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RESEARCH ARTICLE

The Impacts of Food Waste Information on Consumer Preferences for Blemished Produce and Implications for Food Retailers

Alba J. Collart[1]*, Matthew G. Interis[1], Chloe' Henson[2] and Josh Maples[1]

[1]Department of Agricultural Economics, Mississippi State University, Mississippi State, MS, USA and [2]Department of Agricultural Economics, Purdue University, West Lafayette, IN, USA
*Corresponding author. Email: alba.collart@msstate.edu

Abstract
Produce that does not meet sellers' esthetic standards may be redirected to alternative uses or wasted, but consumer trends indicate potential marketability of blemished produce. We conduct a nonhypothetical experimental auction to elicit consumer willingness-to-pay (WTP) for produce of varying degrees of blemish and test whether valuations are affected by (1) information on food waste resulting from grocery stores' esthetic standards and (2) additional information on the environmental impacts of food waste. WTP for blemished produce increases as consumers become informed, but the information effects vary by blemishing degree. Market simulations indicate that introducing blemished produce can increase retailer revenue.

Keywords: Environmental education; food choices; food loss; food waste; suboptimal produce; sustainability marketing; Vickrey auction

JEL classifications: C91; D12; D44

1. Introduction

The quality and esthetic standards of the fresh produce industry influence the filtering out—or culling—of blemished yet edible produce throughout the supply chain and can be a contributing factor to food loss and waste (Buzby et al., 2011; Gunders and Bloom, 2017; Gunders, 2012). Blemished produce, also referred to as suboptimal or substandard produce, might be undersized, have abnormal shapes, or have skin or other cosmetic defects (Aschemann-Witzel, Giménez, and Ares, 2018; Buzby et al., 2011). In the production stage, producers often train agricultural workers to selectively harvest and leave in the field inedible products as well as edible products that will not meet predefined quality and esthetic standards (Minor et al., 2020). In the distribution stage, retailers might reject the distributors' produce for quality and esthetic reasons. If a take-back agreement is in place, retailers might have sole rights of quality determination and return products they deem of 'inadequate' quality to distributors (Eriksson et al., 2017). In the retail stage, stores might remove blemished items and restock their shelves regularly to signal quality and abundance to consumers. At each stage, supply chain actors might redirect the blemished produce to an alternative, sometimes lower-priced use (e.g., processing, direct-marketing, livestock feed, composting, gleaning, donations, etc.) or let it become waste.

Particularly in developed economies, culling is considered a by-product of supplying produce to the fresh market, but it can also result in nontrivial losses. According to a global consulting firm, up to one in seven truckloads of fresh food delivered to North American supermarkets is thrown away (Beswick, 2014). In the United States, retailers lost an estimated $4.3 billion in unsold fresh fruits and $6.6 billion in unsold fresh vegetables in 2008 (Buzby et al., 2011). They also had an estimated 5.9 billion lbs. of fresh fruit and 6.1 billion lbs. of fresh vegetables delivered for sale but not sold between 2011 and 2012 (Buzby et al., 2015). While some losses are due to operational errors, and others are inevitable and necessary (e.g., the discarding of moldy or otherwise inedible produce), the produce industry's rates of rejection and wastage are driven in part by retailers' expectation that consumers will demand produce that is uniform and esthetically pleasing (Baker et al., 2020; Buzby et al., 2011; Gunders and Bloom, 2017; Gunders, 2012; Hartmann, Jahnke, and Hamm, 2021; Minor et al., 2020). However, recent studies suggest that consumer preferences for esthetic imperfections in fresh produce are heterogeneous and might include a higher tolerance for imperfections filtered out by current industry standards (Mookerjee, Cornil, and Hoegg, 2021; Aschemann-Witzel, de Hooge, and Almli, 2021; Hingston and Noseworthy, 2020). Rather than using visual appearance alone as a cue for the internal quality of fresh produce, these consumers might be price-oriented and emphasize the optimal price-quality relationship as a leading factor in their food purchasing choices (Aschemann-Witzel et al., 2015). Because of a higher level of concern for the environment (Yue, Alfnes and Jensen, 2009) or a higher level of awareness of environmental and social issues like food waste (Collart and Interis, 2018), they might be willing to purchase products perceived as visually suboptimal to avoid wasting environmental inputs such as land or water.

The response of food suppliers to these nascent markets has been mixed, with some suppliers not moving beyond trials and others remaining in the market and reportedly doing well (Choi and McFetridge, 2019). In a recent systematic review, Hartmann, Jahnke, and Hamm (2021) found that low environmental awareness (De Hooge et al., 2017; Loebnitz and Grunert, 2015; Van Giesen and De Hooge, 2019; Yue, Alfnes, and Jensen, 2009) and low food waste awareness (Loebnitz, Schuitema, and Klaus, 2015) are among consumer barriers to buy suboptimal food. An emerging stream of literature on upcycled foods shows that educational messages with facts or statistics about food waste and hunger (Bhatt et al., 2020) or information about the nutritional or environmental benefits of upcycled ingredients (Asioli and Grasso, 2021) can increase consumer demand for these types of suboptimal foods. Although some studies point to the potential of consumer food waste education and awareness as a practical marketing option at the micro-level for retailers to entice purchase of suboptimal foods (in contrast with policy changes at the macro-level), the literature calls for more store-tests and studies examining the effects of educational measures (Collart and Interis, 2018; Hartmann, Jahnke, and Hamm, 2021; Loebnitz, Schuitema, and Klaus, 2015). Our study contributes to answering this call. To respond to changing consumer preferences, food suppliers need more insight into the conditions under which it would be profitable to introduce blemished produce lines into their valued fresh produce sections and invest in consumer education. Specifically, whether consumers are willing to pay for different levels of blemished produce, how much, and the effectiveness of specific messaging strategies to induce consumer demand.

1.1 Esthetic Standards and Blemished Sweet Potatoes

While there are several potential esthetic imperfections in produce, which may vary by the type of produce and production method, our application focuses on the impacts of food waste information on consumer preferences for varying degrees of marred skin in fresh sweet potatoes—a commodity important to the U.S. agricultural economy and food security worldwide, prone to blemishing during harvesting and handling, and for which existing quality and esthetic standards determine its marketability in the United States. In 2020, U.S. production of this commodity was estimated at 30.7 million hundredweight and valued at $726.2 million (USDA-NASS, 2022). In general, the U.S. industry markets sweet potatoes as No. 1, No. 2, jumbo, canner, and cull depending on their size (i.e., length, diameter, and weight), shape, and other standards (e.g., texture and skin condition).

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Studies investigating consumer preferences for new sweet potato varieties abound, but the literature on esthetic imperfections is scarce, and there are no studies that have examined the effectiveness of consumer education on food waste. One vein of research has focused on measuring size parameters and identifying factors that would help producers grow uniform and "well-shaped" sweet potatoes (Tsirnikas, 2018). Another vein has focused on developing imaging techniques to measure blemishes and on understanding consumer preferences for labeling. For instance, based solely on labeling the objective extent of skinning, Collart, Meyers, and Ward (2019) suggested that fresh sweet potatoes with skinning levels of 7.5% and below may be acceptable by U.S. consumers.

Producers might implement preharvest treatments to minimize blemishes on the skin. For example, agricultural workers might remove vines and foliage or irrigate the fields before harvest and wear gloves during harvesting. Still, marred skin in sweet potatoes poses a challenge for producers as it can contribute to postharvest losses and result in losses of marketable products due to unattractive appearance (Wang et al., 2013). If retailers reject blemished sweet potatoes because they perceive blemishes to be esthetically displeasing to consumers, the distributor might redirect the produce and sell it via processing contracts to value-added food or non-food processors at 20% or less of the fresh market prices. If the distributor cannot sell the produce for processing and it cannot be profitably stored for future sales, it may be donated, used as livestock feed, or disposed of on-farm or at a landfill as agricultural waste (Collart and Meyers, 2019). Retailers might also remove blemished sweet potatoes and restock their shelves to signal quality and abundance to customers and either repurpose it or let it become waste. Buzby et al. (2011) estimated that U.S. retailers lost $176 million in unsold fresh sweet potatoes in 2008, partly because of improper stock rotation, cosmetic problems, and quality that does not meet retailers' specifications.

1.2 Objectives

Our study examines quantitatively the consumer side (potential benefits) of the market. Using a nonhypothetical (or real), second-price experimental auction, we elicit consumer preferences and willingness to pay (WTP) for fresh sweet potatoes of varying degrees of blemishing. First, we test whether valuations are affected by information on food waste due to grocery stores' esthetic standards for produce. Second, we test whether valuations are affected by additional information on the environmental impacts of food waste. Third, we simulate how a product's market share could change by the introduction of products with varying blemishing levels given different market pricing scenarios. Fourth, we analyze the effects of our food waste information treatments on market shares, consumer surplus, and revenue. Our discussion provides producers, distributors, retailers, and other supply chain stakeholders insights into the conditions under which it might be beneficial to introduce blemished sweet potatoes or other similar blemished fresh produce items (e.g., potatoes, yams, and cassava) to consumers. It also contributes to the growing literature on marketing strategies for suboptimal foods, particularly to the literature on blemished produce and the effectiveness of consumer education (Di Muro, Wongprawmas, and Canavari, 2016; Hartmann, Jahnke, and Hamm, 2021).

2. Methods

2.1 Data and Experimental Auction

Applied economists, psychologists, and marketers frequently use experimental auctions to examine consumer preferences for new products and technologies such as hormone-free beef (Alfnes and Rickertsen, 2003) and cosmetic damage in organic apples (Yue, Alfnes, and Jensen, 2009). In food waste research, Wilson et al. (2017) used a Becker-DeGroot-Marschak experimental auction to study how date labels influence consumers' willingness to waste food. We use a

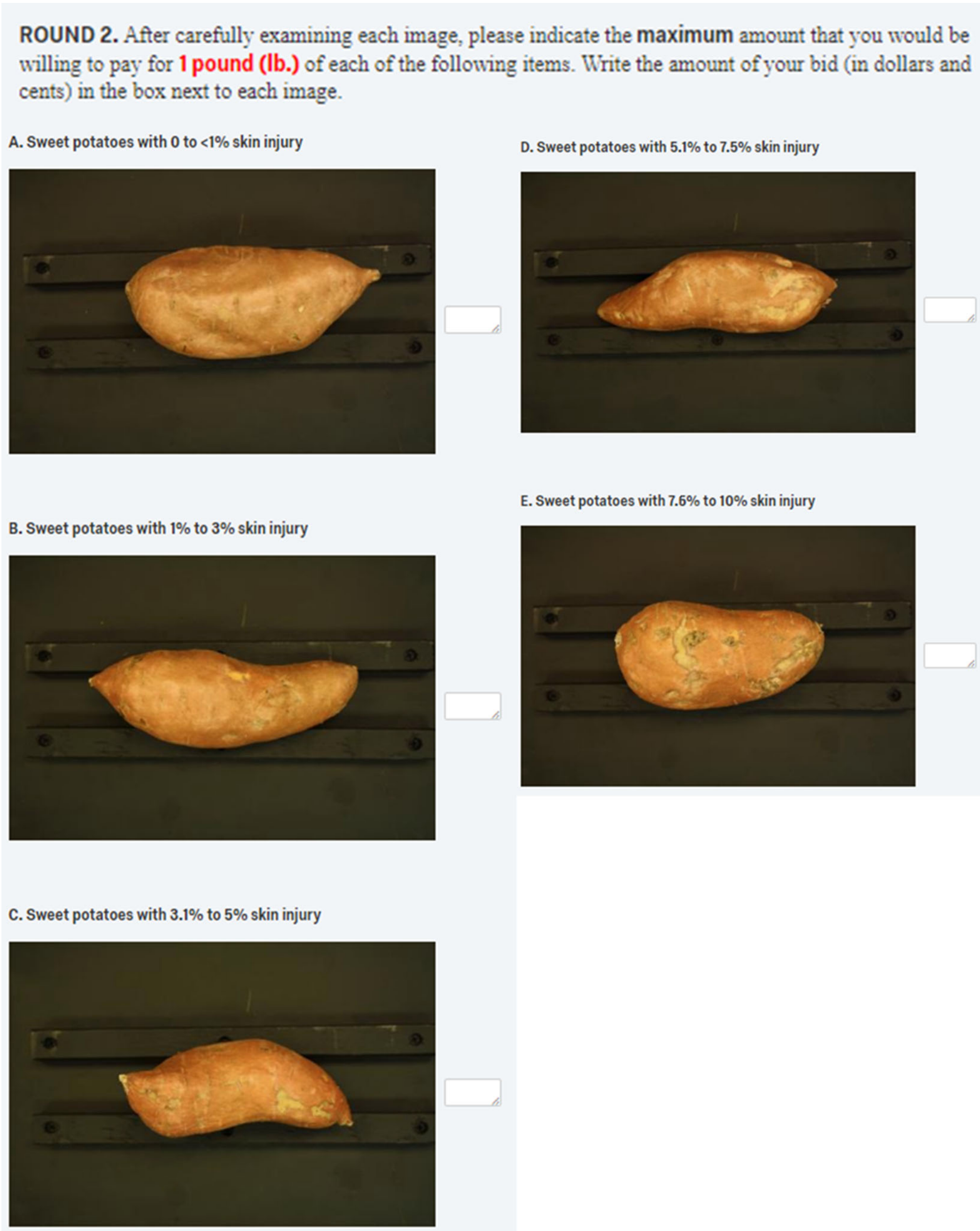

Figure 1. Example screenshot of the bidding page for all nonhypothetical (real) rounds.

nonhypothetical, sealed-bid, incentive-compatible, second-price experimental auction (Lusk and Shogren, 2007; Vickrey, 1961) to identify the effects of two food waste information treatments on consumer willingness to pay (WTP) for sweet potatoes of five blemishing levels. The blemishing levels were measured using the imaging techniques (Sanchez et al., 2020) reported in Collart, Meyers, and Ward (2019) as: 0% to <1.0% blemishing, 1.0% to 3.0%, 3.1% to 5.0%, 5.1% to 7.5%, and 7.6% to 10.0%. Images of these respective skinning levels are contained in Figure 1.

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Except for the blemishing levels, the sweet potatoes used in the study were as homogeneous as possible in other characteristics, including grade (U.S. No. 1),[1] variety (Beauregard), and growing location (Mississippi). Before bidding, participants were informed that all products were graded U.S. No. 1, which meant they were firm, fairly smooth, fairly well shaped, free from insect, disease, or freezing injury, and relatively uniform in size, and that the options differed only in their level of skinning injury.

In a second-price auction, the auctioneer sells the product or service to the highest bidder(s), who pays the second-highest bid for the item. Bidders simultaneously submit sealed bids so that no bidder knows the bids submitted by the other auction participants. This auction mechanism is incentive-compatible, meaning that it gives bidders an incentive to bid an amount equal to their actual value for the item being auctioned (Lusk and Shogren, 2007). In addition, we used a nonhypothetical (real) second-price auction to strengthen the external validity of our findings. In a nonhypothetical auction, the participants face real economic incentives and a trade-off between money and goods.

We conducted ten in-person auction sessions over 2 consecutive days in the experimental economics laboratory at a university campus. Each session lasted about 1 hour and included between 6 and 16 participants, with a total of 88 participants. Given the number of participants (88), the number of sessions (10) depended in part on two factors: the capacity of the experimental economics laboratory (18 computer stations) and the time availability of participants. During each of the 2 days, the sessions for each of the treatments were alternated and conducted during different times of day (morning, midday, afternoon) to account for the potential influence of the time of day on consumer preferences for food.

The participants were consumers aged 18 years and older recruited from the local area through multiple advertisements posted multiple times. The advertisements included flyers placed on bulletin boards in coffee shops across town, university-wide e-mail announcements to listservs distributing messages to faculty and staff, and posts on the area's Craigslist's web page. To ensure that participants were regular buyers of sweet potatoes, we specified in the advertisement and at the time of recruitment that consumption of sweet potatoes was a criterion for eligibility and that the study would involve consumer purchasing decisions for sweet potatoes. We also specified that an individual could participate in only one session. However, we said nothing about blemished produce or produce with marred skin to avoid their influence on sample self-selection. The university's Institutional Review Board (IRB) approved this study for ethical compliance as protocol IRB no. 15-411.

Each session started with participants checking in and signing a consent form. In the consent form and the initial instructions, we informed participants that they would participate in a real auction for sweet potato products. We also assigned participants an anonymous identification number they used throughout the study to minimize any potential effect that researcher observation may have on participants' bidding behavior. They then entered the laboratory and chose one of the available computer stations, all of which had privacy panels. Participants started by reviewing the written instructions and listening to the session moderator explain two examples of multiple-product bidding in a second-price auction setting. After a moment to ask clarifying questions, subjects participated in two hypothetical practice auction rounds and immediately after completed a four-question true/false quiz to ensure their understanding of the second-price auction. Participants saw images of the products, as did the participants in Yue, Alfnes, and Jensen (2009). However, we programmed the bidding pages in the computer using online survey software, so participants saw the images on the computer screen at their respective stations and could enter their bids next to the image. Participants could bid any value, including zero, which would indicate a preference not to purchase the products up for auction. We provided each participant

[1]U.S. No. 1 sweet potatoes are "fairly well-shaped" with a diameter of 1.75–3.5 in., length of 3–9 in., and maximum weight of 20 oz. Furthermore, they are generally firm, smooth, and free of decay and other health- or consumption-experience-related defects (USDA-AMS, 2021).

with earnings consisting of a $5 participation (or show-up) fee and $30 to use as bid money for the auction, which were disbursed after they completed the session's tasks.

Practice rounds with other goods allow participants to gain experience and learn first hand the consequences of bidding suboptimally (Lusk and Shogren, 2007). In the first nonbinding practice round, participants bid on three brands of chips, and in the second practice round on three different brands of chocolate bars. After participants submitted all practice bids and, while the participants completed the knowledge quiz, we downloaded the data from the practice rounds. We then showed participants how we would randomly select one of the two practice rounds and one of the three snacks in that round (each by the roll of a die) to be binding. We also showed them how we would order the bids from highest to lowest to determine who the winner would be and how much the winner would pay for the item had it been the real auction. After another moment to ask clarifying questions, participants proceeded to bid concurrently for the five levels of blemished sweet potatoes during two consecutive real auction rounds. We explained that one item (1 lb. of potatoes with a particular blemishing level) from one round would be randomly selected as the binding round to determine who won the auction at what price and what everyone's experiment payout would be. Figure 1 shows an example screenshot of the bidding page seen by participants during each real round.

2.2 Food Waste Information Treatments

Each participant took part in a control round and a treatment round to identify the effects of information about food waste due to grocery stores' esthetic standards and information about the environmental impacts of food waste on purchase decisions. The first real auction round was the control round, meaning that all participants placed bids for 1 lb. of sweet potatoes at each of the five blemishing levels (with the blemishing level specified and therefore known to participants). Then, within a given session, each participant was assigned to one of the two treatments. In the first treatment (WASTE), participants received information on food waste due to grocery stores' esthetic standards before being asked to resubmit bids for the products at each of the five blemishing levels. The given information stated that fresh produce not considered attractive enough for grocery store displays might be redirected to food processing or wasted (see Appendix A). In the second treatment (WASTE + ENV), participants received the same information on grocery stores' esthetic standards but immediately after also received information on the environmental impacts of food waste before being asked to resubmit bids. The information on the environmental impacts of food waste originated from a report by the Food and Agricultural Organization of the United Nations (FAO, 2013) (see Appendix B). Out of ten sessions conducted, seven sessions (63 participants) were allocated to the WASTE treatment and three sessions (25 participants) to the WASTE + ENV treatment for the second round of bidding. Of 880 total observations (88 participants times two bidding rounds times five products), three bid values were missing. Thus, the total number of observations used in the econometric model is 877 (630 observations to identify the effect of WASTE and 247 observations for that of WASTE + ENV).

After bidding, an online survey elicited sociodemographic, behavioral, and other information. While participants completed the online survey, we randomly selected one of the rounds and one of the five sweet potato categories to be binding. For the auction round and sweet potato category selected, we ordered the bids from highest to lowest and, once all participants had completed the survey, announced the anonymous identification number of the winner of the randomly selected binding auction and the corresponding second-highest bid. Participants then exited the experimental laboratory, earning in cash their $5 participation fee plus their $30 endowment for bidding, minus anything spent on winning the binding auction. If a participant won an auction, the person paid the corresponding price and took home the 1 lb. of sweet potatoes with the corresponding blemishing level.

In Table 1, we compare the sociodemographic characteristics of experimental auction participants with the sociodemographic characteristics of the U.S. population (U.S. Census Bureau,

2016) and the gender distribution of U.S. primary grocery shoppers (FMIFMI, 2015). Most participants specified they were women (59.1%), had an income of less than $50,000 (72.4%), and were employed part- or full-time (88.6%). In each group (control or treated), over 92% of participants indicated being the primary grocery shopper for their household. Results of one-tailed t-tests indicate that the entire sample, as well as the treated subgroups, mirror our targeted population of U.S. primary grocery shoppers in terms of gender. That is, the gender distribution in each group is statistically equal to the gender distribution of U.S. primary grocery shoppers. The groups also reasonably represent the U.S. population in terms of other dimensions, including marital status, household size, and the average number of children per household. The means for marital status in the Control and WASTE treatment groups are statistically equal to that variable's means in the U.S. population. However, possibly because the study took place in a university town, the sample had a higher level of educational attainment, had a higher employment share, and was considerably younger than the U.S. population. All participants were relatively aware (61%) before the session started that food retailers reject produce that does not meet esthetic standards and unaware (80%) of any commercial brand of esthetically challenged produce.

2.3 Econometric Model for Willingness-to-Pay Estimation

Panel data have two dimensions of variation: cross-sectional and intertemporal. In our experimental auction, several participants submitted bids over several subsequent rounds. Thus, the data collected can be thought of as panel data and analyzed using panel data models (Lusk and Shogren, 2007). We specify a random-effects linear model (Woolridge, 2010) as follows:

$$\begin{aligned} WTP_{ijl} &= \beta_0 + \beta_{1,l}(Control \times Blemish_l) + \beta_{2,l}(WASTE \times Blemish_l) \\ &\quad + \beta_{3,l}((WASTE + \mathrm{ENV}) \times Blemish_l) + \beta_4(WASTE + ENV) + u_i + e_{ijl} \qquad (1) \end{aligned}$$

where WTP_{ijl} is the bid (in U.S. dollars) submitted by participant i in round j (control or assigned treatment) for blemishing category l, where l is in the set {1,2,3,4,5} representing the 0% to <1.0%, 1.0% to 3.0%, 3.1% to 5.0%, 5.1% to 7.5%, and 7.6% to 10.0% blemishing levels, respectively. The betas represent parameters to be estimated, which include a constant β_0. *Control* is a dummy indicator for the 1st round of bidding, WASTE and WASTE + ENV are dummy indicators denoting the information treatment to which the participant was assigned before the 2nd round of bidding, and *Blemish* is a dummy variable that equals to 1 when the observation corresponds to blemishing level *l*. Given the relatively small sample size, the model includes a WASTE + ENV dummy indicator to control for differences across the samples assigned to each treatment group. Also, u_i represents an unobserved participant-specific error and e_{ijl} is the typical idiosyncratic error term.

In our experimental design, all the bidding rounds by an individual are either assigned to treatment or not. To account for the potential correlation among the bids submitted by an individual over multiple rounds, we cluster the standard errors at the individual level (Abadie et al., 2017). It is also reasonable to assume that willingness-to-pay values are correlated within the bidding round (i.e., across the five blemishing levels) for a particular individual and that willingness-to-pay values for blemishing levels that are nearer to each other (e.g., blemishing levels 1 and 2) are more strongly correlated than the willingness-to-pay values for blemishing levels that are farther from each other (e.g., levels 1 and 5). To accommodate this, besides clustering errors by the individual, we assume an auto-regressive 1 (AR1) correlation structure[2] among the error terms within the

[2]The AR1 process is the most frequently used autoregressive process in which the disturbance term for a given observation within a panel is influenced more heavily by disturbances nearer to it in the time dimension (see Greene, 2012, p. 909 for more details). In our context, this means that for a given participant in a given round of bidding, the disturbance term, *e*, of a bid for a particular skinning level (e.g., skinning level 5) is more strongly influenced by the disturbance terms of "nearby" skinning levels (e.g., level 4) than by more distant skinning levels (e.g., level 1).

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Table 1. Sociodemographic and other characteristics of experimental auction participants

Variable	Definition	WASTE Treatment	WASTE + ENV Treatment	Control (All Sample)	U.S. Pop.[a]
		Mean			
Age[b]	Age 18–24	0.37	0.24	0.33	0.13
	Age 25–34	0.41	0.48	0.43	0.18
	Age 35–44	0.14	0.08	0.13	0.17
	Age 45–54	0.05	0.08	0.06	0.18
	Age 55 or more	0.03	0.12	0.06	0.35
Gender[c]	Female	0.59	0.60	0.59	0.57
	Male	0.41	0.40	0.41	0.43
Marital status[d]	Married	0.44	0.64	0.50	0.48
	Not married	0.56	0.36	0.50	0.52
Educational attainment[e]	Highest educational attainment is 2-year or associate degree	0.21	0.20	0.20	0.70
	Highest educational attainment is bachelor's degree	0.33	0.32	0.33	0.19
	Highest educational attainment is graduate school degree	0.46	0.48	0.47	0.12
Household size[f]	# of persons per household	2.62	2.44	2.57	2.38
Children[f]	# of children (<18-year-old-persons) per household	0.41	0.44	0.42	0.55
Yearly before taxes household income	$49,999 or less	0.76	0.64	0.72	0.45
	$50,000 to $99,999	0.16	0.20	0.17	0.30
	$100,000 to $149,999	0.08	0.08	0.08	0.14
	$150,000 or more	0.00	0.08	0.02	0.11
Employment[g]	Employed part- or full-time	0.87	0.92	0.89	0.56
	Unemployed	0.13	0.04	0.10	0.07
	Stay at-home-parent or retired	0.00	0.04	0.01	0.37
Primary grocery shopper	Primary grocery shopper for the household	0.94	0.92	0.93	
Standards awareness	Aware of retailer produce rejection due to esthetic standards	0.62	0.60	0.61	
Brand awareness	Aware of commercial brands of esthetically challenged produce	0.22	0.16	0.20	
Number of observations		63	25	88	

[a]Source: U.S. Census Bureau, 2016 American Community Survey (ACS) 5-Year Estimates and FMI U.S. Grocery Shopper Trends, 2015.
[b]U.S. statistics for population ≥18 years old.
[c]U.S. statistics for primary food shoppers per FMI U.S. Grocery Shopper Trends, 2015.
[d]U.S. statistics for population ≥15 years old. The "now married" category in the ACS excludes separated couples.
[e]U.S. statistics for population ≥25 years old.
[f]U.S. statistics calculated as total person or total children population divided by total housing units.
[g]Employment categories in the ACS are: Employed civilians or armed forces in labor force, Unemployed civilians in labor force, and Not in labor force.
Notes: Results of one-tailed t-tests indicate that the means for the gender variable in each group (control or treated) are statistically equal to the means for that variable in the U.S. population. The means for the marital status variable in the Control and WASTE treatment groups are also statistically equal to that variable's means in the U.S. pop.

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bidding round for a given individual. We use the estimated correlation structure when conducting our market simulations, which we discuss in the next section.

2.4 Market Share Simulation

To gain insight into the implications of our results at the market level, we simulate market shares, consumer surplus, and total revenue of each blemishing level, for the control and two information treatment scenarios. First, person-specific draws and person-item-specific draws are taken for each simulated consumer for the random effect u and the error term e, respectively, which each have an estimated variance and where the e are correlated according to an AR1 structure and the estimated correlation parameter, ρ.[3] Then, these random draws and the parameter estimates are used to calculate each simulated consumer's willingness to pay for each blemishing level for each treatment. With an exogenously determined set of prices for each blemishing level, it is assumed that a consumer will consider buying a product only if WTP > price, that is, if consumer surplus is positive. If multiple blemishing levels yield positive consumer surplus, the consumer chooses the blemishing level for which consumer surplus is greatest. This common approach to calculate market shares is known as the first choice or highest utility rule, whereby each person is assumed to choose the product yielding the highest utility from a choice set (Lusk and Shogren, 2007), or to choose not to purchase anything if WTP < price for all blemishing levels. This latter assumption adds realism in that not all consumers make a purchase every chance they have. In the simulation, once the product each consumer purchases, if any, is identified, the quantities purchased, the consumer surplus, and the expenditures for each blemishing level are used to estimate market shares, consumer surplus, and total revenue for each blemishing level for each treatment.

3. Results

3.1 Summary Statistics

Table 2 shows participants' mean bids and their corresponding standard deviation in U.S. dollars per lb. for all products in each round. We also depict the mean bids in Figure 2. For comparison, the average price per pound of fresh sweet potatoes sold by U.S. retailers, which almost exclusively are characterized by the lowest blemishing level used in our experiment, was \$1.05 at the time of the experiment (USDA-ERS, 2020). As can be seen, participants' mean bids for fresh sweet potatoes of all blemishing levels were positive. Participants could bid any value, including bids of zero indicating a preference not to purchase the products up for auction. However, only 5 out of 437 bids submitted in the first round of bidding were zero, and there were no zero bids in the second round of bidding, indicating that censoring (i.e., a high concentration of zero bids) is not a problem in the data.

On average, consumers are willing to pay the most for products with 0% to <1.0% blemishing (up to \$1.21 to \$1.87 per lb.) and the least for products with 7.6% to 10.0% blemishing (up to \$0.52 to \$1.04 per lb.). We see a clear downward trend in mean bids as blemishing level increases, with mean bids increasing in additional information within a blemishing category. For all products, mean bids in the WASTE round are higher than those in the control group consisting of the same WASTE participants, suggesting a positive effect of WASTE info on willingness to pay (WTP). Also, mean bids in the WASTE + ENV round are higher than those in the control group consisting of the same WASTE + ENV participants, suggesting a positive effect of WASTE + ENV info. This positive effect of WASTE + ENV seems higher than that of WASTE, hinting

[3] More explicitly, draws for u are taken from an *iid* $N(0,\sigma_u^2)$ distribution for each simulated individual, where σ_u^2 is the estimated variance of u, and draws for e are taken from a multivariate $N(0,\Sigma)$ distribution for each individual-round, where Σ is the variance-covariance matrix of the errors derived from the estimated variance and ρ for e. Simulations were conducted in Matlab version 9.10, release R2021a.

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Table 2. Mean bids and their standard deviation (SD)

	Group[a]	Blemishing Level (%) 0 to <1.0	1.0–3.0	3.1–5.0	5.1–7.5	7.6–10.0	All Products
Mean bid (US $/lb.)	Control (all participants)	1.67	1.43	1.18	0.94	0.76	1.20
	Control (participants assigned to WASTE info)	1.86	1.59	1.33	1.05	0.84	1.34
	Control (participants assigned to WASTE + ENV info)	1.21	1.03	0.79	0.65	0.52	0.85
	WASTE info	1.87	1.69	1.47	1.27	1.04	1.47
	WASTE + ENV info	1.54	1.35	1.16	1.01	0.83	1.18
SD (US$/lb.)	Control	1.13	1.01	0.92	0.76	0.66	0.97
	Control (participants assigned to WASTE info)	1.22	1.09	0.98	0.81	0.71	1.04
	Control (participants assigned to WASTE + ENV info)	0.68	0.66	0.59	0.50	0.44	0.62
	WASTE info	1.29	1.17	1.10	1.01	0.85	1.13
	WASTE + ENV info	1.22	1.09	0.98	0.91	0.66	1.01

[a]Control corresponds to the 1st round of bidding. WASTE and WASTE + ENV correspond to the information treatments to which we randomly assigned each participant before the 2nd round of bidding.

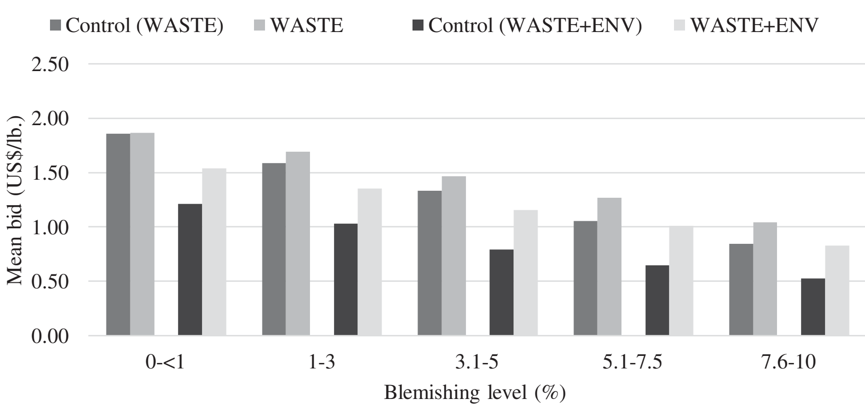

Figure 2. Mean bids for fresh sweet potatoes of five blemishing levels by food waste information treatment group.

at an overall positive effect of ENV info alone for products of all blemishing levels. Both Table 2 and Figure 2 point to differences in participants' bidding behavior across products for a given group and between groups for a given product. They also point to incidental differences between the participants in the control group who were later randomly assigned to the WASTE treatment and those in the control group who were later assigned to the WASTE + ENV treatment, likely due to the relatively small sample size. We control in our econometric model [equation(1)] for these differences across the samples assigned to each treatment group and use the model estimates to test the statistical significance of our information treatment effects more rigorously.

Table 3. Parameter estimates for random effects linear model

Variable[a]	Parameter	Robust SE	*P*-value
Control × Blemish_1	−0.052	0.04	0.236
Control × Blemish_2	−0.297***	0.07	0.000
Control × Blemish_3	−0.549***	0.08	0.000
Control × Blemish_4	−0.789***	0.09	0.000
Control × Blemish_5	−0.977***	0.10	0.000
WASTE × Blemish_2	−0.173***	0.03	0.000
WASTE × Blemish_3	−0.400***	0.06	0.000
WASTE × Blemish_4	−0.599***	0.08	0.000
WASTE × Blemish_5	−0.823***	0.09	0.000
(WASTE + ENV) × Blemish_1	0.164	0.20	0.403
(WASTE + ENV) × Blemish_2	−0.021	0.17	0.897
(WASTE + ENV) × Blemish_3	−0.218	0.15	0.141
(WASTE + ENV) × Blemish_4	−0.363***	0.14	0.008
(WASTE + ENV) × Blemish_5	−0.548***	0.09	0.000
WASTE + ENV Group	−0.491***	0.16	0.002
Constant	1.866***	0.16	0.000
Unobserved individual term variance, σ_u^2		0.722	
Error term variance, σ_{ε}^2		0.219	
Error term correlation, ρ		0.812	
Log pseudolikelihood		−304.952	
X^2 (15)		206.90***	
Groups (id, id_round)		88, 176	
Usable observations (no.)		877	

[a]Blemish_l is a dummy variable for the blemishing percentage (0 to <1.0, 1.0–3.0, 3.1–5.0, 5.1–7.5, 7.6-10.0). WASTE × Blemish_1 is the omitted base category.
***, **, * Denote rejection of the hypothesis at the 1%, 5%, and 10% levels of statistical significance, respectively.
Two tailed p-values test the hypothesis that each coefficient is different from 0.

3.2 Willingness-to-Pay Estimation Results

Table 3 shows the parameter estimates for the random effects linear model described in equation(1), including the results for all the round-blemishing level interactions. The bottom portion of the table shows the estimated value of σ_u^2, the variance of the unobserved individual-specific error, the estimated value of σ_e^2, the variance of the idiosyncratic error term, and the estimated value of ρ, the correlation parameter for the idiosyncratic error terms within the bidding round for a given individual under the AR1 correlation structure. The dependent variable in equation(1) corresponds to the participant's bid in U.S. dollars, so each parameter estimate in Table 3 indicates the effect of the independent variable on WTP. Because all the independent variables denoting the round-blemishing level interactions are categorical, the effect is interpreted relative to the omitted base category of WASTE × Blemish_1 (i.e., the lowest blemishing level in the WASTE treatment).

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Table 4. Price discounts (US$/lb.) for products relative to lowest blemishing level (0% to <1%), and price premiums for information treatments relative to less or no information

	Blemishing Level (%)				
Group	0 to <1	1–3	3.1–5	5.1–7.5	7.6–10
Control	Base	−0.24***	−0.50***	−0.74***	−0.92***
WASTE	Base	−0.17***	−0.40***	−0.60***	−0.82***
WASTE + ENV	Base	−0.19***	−0.38***	−0.53***	−0.71***
WASTE vs. Control	0.05	0.12**	0.15***	0.19***	0.15***
WASTE + ENV vs. Control	0.22	0.28*	0.33**	0.43***	0.43***
WASTE + ENV vs. WASTE	0.16	0.15	0.18	0.24*	0.28***

***, **, * Denote rejection of the hypothesis at the 1%, 5%, and 10% levels of statistical significance, respectively.
Within a treatment (top half of table), Wald tests test the hypotheses that willingness to pay (WTP) for the higher blemishing level is equal to WTP for the lowest blemishing level (base). Across treatments (bottom half of table), Wald tests test the hypothesis that WTP for a given blemishing level in treatments with more information is equal to WTP in treatments with less or no information.
Within a treatment, parameters on neighboring blemishing levels statistically differ at least at the 5% level.

Relative to the omitted base, we can directly infer various effects from observing the coefficients reported in Table 3. When comparing bidding behavior across blemishing levels given that participants received the WASTE information, we find that WTP was significantly lower by $0.17, $0.40, $0.60, and $0.82 per lb. for products with blemishing levels of 1.0% to 3.0%, 3.1% to 5.0%, 5.1% to 7.5%, and 7.6% to 10.0%, respectively, relative to the lowest blemishing level (0% to <1.0%). When comparing bidding behavior across groups for the lowest blemishing level, the lack of statistical significance of the parameters on $\text{Control}\times\text{Blemish}_1$ and $(\text{WASTE}+\text{ENV})\times\text{Blemish}_1$ suggests that the WASTE information alone does not significantly change WTP for the lowest blemishing level compared to receiving no information (i.e., control), nor does the additional ENV information change WTP for the lowest blemishing level compared to receiving only the WASTE information.

Table 4 presents the results in terms of bid differences for easier comparison across blemishing levels for a given group and between groups for a given blemishing level. The top portion of the table shows the price discounts for products with increased blemishing relative to the lowest blemishing level for each group. Participants' WTP in the control group was significantly lower by $0.24, $0.50, $0.74, and $0.92 per lb. for products with blemishing levels of 1.0% to 3.0%, 3.1% to 5.0%, 5.1% to 7.5%, and 7.6% to 10.0%, respectively, relative to the lowest blemishing level (0% to <1.0%). When participants received the WASTE or WASTE + ENV information, they still discount products of increasing blemishing levels but the values of the relative discounts decrease. For example, WTP was significantly lower by $0.19, $0.38, $0.53, and $0.71 per lb. for each higher blemishing level relative to the lowest blemishing level of 0% to <1.0% in the WASTE + ENV treatment.

The bottom portion of Table 4 more formally shows test results illustrating the effects of the food waste information treatments. When participants receive information on food waste due to grocery stores' esthetic standards (WASTE) and additional information on the environmental impacts of food waste (WASTE + ENV), relative to when they do not have that information (Control) they are generally willing to pay statistically significant price premiums for all blemished products except the least blemished category (0% to <1.0%). If participants received the WASTE information, they are willing to pay premiums of $0.12, $0.15, $0.19, and $0.15 per lb. for products with blemishing levels of the four respective highest blemishing categories compared to if they did not receive the WASTE information. If participants received both the WASTE and the ENV information, they are willing to pay premiums of $0.28, $0.33, $0.43, and $0.43 per lb. for products with blemishing levels of the four respective highest blemishing categories compared to if they did not receive any information. And these same participants are willing to pay statistically significant premiums of \$0.24 and \$0.28 per lb. for products with blemishing levels greater than 5%, compared to participants who received only the WASTE information but not the ENV information. Notably, none of the information treatments influenced consumer preferences for products with the lowest blemishing level (0% to <1.0%), and all information effects are observed at higher blemishing levels. In addition, given that participants received the information on food waste (WASTE), adding the information on the environmental impacts of food waste (WASTE + ENV) did not affect consumer preferences for products with less than 5.0% blemishing, but only for the most blemished products.

3.3 Market Share Simulation Results

Using the preference structure reflected by the estimated parameters reported in Table 3, we simulate market shares of each blemishing level, total consumer surplus, and total revenues for each treatment under each of three pricing scenarios chosen to represent a variety of possible pricing strategies by retailers, including discounted and undiscounted prices. We illustrate the results in Figure 3.[4] The simulations assume a market of 100,000 people and assume that each consumer buys a pound of sweet potatoes of only one blemishing level (or buys none if none provide positive consumer surplus). As noted before, the average price per pound of fresh sweet potatoes was \$1.05 at the time. As a baseline, the footnote of Figure 3 summarizes the simulated consumer surplus and total revenue under the "status quo" when only products of the lowest blemishing level are sold.

The first row of Figure 3 simulates conditions akin to horizontal product-line differentiation in which products cannot be ranked in terms of quality (Beath and Katsoulacos, 1991). For example, a given consumer may choose strawberry over vanilla yogurt due to personal flavor preferences, but this preference may not be prevalent enough generally to justify a price differential between the two flavors (Draganska and Jain, 2005). This scenario assumes that sweet potatoes of all blemishing levels are available for purchase in the market at the same price for all (\$1.05 per lb.) and that some nontrivial portion of consumers might find highly blemished products preferable even if priced the same as tradition products. Importantly, the simulation shows that consumers would purchase sweet potatoes with blemishing levels of 1% and above, even if sweet potatoes currently found on the U.S. fresh market commonly have the lowest blemishing level (<1%). In the control treatment, 21% of consumers purchase sweet potatoes blemished by 1–5% (the second- and third-lowest blemishing categories), albeit only 3% purchase products from the two highest blemishing categories.

Why would some consumers purchase products in some of the higher blemishing categories in the control treatment despite the prices for all blemishing levels being the same? One possible reason is that some consumers may already (that is, without any informational intervention) have preferences for more-blemished produce, perhaps because they believe these products are otherwise likely to be wasted. A second reason particular to the simulation is that by random chance resulting from the error draw, simulated consumers might choose a higher blemished product (because it yields a larger consumer surplus). While the underlying model assumes that consumers know their preferences, and in expectation, they monotonically prefer lower-blemished potatoes, the randomness of the simulation may yet have a real-world parallel if consumers imperfectly assess blemishing levels (especially given that nearly all sweet potatoes have at least some level of blemishing, even if very minor) or grab products without careful consideration of blemishing

[4]In calculating WTP, we weighted the estimated parameter controlling for differences in our subsamples across treatments (−0.491) by the proportion of total respondents in the WASTE + ENV treatment (28.4%). Varying this proportion simply shifts WTP for all blemishing levels, affecting consumer surplus and revenues, but not the proportions of each blemishing level purchased in any significant way.

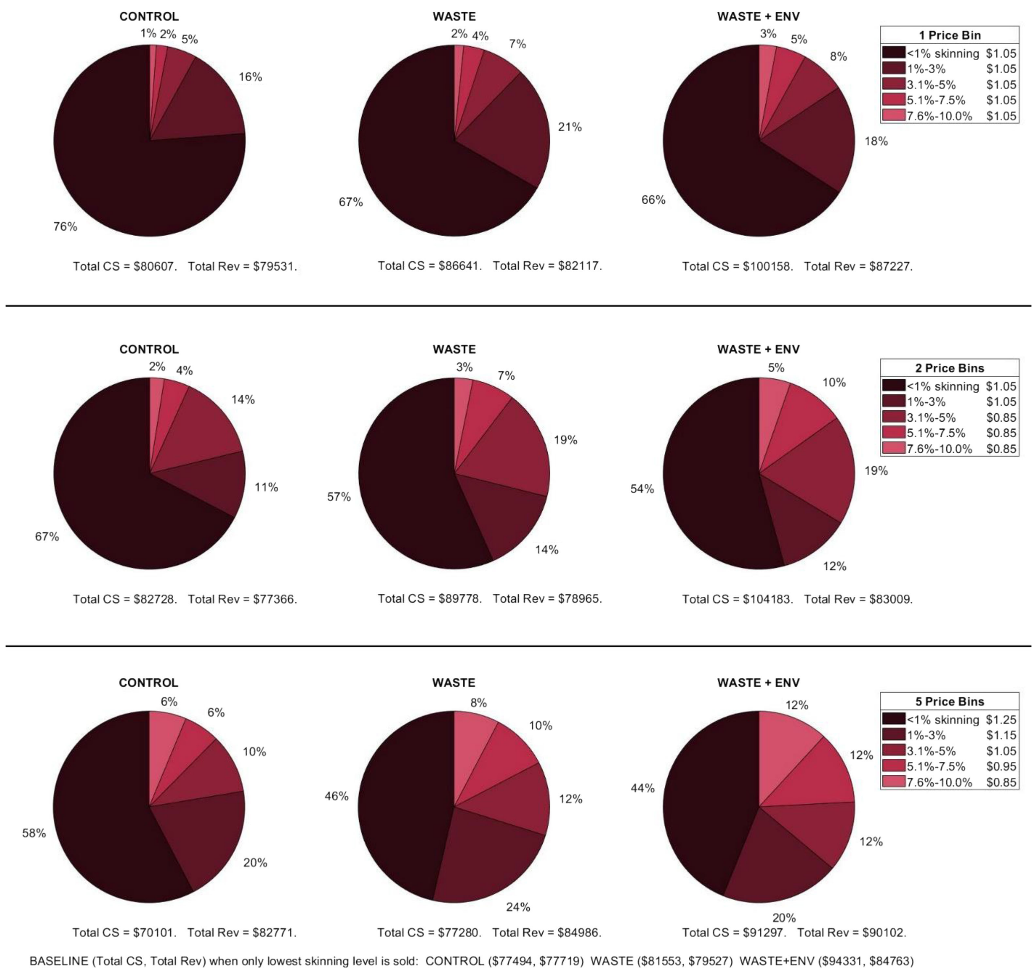

Figure 3. Simulated market shares, consumer surplus, and total revenue in each treatment under three illustrative pricing scenarios.

(e.g., consumers are in a rush and grab them without realizing they are blemished). Either way, the simulation shows that simply expanding the market such that products of additional blemishing levels are sold results in some consumers buying products with blemishing levels of 1% and above, even if retailers offer all products at the same price. Furthermore, the proportion of consumers doing so increases if they are informed about the role of esthetic standards on food waste and the associated environmental impacts, as illustrated in the WASTE and WASTE + ENV treatment simulations. In this row, total revenue in the control group and each of the treatments is higher than their counterparts in the baseline when only products of the lowest blemishing level are sold.

Consumers, however, may discern produce quality based on appearance (Wei et al., 2003; Yue, Alfnes, and Jensen, 2009) and may expect discounts for suboptimal products (Hartmann, Jahnke, and Hamm, 2021). The simulations in the second and third rows of Figure 3 each depict conditions akin to vertical product-line differentiation in which consumers can rank products by quality. If retailers were to offer the products at the same price, every consumer would rank them in the same order (Beath and Katsoulacos, 1991). These preferences allow retailers to offer products at different prices to capture the differential willingness to pay for quality among consumers. For example, yogurt with probiotics and lower fat or sugar content may be priced differently than

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yogurt without probiotics and higher fat or sugar content (Draganska and Jain, 2005). In these simulations, all five blemishing levels are available for consumer purchase but with different prices across the different blemishing levels. In the second row, we assume two "bins" of prices, with the lowest two blemishing levels available at \$1.05 per lb. and the three higher blemishing levels available at \$0.85 per lb. (i.e., a ~20% discount). As in the first row, expanding the market without any informational intervention results in some consumers buying higher blemishing levels. And the market shares of the higher blemishing levels are higher in the WASTE and WASTE + ENV treatments than in the control group. However, another notable outcome is that relative to their counterparts in the first row, the total consumer surplus is higher and total revenue is lower in the control group and each of the treatments in the second row. We would expect consumer surplus to be higher (as some prices were lower), but revenue could have increased or decreased. Although quantities sold are higher for each simulation in the second row than in the corresponding simulation in the first row, the increased quantities sold were not enough to offset the revenue lost from the higher blemishing levels being sold at a lower price. Indeed, total revenue in all groups in the second row is lower than their counterparts in the baseline scenario.

The third row shows simulation results when the price is different for each blemishing level (the price gradually decreases as the blemishing level increases). While one can consider numerous pricing strategies, we analyze a case when the price for the lowest blemishing level increases to \$1.25 per lb., with each subsequent blemishing level \$0.10 less than the previous until reaching \$0.85 per lb. Under this graduated discount pricing strategy, revenues are higher for each simulation than for the other illustrated pricing scenarios and the baseline. The higher revenues are primarily driven by the lowest two blemishing levels being offered at higher prices (higher than \$1.05). Raising prices on the lowest blemishing levels might be more viable from a marketing perspective if other blemishing levels are offered at lower price points, as in this pricing scenario. Like the other rows, simply expanding the market results in some consumers buying products with higher blemishing levels, and the proportions of products of higher blemishing levels purchased are higher in the WASTE and WASTE + ENV treatments, where they even account for more than 50% of total market share in aggregate.

4. Summary and Marketing Implications

To respond to changing consumer preferences for suboptimal foods, food suppliers need insight into the conditions under which it would be profitable to introduce blemished produce lines and invest in suggested marketing strategies such as consumer education. We use a second-price experimental auction to identify the effects of two food waste information treatments on consumer preferences for varying degrees of marred skin in fresh sweet potatoes. We also simulate market shares of each blemishing level, total consumer surplus, and total revenues for each information treatment under three pricing scenarios. Consumers' mean bids for products of all blemishing levels in all rounds were positive, suggesting that, on average, consumers place some positive value on products with varying amounts of blemishing. Clearly and as expected, our results show that all else equal, consumers are willing to pay less the greater the level of blemishing on the product—a finding consistent with Yue, Alfnes, and Jensen (2009)'s finding for organic apples. However, the magnitude of the discounts in our study decreases as consumers become more informed about the possible impacts of their food choices on food waste and the environmental impacts deriving therefrom.

In contrast with Di Muro, Wongprawmas, and Canavari (2016), who found that information on food waste and suboptimal foods did not affect consumer preferences for misshapen vegetables, we find that information on food waste and its environmental impacts significantly increases consumer demand for certain degrees of blemishing. Our findings more closely align with the literature on upcycled foods showing that educational messages related to facts on food waste and hunger (Bhatt et al., 2020), or the nutritional or environmental benefits of upcycled ingredients (Asioli and Grasso, 2021), increase consumer demand. We find that consumers are willing to pay price premiums for all except the least blemished sweet potatoes when they receive information on possible food waste resulting from grocery stores' esthetic standards and information on the environmental impacts of food waste, compared with when they do not receive such information. Across all information treatments, the combined information treatment (WASTE + ENV) was the most effective in inducing price premiums. Given that consumers are provided information on food waste due to esthetic standards, adding information on the environmental impacts increases premiums further, but only for the highest blemishing levels from 5.1% to 10.0%. These results suggest that a marketing strategy entailing informing consumers about food waste due to esthetic standards (WASTE) and the environmental impacts of food waste (WASTE + ENV) would be most effective for products with blemishing levels of 1.0% to 10.0% and would have no effect for products with the lowest blemishing level (0% to <1.0%).

A marketing strategy involving consumer education could be retailer or grower led. Many prominent U.S. grower associations (e.g., U.S. Sweet Potato Council, American Sweet Potato Marketing Institute) invest in marketing their products. In addition, some associations that bring together retailers, growers, and other stakeholders along the supply chain (e.g., the Food Industry Association, the International Fresh Produce Association) make marketing resources available to their members and may work closely with government agencies to issue guidelines for the produce industry or obtain grant funding. The exact form these educational messages might take will be subject to experimentation but could involve a combination of packaging information, online information, or point of sale signage. Market research could also look at combining these and other communication strategies suggested by the literature to stimulate positive perceptions toward suboptimal produce. For example, Grewal et al. (2019) found that communications boosting consumers' self-esteem (i.e., compliments) can increase consumers' willingness to choose suboptimal produce. Suher, Szocs, and van Ittersum (2021) found that esthetic imperfections in produce can signal a lack of human care in production and suggested that retailers may increase demand for suboptimal produce through labels such as "made with care" or "grown with care" or information about the human care involved in the production process. In a European context, Aschemann-Witzel et al. (2019) found that in-store emotional communications that are others-centered or targeted at consumers with others-centered values can improve consumer perceptions of quality and be particularly effective for fresh suboptimal foods. However, other techniques such as humanization and anthropomorphism, which have been found to effectively entice the purchase of misshapen produce, might not be applicable to blemished produce (Hartmann, Jahnke, and Hamm, 2021).

Our simulations under three pricing scenarios show that simply expanding the market (without any informational intervention) such that products of additional blemishing levels are sold results in some consumers buying products with blemishing levels of 1% and above, even if sweet potatoes currently found on the U.S. fresh market commonly have the lowest blemishing level (<1%). They also show that the proportion of consumers doing so increases if they are informed about the role of esthetic standards on food waste and the associated environmental impacts. These results support recent studies finding heterogenous consumer preferences for esthetic imperfections in fresh produce and provide evidence on the malleability of those preferences. Importantly for suppliers, our simulations show that total revenue can be higher under alternative pricing scenarios. While there are various price points retailers may choose, which could even be dynamic and vary over time (Chung and Li, 2013; Wang et al., 2015), we choose three pricing strategies as illustrative examples. We find that total revenue in the control group and each of the treatments is highest when we assume vertical product-line differentiation with graduated discounted prices (third row of Figure 3), followed by horizontal product-line differentiation with the same price point for all products (first row of Figure 3), the baseline scenario when only products of the lowest blemishing level are sold, and vertical product-line differentiation with "binary" price differences (second row of Figure 3). Knowing more about the pricing and marketing strategies under which retailer revenue would be highest is also advantageous to growers and distributors. If retailer revenue outweighs their costs, they might demand these products from growers and distributors.

We find that total retailer revenue is highest when we assume a graduated discount pricing strategy (the price would gradually decrease as the blemishing level increases). Price discounts can stimulate demand, and depending on the product and the retailer's marketing strategy, consumers may already expect discounts for suboptimal produce. However, when choosing their price points, retailers should consider the growing literature on pricing strategies for suboptimal produce. In some contexts, discounted prices can also trigger concerns about product quality and brand reputation (Konuk, 2015). Whether and how much to discount suboptimal foods can vary depending on factors such as the type of product, processing level, flaw, promotion strategy, production method, and the consumer's perceived risk from consuming the product (Hartmann, Jahnke, and Hamm, 2021; Suher, Szocs, and van Ittersum, 2021; Van Giesen and De Hooge, 2019).

5. Limitations and Future Research

Our application investigated the effects of consumer education on food waste and its environmental impacts on consumer preferences for a particular form of an esthetic flaw in produce—marred skin of sweet potatoes. While informational interventions could have similar effects on similar crops, such as blemished potatoes, yams, taro, or cassava, the tolerance of informed consumers to blemishes in other types of products might differ. For instance, the tolerance of sweet potato buyers may vary depending on seasonality, which is an important factor in sweet potato purchasing decisions. Our experiments were conducted only within a narrow time frame, so we cannot observe a seasonality effect. However, additional research on products with different levels of perishability, production methods, and seasonality effects will help us better understand the sensitivity of consumers to blemishes in fresh produce and the generalizability of our results. Other types of produce with other types of flaws[5] (e.g., undesirable shapes, sizes, crooks, colors) that preclude them from being sold generally by retailers are sometimes aggregated in the ``ugly'' produce category and marketed as such at discounted prices by startup firms with direct-to-consumer channels (e.g., Imperfect Foods, Misfits Market, Hungry Harvest) as well as major retail chains (e.g., Hy-Vee supermarkets, Kroger's launch of Peculiar Picks). Future research could give retailers insight into strategies to boost the demand for bundles of suboptimal foods and to ensure consistent demand in the long term. Ensuring consistency might entail a set of coordinated and repeated marketing strategies beyond the one-shot discounting and messaging strategies we discuss here.

In addition, our sample consisted of participants who self-described as primary grocery shoppers in a U.S. university town. This sample matched the population of U.S. primary grocery shoppers in terms of gender. However, the purchasing behavior for blemished produce and the effectiveness of educational interventions could differ between primary grocery shoppers in U.S. university towns and those in the general U.S. population. Future research could investigate differences in consumer purchasing behavior for suboptimal foods between primary grocery shoppers in U.S. university towns and the general U.S. population. For example, Zepeda and Deal (2009) found that motivations such as knowledge and information-seeking partly explain why consumers buy organic and local foods. Similar reasons could influence consumer purchases of blemished foods and could also be more salient in university towns relative to other settings.

[5]Words like "flaw", "undesirable", and "ugly" entail a judgment, one which we do not necessarily hold ourselves, but we use the terms to indicate "market-level" judgments, as revealed through the general current produce market.

Lacking data on firm-level costs, we focus on simulating total revenue, which provides partial insight into firm profitability. Our simulation results indicate how revenue might change under different pricing strategies, yet profits for food suppliers may increase or decrease regardless of whether revenue increases or decreases. For example, while currently there may be costs at the retailer level (or upstream in the supply chain) associated with weeding out potatoes of higher blemishing levels, it might also be costly to logistically manage products of multiple blemishing levels, particularly if a retailer wants to differentiate its products. Notwithstanding the cost of conducting an educational campaign on food waste, other cost variations could stem from volume changes (and associated transportation costs), changes in storage or inventory management costs linked to increased water loss in produce with blemishes, or to opportunity costs related to limited shelf space in highly valued produce sections. These costs could vary for different retailers. In some cases, demand heterogeneity and product differentiation can enable firms to exploit joint economies of scale across multiple versions of the same product and lower average total costs (Duke, 1994; Tellis, 1986). In the end, a firm's profitability will depend on its costs, which will depend on multiple firm-specific marketing mix considerations, including its choice of product, place, and promotion strategies.

From the three pricing strategies we simulated as illustrative examples (under a given set of assumptions), we observe that there is potentially a large market for blemished sweet potatoes and provide insights on the potential benefits to food suppliers. Further research could shed light on the potential costs of introducing blemished produce and conducting educational campaigns on food waste. While some food suppliers could be considering trying, re-trialing, or honing their participation in these markets (Choi and McFetridge, 2019), others might not know about them or consider them profitable. Food suppliers might use these two sets of information (i.e., benefits and costs) to conduct cost—benefit analyses that reflect their firm-specific market conditions and determine whether it would be profitable to market blemished produce to consumers. The marketing of suboptimal produce might be economically viable if the expected benefits outweigh the expected costs of bringing them to market.

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Conflict of interest. None.

Data availability. The data that support the findings of this study are available from the corresponding author, AJC, upon request.

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Appendix A: Information on Grocery Stores' Cosmetic Standards Shown to Participants

Esthetic Perceptions, Grocery Store Standards, and Food Waste

Each year, 20% of the fruits and vegetables grown in America are rejected from grocery stores because they do not meet cosmetic standards and are not considered attractive enough for grocery store displays. Cosmetically challenged fruits and vegetables, despite having at least the same nutritional content, are typically sold to food processors at prices lower than fresh market prices or thrown back to the soil. When edible food is thrown back to the soil, all the resources that were used in growing this food are also thrown away—an issue that is contributing greatly to food waste and its various impacts.

Skinning injury is very common when harvesting sweet potatoes. However, there is a certain threshold at which sweet potatoes with skinning injury are no longer sold for fresh consumption. Moreover, what is considered an allowable percentage of skinning is often determined arbitrarily by retailers.

Appendix B: Information on the Environmental Impacts of Food Waste Shown to Participants

Environmental Impacts of Food Waste

Each year, about one-third of all food produced for human consumption is wasted.

Food waste has implications for the environment. Here are some highlights from a 2013 report by the **Food & Agriculture Organization of the United Nations (FAO)** on the impacts of food wastage on natural resources:

- The **carbon footprint** resulting from wasted food is 3.3 Gigatonnes of CO2 equivalent—higher than the carbon footprint of any single country except China and the USA.
- 250 km^3 of **ground and surface water** are used to grow wasted food—3.6 times as much as is used in the USA for all purposes and more than is used by any single country.
- The amount of **land** used to produce wasted food is nearly 1.4 billion hectares—an area larger than that of any country except Russia.

Production of wasted food is a major threat to **biodiversity** worldwide.

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