sustainability

Article

Consumer Imperfect Information in the Market for Expired and Nearly Expired Foods and Implications for Reducing Food Waste

Alba J. Collart * and Matthew G. Interis

Department of Agricultural Economics, Mississippi State University, P.O. Box 5187, Starkville, MS 39762, USA; m.interis@msstate.edu

* Correspondence: alba.collart@msstate.edu; Tel.: +1-662-325-0413

Received: 1 October 2018; Accepted: 19 October 2018; Published: 23 October 2018

Abstract: A substantial source of food waste occurs when consumers and sellers dispose of expired food despite it being safe to eat. We conduct an incentive-compatible, non-hypothetical laboratory choice experiment in which 150 participants choose between food products of varying perishability level at various dates before or after their best-before dates. In one treatment, participants received information about the interpretation of food date labels. In another they received this information plus additional information on food waste due to date label confusion and its environmental impacts. We find that clarifying the meaning of date labels is insufficient to change preferences for food past its best-before date, but when a link between date labels, food waste, and its environmental impacts is made, participants' willingness-to-pay for expired food increases, particularly for expired frozen or recently expired semi-perishable products. Our findings have implications for food waste reduction efforts because increasing the value of expired food increases the opportunity cost of wasting expired but consumable food.

Keywords: food waste; food date labels; environmental impacts; choice experiment

1. Introduction

Food waste is an issue that has received increased attention in many academic disciplines, as well as in the popular media, given the social, environmental, and economic challenges it presents to the sustainable management of food. While no universal definition has been agreed on, food waste, a part of food loss, can be defined as food that is discarded despite being suitable for human consumption, which may [1–3] or may not [4,5] include food recovered for productive nonfood use. Food waste reduction strategies could potentially contribute to sustainable development by aiding food recovery and redistribution efforts, conserving natural resources, and saving businesses and consumers money [6].

A major source of food waste in developed countries is the discarding by the consumer or food seller of foods that are perceived by the consumer to be relatively undesirable compared to other foods of similar consumption suitability, including foods close to, at, or beyond their 'best-before' date labels [7–11]. Best-before date labels, however, are not related to food safety but are used by food manufacturers to indicate peak quality. Even after the best-before date has passed, a product should be safe to consume, and be wholesome and of good quality if handled properly [12]. In the United States, except for specific milk products and canned foods, date labeling of foods by food manufacturers is generally not required by federal law and requirements may vary at the state level [13]. Instead, food manufacturers determine whether to place a label and which label is placed. Many studies report that consumers worldwide are mostly confused and uneducated on the meaning of date labels [7,13–17]. In the United States, this confusion accounts for 20% of consumer food waste and leads U.S. consumers to spend $29 billion annually on wasted food [18]. In Europe, it has been estimated that up to 8.8 million tons of food are wasted annually in the European Union due to date labeling [3]. Consumer misperceptions on the meaning of date labels cause household food waste and also feed back into the decisions of food sellers, who typically remove food products from their shelves two to three days before the expiration date [19]. The result is that date label confusion leads to food waste at both the consumer and retailer levels. As a potential action to alleviate consumer-related food waste, the literature calls for consumer education on food dating and for experiments and interventions that identify effective messaging strategies, that examine viral approaches, and that target consumer perceptions of sub-optimal foods [7,17]. Our study answers this call.

We use an incentive-compatible non-hypothetical laboratory choice experiment to examine whether and how consumer knowledge about the meaning of food date labels affects consumers' willingness-to-pay for food beyond its best-before date (which we refer to as being 'expired'). Moreover, using results from an FAO report [20] which assessed the extent of environmental damages from food waste including carbon footprint, use of blue water, land use, and biodiversity effects, we investigate whether and how information about the environmental impacts of food waste affects consumer value for expired products.

Date Labeling Literature

One vein of the date labeling literature [10,13,14] examines how different types of food date labels (e.g., best by, use by, sell by) are used by manufacturers and retailers, and how consumers interpret them (another vein of food waste literature examines the optimal level of food waste from an economics standpoint [21,22]). The general finding is that there is very little consistency both in how they are used and in how they are interpreted. Other related studies examine how date labels affect consumer perceptions of and value for food products. In a study conducted by Wansink and Wright in 2006, they found that labels that indicate freshness (i.e., 'best if used by') affect consumer perceptions of the freshness and healthfulness of food but not of the safety or risk of food consumption [23]. In 2005, Tsiros and Heilman conducted a hypothetical survey with an open-ended willingness-to-pay question examining how willingness-to-pay changes as a product's expiration date approaches, and naturally found that willingness-to-pay decreases (at varying rates depending upon the product) with time [24]. In 2017, Wilson et al. conducted an incentive-compatible experimental auction in which participants bid over products of increasing perishability which had different times until their expiration dates and used different language in the date labels. They calculated a willingness-to-waste measure—the portion of willingness-to-pay expected to go to unconsumed food—and found that willingness-to-waste was greatest for the 'use by' label relative to 'fresh by', 'best by' and 'sell by' labels, with their results also depending on shelf life [11]. Notably, neither Tsiros and Heilman nor Wilson et al. calculated willingness-to-pay or willingness-to-waste for items beyond their expiration dates or looked at the effects of information treatments which might be directed towards consumer education or marketing campaigns. Most recently, Qi and Roe looked at the effects of two information treatments on plate food waste in a dining experiment setting. They found that providing information on the negative effects of food waste in landfills reduced the amount of food left on the plates by diners, whereas the amount of wasted food was greater if diners were also told that the remaining plate food waste would be composted. Their experiment did not look at willingness-to-pay estimates, date labeling, or retail food products, but provides evidence that under certain circumstances, information treatments designed to mitigate food waste may work against each other [25].

From these studies, we observe (i) that food date labels—both their wording and the dates themselves—affect perceived consumer value, and (ii) that information on the effects of food waste can affect food waste behaviors. However, no study has yet examined the effect of information on the impacts of food waste on consumer value for expired or nearly expired food products, a knowledge gap which our study addresses. Our study is the first food waste study to estimate willingness-to-pay for expired food products, providing a broader picture of how willingness-to-pay changes both as the expiration date approaches and after it has passed, and how this time path varies under treatments of differing consumer information about food waste. Understanding what type of information related to food waste increases consumer willingness-to-pay has implications for potential solutions both at the consumer level, because if value increases it becomes costlier to waste food, and at the retailer level, because there may now be additional incentives to keep expired or nearly expired foods on the shelves.

We primarily conclude that simply educating consumers on the meaning of food date labels does not affect consumer preferences for expired foods, but educating them on the link between food date labels, food waste, and the environmental impacts of food waste does increase willingness-to-pay for expired products, although the perishability of the product plays a role as well. These results provide evidence of a market failure (imperfect information), which, if addressed by policy-makers and/or profit-conscious food sellers, could have implications for reducing food waste.

2. Methodology

2.1. Data and Choice Experiment

The data were collected through an incentive-compatible, non-hypothetical laboratory choice experiment, and the context of our experiment was the purchasing of different food products. The university's Institutional Review Board approved this project as protocol 14-413 in April of 2015 (in accordance with the Declaration of Helsinki) and we conducted the experiment in November of 2015. Given that food is a private good (at the retail level, albeit perhaps not in a home with multiple people, where it might be considered common property) and that we used food items that could actually be produced, we were able to use a non-hypothetical choice experiment. Hypothetical choice experiments, in contrast, can sometimes suffer from hypothetical bias [26], and are particularly ill-suited for new private goods [27]; in our case, a product past its best-before date might be considered a 'new' product for many consumers, as it is still relatively rare for retailers to keep such items on the shelves (retailers may also not be allowed by regional/state law to sell certain expired food items. In Montana, for example, milk must bear a date of 12 days after pasteurization. After that date, retailers cannot sell nor donate it [28]).

We conducted nine in-person sessions over two consecutive days in the experimental economics laboratory at the university campus. Each session lasted about 1 h and included between 16 and 18 participants, with a total of 150 participants. We recruited participants from the general (non-student) population through printed advertisements in the local newspaper, online advertisements on craigslist.com, and a university mailing list for faculty and staff, and we pre-screened them to be at least 18 years old and to have purchased similar food products within the past year. Given the capacity of the experimental lab, the first 18 people aged at least 18 years who signed up for a given time slot were accepted as participants. Before each session began, participants gave their written informed consent for inclusion in the study.

Lacking data on the population of individuals who had purchased similar food products within the last year, we compared demographic characteristics of the sample with U.S. Census data in Table 1. Our sample is comparable to the state and national populations in terms of household size and, as in the state and national populations, most participants in our sample are female, not married, and have an income of less than $50,000. Despite our attempts to draw from the university staff and the general pool of residents near the university, however, our sample almost certainly has a high number of student participants, explaining why our sample is younger, more educated, less likely to be married, and has lower income than the state and national populations. That our sample contains a higher percentage of females (64.7%) is likely in line with our target population of purchasers of similar food products as it has been reported that females are more likely to be the primary grocery shoppers in a household [29]. Indeed, most participants in our sample are the primary grocery shopper in their household (83.3%).

Table 1. Demographic characteristics of the sample versus population.

		Sample		State Population [1,2]		U.S. Population [1,2]	
Variable	**Category**	**Mean**	**Percent**	**Mean**	**Percent**	**Mean**	**Percent**
Age	18 to 24 years of age		54.7		10.4		10.0
	25 to 29 years of age		12.0		6.5		6.8
	30 to 39 years of age		17.3		12.6		12.9
	40 to 49 years of age		6.0		13.0		13.6
	50 to 59 years of age		6.7		13.4		13.8
	60 to 64 years of age		3.3		5.7		5.7
	65 years of age or older		0.0		13.4		13.7
Educational level	At most some college, no degree		31.3		81.6		73.3
	Associate's degree		13.2				
	Bachelor's degree		9.0		18.4		26.7
	Some Graduate School or Master's degree		36.8				
	Doctoral degree		9.7				
Household size	Number of individuals	2.7		2.6		2.6	
Gender	Female		64.7		51.5		50.8
	Male		35.3		48.5		49.2
Marital status	Married		32.7		45.2		48.4
	Not married		67.3		54.8		51.5
Yearly household income	Less than $50,000		75.3		60.2		46.9
	$50,000 to less than $100,000		16.0		26.9		30.0
	$100,000 or more		6.7		13.1		23.0
Primary grocery shopper	Yes		83.3				
	No		16.7				
Risk love	Willingness-to-pay for risk game ($0 min, $100 max)	$14.13		NA		NA	
Protects environment	Takes action to protect environment more often than friends & family		56.6		NA		NA
Checks expiration dates in store	Checks often or always for at least 4 of the 5 products used in experiment		40.0		NA		NA

[1] Source: 2014 American Community Survey (ACS). [2] The two mutually exclusive educational level categories that can be calculated from ACS data are: (1) At most some college or Associate's degree, and (2) Bachelor's degree or higher.

The choice experiment attributes and their levels are shown in Table 2. Product type refers to the five food products (and their quantities) that participants had the opportunity to purchase in the experiment, which were chosen to represent a variety of blueberry-based food product types and perishability levels subject to the feasibility of those products being produced by the university's Pilot Food Processing Laboratory. Following Newsome et al. [14], the food products were selected to represent perishable foods—those with a shelf life of days to several weeks, such as muffins with no food preservatives; semi-perishable foods—those with an extended life as a result of a processing or preservation method, such as juices and preserves; and frozen foods—those which if properly stored at approximately 0 °F (−17.8 °C) have a shelf life of 6 months to 1.5 years, such as ice cream and frozen berries.

Production method describes whether the food products contained USDA-certified organic blueberries as an ingredient. In the choice sets, products made with organic berries had a special label indicating that they were either 'made with USDA-certified organic blueberries' in the case of processed food products or contained 'USDA-certified organic blueberries' in the case of frozen fruit. Products made with traditional (non-organic) blueberries contained no label about the organic status of the berries, just as would be the case for consumers in a retail setting. The 'best-before' date attribute indicates whether a best-before date label was placed on the product, and if so, whether the best-before date printed on the label corresponded to 9 days or 1 day before the experiment was held (expired products), or to 7 or 15 days after the experiment was held (unexpired products). For example, the first day of the study was scheduled on a specific day (16 November), and the date printed on the labels for this day could have indicated that the product was either 9 days past expiration (7 November), 1 day past expiration (15 November), 7 days from expiration (23 November), or 15 days from expiration (1 December). This approach, similar to that used by Wansink and Wright [23], helped ensure that the attribute levels were balanced (8 days apart), yet salient enough to consumers. Price levels were also balanced and varied from $0.79 to $3.59 in $0.70 increments.

Table 2. Choice experiment attributes and levels.

Attributes	Levels	Description
Product type	Frozen blueberries [1] Ice cream Juice Preserves Muffins	1 bag, net wt. 0.22 kg. 1 container, net wt. 0.17 kg. 1 bottle, net wt. 0.34 kg. 1 jar, net wt. 0.22 kg. 3 muffins, net wt. 0.34 kg. total
Production method	Traditional [1] Organic	
Best-before date	No label [1] 9 days before experiment (expired) 1 day before experiment (expired) 7 days after experiment (unexpired) 15 days after experiment (unexpired)	
Price (US$)	$0.79, $1.49, $2.19, $2.89, $3.59	

[1] Used as reference levels in Ngene experimental design.

The experimental design was programmed in Ngene targeting D-efficiency (minimizing D-error). The final design was a fractional factorial design consisting of 10 choice sets, all seen by each individual, and yielded a D-error of ~1.3 and an S-estimate [30] of ~38, which provides a lower bound on the sample size necessary to yield significant parameter estimates for each parameter. The design specified the product types, production method, and date labels as binary variables and the price variable as continuous. For a conditional logit design, the priors—based on researcher expectations about preferences—were (2, 1.5, 1, 0.5) for product types juice, ice cream, muffins, and preserves, respectively; a prior of 1 for the organic dummy; and priors of (2, 1, −1, −3) for best-before dates of 15 days and 7 days after the experiment and 1 day and 9 days before the experiment, respectively. This conditional logit 'main-effects' model is presented in Table S1, but we focus our discussion on a model containing interactions between expiration dates and perishability, which accounts for the influence of perishability on preferences for expired food and yields significant effects of interest. The resulting S-estimate of 38 indicates that we would need 38 choice observations on each of the 10 choice questions, or 380 observations total, to yield significant coefficients given correct priors (we had between 440 and 510 observations per treatment). In each of the 10 choice sets, a participant saw three food product alternatives and had the option to purchase one or none of the presented products. The no-purchase or status quo option was included to resemble a setting in which shoppers may evaluate the options but decide not to make a purchase.

Given the nature of the purchase scenario, two attribute-level constraints were added to the experimental design. First, a price was drawn from the lower end of the price distribution ($0.79 to $2.19) if the product was expired, from the upper end if unexpired (from $1.49 to $3.59), and from the entire distribution if no date label was specified (because other attributes such as product type and production method also varied, these restrictions on the prices for expired or unexpired products cannot be made purely on dominance grounds but were made based on researcher judgment). Second, given the high perishability of muffins without food preservatives, muffins could not have a best-before date of 15 days after the experiment.

Participants saw enlarged images of the actual products on a computer screen, and all the attribute information (best-before date, price, as well as product information and production method of the blueberries used as ingredients) were shown clearly in matrix format. An example choice set is provided in Table 3. This example choice set was used on 16 November 2015, thus the actual best-before dates seen by participants on the screen were 15 November (expired 1 day), 23 November (expires in 7 days), and 1 December (expires in 15 days) for options 1, 2, and 3, correspondingly. Moreover, best-before date, and product and production method information were printed on labels placed on the actual products.

Table 3. Example choice set used on November 16.

Attribute	Option 1	Option 2	Option 3 [1]	Option 4
Product type (with description and image) and production method	Muffins Made with USDA-certified organic blueberries 1 pack of 3 muffins NET WT. 0.34 kg. 	Frozen blueberries USDA-certified organic blueberries NET WT. 0.22 kg. 	Juice 100% juice NET WT. 0.34 kg. 	Purchase none
Best-before date	BEST BEFORE 15 NOV 2015	BEST BEFORE 23 NOV 2015	BEST BEFORE 1 DEC 2015	
Price (US$)	$0.79	$2.19	$3.59	

[1] Products made with traditional (non-organic) ingredients contained no label about organic status, just as would be the case for consumers in a retail setting.

After the choice experiment, participants completed an online survey which elicited demographic information and, in particular: whether they believed they consciously act to protect or restore the environment more frequently than their friends and family members; the most they would be willing to pay to participate in a gamble in which they earn $0 or $100 based on a coin flip (our measure of risk love); and whether they often or always check expiration dates in stores for at least 4 of the 5 types of products used in the experiment. They then exited the experimental laboratory. Because the experiment was non-hypothetical, each participant selected a binding choice set by rolling a 10-sided die. If the participant made a purchase in the binding choice set, she or he paid the price specified, which was deducted from the monetary endowment (of $35), and took home the food product. This process was explained to participants before the experiment began, so that they knew before participating how their actions would affect their experiment earnings. Furthermore, to minimize the effect of researcher observation on participant choices, it was explained that choices were linked to participants only through a randomly assigned number which, after redemption of their winnings, was destroyed by the participant.

2.2. Treatments

The study contained two treatments and a control group designed to isolate the effect of information about food dating and information about the environmental effects of food waste on food purchase decisions. All ten choice sets were replicated in each of the three groups; however, in one treatment (LABELS), participants were educated about the meaning of different expiration date labels (Sell By, Best Before or Best By, and Use By) prior to the choice experiment—in particular that best-before dates (which was the label placed on the products) are not linked to food safety and that expired food is often still of high quality if handled and kept properly (food dating information shown to participants is provided in Appendix A). To ensure participant understanding, participants took part in a knowledge quiz immediately thereafter in which they were sequentially asked two questions about the information given and clarifying remarks appeared in the screen for any incorrect responses. In the second treatment (LABELS+ENV), participants were given the same information and follow-up knowledge questions on food date labels (overall, participants understood the information presented, with 90% of participants earning correct answers across the two questions), but were immediately thereafter also given information on the link between misperceptions about date labels and food waste and on the environmental impacts of food waste using information from an FAO report [20] prior to the choice experiment (information on the environmental impacts of food waste shown to participants is provided in Appendix B). In the control group, neither of these educational interventions was made; all the same choice sets were used as in the two treatments, but with no discussion about the meaning of date labels or the environmental impacts of food waste prior to the participant answering the choice questions. Given existing literature and recent policy initiatives, we view addressing the misperceptions about date labels as central to any proposed food waste solution and therefore did not conduct a treatment which contained only the information on the environmental impacts of food waste but which did not discuss the meaning of date labels. Out of nine sessions conducted, three sessions were allocated to each group (control, LABELS, LABELS+ENV). In addition, out of 150 participants recruited, 52 were randomly assigned to control group sessions, 47 to LABELS sessions, and 51 to LABELS+ENV sessions. We omitted 6 'protest' participants who selected 'no purchase' for all choice sets. We also omitted 3 participants who did not report their income. Therefore, the total number of observations (number of participants times number of choice sets) used in the econometric models is 510 in control, 440 in LABELS, and 460 in LABELS+ENV. Furthermore, the sessions were alternated, and each treatment 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.

2.3. Econometric Model

The conceptual framework used in this study is random utility theory. A rational economic agent, i, facing choice set t, will choose among J mutually exclusive alternatives, each of which yields utility, U_{ijt}:

$$U_{ijt} = V\left(\boldsymbol{X_{ijt}}\right) + e_{ijt} \qquad j = 1, \ldots l, \ldots J$$

where V is the deterministic portion of utility, $\boldsymbol{X}$ is a vector of attribute levels defining the alternatives, and e is the portion of utility unobserved by the researcher. Within any given choice set t, the probability that individual i chooses alternative l can be described as:

$$P_{il} = \Pr\left(U_{il} > U_{ij}\right) \quad \forall j \neq l$$
$$P_{il} = \Pr\left(V_{il} - V_{ij} > e_{ij} - e_{il}\right) \quad \forall j \neq l$$

Recall that each individual faced 10 choice sets with 4 alternatives per choice set, including a no-purchase alternative. Therefore, the appropriate model would be analogous to a pseudo-panel data model in which the cross-sectional component is given by individual i and the time-series component is given by the t choice situations. It is possible in this type of data that correlation might exist among the choices submitted by the same individual. To account for within-cluster correlation, we examine the results in a random-parameters logit model which allows for preference heterogeneity and relaxes the assumption of independence of irrelevant alternatives [31]. Following Hole [32], the utility obtained from consuming the food products in this study can be specified as:

$$U_{ijt} = \beta_p Price_{jt} + \alpha_i Purchase + \boldsymbol{\beta'_{1i} X_{1ijt}} + \boldsymbol{\beta'_{2} X_{2ijt}} + e_{ijt} \quad \forall j = 1, 2, 3 \tag{1}$$

$$U_{ijt} = \delta \quad \forall j = 4 \tag{2}$$

where β_p is the price parameter, α_i represents a random parameter to be estimated for the purchase (versus no purchase) alternative-specific constant (assumed equal across all products), $\boldsymbol{\beta_{1i}}$ is a vector of random coefficients to be estimated that vary with density $f(\boldsymbol{\beta_1}|\theta)$, θ are the parameters of the distribution f such as the mean and standard deviation of the elements of $\boldsymbol{\beta_1}$, $\boldsymbol{X_{1ijt}}$ is the vector of non-price attributes of the alternative specified as having random coefficients, $\boldsymbol{\beta_2}$ is a vector of fixed coefficients, and $\boldsymbol{X_{2ijt}}$ is the vector of non-price attributes of the alternative specified as having fixed coefficients. δ is normalized to 0, representing the utility of choosing none of the presented products.

Our estimated models include two sets of interaction variables in $\boldsymbol{X}$. First, we interacted the perishability levels (frozen for ice cream and frozen berries, semi-perishable for the juice and preserves, and perishable for the muffins) with dummies for the 'best-before' date label to allow for the effect of date labeling to vary by perishability category. Second, the purchase alternative-specific constant is interacted with individual-specific variables such as demographics, preferences for protecting or restoring the environment, risk preference, and whether the person frequently checks expiration dates in the store.

Other variables include dummy indicators for each product type (muffins, ice cream, etc.) and production method (certified organic berries). Given our focus on consumer value for expired products under different information treatments, we allow for preference heterogeneity for expired alternatives, for alternatives with no best-before date label, and for the 'purchase' constant, so their corresponding parameters are modeled as being random (with normal distributions). The exceptions are frozen or perishable foods that expired 9 days before the experiment, as too few participants chose these items in any choice set, thereby not yielding enough observations to model them as random. Also, our selected design focused on expired foods and did not include semi-perishables with no date label, so there is no corresponding parameter for that interaction. Since the log-likelihood function for the random-parameters logit model cannot be solved analytically, it is approximated using simulated maximum likelihood estimation [31]. We use 100 Halton draws and NLOGIT 6 to simulate the random parameters. Bhat [33] and Train [31] both found that standard errors tended to be lower when using around 100 Halton draws than when using a more typical number for pseudo-random draws, such as 1000 or 2000.

2.4. Post-Estimation Analysis

After estimating the parameters of the utility function, we conducted several post-estimation analyses. First, we estimate willingness-to-pay for each attribute, which, in our model, consists of all the interactions of product category and date label and of all the indicators for product type and organic production. For a given attribute parameter, β_k, on attribute level X^k, and price parameter, β_p, willingness-to-pay for attribute level X^k relative to the omitted base level of that attribute is equal to [34]:

$$WTP_k = -\frac{\beta_k}{\beta_p}$$

Confidence intervals can then be calculated using the Krinsky and Robb procedure, in which n draws of each parameter are taken from the sampling distribution, willingness-to-pay is calculated for each draw, and, for 95% confidence intervals, the top and bottom 2.5% of simulated willingness-to-pay values are eliminated [35]. If β_k is specified as a random parameter, however, an additional level of simulation is necessary. First, the previous procedure results in n paired values for the mean and standard deviation of its distribution (if β_k is distributed normally). Second, m draws of the random parameter from each of these n distributions are taken in order to account for the randomness of the parameter. The confidence interval is then calculated over all of the nm draws [36,37].

Second, we examine individual-level willingness-to-pay values. The intuition is that the series of choices made by a respondent can be used to infer where within the overall (population) distribution of a random parameter a particular individual's parameter value lies [31] (chapter 11), [38]. Individual-level willingness-to-pay confidence intervals can then be estimated. There are different ways to calculate individual-level willingness-to-pay values and we use approach '4' in Train [31] (chapter 11), a key feature of which is that it accounts for both the random variation in the parameters and the sampling variation. Although the estimates of a random-parameters logit model can tell us whether there is unobserved preference heterogeneity, they do not directly quantify it. We use individual-level willingness-to-pay values and their confidence intervals to examine the percentage of the sample whose confidence interval lies entirely in the negative domain, entirely in the positive domain, or spans zero.

In our post-estimation analysis, we use 5000 pseudo-random draws from the sampling distribution (using the Krinsky and Robb procedure) and 200 Halton draws of each random parameter from each of the 5000 simulated distributions.

3. Results

3.1. Econometric Models

The estimation results of the random-parameters logit model for each treatment are shown in Table 4. The omitted production method is traditional (non-organic), the omitted product type is muffins, and the omitted product category-date label interaction for each product category is the date label expiring seven days after the experiment was held. Towards the top of the table, the estimates of the random parameters are displayed. The standard deviations of the random parameters, which are specified as random normal, are shown towards the bottom of the table. Notably, several of the standard deviations are highly significant, yielding evidence of heterogeneity or variation in participants' preferences for expired date labels for the different product categories, regardless of treatment. The exception for all treatment groups is frozen foods that expired the day before the experiment, for which there is no evidence of preference heterogeneity. The discussion below of the results concerning random parameters is based on their mean values in the population (shown in the top of the table), but, because of the evidence of heterogeneity, one must be conscious of the fact that preferences for these corresponding variables vary significantly in the population. The examination of individual-level willingness-to-pay values in Section 3.2 sheds light on the nature of the heterogeneity.

In all treatments, the negative and significant price parameter indicates that a higher price causes people to be less likely to choose to purchase a product and the positive and significant organic parameter indicates a preference for organic over non-organic products, all else equal. The dummy for whether a given alternative is a purchased alternative (relative to the alternative to purchase nothing) is positive and significant. Were there no respondent-specific variables (gender, risk preferences, etc.) interacted with this dummy, this result by itself would indicate an inherent preference for purchasing a product (over purchasing no product), based on the mean parameter value. However, since the model includes interactions of the purchase dummy with respondent-specific variables, whether there is an inherent tendency to purchase a product or not will depend on the values assigned to the respondent-specific variables included.

The parameters on the interactions between perishability levels and date labels are all interpreted relative to the omitted base level of the product expiring in seven days. We find that individuals prefer unexpired over expired frozen, semi-perishable, and perishable foods in the control and LABELS treatments, as all parameters on expired products are negative and significant (indicating that the expired product is less preferred to the omitted base, a product that expires in 7 days). However, after receiving information on food dating and the environmental impacts of food waste, preferences change; individuals in the LABELS+ENV group do not prefer frozen foods due to expire in 7 days more than expired frozen foods, nor semi-perishable foods due to expire in 7 days more than semi-perishable foods that expired the day before. The lack of statistical significance on the parameters on expired frozen foods and 1-day expired semi-perishables indicates that individuals are indifferent between these and the omitted base.

Regarding unexpired food, we find, somewhat expectedly, that individuals in the Control and LABELS groups prefer semi-perishable foods due to expire further in the future (in 15 days) to semi-perishable foods due to expire nearer in the future (in 7 days), as the parameters on semi-perishables that expire in 15 days are positive and significant, and that individuals are indifferent between the two date labels for frozen foods. Individuals in the LABELS+ENV group prefer semi-perishable as well as frozen foods due to expire further in the future.

Table 4. Random parameters logit estimation results.

	Control		LABELS		LABELS+ENV	
	Parameter	**Clust. SE**	**Parameter**	**Clust. SE**	**Parameter**	**Clust. SE**
Random parameters [1]						
Purchase (Pur.)	1.615 *	0.973	3.685 ***	1.044	3.232 ***	0.953
Frozen foods × No label	−0.731 *	0.388	−1.504 ***	0.521	−0.229	0.437
Frozen foods × Expired 1 day	−2.214 ***	0.853	−2.860 ***	1.065	−0.142	0.798
Semi-perishables × Expired 1 day	−1.642 **	0.768	−1.454 **	0.698	−0.710	0.652
Semi-perishables × Expired 9 days	−3.684 ***	1.188	−3.773 ***	0.979	−3.432 **	1.482
Perishables × No label	−3.452 ***	1.176	−2.337 ***	0.742	−2.209 **	1.033
Perishables × Expired 1 day	−2.310 ***	0.649	−2.900 ***	0.736	−2.196 ***	0.802
Non-random parameters						
Price	−0.969 ***	0.143	−1.161 ***	0.180	−0.977 ***	0.156
Organic	0.602 ***	0.218	0.397 *	0.226	0.395 *	0.227
Juice	−0.779	0.625	−0.906	0.683	−1.028	0.657
Ice cream	−0.929	0.604	−0.961	0.672	−1.563 **	0.646
Preserves	−2.339 ***	0.741	−2.470 ***	0.824	−0.891	0.727
Frozen berries	−0.845	0.560	−1.461 **	0.627	−0.948	0.591
Frozen foods × Expired 9 days	−1.411 *	0.754	−1.753 **	0.857	0.049	0.747
Frozen foods × Expires in 15 days	0.440	0.328	0.494	0.368	0.992 ***	0.382
Semi-perishables × Expires in 15 days	1.110 **	0.487	1.405 ***	0.496	1.165 **	0.528
Perishables × Expired 9 days	−4.166 ***	0.820	−4.673 ***	0.909	−2.382 ***	0.788
Pur. × Female	2.691 ***	0.877	1.701 **	0.734	0.963	0.733
Pur. × Risk love	0.116 ***	0.043	0.044 **	0.018	−0.008	0.014
Pur. × Protects environment	2.386 ***	0.764	1.053	0.806	0.596	0.604
Pur. × Checks expiration dates in store	−1.647 **	0.696	−0.386	0.678	−2.206 **	0.857
Pur. × Income in thousands of dollars	−0.020 *	0.012	−0.034 ***	0.013	−0.001	0.009
St. deviations of random parameters						
Purchase	1.923 ***	0.447	1.925 ***	0.402	2.400 ***	0.471
Frozen foods × No label	0.518 *	0.308	0.813 **	0.340	1.165 ***	0.430
Frozen foods × Expired 1 day	1.776	1.368	1.529	1.897	1.604	1.414
Semi-perishables × Expired 1 day	2.032 **	0.933	1.392 **	0.622	1.805 ***	0.634
Semi-perishables × Expired 9 days	1.628 *	0.951	1.770 ***	0.660	2.556 **	1.299
Perishables × No label	2.934 **	1.302	0.440	1.075	1.194	0.918
Perishables × Expired 1 day	1.690 ***	0.422	2.099 ***	0.533	4.609 ***	1.165
Number of usable obsv.	N = 510		N = 440		N = 460	
Log-Likelihood	−521.18		−463.13		−467.65	

***, **, * Indicate statistical significance at the 1%, 5%, and 10% levels, respectively. Note: For each treatment and product category, the omitted base is the interaction with the label expiring in 7 days. [1] Variables were modeled as random parameters with a normal distribution.

Regarding unlabeled foods, our estimates suggest that individuals in the Control and LABELS groups prefer perishable or frozen foods due to expire in 7 days over unlabeled perishable or frozen foods. Individuals in the LABELS+ENV treatment also prefer unexpired perishable foods over unlabeled perishable foods; however, they do not prefer frozen foods due to expire in 7 days more than unlabeled frozen foods.

Several of the parameters on individual-specific variables are strongly significant in the control group, though their significance decreases with each subsequent information treatment. Female, more risk-loving, and lower-income participants are more likely to purchase a product (either expired, unexpired, or unlabeled) in the Control and LABELS treatments, all else being equal. Those who believe they take more measures to protect the environment than their friends or family are more likely to purchase a product in the control treatment, but not in either of the information treatments. Those who check expiration dates in store less often are also more likely to purchase a product in the control and LABELS+ENV treatments.

To examine the robustness of our results, we estimate the full model in Table 4 as a conditional logit model. These results are available as supplementary materials in Table S2. The conditional logit versions of the full model are largely the same as the models in Table 4 as far as parameter direction and significance, and we observe the same changes in date labeling preferences in the LABELS+ENV group—respondents in the LABELS+ENV group do not prefer unexpired frozen foods (expires in 7 days) more than expired frozen foods (expired 1 day or 9 days), or unexpired semi-perishable foods (expires in 7 days) more than semi-perishable foods that expired the day before. Neither do they prefer unexpired over unlabeled frozen foods nor are they indifferent between frozen foods expiring in 7 or 15 days. The only different date labeling parameter is that on semi-perishables expiring 1 day before in the control treatment, which is significant in the random parameters model but not in the conditional logit model. Of course, the main disadvantage of the conditional logit is that it does not capture the existing heterogeneity in preferences, particularly for expired products.

3.2. Post-Estimation Analysis

Table 5 displays willingness-to-pay values for the product attributes. The first three columns of each treatment display the mean willingness-to-pay values and their confidence interval bounds in U.S. dollars, accounting for the sampling distribution and the distributions of the random parameters. The fourth and fifth columns of each treatment depict information based on the individual-level willingness-to-pay estimates which give us more insight into the heterogeneity of preferences (recall that our discussion of results in Section 3.1 was based only on the means of the random parameters). In column 4, we display the percentage of respondents whose 95% confidence interval lies entirely in the positive domain, and in column 5 the percentage of respondents whose 95% confidence intervals lie entirely in the negative domain. In this way, we can, for example, examine the proportion of the sample who have a strictly positive or negative willingness-to-pay for a given attribute, even if the 95% confidence interval of the unconditional willingness-to-pay distribution spans zero.

In particular, we focus on the analysis of individual-level willingness-to-pay for food products that are expired (highlighted in the table) and, again, these values are interpreted relative to the omitted base of a product expiring in 7 days. One outcome that stands out is that there is clearly a discrete difference between willingness-to-pay for expired frozen products in the LABELS+ENV treatment compared with the LABELS and control treatments. Whereas in the latter two treatments, 100% of participants are not willing to pay as much for an expired frozen product as for an unexpired frozen product, in the former treatment 100% of the individual-level confidence intervals span zero, indicating no strong preference for an unexpired frozen product to an expired one in this group. When looking at mean willingness-to-pay values, it may appear that the price discounts for 1-day expired frozen foods (relative to unexpired frozen foods) are higher than the discounts for 9-days expired frozen foods. However, using the complete combinatorial approach of Poe, Giraud, and Loomis [39] to test for equivalency of simulated willingness-to-pay distributions, we find no statistical difference in willingness-to-pay between these two categories in any treatment.

For semi-perishable products, there appears to be an increase in the percentage of participants indifferent between a semi-perishable product that expired 9 days ago and one expiring in 7 days in the LABELS+ENV treatment (20%) compared to the other two treatments (4–5%), but there is an even more discernible increase across treatments when it comes to semi-perishable products that expired one day ago. While 73% of participants are willing to pay less for the 1-day expired semi-perishable product in the control treatment, this percentage falls to 57% in the LABELS treatment and to 22% in the LABELS+ENV treatment. It is also worth noting that although the coefficients on 1-day expired semi-perishables are negative and significant for both control and LABELS treatments in Table 4, individual-level willingness-to-pay estimates reveal that more people are indifferent between unexpired semi-perishables and semi-perishables that expired the day before in the LABELS treatment (43%) than in the control treatment (27%).

Table 5. Consumer mean willingness-to-pay (WTP) for attributes in US$ and analysis of individual-level WTP confidence intervals.

	Control					LABELS					LABELS+ENV				
Variable	**Mean WTP**	**95% CI [1]**		**Individual-Level WTP**		**Mean WTP**	**95% CI [1]**		**Individual-Level WTP**		**Mean WTP**	**95% CI [1]**		**Individual-Level WTP**	
		Min	**Max**	**CIs [2] > 0**	**CIs [2] < 0**		**Min**	**Max**	**CIs [2] > 0**	**CIs [2] < 0**		**Min**	**Max**	**CIs [2] > 0**	**CIs [2] < 0**
Organic	0.62	0.20	1.00	100%	0%	0.34	-0.05	0.68	0%	0%	0.40	−0.06	0.82	0%	0%
Juice	−0.80	−2.43	0.41	0%	0%	−0.78	−2.37	0.36	0%	0%	−1.05	−2.86	0.24	0%	0%
Ice cream	−0.96	−2.58	0.23	0%	0%	−0.83	−2.36	0.31	0%	100%	−1.60	−3.48	−0.27	0%	100%
Preserves	−2.41	−4.35	−0.88	0%	100%	−2.13	−4.07	−0.70	0%	100%	−0.91	−2.66	0.52	0%	0%
Frozen berries	−0.87	−2.17	0.28	0%	0%	−1.26	−2.62	−0.18	0%	100%	−0.97	−2.36	0.19	0%	0%
Frozen foods × No label	−0.75	−2.27	0.91	0%	75%	−1.30	−3.11	0.62	0%	86%	−0.23	−3.00	2.46	0%	13%
Frozen foods × Expired 9 days	−1.46	−2.80	0.10	0%	100%	−1.51	−2.76	−0.06	0%	100%	0.05	−1.38	1.90	0%	0%
Frozen foods × Expired 1 day	−2.29	−4.05	−0.62	0%	100%	−2.46	−4.18	−0.77	0%	100%	−0.15	−1.77	1.56	0%	0%
Frozen foods × Expires in 15 days	0.45	−0.23	1.11	0%	0%	0.43	−0.21	1.11	0%	0%	1.02	0.29	1.85	100%	0%
Semi-perishables × Expired 9 days	−3.80	−7.84	1.50	0%	96%	−3.25	−6.86	0.66	0%	95%	−3.51	−11.22	1.71	0%	80%
Semi-perishables × Expired 1 day	−1.69	−6.63	3.66	0%	73%	−1.25	−4.58	1.52	0%	57%	−0.73	−5.30	3.46	0%	22%
Semi-perishables × Expires in 15 days	1.15	0.18	2.16	100%	0%	1.21	0.41	2.10	100%	0%	1.19	0.15	2.28	100%	0%
Perishables × No label	−3.56	−11.26	4.22	0%	82%	−2.01	−3.79	−0.70	0%	100%	−2.26	−4.94	−0.20	0%	100%
Perishables × Expired 9 days	−4.30	−6.63	−2.65	0%	100%	−4.03	−6.20	−2.43	0%	100%	−2.44	−4.36	−0.92	0%	100%
Perishables × Expired 1 day	−2.38	−6.54	1.07	0%	80%	−2.50	−6.74	1.15	0%	80%	−2.25	−12.90	6.80	20%	70%

[1] Calculated with Krinsky and Robb procedure using 5000 pseudo-random draws from the sampling distribution and 200 Halton draws from each random parameter distribution.
[2] Calculated with Krinsky and Robb procedure using 100 pseudo-random draws from the sampling distribution and 100 Halton draws from each random parameter distribution.

For perishable products, there is no difference across treatments for willingness-to-pay for a product that expired 9 days ago compared to one expiring in 7 days (100% of participants in all treatments are not willing to pay as much for the expired product). However, for a perishable that expired 1 day ago, the percentage who are not willing to pay as much for it as for an unexpired product falls from 80% in the control and LABELS treatments to 70% in the LABELS+ENV treatment. In other words, participants in LABELS+ENV are more likely to prefer perishables that expired the day before over unexpired perishables or to be indifferent between the two (30%) than participants in either the control or LABELS treatment (20%).

This examination of individual-level willingness-to-pay corroborates our conclusion in the previous section that participants in the LABELS+ENV treatment are indifferent between expired and unexpired frozen products. It also illustrates additional nuances on the heterogeneity of preferences across treatments for expired semi-perishable and perishable products that were not evident before.

4. Discussion and Conclusions

Consumers may have limited or incorrect information when buying food [40] and may throw away edible food due to confusion on the meaning of date labels [7,13–17]. We use an incentive-compatible non-hypothetical choice experiment to study if and how information about food date labels and the links between date label misperceptions, food waste, and its environmental impacts affects consumer choices for food products of varying perishability and at varying dates before or beyond their best-before date (i.e., expired products).

In summary, we find that information on food dating alone was not enough to affect the value of food products beyond their best-before date. In the control treatment and the LABELS treatment in which participants received education only on the interpretation of food date labels, participants prefer unexpired food to expired food, regardless of perishability. On the other hand, after receiving additional information on food dating, and the environmental impacts of food waste in the LABELS+ENV treatment, their preferences change. The most noticeable increases in consumer value for expired products occurred for expired (1 or 9 days ago) frozen or recently expired (1 day ago) semi-perishable products. Participants in this treatment are indifferent between expired and unexpired frozen products and mostly indifferent (78%) between unexpired semi-perishables and semi-perishables that expired the day before. We also find that preferences for expired food products were generally heterogeneous. A closer look at individual-level willingness-to-pay values (a) corroborated our conclusions regarding expired frozen foods and recently expired semi-perishables, and (b) quantified additional nuances on the heterogeneity of preferences across treatments for expired semi-perishable and perishable products. Though our focus is on expired food products, we also observe changes in consumer preferences for unlabeled and unexpired frozen foods in the LABELS+ENV treatment. While we know of no other studies estimating willingness-to-pay for expired food products, some of our more general findings are consistent with existing studies. Whereas Wilson et al. [11] focus primarily on the effects of different types of expiration labels, they, like we do, also find that results differ depending upon the perishability of the food items. In addition, as we do, Qi and Roe [25] also find that providing information about environmental impacts of food waste can induce food waste reduction behaviors, although their information pertained to food waste ending up in landfills as opposed to the more general information on the environmental impacts of food waste our participants received.

Our results show evidence of an information gap about the link between date label confusion, food waste, and its environmental impacts, which if addressed by policy-makers and/or profit-conscious food sellers, shows promise for raising the value to consumers of expired food products depending on their perishability. At home, if consumers are indifferent when choosing between unexpired and expired food items, they may be more likely to consume an item past its best-before date rather than throwing it away and buying a new unexpired one. In stores, if consumers are indifferent when choosing between unexpired and expired food items (likely at discounted prices as we assumed in our experiment), retailers may be more likely to leave food items past their best-before dates on the shelves rather than disposing of them (if allowed by law). We also find that the most perceptible changes in consumer behavior prompted by the environmental information are related to frozen foods. This may be because the prospect of consuming expired frozen foods might not be perceived as risky from a food safety or food quality standpoint as that of consuming expired perishables or semi-perishables. Other studies have found that some individuals who freeze food products consider this technique as a good guarantee for food preservation and thus not take the shelf life date into account anymore [13].

Moreover, the lack of significance of the information in the LABELS treatment indicates that if industry and policy-makers wish to reduce food waste, insofar as it results from expired food products having to be discarded rather than sold, consumers need to be given a reason to do so, say, through public consumer awareness campaigns or marketing, that goes beyond clarification of food date labels. Date label education and standardization is the current focus of recent proposals by policy-makers and grocery trade groups in Europe and the United States [41]. Two ongoing efforts in the United States are the introduction of the Food Date Labeling Act of 2016 [18] and the promotion of voluntary standard date labeling regulations for industry by the Food Marketing Institute and the Grocery Manufacturers Association. In Europe, the European Platform on Food Losses and Waste recently established a sub-group tasked with working exclusively on date labeling. Though ReFED [17] recognizes both consumer education and standardized date labeling as the most cost-effective solutions to reduce consumer confusion and related food waste, our results show that even if consumers understand food date labeling, their preferences across unexpired and expired foods may remain largely unchanged.

Limitations and Future Research

One caveat when interpreting the results of our study is that we do not directly measure food waste as part of the study. Rather, the assertions about these information interventions reducing food waste are valid only if our underlying assumption (which is supported by the literature, however) that consumable but expired food is generally discarded by both food sellers and consumers is correct. Furthermore, while we examine how the information interventions affect preferences and willingness-to-pay, we do not directly link those preference changes to changes in waste behavior. Instead, we have demonstrated conditions under which consumer value for certain expired (but still consumable) food products increases, which increases the opportunity cost both to food sellers of not selling expired food and to consumers of discarding expired foods in the home. Ultimately, the effect on actual food waste will be borne out in what types of informational interventions policy-makers and food sellers actually make, and the prices charged for expired products. A second caveat pertains to how our sample might differ from the target population. Our sample has a higher proportion of younger participants, who tend to waste more food, than the state and national populations, and it has a greater proportion of females and lower-income participants who tend to waste less food [42]. We cannot tell from our study alone whether these deviations of the sample from the target population would affect the marginal effects of expiration dates or of the information treatments; our interest, however, is in behavioral changes among primary grocery shoppers, who have been reported to be mostly female [29], and so our sample may be more representative of this population than the state or national populations are.

Given that a gain in control in laboratory experiments is typically traded off with diminished context [43], future studies might examine other settings, products, and populations to increase the ecological validity (i.e., the robustness of these results in different choice contexts, including actual food market purchases) of our findings. Future studies might also examine the long-term sustainability of an environmental stimulus and other reasons that may induce consumers to reduce food waste. For example, cost-conscious consumers may be motivated to reduce food waste if they could clearly be shown the typical effect of food waste on the average consumer's food expenditures over a lifetime, or if food waste were linked to difficulties in distributing food to the hungry or poor.

Supplementary Materials: The following are available online at http://www.mdpi.com/2071-1050/10/11/3835/s1, Table S1: Conditional logit estimation results, main-effects model, Table S2: Conditional logit estimation results.

Author Contributions: Conceptualization, A.J.C. and M.G.I.; Formal analysis, A.J.C. and M.G.I.; Funding acquisition, A.J.C. and M.G.I.; Project administration, A.J.C.; Writing—original draft, A.J.C. and M.G.I.; Writing—review & editing, A.J.C. and M.G.I.

Funding: This research was funded by the United States Department of Agriculture (USDA) Specialty Crop Block Grant Program.

Conflicts of Interest: The authors declare no conflicts of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

Appendix A. Food Dating Information Shown to Participants

Information on food dating (U.S. Food Safety and Inspection Services-FSIS, Newsome et al. 2014, and Tsiros and Heilman 2005):

- The U.S. Food and Drug Administration (FDA) does not require food manufacturers to place any date labels on food products nor does it regulate their use. Determining and providing this information is at the discretion of the food manufacturer.
- A "Sell By" or "Display Until" date tells the store how long the product should be displayed for sale. It facilitates in-stock inventory management and is not an indication of a product's safety or quality.
- A "Best Before", "Best By", or "Best If Used By" date tells the purchaser the date after which the food's quality or flavor may deteriorate. After that date, while it may not be of ideal quality, the product should still be safe to consume if handled and stored properly.
- A "Use By" date indicates the last date recommended for the consumption of the product, but does not necessarily convey safety information. The product should be discarded after this date.

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

What are the Environmental Impacts of Food Waste?

Each year, millions of tons of quality and edible food are thrown away by grocery stores and other food sellers and by people in their homes because the products are near, at, or beyond their "Sell By", "Best Before" or "Use By" date. This discarded food is known as "food waste" and 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 CO_2 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 United States 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.

References

1. FAO (Food and Agriculture Organization of the United Nations). Food Loss and Food Waste. Available online: http://www.fao.org/food-loss-and-food-waste/en/ (accessed on 22 October 2018).
2. Buzby, J.C.; Farah-Wells, H.; Hyman, J. *The Estimated Amount, Value, and Calories of Postharvest Food Losses at the Retail and Consumer Levels in the United States*; Economic Information Bulletin 121; U.S. Department of Agriculture, Economic Research Service: Washington, DC, USA, 2014.

3. *FUSIONS Estimates of European Food Waste Levels*; European Union: Brussels, Belgium, 2016; Available online: https://www.eu-fusions.org/phocadownload/Publications/Estimates%20of%20European%20food%20waste%20levels.pdf (accessed on 22 October 2018).
4. U.S. EPA (Environmental Protection Agency). *United States 2030 Food Loss and Waste Reduction Goal*; EPA: Washington, DC, USA, 2015. Available online: https://www.epa.gov/sustainable-management-food/united-states-2030-food-loss-and-waste-reduction-goal (accessed on 22 October 2018).
5. Bellemare, M.F.; Çakir, M.; Peterson, H.H.; Novak, L.; Rudi, J. On the Measurement of Food Waste. *Am. J. Agric. Econ.* **2017**, *99*, 1148–1158. [CrossRef]
6. U.S. EPA (Environmental Protection Agency). Sustainable Management of Food Basics. Available online: https://www.epa.gov/sustainable-management-food/sustainable-management-food-basics (accessed on 22 October 2018).
7. Aschemann-Witzel, J.; De Hooge, I.; Amani, P.; Bech-Larsen, T.; Oostindjer, M. Consumer-Related Food Waste: Causes and Potential for Action. *Sustainability* **2015**, *7*, 6457–6477. [CrossRef]
8. Parfitt, J.; Barthel, M.; Macnaughton, S. Food Waste within Food Supply Chains: Quantification and Potential for Change to 2050. *Philos. Trans. R. Soc. B* **2010**, *365*, 2065–3081. [CrossRef] [PubMed]
9. Williams, H.; Wikström, F.; Otterbring, T.; Löfgren, M.; Gustafsson, A. Reasons for Household Food Waste with Special Attention to Packaging. *J. Clean. Prod.* **2012**, *24*, 141–148. [CrossRef]
10. Milne, R. Arbiters of Waste: Date Labels, the Consumer and Knowing Good, Safe Food. *Sociol. Rev.* **2013**, *60*, 84–101. [CrossRef]
11. Wilson, N.L.W.; Rickard, B.J.; Saputo, R.; Ho, S. Food Waste: The Role of Date Labels, Package Size, and Product Category. *Food Qual. Preference* **2017**, *55*, 35–44. [CrossRef]
12. USDA-FSIS (Food Safety and Inspection Service of the United States Department of Agriculture). Food Product Dating Fact Sheet. Available online: http://www.fsis.usda.gov/wps/portal/fsis/topics/food-safety-education/get-answers/food-safety-fact-sheets/food-labeling/food-product-dating/food-product-dating (accessed on 22 October 2018).
13. Boxstael, S.V.; Devlieghere, F.; Berkvens, D.; Vermeulen, A.; Uyttendaele, M. Understanding and Attitude Regarding the Shelf Life Labels and Dates on Pre-Packed Food Products by Belgian Consumers. *Food Control* **2014**, *37*, 85–92. [CrossRef]
14. Newsome, R.; Balestrini, C.G.; Baum, M.D.; Corby, J.; Fisher, W.; Goodburn, K.; Labuza, T.; Prince, G.; Thesmar, H.S.; Yiannas, F. Applications and Perceptions of Date Labeling of Food. *Compr. Rev. Food Sci. Food Saf.* **2014**, *13*, 745–769. [CrossRef]
15. NRDC (National Resources Defense Council). Wasted: How America Is Losing Up to 40 Percent of Its Food from Farm to Fork to Landfill. Issue Paper: 12-06-B. Available online: https://www.nrdc.org/sites/default/files/wasted-2017-report.pdf (accessed on 22 October 2018).
16. NRDC (National Resources Defense Council). The Dating Game: How Confusing Food Date Labels Lead to Food Waste in America. Report: 13-09-A. Available online: https://www.nrdc.org/sites/default/files/dating-game-report.pdf (accessed on 22 October 2018).
17. ReFED (Rethink Food Waste through Economics and Data). A Roadmap to Reduce U.S. Food Waste by 20 Percent. Report. Available online: https://www.refed.com/downloads/ReFED_Report_2016.pdf (accessed on 22 October 2018).
18. Food Date Labeling Act of 2016, H.R.5298, 114th Cong. 2016. Available online: https://www.congress.gov/bill/114th-congress/house-bill/5298/text (accessed on 22 October 2018).
19. Gunders, D. *Wasted: How America Is Losing up to 40 Percent of Its Food from Farm to Fork to Landfill*; NRDC Issue Paper; Natural Resources Defense Council: New York, NY, USA, 2012.
20. FAO (Food and Agriculture Organization of the United Nations). Food Wastage Footprint: Impacts on Natural Resources, Summary Report. Available online: http://www.fao.org/docrep/018/i3347e/i3347e.pdf (accessed on 22 October 2018).
21. Katare, B.; Serebrennikov, D.; Wang, H.H.; Wetzstein, M. Social-Optimal Household Food Waste: Taxes and Government Incentives. *Am. J. Agric. Econ.* **2017**, *99*, 499–509. [CrossRef]
22. Lusk, J.; Ellison, B. A Note on Modelling Household Food Waste Behaviour. *Appl. Econ. Lett.* **2017**, *24*, 1199–1202. [CrossRef]
23. Wansink, B.; Wright, A.O. “Best if Used By . . . ” How Freshness Dating Influences Food Acceptance. *J. Food Sci.* **2006**, *71*, 354–357. [CrossRef]

24. Tsiros, M.; Heilman, C.M. The Effect of Expiration Dates and Perceived Risk on Purchasing Behavior in Grocery Store Perishable Categories. *J. Mark.* **2005**, *69*, 114–129. [CrossRef]
25. Qi, D.; Roe, B.E. Foodservice Composting Crowds Out Consumer Food Waste Reduction Behavior in a Dinning Experiment. *Am. J. Agric. Econ.* **2017**, *99*, 1159–1171. [CrossRef]
26. List, J.A.; Gallet, C.A. What Experimental Protocol Influence Disparities between Actual and Hypothetical Stated Values? Evidence from a Meta-Analysis. *Environ. Resour. Econ.* **2001**, *20*, 241–254. [CrossRef]
27. Carson, R.T.; Groves, T. Incentive and Informational Properties of Preference Questions. *Environ. Resour. Econ.* **2007**, *37*, 181–210. [CrossRef]
28. Leib, E.B. Is That Milk Past Its 'Sell By' Date? Drink It Anyway. Available online: http://www.latimes.com/opinion/op-ed/la-oe-0211-broad-leib-food-label-accuracy-20160211-story.html (accessed on 22 October 2018).
29. Private Label Manufacturers Association (PLMA). "Today's Primary Shopper. Society May Be Radically Changing but Women Still Dominate the Marketplace." PLMA Consumer Research Study. 2013. Available online: https://plma.com/2013plma_gfk_study.pdf (accessed on 22 October 2018).
30. Rose, J.M.; Bliemer, M.C.J. Sample Size Requirements for Stated Choice Experiments. *Transportation* **2013**, *40*, 1021–1041. [CrossRef]
31. Train, K.E. *Discrete Choice Methods with Simulation*; Cambridge University Press: New York, NY, USA, 2009.
32. Hole, A. Fitting Mixed Logit Models by Using Maximum Simulated Likelihood. *Stata J.* **2007**, *7*, 388–401.
33. Bhat, C. Quasi-random maximum simulated likelihood estimation of the mixed multinomial logit model. *Transp. Res. B* **2001**, *35*, 577–669. [CrossRef]
34. Alpízar, F.; Carlsson, F.; Martinsson, P. Using Choice Experiments for Non-Market Valuation. *Econ. Issues* **2001**, *8*, 83–110.
35. Haab, T.C.; McConnell, K.E. *Valuing Environmental and Natural Resources: The Econometrics of Non-Market Valuation*; Edward Elgar: Northampton, MA, USA, 2002.
36. Bliemer, M.C.J.; Rose, J.M. Confidence Intervals of Willingness-to-Pay for Random Coefficient Logit Modles. *Transp. Res. Part B* **2013**, *58*, 199–214. [CrossRef]
37. Hensher, D.A.; Greene, W.H. The Mixed Logit Model: The State of Practice. *Transportation* **2003**, *30*, 133–176. [CrossRef]
38. Revelt, D.; Train, K. *Customer-Specific Taste Parameters and Mixed Logit*; Working Paper No. E00-274; Department of Economics, University of California: Berkeley, CA, USA, 2000.
39. Poe, G.L.; Giraud, K.L.; Loomis, J.B. Computational Methods for Measuring the Difference of Empirical Distributions. *Am. J. Agric. Econ.* **2005**, *87*, 353–365. [CrossRef]
40. Stiglitz, J.E. Imperfect Information in the Product Market. *Handb. Ind. Organ.* **1989**, *1*, 769–847.
41. Dewey, C. You're about to See a Big Change to the Sell-By Dates on Food. *The Washington Post*. 16 February 2017. Available online: https://www.washingtonpost.com/news/wonk/wp/2017/02/16/a-barely-noticeable-change-to-how-food-is-labeled-could-save-americans-millions/?utm_term=.858d640be2d0 (accessed on 22 October 2018).
42. Ellison, B.; Lusk, J. Examining Household Food Waste Behavior: A Vignette Approach. Presented at the 2016 Agricultural and Applied Economics Association Annual Meeting, Boston, MA, USA, 31 July–2 August 2016.
43. Lusk, J.; Shogren, J.F. *Experimental Auctions*; Cambridge University Press: New York, NY, USA, 2007.