to not depart from social norms (Bursztyn & Jensen, 2017).

Close to our article is a recent study by Bursztyn et al. (2020) about misperceived norms and women labor market participation. The authors show that misperceived social norms negatively affect participation of women in labor markets and that correcting these beliefs increased women labor participation. We bring these insights into a technology adoption context in the domain of agriculture and investigate if carefully crafted normative messages stimulate demand for a new crop variety.

Though the biofortified seeds are not widely available in Ethiopia, the social norm treatment is based on the findings of studies conducted in places where the seeds were available. In these studies, subjects were asked to evaluate foods prepared from biofortified maize and conventional maize and most of them preferred foods prepared from biofortified maize (De Groote et al., 2014; Gunaratna et al., 2016; Teklewold et al., 2015). The text used for the social norm treatment was:

> *"A lot of people aren't aware that farmers prefer food prepared from nutritionally enhanced maize. When asked to choose between foods prepared from nutritionally enhanced and conventional maize, most farmers chose foods prepared from nutritionally enhanced maize variety"*

Farmers who are provided with these two types of information are expected to update their beliefs about the benefits of consuming biofortified maize, and this in turn is expected to be reflected in a higher WTP. More formally, farmers make decisions based on their information set. Their posterior belief or perception about bio-fortified maize is assumed to be a function of their prior belief and how they incorporate the information they received. Farmers adjust their choices if their posterior assessment is sufficiently different from their prior. The implication is that even if farmers incorporated the new information they received and update their belief on biofortified maize, they are not expected to change their actions if their posterior belief is not sufficiently different from their prior.

2.3 | Data collection

The experiment was carried out as part of the nationally representative survey of the International Livestock Research Institute (ILRI-Ethiopia) conducted for its LIVES project[2]. Data collection took place in March–May 2018, using a Computer Aided Survey Instrument (CAPI) by a trained survey team. The choice experiment was added to the survey for 2022 smallholder households, selected randomly from 184 rural *kebeles*[3] in the six high maize producing zones of the three highland regions of Ethiopia (Amhara; Oromia; and Southern Nations, Nationalities and Peoples (SNNP) regions). Each respondent was randomly assigned to a treatment arm and to one of the six blocks. In total, we obtained responses to 16,176 choice sets, eight for each of the 2022 household representatives.

Respondents first received the treatment and then were asked to state their choices. The treatments involved audio recordings of messages prepared in a professional studio. The messages were translated into four local languages (Amharic, Oromifa, Gamo-Gofa-Dawro, and Sidamo) and the respective audio recordings were prepared using native speakers. Before they were presented with the choice sets, respondents received a short description of the experiment, clear definitions of the product attributes, an explanation of how to respond to questions, and assurance of the confidentiality of their responses. Participation was completely voluntarily. Moreover, participants were informed that they could opt out from the experiment at any time with no penalty. During the experiment, participants were asked to evaluate very carefully the attributes of the maize seed before deciding which option they choose to buy. They were reminded repeatedly that the two maize seeds were identical in terms of agronomical properties such as productivity, diseases, and drought resistance, but different in terms of the five attributes. This information was highlighted to minimize the likelihood of participants evaluating the two maize seeds in terms of attributes not included in the choice experiments. They were also instructed that if they did not prefer any of the two options, they could choose none.

The study protocols, process, data management and risks related to participation in the experiment study are as per ILRI Policy and Guidelines of Research Ethics. The Ministry of Agriculture and Natural Resources and the relevant Regional Bureaus of Agriculture granted permission to conduct the survey. All participants provided written informed consent before participation.

[2] For details, please see the project website https://cgspace.cgiar.org/handle/10568/25098

[3] In rural areas, kebele is the lowest administrative unit in Ethiopia and comprises of 4–5 villages and is a primary sampling unit.

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3 | EMPIRICAL APPROACH

3.1 | Theoretical foundations

The theoretical foundation of discrete choice models is built upon consumer theory, as outlined by Hendler (1975) and Lancaster (1966), along with McFadden's (1974) random utility theory. A decision maker faces a choice among j alternatives. Indexing an individual consumer by n, maize seed type (alternatives) by j and in choice situation t, utility can be written as:

$$U_{njt} = -\alpha_n \, p_{njt} + \beta_n' \, x_{njt} + \varepsilon_{njt} \tag{1}$$

where p_{njt} is price and x_{nj} are nonprice attributes, α_n and β_n is a vector of coefficients of these variables for person n representing that person's tastes, and ε_{nj} is a random term that is iid type-one extreme value. The variance of ε_{nj} can be different for different decision makers: $\mathrm{Var}(\varepsilon_{njt}) = k_n^2(\frac{\pi^2}{6})$, where k_n is the scale parameter for decisionmaker n. The coefficients are expected to vary over decision makers in the population with density $f(\beta)$. Consumer n chooses alternative j if and only if $U_{njt} > \; U_{nit} \; \forall \; j \neq i$. Since a person's tastes (β_n) are not observed by the researcher, the unconditional choice probability will be used to extract the estimates, and this is given as.

$$P_{ni} = \int \prod_{t=1}^{T} \frac{e^{\beta_n' x_{nit}}}{\sum_j e^{\beta_n' x_{njt}}} \; f(\beta) \, d\beta \tag{2}$$

To estimate the parameters, assumptions will be made about the specific functional form $f(\beta)$ would take.

To show how willingness to pay will be extracted, Equation (1) can be specified utility as separable in price, p, and nonprice attributes, x^* and divided by the scale parameter k_n.

$$U_{njt} = -\lambda_n \, p_{njt} + \, c_n' \, x_{njt} + \eta_{njt} \tag{3}$$

where η_{njt} is iid type-one extreme value, with constant variance $\frac{\pi^2}{6}$. The utility coefficients are defined as $\lambda_n = (\frac{\alpha_n}{k_n})$ and $\lambda_n = (\frac{\beta_n}{k_n})$. Then, willingness to pay for an attribute is the ratio of the attribute's coefficient to the price coefficient: $\mathrm{wtp}_n = c_n/\lambda_n$.

Let $\mathrm{y}_n = (\mathrm{y}_{n1}, \ldots, \mathrm{y}_{nT})$ denote the person's sequence of chosen alternatives and θ denote the parameters of the distribution, such as the mean and variance. Following (Train, 2009), individual level estimates are given by;

$$\bar{\beta}_n = \frac{\int \beta * P\,(\mathrm{y}_n|\mathrm{x}_n,\, \beta)\; f\,(\beta|\theta)\, d\beta}{\int P\,(\mathrm{y}_n|\mathrm{x}_n,\, \beta)\; f\,(\beta|\theta)\, d\beta} \tag{4}$$

3.2 | Empirical analysis

Different econometric models are available to estimate the parameters in Equation (2). We used a mixed logit (MXL) model. MXL models provide several advantages to most choice models.

The Mixed Logit (MXL) model offers a significant improvement over traditional discrete choice models by providing a more nuanced understanding of how individuals make choices. Unlike models that rely on the restrictive Independence from Irrelevant Alternatives (IIA) assumption, MXL allows for the relative attractiveness of options to vary depending on individual characteristics and the specific context (Cheng & Long, 2007). This flexibility is achieved through the use of random parameters that capture the unobserved heterogeneity in preferences and decision-making processes. Additionally, MXL offers greater freedom in model specification (Hensher & Greene, 2002) and can handle correlations between parameters and choice situations (Hess & Train, 2017).

However, it is important to note that MXL does not eliminate the need for assumptions entirely. While it relaxes the IIA assumption, MXL still relies on assumptions about the distribution of the random parameters used to capture individual heterogeneity. The choice of distribution (e.g., normal, lognormal) can impact the model's results, and necessitates a careful consideration about the appropriateness of different distributions in the specific context. Finally, the increased flexibility of MXL comes at the cost of slightly more complex model interpretation.

Given the advantages of MXL in capturing individual variability, we employed this model in our study to examine how two treatments are associated with respondents' WTP for biofortified crops. To ensure the reliability of our findings, we employed statistical tests to compare different model specifications (e.g., exploring distributions for random parameters) and select the one that best explains the data.

Our randomized study design, combined with the MXL model's ability to capture individual heterogeneity, allows us to isolate the influence of the two treatments on respondents' WTP for biofortified crops. Using the framework of Equation (3), individual preferences are specified as follow.

$$\begin{aligned} U_{njt} = \mathrm{C}_n + \; & \beta_1 \, Costseed_{njt} + \; \beta_2 \, Pprice_{njt} \\ & + \beta_3 \, SorPivte_{njt} \; + \beta_4 \, SorFarmr_{njt} \\ & + \beta_5 \, SorNGOs_{njt} + \beta_6 \, Bio\_Status_{njt} + \beta_7 \, Color_{njt} \\ & + \beta_8 \, Color_{njt} \# Bio\_Status_{njt} + \; \beta_9 \, Color_{njt} \# \, T1_n \\ & + \beta_{10} \, Color_{njt} \# \, T2_n + \; \beta_{11} \, Color_{njt} \# \, T3_n \end{aligned}$$

$$+\beta_{12}\, Bio\_Status_{njt} \# T1_n$$
$$+\beta_{13}\, Bio\_Status_{njt} \# T2_n$$
$$+\beta_{14}\, Bio\_Status_{njt} \# T3_n$$
$$+\beta_{15}\, Color_{njt} \# Bio\_Status_{njt} \# T1_n$$
$$+\beta_{16}\, Color_{njt} \# Bio\_Status_{njt} \# T2_n$$
$$+\beta_{17}\, Color_{njt} \# Bio\_Status_{njt} \# T3_n + \eta_{njt}. \quad (5)$$

where C_n is constant representing the Neither option; $Costseed_{njt}$ is cost of maize seed; $Pprice_{njt}$ is producer price of maize; $SorPivte_{njt}$, $SorFarmr_{njt}$, and $SorNGOs_{njt}$ represent source of maize seeds that takes one if the source of seeds is private traders, other farmers and NGOs, respectively, where government is used as the base category. Bio_Status_{njt} is dummy variable that takes 1 if the maize is biofortified and 0 otherwise, $Color_{njt}$ dummy variable that takes 1 if the maize is yellow and 0 otherwise. $T1_n$, $T2_n$, and $T3_n$ represent the treatment group of participants that takes 1 for information only, normative message only and information and normative messages. No treatment is used as the base category.

3.3 | Estimation strategy

The estimation of WTP and treatment effect in this study was performed using a rigorous two-step process. In the first step, we estimated four competing models in preference spaces. Each of these models made different assumptions regarding the correlation among parameters and the presence of interactions among attributes. We used information criteria (AIC and BIC) and the log-likelihood value at convergence, to compare the goodness of fit of the models. These indicators are widely used in statistical modelling to select the best fitting model from a set of competing models.

The model that allows for full correlation among parameters was ultimately retained as it provided the best fit for the data, outperforming the alternative models. In the second step, we utilized the selected model to compute the starting values for the parameters and estimated the WTP parameters in MATLAB, using the code made available by Train (2015).

In the second stage, we further considered four competing models, which differed in their assumptions regarding the correlation among parameters, the distribution of each parameter, and the interaction among attributes. Again, we employed AIC, BIC, and the SLL value at convergence to compare the fit of these models and ultimately selected the model that provided the best fit for the data. Overall, this two-step process allowed us to robustly estimate the WTP and treatment effect, taking into account the complex interactions among attributes and ensuring that the selected models fit the data well.

4 | RESULTS

4.1 | Descriptive statistics and balance test

Table 3 shows the descriptive statistics for the sample and the balance test. 82.5% of the sample is male and the mean age of the sample is 48.6 years. Most of the participants are married (82.7%) and a little more than half of the participants (51.6%) have no formal education. Among those with education, primary education is the highest level achieved for 86.8% while the remaining 13.2% had some postprimary education.

The study was conducted in maize surplus areas where farms are expected to participate in the maize market. Of the 2022 participants, 1411 (67.4%) participated in the maize market as sellers. Use of improved maize seed was common among the sample: 60.4% reported using improved seeds, which is more than the national average of 34% in 2017 (CSA, 2017).

Maize is a main staple in the study areas, and almost 87% consume food prepared from maize regularly. 37.7% reported eating food prepared from maize every day, while another 21.3% consume food prepared from maize at least twice a week. 41.6% of the sample had been exposed to nutritionally enhanced maize varieties previously.

Participants were asked questions to measure their trust level. The results indicate that more than half of the sample (58.2%) answered affirmatively to the question, “when dealing with strangers, one is better off using caution before trusting.” This trust question, used in a field experiment, has been shown to be a valid measure of trust (Glaeser et al., 2000).

Table 3 also presents means and tests of mean differences across the treatment groups for demographic characteristics and other pretreatment measures. Scanning across each row reveals no significant difference among the different treatment groups in terms of observable characteristics. Though not a conclusive evidence against randomization problems, absence of notable imbalances provides some evidence that the randomization plan was successful.

4.2 | Results of model estimation

We estimated four models with different assumptions about the correlation of parameters (no correlations and

TABLE 3 Descriptive statistics and balance table.

Variable description	Pooled	Treatment arms 1	2	3	Control	*p*-value
Sex of household head						
Male (1=Yes)	82.5%	80.3%	83.3%	80.8%$_a$	85.8%$_a$	.083
Marital status						.132
Single	1.2%	1.4%	.8%	1.7%	1.1%	
Married	82.7%	81.9%	84.9%	79.7%	84.6%	
Divorced	5.2%	4.7%	3.3%	7.2%	5.5%	
Widowed/Widower	10.9%	12%$_a$	11.0%	11.4%	8.9%	
Education						
No education	51.6%	54.2%	53.3%	51.3%	47.2%	.402
Primary	42.0%	40%	40.9%	41.8%	45.7%	
Secondary and above	6.4%	5.7%$_a$	5.8%	6.8%	7.2%	
Maize output market participation as seller (1=Yes)	67.4%	67.1%	69.0%	66.7%	66.6%	.869
Consumption of food prepared from maize						
Every day	37.7%	36.5%	39.3%	34.0%	41.2%	.121
Often (more than twice a week)	21.3%	21.9%	18.6%	23.4%	21.4%	
Sometimes (more than once a month, up to twice a week)	20.8%	20.5%	23.3%	21.1%	18.2%	
Rarely (once a month or less)	13.1%	15.0%	11.4%	12.4%	13.5%	
Never	7.1%	6.1%	7.4%	9.1%	5.7%	
Previous exposure to nutritionally enhanced maize variety (1=Yes)	41.6%	39.3%	40.5%	43.3%	43.6%	.422
Used improved maize seeds (1=Yes)	60.4%	60.9%	61%	60.8%	58.7%	.894
When dealing with strangers, one is better off using caution before trusting them (1=Yes)	58.2%	59.2%	59.9%	55.5%	58.4%	.501
Age of household head (years)†	48.6	49.3	48.8	48.1	48.4	.392
Income (Birr)†	18,351	19,416	18,553	16,601	18,934	.083
Number of observations	2022	507	516	526	473	–

Note: Treatment arms: (1) Participants receiving nutrition information; (2) Participants exposed to normative messaging; (3) Participants receiving both nutrition and normative messaging and Control Group – Participants who did not receive either the nutrition information or the normative messaging. The *p*-values are for the test of association among the treatment groups. The test used for categorical variables is chi squared. For continuous variables (†) the statistics is F.

full covariance) and about the interaction effect (with and without interaction), and two estimation methods (maximum simulated likelihood (MSL) and Hierarchical Bayes (HB)). The models are estimated in Stata using the user-written command "mixlogit" and MATLAB using the estimation command made available by (Train, 2006). The coefficients for sources, color, and biofortification status are assumed to follow a normal distribution, while the monetary attributes – producer selling prices, are assumed to follow a lognormal distribution. The cost attribute–price of maize seed– is assumed to be fixed.

Table 4 reports the estimates for the first stage which has four competing specifications denoted as Model 1–Model 4. Allowing interaction in the model increases the simulated log-likelihood (SLL) at convergence from −7596.50 (for model 1) to −7542.29 (for Model 2). The results from Bayesian estimation procedures are presented in the third and fourth column. We used 10,000 iterations for the burn-in period. After convergence, 10,000 draws were specified of which every 10th is retained to calculate the relevant statistics. Compared to Model 2, Model 3 reached a higher SLL (−7354.40 compared to −7542.29). With regard goodness-of-fit statistics, Model 3 also has lower AIC (14742.79 compared to 15154.58) and BIC (14873.54 compared to 15462.22).

Allowing for full correlation amongst coefficients (model 4) further increases the simulated log-likelihood (SLL) at convergence from −7354.40 to −7240.00. The likelihood ratio test suggests that the hypothesis that the extra parameters in Model 4 are zero can be rejected at the 99% confidence level (χ^2 (136) = 228.8028, P = .000). In addition, Model 4 attained lower AIC (14513.99 compared to 14742.79) and BIC (14644.74 compared to 14873.54). Since the model that allows full correlation among parameters fits the data much better than its alternative, it is used for further analysis.

The estimates are reasonably stable across models and the coefficients have the expected signs (Table 4). All else equal, farmers preferred nutritionally enhanced maize seeds to seeds that are not nutritionally enhanced. However, if those seeds turned out to be yellow, their interest decreased significantly. Respondents preferred white maize to yellow, and the coefficient for the interaction of biofortification status with the color attribute is significant and negative. White maize is more widely cultivated in Ethiopia, and a significant proportion of maize produced is consumed at home. Color of food has long been shown to affect how appealing or unappealing a food is (Clydesdale, 1991; Delwiche, 2012). Since white maize is what the study participants are used to eating, uncertainty about the taste and flavor of food prepared from yellow maize may explain their hesitancy towards yellow maize. The preference of white maize is reported for other countries in Sub-Saharan Africa country where consumers showed a strong preference for white maize and required a significant price discount (37%) to accept yellow maize (De Groote & Kimenju, 2008). A study on orange sweet potatoes in rural Mozambique finds different results where the color of the crops was found to be not a barrier to adoption (Hotz et al., 2012). However, there is a small but significant difference in these two settings. The sweet potato study was conducted in areas where different colored crops are commonly produced and consumed, which eased the resistance to one additional color, while in the current study was conducted in areas where most of the farmers produced only white maize. This result may partially explain why the adoption of nutritionally enhanced maize is limited in the country.

The respondents preferred maize seeds sourced from the government. Though the private sector and NGOs play a role in seed market, the government is currently the main source of seeds for smallholder farmers. The least popular source of seed is the private sector. This is not surprising since the role of the private sector in seed supply is limited, and farmers might not have had adequate opportunities to try seeds from the private sector and form believes about their quality and performance.

Farmers preferred maize seeds that command a higher price in the market. In Ethiopia, farmers produce maize mainly for consumption. However, the study participants are in high maize producing zone and market consideration are incorporated in the farming decision.

The variance of each random coefficient is highly significant, indicating that there is heterogeneity in the preferences for the various attributes of maize seeds. For instance, white maize was preferred by 82.9% of farmers, and 82.6% of farmers were estimated to prefer having biofortified white maize, while the other one fifth preferred the regular white maize.

4.3 | Estimated willingness to pay

We used the results of Model 4 above to estimate the WTP for each attribute. We estimated four models denoted by Mode 5–Model 8 (Table A1). The negative of the simulated log-likelihood at convergence decreases from 7690.69 (model 5) to 7640.17 (Model 6) when interaction in the model is allowed (Table A1). Model 7 and 8 relax the key assumptions further. Model 7 permits correlation among parameters and Model 8 assumes a higher order polynomial to represent the distribution of the parameters for more flexibility. Compared to Model 6, Model 7 has a lower value of the negative of the log-likelihood at convergence (7476.54) and lower AIC (14917.07) and BIC (14778.63). Model 8 allows for full correlation among coefficients and specifies a logit formula as a mixing distribution

TABLE 4 Estimates of the models.

	Model 1	Model 2	Model 3	Model 4
Mean of coefficients				
Cost of maize seed (ETB/kg)	−.207***	−.214***	−.291***	−.305***
	(.005)	(.006)	(.0062)	(.0052)
Selling price of maize (ETB/kg)	.826***	.974***	1.281***	1.217***
	(.031)	(.033)	(.045)	(.034)
Source of seeds (ref: government)				
Private traders	−2.307***	−2.48***	−3.447***	−2.469***
	(.103)	(.116)	(.177)	(.189)
Farmers	−1.381***	−1.343***	−1.628***	−1.418***
	(.086)	(.089)	(.15)	(.088)
NGOs	−1.316***	−1.288***	−1.619***	−1.25***
	(.084)	(.089)	(.1)	(.104)
Biofortified maize (ref: not biofortified)	3.054***	2.707***	4.239***	2.999***
	(.09)	(.196)	(.124)	(.173)
Color of the grain (ref: white)	−2.064***	−2.546***	−3.117***	−2.925***
	(.086)	(.204)	(.169)	(.194)
Biofortification # color		−.554**	−.901***	−.763***
		(.258)	(.098)	(.197)
Color # Info only		.947***	.549***	1.007***
		(.267)	(.147)	(.152)
Color # Norm only		.669***	−.237	.098
		(.258)	(.203)	(.17)
Color # Infor and Norm		1.311***	1.266***	.861***
		(.265)	(.14)	(.169)
Biofortification # Info only		1.232***	.625***	.981***
		(.263)	(.134)	(.21)
Biofortification # Norm only		.81***	.147	.671***
		(.263)	(.107)	(.25)
Biofortification # Info and Norm		.968***	.863***	1.107***
		(.262)	(.094)	(.119)
Color # Biofortification # Info only		−.157	−.137	−.357**
		(.344)	(.103)	(.163)
Color # Biofortification # Norm only		−.347	.208**	−.188
		(.343)	(.099)	(.141)
Color # Biofortification # Info and Norm		.603*	1.142***	1.089***
		(.336)	(.086)	(.17)
No purchase	.318	.202	1.103***	−2.218***
	(.288)	(.286)	(.369)	(.254)
Variance of coefficients				
Selling price of maize (ETB/kg)	.443***	.657***	1.219***	2.127***
	(.049)	(.076)	(.06)	(.07)
Source of seeds (ref: government)				
Private traders	3.227***	5.366***	10.405***	11.77***
	(.467)	(.605)	(1.162)	(1.269)

(Continues)

TABLE 4 (Continued)

	Model 1	Model 2	Model 3	Model 4
Farmers	.024	.006	.518***	2.349***
	(.042)	(.025)	(.116)	(.542)
NGOs	−.014	.003	1.184***	3.393***
	(.035)	(.014)	(.2)	(.435)
Biofortified maize (ref: Not biofortified)	3.316***	4.707***	9.976***	10.849***
	(.423)	(.459)	(1.053)	(1.279)
Color of the grain (ref: white	2.87***	1.637***	6.821***	8.744***
	(.376)	(.29)	(.67)	(1.052)
Biofortification # color		0	.303***	1.81***
		(.001)	(.045)	(.417)
Color# Info only		.796*	.465***	2.803***
		(.413)	(.067)	(.531)
Color# Norm only		.774**	1.374***	3.49***
		(.341)	(.327)	(1.031)
Color# Infor and Norm		.363	1.33**	2.208***
		(.272)	(.61)	(.469)
Biofortification# Info only		.062	.553***	3.139***
		(.12)	(.15)	(.427)
Biofortification# Norm only		.183	.374***	2.521***
		(.157)	(.082)	(.406)
Biofortification# Info and Norm		.046	.901***	3.273***
		(.113)	(.285)	(.514)
Color # Biofortification # Info only		.001	1.375***	2.721***
		(.013)	(.239)	(.748)
Color # Biofortification # Norm only		.007	1.02***	1.625***
		(.04)	(.199)	(.215)
Color # Biofortification # Info and Norm		.518*	.356***	3.727***
		(.287)	(.135)	(.792)
No purchase	−38.45***	40.926***	69.93***	25.389***
	(2.88)	(2.741)	(6.963)	(2.645)
Number of observations	48,528	48,528	48,528	48,528
Number of participants	2022	2022	2022	2022
Estimation approach	Classical	Classical	Bayesian	Bayesian
Correlation among parameters	NO	NO	NO	YES
Interaction	NO	YES	YES	YES
Log-likelihood value at convergence	7596.50	7542.29	7354.40	7240.00
Akaike information criterion (AIC)	15222.99	15154.58	14742.79	14513.9903
Bayesian information criterion (BIC)	15354.84	15462.22	14873.54	14644.7421

Note: The presented data in this table shows coefficients (standard error) for different treatment combinations: nutrition information only, social norm messaging only, and nutrition information combined with social norm messaging. Four different models (Model 1–Model 4) were estimated using different estimation methods, such as classical (traditional statistical approach) or Bayesian, with different assumptions made about the correlation among parameters (correlated vs. not correlated) and the existence of interaction effects between selected attributes (exist vs. does not exist). Model 1, estimated through the classical approach, assumes no parameter correlation and no interaction effects. Model 2 mirrors Model 1 but assumes the presence of interaction effects. Model 3, estimated via Bayesian methods, assumes no parameter correlation and includes interaction effects. Lastly, Model 4, akin to Model 3, assumes correlated parameters. The coefficients for sources, color, and biofortification status follow a normal distribution, while the monetary attributes – producer selling prices – follow a lognormal distribution. The cost attribute, price of maize seed, is assumed to be fixed. The reference category is denoted as "Ref," which for the sources attribute is seeds from government sources. "Classical" refers to the estimation approach where the mixed logit model is estimated using maximum simulated likelihood, while "Bayesian" estimation refers to estimating the mixed logit model with hierarchical Bayes procedures. Standard errors were calculated using bootstrapping. The significance levels are denoted by *, **, and ***, indicating significance at the 10%, 5%, and 1% levels, respectively.

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TABLE 5 Mean and standard deviation of WTPs.

Attribute	Mean WTP Estimate	Mean WTP SE	Std Dev WTP Estimate	Std Dev WTP SE
Selling price of maize (ETB/kg)	3.46***	.105	4.17***	.276
Source of seeds (ref: government)				
Private traders	−10.40***	.526	10.88***	.404
Farmers	−5.10***	.468	5.72***	.267
NGOs	−4.86***	.148	7.01***	.097
Biofortified maize (ref: not biofortified)	12.18***	.418	11.42***	.292
Color of the grain (ref: white)	−12.00***	.652	9.70***	.183
Attribute interaction				
Biofortification # Color	−2.52***	.372	5.12***	.167
Attribute and treatment interaction				
Color# Info only	4.03***	.703	6.16***	.081
Color# Norm only	.63	.982	7.08***	.268
Color# Infor & Norm	2.66***	.505	5.43***	.138
Biofortification# Info only	4.31***	.489	6.68***	.078
Biofortification# Norm only	1.50***	.508	5.76***	.085
Biofortification# Info and Norm	4.30***	.635	7.33***	.259
Color # Biofortification # Info only	−1.96***	.599	6.16***	.170
Color # Biofortification # Norm only	−.96***	.368	4.93***	.113
Color # Biofortification # Info and Norm	2.34***	.353	6.85***	.407
No purchase	−4.19***	1.508	17.97***	.351
Price/scale	.744***	.018	.576***	.0054

Note: Coefficients are presented with their standard errors. "Info only" refers to the Information treatment only, "Norm only" refers to the social norm treatment only, and "Info and Norm" refers to both treatments. "Ref" indicates the reference category. For example, for the sources attribute, the reference category is seeds from government sources. Each parameter's distribution is represented by a logit formula with z-variables representing the probability of each parameter specified as a 12th-order polynomial. Parameters were estimated using maximum simulated likelihood and standard errors were calculated using bootstrapping. Significance levels are denoted by *, **, and *** for 10%, 5%, and 1%, respectively.

where the shape of the mixing distribution is a 12th-order polynomial. This model fits the data much better than its alternatives, as it has the lowest negative of the log-likelihood at convergence (7267.88), AIC (14499.77), and BIC (14361.32). The likelihood ratio test strongly rejects the null hypothesis of equal likelihoods for both Models (χ^2 (180) 417.32, $P = .000$). Using a logit formal to represent a mixing distribution for the utility parameters is a recent development and is shown flexible approach and allows the results to be determined by the data rather than by assumption (Train, 2016).

Table 5 presents the results of the selected model (Model 8). The parameters were estimated by maximum simulated likelihood method in MATLAB using the code made available by (Train, 2015). The results are based on a random sample of 1500 points drawn independently for each person in the sample.

Biofortification had a positive effect on farmers' WTP for maize seed. Compared to nonbiofortified white maize, farmers were willing to pay 12.18 birr per kg more for white biofortified maize seeds. However, as indicated before, the color of the maize affected their preferences: On average, farmers were willing to pay 12 birr less per kilo of nonbiofortified maize seeds if the color of the maize was yellow. Compared to nonbiofortified white maize–which is what they usually buy, farmers were willing to pay 2.34 (12.18 – 12 – 2.52) less per kilo of biofortified yellow maize seeds, without any interventions. Hence, on average our sample farmers are less likely to switch to biofortified yellow maize seeds without any intervention.

Though a significant proportion of maize production is used for household consumption, the results indicated that farmers were willing to pay more for maize seeds if they could sell the produce at a higher price. The estimates indicate that farmers were willing to pay 10.4 birr per kilo of maize seed to avoid seeds from private traders (Table 5). The output price of maize is positively associated with farmers' willingness to pay for seeds.

4.4 | Treatment effects

The effects of the treatments on farmers WTP for biofortified yellow maize seed can be calculated from Table 5. To compute the treatment effect from Table 5, which involves three-way interactions, first remember that WTP for biofortified yellow maize of farmers in the control group was −2.34 (computed in the previous section). Then, computing the effect of each treatment involves adding the relevant interaction terms. For instance, WTP of farmers who received nutrition message was 4.04 (−2.34 + 4.03 + 4.31 −1.96) birr per kg. In other words, information only increased WTP for biofortified yellow maize by 6.38 (4.03 + 4.31 −1.96) as compared to the control group who did not receive information.

The effect is significant and consistent with a recent study conducted in Ethiopia, which showed a positive effect of nutrition messaging in changing consumption behaviors (Donato et al., 2020). The result is also consistent with a study conducted in Kenya and Uganda that also showed that availing nutrition information increases consumers' WTP for improved porridge flour (Chege et al., 2019). De Groote et al. (2017) also reported a positive relationship between nutrition information and WTP for fortified pearl millet in Senegal.

Similarly, the effect of the social norm treatment is found to be positive and statistically significant. In terms of magnitude, however, the effect on WTP is only 1.17 (.63+1.50−.96) birr per kg, which was not enough to counter the disinclination among farmers towards yellow maize, as demonstrated by a negative WTP (−2.34).

The two treatments are complementary and have a synergetic effect: Combining the treatments increased the WTP for biofortified yellow maize by 9.3 birr more (2.66+ 4.30+2.34), which is higher than the sum of the individual treatment effects (6.38 + 1.17 = 7.55) and the difference is found to be statistically significant (F1, 2013 = 21.30, P = .000) We thus find evidence of information strengthening the effect of the social norm treatment. As the costs of adding social norm information to a regular information campaign are small, combining the treatments is suggested in future behavior change campaigns.

Apart from the content of the message, the source of the information and the way it is delivered are expected to affect the believability of the information. In the study context, people are accustomed to hearing health messages through radio. Leveraging this norm, the message for the treatment were recorded in professional studio using with experience in radio broadcasting. Thus, instead of making the field team provide the information, the experiment participants were asked to hear the recorded message. This is expected to increase the reliability of the messages in the eyes of the experiment participants and encourage participants take the message seriously. While we did not collect direct information on respondent's perception about the reliability of the message, our analysis provides an indirect test. We assessed participants' trust levels through survey questions outlined in Section 4.1. The underlying notion was that individuals may not act on health messages or social cues if they lack trust in the information or the providers. We investigated whether the trust variable moderated the effect of the social norm message. Participants were classified as either "More trusting" or "More cautious" based on their agreement or disagreement with the statement "When dealing with strangers, one is better off using caution before trusting." We found that individuals categorized as "More trusting" responded more favorably to the information and normative message compared to those with lower levels of trust (refer to Table A3).

5 | DISCUSSION

Our study tested two interventions – nutrition education and normative messaging – to provide insights into their effect on farmers' willingness to pay for biofortified maize in Ethiopia. Our approach is novel in that it explores the effect of combining nutrition education with social norm messaging, which has not been studied before.

We find that nutrition education increased farmers' WTP for yellow biofortified maize. The social norm treatment also affected farmers' WTP positively but was not enough to compensate for the reluctance farmers showed towards yellow maize. However, combining the two treatments had synergistic effects in stimulating demand for biofortified maize.

Our study builds on public health literature examining nutrition and health education interventions on food choice. Our results are in line with the consistent pattern emerging from this literature that there is a strong relationship between nutrition knowledge and healthy food choice (Scalvedi et al., 2021; Snyder, 2007; Spronk et al., 2014; Wardle et al., 2000). Also, several studies in developing countries identify gaps in nutrition knowledge as one of the barriers to eating healthy. In Uganda, a nutrition knowledge gap is observed, and this in turn is shown to influence household dietary diversity (Nabuuma et al., 2021). Similar findings in reported for rural South Africa (Taruvinga et al., 2013) and Tanzania (Mbwana et al., 2016). Limited access to nutrition knowledge is also linked with worsened household nutrition outcomes in Bangladesh (Zongrone et al., 2018), Nepal (Osei et al., 2017), and Cambodia (Michaux et al., 2019). Based on randomized field experiments and causal mediation analysis, de Brauw et al. (2018) showed that maternal knowledge of nutrition messages had an effect, albeit small, on the adoption of nutritionally enhanced potato varieties in both Mozambique and Uganda.

Our study also builds on the health communication literature examining how social norms can be leveraged to promote healthy diets. Higgs et al. (2019) argued that the eating habits of others are used by people to guide their consumption. In their study, the authors demonstrated that exposure to a descriptive social norm message increased intake of vegetables in both laboratory and field settings. In addition, our results contribute to the growing literature that demonstrates the utility of using nudging interventions to influence people's food choices (Bucher et al., 2016; Hollands et al., 2017; Lehner et al., 2015; Lycett et al., 2017). Our results are also consistent with the findings that knowledge about the social norms with regard to a new technology affects people's behavior and that this, in turn, affects the decision to adopt the new technology (Bandiera & Rasul, 2006; BenYishay & Mobarak, 2019; Donato et al., 2020; Krishnan & Patnam, 2014).

To our knowledge, this is the first study that explores nutrition education and social norm intervention in a single study. As such, our results are a contribution to the limited literature that combines psychological insights into educational interventions. The synergetic effect of the two treatments is consistent with the idea that people tend to conform to norms because they find it rewarding to do so (Higgs, 2015), such that knowing the consequence of following norms makes the tendency to conform even more strong.

6 | CONCLUSION AND IMPLICATIONS

Malnutrition remains an important public health problem in Ethiopia, where the prevalence of child stunting and underweight is high. Biofortification has been shown to be effective in availing essential nutrients to poor rural populations who have little access to nutritious food. A key concern, however, is how to effectively promote the adoption and consumption of nutritionally enhanced crops.

Nutrition messages have long been an important component of such efforts. In addition, describing how most people behave in a given situation—social norm treatment—has been shown to affect agents' information set and this, in turn, is expected to affect people's preferences. Combining these two approaches represents one potential solution that helps to prompt the adoption and consumption of biofortified crops. Overall, our results suggest that a nutrition message can be made more effective in bringing about behavior changes needed to adopt and consume biofortified crops by combining it with information about how common consumption of biofortified crops is.

Our results should be considered in light of the following limitations. First, the study assessed the short-term effect of the two interventions only. We measured the WTP of participants for nutritionally enhanced maize seeds immediately after exposure to the treatments and did not document the long-term effects. Second, the effect of the social norm messages is expected to be more effective if the target population strongly identifies with the reference group (Higgs, 2015). People's eating behavior is influenced by knowledge of how people with whom they are socially connected eat (Higgs et al., 2019). Our social norm message referred to the behavior of farmers in general. The effects could be stronger for more specific reference groups. Third, the credibility and familiarity of the information provided under the two treatments is expected to affect the effectiveness of our treatment. If participants do not believe the information contained in the nutrition message or are already familiar with it, they are unlikely to update their information set and their choice would not be influenced by the treatment. Likewise, if different people evaluate the credibility and familiarity of the messages differently, then the effects of the treatment are likely to vary among the participants. In this study, we assumed that the majority of participants believed the information contained in our treatment and that the information was new to them. We did not explore the potential treatment heterogeneity that would emanate from variation in perceived credibility and familiarity of the information. Finally, though the two interventions are cost-effective to implement and have the potential to reach those who suffer the most from lack of inadequate intake of nutrients, whether the potential effect would be clinically relevant or meaningful is unclear.

From our results we draw the following implications. First, our findings suggest that provision of nutrition education may be effective in promoting production and consumption of biofortified staple crops. Our results also suggest that efforts to encourage consumption of food prepared from biofortified crops may find it useful to leverage people's tendency to follow norms and combine normative messages with nutrition education. Second, future studies that aim to improve the effectiveness of nutrition education by combining it with normative messages need to pay attention to the extent to which the target population identifies with the reference group. Third, whether the two interventions considered here would have positive outcomes that are clinically significant remains an open question. This is an important consideration for future research for proposing the best policies to improve adoption of biofortified staple crops and ultimately increase consumption of food prepared from these crops.

Finally, it is important for policymakers and health communication practitioners to recognize the significant role of trust in the effectiveness of health messages. Interventions aimed at promoting behavior change should consider building trust among the target population as a key component. Additionally, tailoring messages to be more appealing to individuals with lower levels of trust may be an effective strategy to improve their response to health communication efforts (Table A3, S1).

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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