Food Distribution Research Society

Journal of Food Distribution Research
Volume 51, Issue 3, pp. 41–62

Factors Influencing Consumers' Expected Food Waste

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Abstract

This study analyzes the factors influencing consumers' self-reported expected food waste when preparing a meal at home versus buying the meal already prepared. Results show that far-off expiration dates are expected to generate less food waste—particularly for fresh produce used in larger quantities and chicken. The Ready to Heat meal generated the lowest expected food waste. Convenient meal alternatives have the potential to reduce organic food waste, aside from any potential packaging waste, by facilitating the handling of products in transit, improving logistics, and reducing organic food waste.

Keywords: fresh produce, RTH meals, shelf life, food waste

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Introduction

While waste is inevitable at any stage of the food supply chain, the amount of waste at the consumer level is large. At earlier points of the supply chain, much of the pre- and post-harvest food that a farmer or distributor cannot sell can be repurposed in many ways, such as animal feed, compost, and biomaterials (Ellison, Muth, and Golan, 2019). However, at the consumer level, there is little opportunity for repurposing and recycling; instead, most of it goes to waste (Parfitt, Barthel, and Macnaughton, 2010; Buzby, Wells, and Hyman, 2014). The U.S. Environmental Protection Agency (EPA) reported that in 2018, 63 million tons of food waste originated from commercial, institutional, and residential sectors in the United States. Also, the EPA reported that in 2017, 41 million tons of food waste were generated, constituting 22% of discarded municipal solid waste (U.S. Environmental Protection Agency, 2020). The problem is not exclusive to the United States; Gustavsson et al. (2011) argue that approximately one-third of the food produced for human consumption along the global supply chain is lost or wasted.

The negative impacts of food waste include the loss of valuable resources, both the food itself and the water and energy that went into the production of that food (Hall et al., 2009; Cuellar and Webber, 2010; Kummu et al., 2012; Birney et al., 2017). Moreover, food waste that ends up in landfills generates harmful greenhouse emissions, such as CO2 and methane, that have been linked to global warming and other environmental costs (Venkat, 2011; United Nations, Food and Agriculture Organization, 2013; Heller and Keoleian, 2015; Moult et al., 2018).

Based on economic theory, the optimal level of food waste is the quantity at which the marginal benefit of reducing food waste is equal to its marginal cost. Lusk and Ellison (2017) found that the optimal level of household-level food waste is a function of prices, wages, time constraints, and marginal productivities of raw food and time in producing meals. They note that an individual's characteristics will affect these marginal productivities. In addition to traditional economic theory arguments, consumers might experience disutility from the regret of being wasteful when throwing out food, or disutility from the lack of variety when eating leftover foods. In practice, there are multiple challenges to achieving the optimal level of food waste on an aggregate or national level. First, there is no consensus on the definition of food waste, and there are no standard procedures to measure food waste (Buzby, Wells, and Hyman, 2014; Ostergren et al., 2014; Ellison, Muth, and Golan, 2019). As a result, the socially optimal amount of food waste is unknown, making it difficult to set goals for the level of food waste reduction that would generate a positive impact on society (Katare et al., 2017). Ellison, Muth, and Golan (2019) suggest that reducing food waste and food loss at earlier stages of the production cycle is likely costly, and the reduction methods may impose environmental costs. The earlier stages of the production cycle refer to all stages of the agri-food supply chain before reaching the consumer (i.e., production at the field, processing, shipping, transportation, and retail). Other researchers claim that a more impactful measure is to target consumers because much of their waste stems from improper grocery planning, lack of understanding of date labels and expiration dates, general indifference toward waste, or the opinion that food waste reduction is someone else's responsibility (Gustavsson et al., 2011; Stefan et al., 2013; Graham-Rowe, Jessop, and Sparks, 2014).

In light of the problem that food waste represents to society, in this study, we aim to investigate whether ready-to-heat (RTH) meals, besides convenience, offer an opportunity to reduce household food waste. This aim is based on the finding by Wilson et al. (2017), who found that consumers perceive that convenient meals, such as fresh salads with a longer shelf-life, can reduce food waste. Convenient prepared meals offer an interesting case to measure preference for meal options with reduced food waste. In general, convenient foods are categorized into four groups: (1) Ready-to-eat (RTE) meals that are consumed as purchased (e.g., sandwiches, salads, etc.), (2) Ready-to-heat (RTH) meals that require no more than 15 minutes of heating before consumption (e.g., refrigerated, frozen, dehydrated, and canned meals), (3) Ready-to-end-cook (RTEC) meals that require more than 15 minutes of heating before consumption, and (4) Ready-to-cook (RTC) meals that are minimally prepared and require full cooking (Costa et al., 2001).

The objective of this study is to estimate the factors influencing consumers' self-reported expected food waste for selected food products. The selected foods include a meal purchased already prepared and RTH, and a bundle of raw ingredients used to prepare that same meal at home. The factors considered in this analysis are: (1) three different expiration-dates for the raw ingredients and the RTH meal: close, medium, and far-off; (2) sociodemographic characteristics, and (3) grocery purchase habits of survey respondents.

The inclusion of the bundle of raw ingredients and a RTH meal is further aligned by the literature analyzing the food sustainability paradox, raised by Cavaliere and Ventura (2018). These authors claim that food products with an enhanced shelf-life and convenient meal alternatives increase the sustainability of the food supply chain by facilitating the handling of products in transit, improving logistics, and reducing food waste. However, consumers relate an enhanced food shelf-life and convenience with a lack of naturalness or freshness. Our study further explores the food sustainability paradox by comparing consumers' expected food waste of two products, one bundle perceived as natural and fresh versus a food product that is not. It is worth noting that RTH meals may lower food waste at the consumer level, yet may generate more food waste at earlier stages of the supply chain. We underscore the importance of reducing waste at the consumer level, as literature has demonstrated that at earlier stages of the supply chain, farmers and distributors can repurpose products that are imperfect for the fresh market; however, at the consumer level there are limited options for repurposing or recycling (Parfitt, Barthel, and Macnaughton, 2010; Buzby, Wells, and Hyman, 2014; Ellison, Muth, and Golan, 2019).

Literature Review

A branch of the literature on food waste focuses on food waste mitigation strategies. Reutter et al. (2017) and Ellison, Muth, and Golan (2019) suggest that there are tradeoffs along the supply chain where reducing food waste in earlier stages (in the field or processing facility) may be more beneficial or less costly from an environmental standpoint, compared to reducing it at the retail or consumer stage. Rutten (2013) analyzes whether food waste mitigation strategies would have a positive impact on societal welfare and food security and finds that the demand and supply of food play a role in estimating such impact. For example, in the presence of perfectly inelastic supply and demand curves, if loss reductions in the supply level involve cost increases (resulting in a

decrease in quantity supplied), then the welfare impacts will be lower, as the effect will be that prices will increase and quantities supplied will decrease. Aligned with such findings, Ellison, Muth, and Golan (2019) stress the importance of cost-benefit analyses when assessing food waste mitigation strategies. They suggest these costs include those faced by businesses, the government, and consumers, as well as the opportunity cost of the time needed to reduce food waste.

Understanding consumers' motives to waste food can improve mitigation strategies. For example, Visschers, Wickli, and Siegrist (2016) found that consumers are motivated to waste food when they have a "good-provider" identity, a general term that describes a type of person who enjoys having ample amounts of food even if it generates more waste. Delley and Brunner (2017) classified a sample of consumers based on their attitudes toward food waste using parameters such as whether they review what they have in stock at home, their thriftiness, usage of leftovers, perceived environmental impact, general awareness of food waste behavior, and good provider identity, and their likelihood to engage in planned shopping and be price- and discount-driven.

Neff, Spiker, and Truant (2015) suggested that consumers' main motivations to reduce food waste involve saving money and setting an example. They argued the main reasons for wasting food stem from avoidance of foodborne illness and preference for freshness. Qi and Roe (2016) found that 70% of the respondents in their study agreed that discarding food when the expiration date passes reduces the chance of foodborne illness, whereas 60% of respondents agreed that in order to eat fresh meals some food waste is needed.

Date labels on food products are believed to be a major cause of food waste. In fact, the lack of standard regulations for expiration dates leads to inconsistent labeling practices across states and to the discretion of industries. Consumers are often misled by the labels "use by," "best before," and "sell by" labels; these labels are perceived as indicators of safety, when they are meant to indicate when food will be at its peak taste. This leads food processors, retailers, and consumers to discard food that is perfectly safe to sell or eat (Broad Leib et al., 2013). Researchers have measured the impact of these different labels on food waste. Wilson et al. (2017) measured the impact of date labels, such as "use by," "sell by," "fresh by," and "best by," on food waste through auctions for products of diverse sizes and types. They found that, overall, the label "use by" had the lowest mean expected waste. Wilson, Miao, and Weis (2019) analyzed the effect of quality ("best if used by") versus safety labelling ("use by") and found that the likelihood of consuming a product based on the type of label varies by product.

In general, studies agree that consumers' previous negative experiences and perceived risk affect their interpretation of date labels, making them more likely to discard a product before it expires and increasing food waste (Broad Leib et al., 2013; Miles and Frewer, 2001; Tsiros and Heilman, 2005; Wilson et al., 2017). To our knowledge, this is the first study to estimate expected percentages of food waste comparing a bundle of raw ingredients and a prepared RTH meal made with the same bundle of raw ingredients.

Methodology

Data Collection and Survey Design

Data were collected through an online survey using the Qualtrics platform and the Qualtrics market research consumer panel. Qualtrics randomly selected and recruited a representative sample of U.S. consumers, following Census sociodemographics in terms of age, income, education, ethnicity, and rural/urban place of living. In addition, the selection criteria included individuals who were 18 years old or older, in charge of the grocery shopping in the household, and had consumed a convenient prepared meal within the 3 months prior to taking the survey. The survey was distributed from September 13 to October 1, 2017. In total, 377 complete responses were obtained.

Respondents were asked to report what percentage, ranging from 0% to 100%, of the product their household was likely to consume before each of a set of three different expiration dates—a close, a middle, and a far-off date. The products included selected raw ingredients, including chicken, broccoli, tomatoes, garlic, and basil; also included was a refrigerated RTH meal, chicken piccata and penne rigate with broccoli. The latter was selected because this is a product that exhibited a balanced combination of protein (chicken), carbohydrate (pasta), and vegetable (broccoli) in the meal. These raw ingredients were chosen because they are ingredients found in the RTH meal. In this way, it is possible to compare side by side how much food is wasted when preparing the meal at home versus when buying the already prepared meal. An example of the question used to elicit expected food waste is included in Figure 1. To analyze the expected food waste, the data were tabulated as the difference between 100% minus the percentage they indicated they are likely to consume.

Suppose you are grocery shopping today and purchase the product below. What percentage of the following product are you (or your household) likely to consume before it expires, based on your recent consumption habits? For example, purchased 7/13/17.

		0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100 %
Q14a. Chicken breast (stored in your refrigerator) 	Use by (next day) Ex. 7/14/17											
	Use by (three days after) Ex. 7/16/17											
	Use by (5 days after) Ex. 7/18/17											

		0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100 %
Q14b. Broccoli (stored in your refrigerator) 	Use by (next day) Ex. 7/14/17											
	Use by (3 days after) Ex. 7/16/17											
	Use by (5 days after) Ex. 7/18/17											

		0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100 %
Q14c. Garlic (stored in your pantry) 	Use by (3 days after) Ex. 7/16/17											
	Use by (2 weeks after) Ex. 7/27/17											
	Use by (a month later) Ex. 8/13/17											

		0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Q14d. Tomatoes (stored in your pantry) 	Use by (next day) Ex. 7/14/17											
	Use by (3 days later) Ex. 7/16/17											
	Use by (a week later) Ex. 7/20/17											

		0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Q14e. Fresh Basil (stored in your refrigerator) 	Use by (next day) Ex. 7/14/17											
	Use by (a week later) Ex. 7/20/17											
	Use by (10 days later) Ex. 7/24/17											

		0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Q14f. Ready-to-eat meal (stored in your refrigerator) 	Use by (next day) Ex. 7/14/17											
	Use by (four days later) Ex. 7/17/17											
	Use by (two weeks later) Ex. 7/27/17											

Figure 1. Example of the Question Eliciting Expected Percentages of Food Consumed/Wasted

The expiration dates vary to match each product's typical shelf-life. These are obtained from the FoodKeeper App (U.S. Department of Health and Human Services, 2019). For example, raw chicken typically has a shelf-life of 3 to 5 days, so the survey specifies that the chicken expires within 1, 3, and 5 days from the date of purchase. Broccoli is presented with similar expiration dates: 1, 3, and 5 days. Tomatoes are presented with expiration dates of 1 day, 3 days, and 1 week. Basil is presented with expiration dates of 1 day, 1 week, and 10 days. Garlic had 3 days, 2 weeks, and 1 month. Finally, the refrigerated RTH meal chicken piccata and penne rigate with broccoli exhibited the expiration dates of 1 day, 4 days, and 2 weeks. This was based on the shelf-life of vacuum-packed-in-store refrigerated RTH meals (4 days) and commercially sealed RTH meals with USDA label (up to 2 weeks). The online survey was programmed in a way that the date of purchase coincided with the day the respondent took the survey. In addition, the survey included questions about food shopping habits, food consumption habits in general, consumption of RTH meals, and sociodemographic questions.

Data Analyses

Summary statistics of sociodemographic profiles include the estimation of frequency distributions and weighted averages. Summary statistics of expected food waste include the means and Tukey difference test estimation. A double-bounded Tobit model is used to estimate the parameter estimates of sociodemographic and purchase habit factors affecting the percentage of expected food waste. This model allows censoring in both tails of the probability distribution of the dependent variable. In our case, the dependent variable is the stated percent of expected food waste, whose reported values are in the interval [0–100]. Figure 2 presents the histogram showing the distribution of the dependent variable, expected food waste percentage.

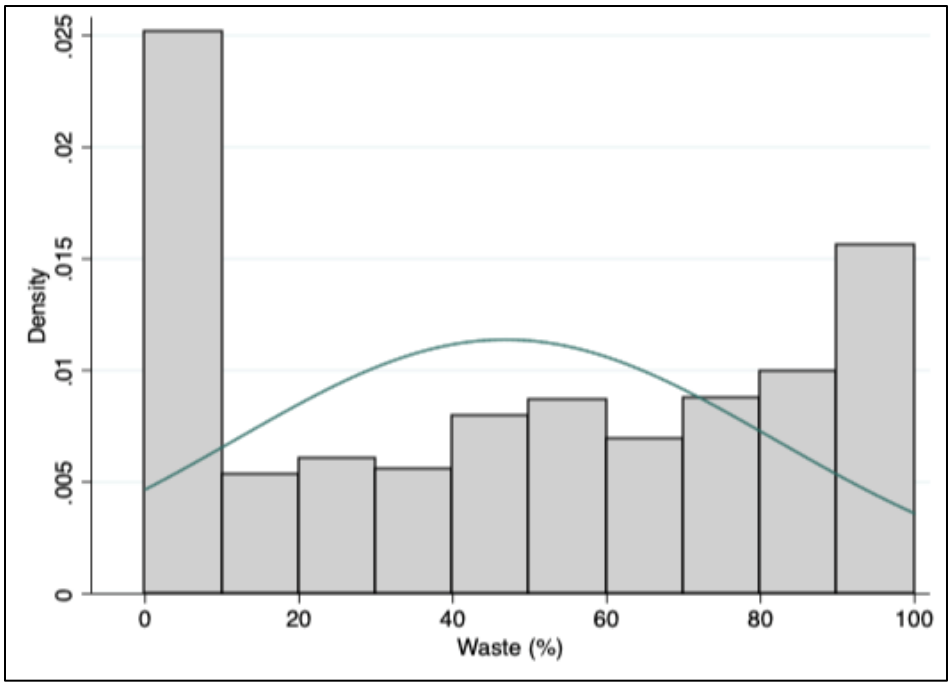

Figure 2. Histogram Showing the Distribution of the Dependent Variable, Waste Percentage

The Tobit model follows:

$$Y = \begin{cases} 0 & if\ Y^* \leq 0 \\ y^* & if\ 0 < Y^* < 100 \\ 100 & if\ Y^* \geq 100 \end{cases} \quad (1)$$

$$Y_i^* = X_i\beta + \epsilon_i \quad (2)$$

where $Y^*$is a latent variable that is observed for values within the range [0–100] and censored otherwise. X_i is the vector of explanatory variables, which include: expiration dates (close, medium, and far, which was excluded to omit the dummy variable trap); product category (garlic, basil, tomato, broccoli, chicken, and RTH meal [excluded option]); and sociodemographic characteristics of the respondent, which encompasses if female, if millennial (born after 1985); if income is above the U.S. median ($61.372 per year; U.S. Census, 2018c); if attained a 4-year college degree; if white ethnicity; if lives in a large city; if lives in the West, South, Midwest, and Northeast, which was omitted to avoid the dummy variable trap; if more than two individuals in the household; if children are present in the household; and if employed. Other respondents' characteristics of if consider themselves healthy, active, or if pay attention to food labels, and places they grocery shop (limited assorted establishments, online, farmers' markets, drugstore, convenience store, supermarkets, ethnic food stores, supercenter, warehouse, organic specialty stores, and discount stores), were also collected. Among these, farmers' markets was omitted to avoid the dummy variable trap. β is the vector of parameters to be estimated, and ϵ_i represents the error term that captures possibly unobservable factors affecting the expected percent of food waste and is assumed to follow a normal distribution.

The sociodemographic characteristics of the respondent were chosen based on previous findings on sociodemographic predictors of food waste behavior. Grasso et al. (2019) found that being older, unemployed, and working part-time were associated with less food waste in Europe (Spain and Denmark). In Denmark, being male was associated with more waste, but being part of a larger household implied less waste. Dusoroth and Peterson (2020) conducted a survey in Minnesota, U.S., and found that consumers who have established a pre-shopping and in-store behavior were less prone to waste fresh spinach and ground beef products. Pre-shopping routine includes making grocery shopping lists and checking food inventories at home before grocery shopping. The in-store behavior refers to buying impulses in the store or how prone shoppers are to stick to the shopping list. The place for grocery shopping could be an indicator of the level of pre-shopping and in-store behavior and, therefore, may impact one's proneness to waste food. Finally, we include self-perceptions of health and physical activity since these variables have been found to influence consumption of RTH meals (Cavaliere and Ventura, 2018). A Variance Inflation Factor (VIF) was conducted to infer whether independent variables included in the model exhibited collinearity. Test results prove no evidence of collinearity.

Results and Discussion

Respondents' Sociodemographic Profile

The sociodemographic characteristics of the sample of respondents to this survey are compared to the U.S. Census 2018 in Table 1 (U.S. Census Bureau, 2016a–b, 2018a–c). The data in this study represent more women, more educated, wealthier, more of white ethnicity individuals, and somewhat similar age compared to the general U.S. population. This profile is aligned with the selection criteria for the sample of respondents: should be in charge of the grocery shopping in the household and had consumed a convenient prepared meal within the 3 months prior to taking the survey. The requirement of being in charge of the grocery shopping explains the higher proportion of women in the sample of respondents (Dusoruth and Peterson, 2020). Besides the sociodemographic profile of respondents to this survey (e.g., more women, more educated, wealthier, more of white ethnicity individuals) follows the profile of individuals who tend to be more responsive to surveys (Curtin, Presser, and Singer, 2000). Urban/rural residency, employment, and regional distribution of respondents of our survey are comparable to those estimated for the general population using the U.S. Census data (2016a-b). In relation to shopping habits, 53% of the respondents reported shopping for two people, and around 82% said they do not shop for someone under the age of 18. Concerning self-reported health, 37% of the respondents reported being somewhat healthy, and 31% reported being healthy. Thirty-one percent of respondents reported being somewhat active, and 38% of respondents reported being active.

Table 1. Sociodemographic Variables by Frequency for Selected Characteristics

		Frequency (%)	
Variable	**Description**	**Survey Sample**	**U.S. Census 2018**
Gender	Male	28.12	49.20
	Female	71.88	50.80
Education	Some school	0.80	12.40
	High school graduate	9.55	27.10
	Community college	16.98	29.00
	4-year college or university	37.93	19.40
	Advanced or professional degree	34.75	12.10

Table 1 (continued).

		Frequency (%)	
Variable	**Description**	**Survey Sample**	**U.S. Census 2018**
Community	Rural area	19.89	19.30[a]
	Small town	19.89	
	Small city	22.55	80.70
	Large city	37.67	80.70
Occupation	Manual labor	8.49	–
	Services and hospitality	8.22	–
	Education, business, and information	36.34	–
	Miscellaneous	2.65	–
	Retired	12.73	–
	Not employed	31.56	–
Age	18–24 years	4.77	9.54
	25–34 years	11.67	13.80
	35–44 years	13.00	12.60
	45–54 years	10.88	13.20
	55–64 years	22.55	12.80
	65+ years	37.14	15.20
Income	Less than $25,000/year	7.96	20.20
	$25,000–$34,999/year	6.10	9.30
	$35,000–$49,999/year	10.34	12.60
	$50,000–$74,999/year	19.36	17.50
	$75,000–$99,999/year	19.63	12.50
	$100,000/year or more	36.60	27.90
Number of people you shop for	One person	20.69	–
	Two people	53.32	–
	Three people	13.00	–
	Four or more people	13.00	–
Number of people you shop for who are under 18	None	81.70	–
	One person	7.69	–
	Two people	7.16	–
	Three people	1.86	–
	Four or more people	1.59	–

Table 1 (continued).

Variable	Description	Frequency (%)	
		Survey Sample	U.S. Census 2018
Race	American Indian or Alaskan Native	0.80	0.70
	Asian	2.12	5.40
	Black	2.65	12.30
	Hispanic	3.45	17.80
	Middle Eastern	–[b]	–
	Pacific Islander	0.27	0.20
	White	86.47	61.10
	Mixed race	1.59	2.60
	Prefer not to respond	2.65	–
Region	New England	7.16	4.56[c]
	Middle Atlantic	10.88	12.86
	East North Central	13.26	14.47
	West North Central	7.16	6.55
	South Atlantic	16.71	19.79
	East South Central	1.33	5.85
	West South Central	4.77	12.21
	Mountain	9.55	7.36
	Pacific	28.91	16.34
	Other	0.27	–
Health status	Not healthy	0.80	–
	Somewhat healthy	6.90	–
	Neither healthy nor unhealthy	9.28	–
	Somewhat healthy	36.87	–
	Healthy	46.15	–
Activity level	Not active, never exercise	5.57	–
	Somewhat active, occasionally exercise	30.50	–
	Active, exercise 1–3 times per week	38.46	–
	Very active, exercise > 4 times per week	25.46	–

[a] Based on 2015 estimates.

[b] There was no direct group Middle Eastern nor respondents who selected this category in the survey.

[c] Based on 2016 estimates.

Summary Statistics for Expected Food Waste

The means and differences of the waste percentage for the three expiration date categories, close, medium, and far, are presented in Table 2. Respondents stated they would waste a larger percentage of food with a close expiration date (57%), followed by a medium (47%), and finally by a far-off date (36%), with respect to the time the survey was taken. The pairwise differences

among expiration date categories are all statistically significant. The food waste reduction between a far and close expiration date is at 22%, and the reduction between a far and medium expiration date is at 11.7%. These results suggest that post-harvest technologies that could enhance the shelf-life of fresh produce may reduce expected food waste. Also, these results support that enhancements to shelf-life shall be applied to all products included in this study, that is, fresh produce, protein source, and even prepared meals.

The mean percent of food waste across food products included in this study are also presented in Table 2. Consistently, one can observe four groups of foods in terms of food waste, across all expiration date categories. The largest expected waste percentage is for garlic (57%) and basil (56%). The second largest expected food waste percentage is for tomato (45%) and broccoli (44%). The third largest expected waste is for chicken (42%), and the smallest food waste percentage is for the refrigerated RTH meal (37%). These results suggest that perishable produce, such as garlic, basil, tomato, and broccoli, is contingent to more food waste compared to protein sources, such as chicken. This could be attributable to the relatively higher unit prices of chicken, and the type of food preparation used for these products (often served raw versus cooked or reheated). Also, garlic and basil are subject to higher waste percentages compared to tomatoes and broccoli. This may be because the former are usually sold in bunches and are used in small quantities in meals prepared at home. These results imply that selling fresh produce, such as garlic or basil, in smaller quantities is a possible food waste mitigation strategy.

Table 2. Expected Percentage of Food Waste by Expiration Date and Food Product—Means and Tukey Differences

	Expected Food Waste Percentage		
Variables	**Means**	**Difference**	***p*-value**
Food waste percentage by expiration date			
Close expiration date	57.29	–	–
Medium expiration date	47.42	–	–
Far expiration date	35.72	–	–
Food waste percentage comparison across expiration dates			
Far–close	–	-21.57	0.00
Medium–close	–	-9.87	0.00
Medium–far	–	11.70	0.00
Food waste percentage by food product			
Garlic	56.81	–	–
Basil	55.99	–	–
Tomato	45.24	–	–
Broccoli	44.39	–	–
Chicken	41.81	–	–
RTH meal chicken piccata	36.62	–	–

Table 2 (continued).

	Expected Food Waste Percentage		
Variables	**Means**	**Difference**	***p*-value**
Food waste percentage comparison across food products			
Garlic-chicken	–	15.01	0.00
Garlic-broccoli	–	12.43	0.00
Tomato-RTH meal	–	8.62	0.00
Tomato-chicken	–	3.43	0.14
Tomato-broccoli	–	0.85	0.99
Garlic-basil	–	0.83	0.99
Chicken-broccoli	–	-2.58	0.43
RTH meal-chicken	–	-5.19	0.003
RTH meal-broccoli	–	-7.77	0.00
Tomato-basil	–	-10.75	0.00
Tomato-garlic	–	-11.58	0.00
Broccoli-basil	–	-11.60	0.00
Chicken-basil	–	-14.18	0.00
RTH meal-basil	–	-19.37	0.00
RTH meal-garlic	–	-20.19	0.00

Note: Expiration date varies by product.

Results from the Tukey difference test indicate that there are no statistically significant differences between garlic and basil waste, but differences are observed between garlic and tomatoes, garlic and broccoli, basil and tomatoes, and basil and broccoli waste. Meanwhile, there are no statistically significant differences between tomatoes and broccoli. However, there are statistically significant differences between the waste of chicken and garlic, chicken and basil, chicken and tomatoes, and chicken and broccoli. Finally, the differences in food waste between the refrigerated RTH meal and each of the raw ingredients included are statistically significant.

The average food waste percentages by product and expiration date category are presented in Table 3. These results are consistent—closer expiration dates imply higher food waste percentages for all products included in this study. Also, across expiration date categories, the product exhibiting the highest food waste percentage is garlic, followed by basil, tomatoes, broccoli, chicken, and the refrigerated RTH meal. The differences in the average food waste by product and by expiration date category are also presented in Table 3. The results are not consistent with those in Table 2. These differences highlight the importance of the different expiration dates on the propensity to waste food. Mixed evidence is found when food waste percentage is analyzed by each expiration date category. For example, no differences are found between food waste percentages of garlic and basil across three expiration date categories. When comparing garlic with chicken and tomato, statistically significant differences are observed across three expiration dates. However, statistically significant differences are observed between food waste for garlic and broccoli for a close and medium, but not for a far expiration date.

Table 3. Expected Food Waste Percentage by Expiration Date and Food Product—Means and Tukey Difference Test

	Means		
Food Product	**Close**	**Medium**	**Far**
Garlic	71.78	58.54	40.12
Basil	65.59	56.28	46.10
Tomato	58.43	46.21	31.07
Broccoli	55.47	45.36	32.33
Chicken	50.89	42.91	31.62
RTH meal	41.56	35.21	33.08

	Comparisons					
Food Product	**Difference**	***p*-value**	**Difference**	***p*-value**	**Difference**	***p*-value**
Broccoli-basil	-10.114	0.004	-10.918	0.001	-13.769	0.000
Chicken-basil	-14.695	0.000	-13.369	0.000	-14.480	0.000
Chicken-broccoli	-4.581	0.911	-2.451	1.000	-0.711	1.000
Garlic-basil	6.191	0.474	2.265	1.000	-5.979	0.542
Garlic-broccoli	16.305	0.000	13.183	0.000	7.790	0.107
Garlic-chicken	20.886	0.000	15.634	0.000	8.501	0.043
RTH meal-basil	-24.021	0.000	-21.069	0.000	-13.013	0.000
RTH meal-broccoli	-13.907	0.000	-10.151	0.003	0.756	1.000
RTH meal-chicken	-9.326	0.013	-7.700	0.119	1.467	1.000
RTH meal-garlic	-30.212	0.000	-23.334	0.000	-7.034	0.239
Tomato-basil	-7.159	0.212	-10.069	0.004	-15.024	0.000
Tomato-broccoli	2.955	0.999	0.849	1.000	-1.255	1.000
Tomato-chicken	7.536	0.143	3.300	0.997	-0.544	1.000
Tomato-garlic	-13.350	0.000	-12.334	0.000	-9.045	0.020
Tomato-RTH meal	16.862	0.000	11.000	0.001	-2.011	1.000

The differences in food waste percentages are not consistent for basil and other foods. For example, considering a close expiration date, there are no statistically significant differences in food waste between basil and tomato, but differences are observed between basil and tomato for medium and far expiration dates. Meanwhile, consistently across all three expiration dates, higher food waste percentages are stated for basil compared to broccoli and chicken.

Similarly, across all three expiration date categories, statistically significant differences in food waste percentages are observed between broccoli and basil, but not for broccoli and tomato, or broccoli and chicken. These results highlight the importance of the time-until-expiration dates when considering food waste. For example, the consumer will be indifferent between wasting chicken, broccoli, or garlic with an enhanced shelf life (far expiration date) or buying a refrigerated RTH meal.

Factors Affecting Food Waste

Parameter estimates from the double censored Tobit model are presented in Table 4. Marginal effects of each of the variables are also presented in Table 4, and are discussed in the following paragraphs. Results are consistent with the summary statistics in that a closer expiration date implies higher waste percentages compared to longer expiration dates. The expected waste for foods with a close and medium expiration date is 18% and 10% larger, respectively, than the expected waste for foods with a far-off expiration date. These results are consistent with findings in Qi and Roe (2016), who found that consumers discarded food when the expiration date had passed to reduce the risk for foodborne illness. The results are also consistent with findings in Tsiros and Heilman (2005) and Miles and Frewer (2001) in that consumers are more likely to discard a product before it expires, increasing food waste.

Table 4. Parameter Estimates and Marginal Effects for the Double Censored Tobit Model Depicting Factors Affecting Expected Food Waste Percentage

Variables	Parameter Estimate	Standard Error	Marginal Effects	Standard Error
Intercept	34.087***	3.701		
Close expiration date	27.081***	1.259	18.225	0.889
Medium expiration date	16.118***	1.261	10.644	0.857
Garlic	26.855***	1.783	18.906	1.362
Basil	25.457***	1.784	17.843	1.353
Tomato	12.643***	1.790	8.488	1.255
Broccoli	11.848***	1.791	7.932	1.249
Chicken	7.816***	1.798	5.158	1.220
Female	5.726***	1.189	3.620	0.741
Millennial	2.398	1.610	1.551	1.051
Income above U.S. median	1.016	1.376	0.650	0.877
4-year college	-2.336*	1.287	-1.507	0.835
White	-8.756***	1.625	-5.815	1.117
Lives in large city	3.890***	1.141	2.508	0.739
Lives in the West	3.726**	1.611	2.400	1.043
Lives in the South	1.384	1.684	0.891	1.089
Lives in the Midwest	-4.005**	1.701	-2.533	1.062
More than two in household	-4.878***	0.736	-3.128	0.472
Presence of children	1.559	1.687	1.005	1.094
Healthy	-4.034***	1.498	-2.625	0.989
Active	3.139***	1.194	2.003	0.758
Employed	-4.385***	1.118	-2.819	0.721
Attention to labels	-2.235	1.605	-1.446	1.047
Limited assortment stores	6.000***	1.635	3.943	1.101

Table 4 (continued).

Variables	Parameter Estimate	Standard Error	Marginal Effects	Standard Error
Online	5.677**	2.499	3.744	1.694
Drugstore	1.449	1.366	0.933	0.883
Convenience stores	1.200	1.659	0.773	1.073
Supermarket	-0.485	1.383	-0.312	0.890
Ethnic food stores	-0.428	2.536	-0.274	1.619
Supercenter	-1.385	1.290	-0.886	0.822
Warehouse	-2.373	1.542	-1.508	0.972
Organic specialty stores	-5.537***	1.228	-3.518	0.773
Discount stores	-13.205***	2.519	-7.910	1.404
Log likelihood	-20,169.602	No. obs.	6,786	

Notes: *, **, *** means the parameter estimates are statistically significant at the 10%, 5%, and 1% level. There are 6,786 observations as the study; this includes six products, each with three expiration dates, and 377 respondents (6 x 3 x 377 = 6,786).

Four groups can be observed in terms of food waste when comparing ingredients to RTH meals. The largest expected food waste percentage is for fresh produce that is used in small quantities in recipes. The expected food waste percentage for garlic is 19%, and basil is 18% larger than the expected waste of RTH meals. The second group is fresh produce that is used in larger amounts in prepared at-home meals. The expected waste of tomato and broccoli is 8% larger than the expected food waste percentage of RTH meals. The third group is chicken, the protein source, with an expected food waste percentage that is 5% larger than the expected food waste percentage of RTH meals. This result is consistent with Qi and Roe (2016), who found that consumers expect to waste food in order to eat fresh meals, however, from a different perspective. Qi and Roe (2016) center their findings on the fact that consumers tend to waste leftovers or ingredients with limited remaining shelf-life.

With respect to sociodemographic characteristics of the sample, females stated they would waste 4% more, compared to males. This finding contrasts with Dusoruth and Peterson (2020), who found that male respondents to a survey conducted in Minnesota, U.S., exhibited a higher tendency to waste fresh spinach. Parameter estimates for being a millennial and having an income higher than the U.S. median are not statistically significantly different from 0. This finding is different from Dusoruth and Peterson (2020), who found that younger and higher income individuals in their study showed a lower tendency to waste fresh spinach. Estimates for completion of a 4-year college degree and for white ethnicity are statistically significant and negative for the food waste percentage. Consumers with a 4-year college degree stated they would waste 2% less food than those without a 4-year college degree. This finding coincides with Dusoruth and Peterson (2000), who found that individuals with higher educational attainment had a lower tendency to waste ground beef products. White-ethnic respondents stated they would waste 6% less food than non-white respondents. Similarly, this finding coincides with Dusoruth and Peterson (2000), who found that white respondents had, on average, a lower tendency to discard ground beef.

Estimates for living in large cities and the U.S. West region are positive and statistically significant. Results indicated that survey respondents living in large cities exhibited a higher expected waste by 3% more compared to respondents living in non-large cities. Similarly, survey respondents living in the U.S. West region, exhibited a higher expected waste by 2%, compared to respondents living in the Northeast. In contrast, individuals living in the Midwest exhibited a lower expected food waste by 3% less compared to those in the Northeast. These results signal regional differences in expected food waste percentage; however, we cannot identify the specific lifestyle factors, including ability and access to compost, that would explain such differences.

Respondents in households with more than two individuals stated that they would waste 3% less food, compared to households with less than two individuals. This is consistent with Grasso et al. (2019) in that consumers in Denmark with larger households wasted less food. The parameter estimate for presence of children is not statistically significantly different from 0. Individuals who consider themselves healthy stated they would waste 3% less food, compared to those who considered themselves not healthy. Also, those who consider themselves as active stated that they would waste 2% more food, compared to those who consider themselves as not active. Individuals who are employed full-time would waste 3% less food compared to those who are retired or unemployed. This finding is different from Grasso et al. (2019), who found that unemployed and employed part-time respondents were associated with less food waste. Interestingly, the parameter estimate for attention to labels was not statistically significantly different from 0. The different findings on the effects of sociodemographics on expected food waste between this study and Grasso et al. (2019) may be explained by the specific contextual circumstances faced by consumers in each country being surveyed. Grasso et al. (2019) surveyed consumers in Spain and Denmark, and the present study surveyed consumers in the U.S. The effect of the specific context of each country is further supported by the differences in food waste behavior between the two countries surveyed by Grasso et al. (2019).

With respect to places where respondents shop for groceries, findings show that those buying food at limited assortment stores (e.g., Grocery Outlet, Aldi's, Save-A-Lot) and online (e.g., Amazon Fresh) stated they would waste 4% more compared to respondents who buy at farmers' markets. Those buying food at organic specialty stores (e.g., Whole Foods, Trader Joe's) and discount stores (e.g., WinCo, Fareway) stated they would waste less food, 4% and 8%, respectively, compared to respondents who buy from farmers' markets. These latter results are aligned with Delley and Brunner (2017), who found that consumers who are price- and discount-driven are more likely to waste less food. Dusoroth and Peterson (2020) found that consumers who have established a pre-shopping and in-store behavior were less prone to waste spinach. These results emphasize that food retailer format (e.g., online and "brick and morter") could indicate the level of pre-shopping and in-store behavior and, therefore, the proneness to waste.

Conclusions

Food waste is a sizable problem for society. Valuable resources are wasted, and pollution is generated. Researchers studying food waste concur that food waste at the consumer level is the most problematic and that mitigation strategies should be directed to consumers. This study

estimates the factors influencing consumers' self-reported expected food waste for a bundle of raw ingredients used to prepare a meal at home compared to the same meal bought already prepared and RTH.

Findings in this study indicate that expiration dates further away leave respondents less food waste across all food products included in this study. Also, fresh produce used in smaller quantities in meals prepared at home, such as garlic and basil, are expected to generate more food waste compared to fresh produce used in larger quantities, such as broccoli and tomatoes. Among the bundle of raw ingredients, the lowest expected food waste percentage was for the protein source, chicken. Comparing the bundle of raw ingredients with the RTH meal, the latter implied the lowest expected food waste percentage.

Results from this study support the idea that fresh produce with enhanced shelf-life could mitigate food waste. Since the taste, quality, and safety of food deteriorate over time, and consumers are risk averse, they waste more of a food product that is closer to the expiration date. Hence, part of a mitigation strategy could rest on advancing post-harvest technologies that improve fresh produce shelf-life, provided consumers accept these novel post-harvest technologies. These results also suggest that a potential food waste mitigation strategy at the grocery store retail level could include selling some types of fresh produce in smaller quantities.

Further, findings from this study imply that refrigerated RTH meals can reduce food waste compared to a bundle of raw ingredients, adding to the food sustainability paradox raised by Cavaliere and Ventura (2018). Convenient meal alternatives have the potential to reduce organic food waste, aside from packaging waste, by facilitating the handling of products in transit, improving logistics, and reducing organic waste. Even considering that food waste could be generated at an earlier stage of the supply chain, past research demonstrates that there are more alternatives to mitigate or repurpose waste at earlier stages of the supply chain compared to the consumer stage. This research highlights the need to improve policies and other efforts to increase consumer knowledge and awareness of the trade-offs of preparing foods at home, that is, natural and fresh foods; with perceptions of environmental consciousness, that is, options to reduce food waste, to aid in the decision-making process of choosing a food product.

Limitations of the study include that the survey tool was administered to subjects who are in charge of grocery shopping and who have consumed a RTH meal in the last 3 months. While it was important for the study to gather subjects in charge of deciding what food items to purchase and were knowledgeable of RTH meals, this could have affected the generalizability of the findings. Further research warrants a more ample selection of consumers, not screening for subjects in charge of grocery shopping or who have consumed a RTH meal. Suggestions for further research warrant the collection of information on respondents' perceptions and level of knowledge on how food waste affects the environment, accessibility and availability to large food storage appliances, and to compost options.

Acknowledgment

This work was supported by the U.S. Department of Agriculture, National Institute of Food and Agriculture, and the Agriculture and Food Research Initiative project [grant number 2016-68003-24840].

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