OUTDATED: THE EFFECT OF NOVEL FRESHNESS INDICATORS ON CONSUMER LIKELIHOOD TO WASTE FOOD

A Thesis

Presented to the Faculty of the Graduate School

of Cornell University

In Partial Fulfillment of the Requirements for the Degree of

Master of Science

by

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May 2021

ABSTRACT

Over 30% of total food production is wasted each year in the United States, with similarly concerning levels of food waste arising in countries across the world. In the United States and the United Kingdom, over 60% of food waste occurs at the consumer level. Consumer confusion over date label meanings is a major driver of consumer-level food waste and date labels represent an opportunity for improvement. Research is needed to investigate how consumers respond to date labels currently present in the market and how they may respond to date label innovations that provide new types of information. Here, I use an ordinal logit model to examine the effect of different date label treatments and food product types on consumer likelihood to discard past date food products in the United States and United Kingdom. Date label treatments include a novel Freshness Indicator, which provides consumers with clear, visual information about product quality in addition to common date label language. I find similar likelihood to discard across the US (n=579) and the UK (n=583) samples in the control treatment (no date label), with 26.35% and 23.40% of participants predicted to be likely to discard food products one day past the posted date. Our results show that participants in both the US and UK are predicted to have a similar likelihood to discard under the “Use By” and “Best if Used By” / “Best Before” date labels commonly seen in the market. The novel Freshness Indicator treatments show the greatest change in predicted likelihood to discard from the control treatment in both the US and UK samples. While our results find meaningful differences in predicted likelihood to waste across different types of food products, the date label treatment effects are relatively consistent across products in both countries overall.

BIOGRAPHICAL SKETCH

Born and raised in Birmingham, Alabama, Carter Weis has spent a majority of his intellectual life focused on food and agriculture topics. In 2013, he followed his agricultural interests to Auburn University, the land grant institution in Alabama. At Auburn, Carter was highly involved with the College of Agriculture as a student ambassador, peer advisor, and research assistant (RA). He worked closely with Dr. Norbert Wilson, professor of agricultural economics, to execute research related to food date labeling and food waste. He completed his Bachelor of Science in Agricultural Business and Economics in May 2017.

In continued pursuit of his food economics and food waste interest, Carter matriculated to Cornell University's Dyson School of Applied Economics and Management in August 2017 to pursue a Master of Science in Applied Economics and Management. Mr. Weis contributed to the Cornell academic community, serving as a Teaching Assistant for a variety of courses in the Dyson school curriculum.

In addition to professional and academic interests, Carter enjoys sharing meals with friends and family and exploring new places.

ACKNOWLEDGMENTS

I would like to thank Dr. Bradley Rickard for his support and patience throughout the research and writing process for this thesis. I would also like to thank Dr. Miguel Gomez for his helpful feedback as a member of my committee. Lastly, I would like to express my greatest appreciation for my family, who love and support me in all of my triumphs and challenges.

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LIST OF ABBREVIATIONS

AAP – Average Adjusted Probability

AME - Average Marginal Effects

BIUB – Best If Used By

Defra – Department for Food, Environment, and Rural Affairs

EU – European Union

FDA – Food and Drug Administration

FSA – Food Standards Agency

FI – Freshness Indicator

FWRA – Food Waste Reduction Alliance

HAPW – High Adjusted Probability of Waste

LTD – Likelihood to Discard

LTW – Likelihood to Waste

NGO – Non-governmental Organization

ReFED – Rethink Food Waste through Economics and Data

US – United States

USDA – United States Department of Agriculture

UK – United Kingdom

WRAP - Waste & Resources Action Programme

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CHAPTER 1

INTRODUCTION / BACKGROUND

1.1 Food Waste Patterns and Mitigation Strategies

Across the rich world, there has been increased interest in efforts to reduce food waste at the consumer level as countries implement different policy strategies to reach the United Nations' Sustainable Development Goal Target 12.3 to "halve per capita global food waste at the retail and consumer levels" by the year 2030 (UN, 2017). While global and national estimates of food waste vary depending on the methodology used, it is clear that a substantial amount of food is lost or wasted and not consumed by humans. In the 2021 Food Waste Index Report, the United Nations Environment Program estimates that around 931 million tons (17% of total global food production) of food waste was generated in 2019, 61% of which came from households, 26% from food service, and 13% from retail.

In response to the Sustainable Development Goals, countries have taken different approaches to work towards reducing food waste within their unique food systems. While consumer food waste is a problem across the world, rich countries in the West have been identified as particularly wasteful. A 2014 USDA report estimates that "in the United States, 31 percent—or 133 billion pounds—of the 430 billion pounds of the available food supply at the retail and consumer levels in 2010 went uneaten. Retail-level losses represented 10 percent (43 billion pounds) and consumer-level losses 21 percent (90 billion pounds) of the available food supply" (Buzby, Wells, and Hyman 2014). In the United States, this 2010 estimate is used as the baseline for the 2030 SDG food waste reduction goal, with a 50% reduction translating to reducing food waste by approximately 66 billion pounds per year. The USDA has not provided an official update on progress toward this goal. Rethink Food Waste through Economics and Data (ReFED) is a US non-profit focused on

combatting food waste. In the 2016 Roadmap to Reduce U.S. Food Waste by 20 Percent, ReFED estimates that roughly 63 million tons (126 billion pounds) of food waste is generated in the United States annually (ReFED, 2016). ReFED estimates that US food waste increased by 11.2% from 2010 to 2016 and leveled off around 80 million tons from 2016 to 2019 (ReFED Insights Engine). Of this wasted food, 37% ($158 billion) was wasted at the household level (ReFED, 2021).

In the United Kingdom, the Waste and Resources Action Programme (WRAP) leads national food waste management efforts in cooperation with the Department for Environment, Food, and Rural Affairs (Defra) and the Food Standards Agency (FSA) (WRAP, 2019). WRAP estimated annual food waste in the UK at around 9.5 million tons in 2018, with household food waste making up 70% of the total (6.6 million tons).This had a value of over £19 billion a year and would be associated with more than 25 million tons of greenhouse gas (GHG) emissions (WRAP, 2020). The UK reduced food waste by 27% from the period between 2007 (SDG base year) and 2018 (WRAP 2020), the largest decrease of any country measuring progress toward SDG Target 12.3. This reduction in food waste is correlated with national public education campaigns and efforts to reform food product date labeling since 2015. WRAP estimates that as much as 20% of household food waste in the UK is a result of date label confusion (WRAP, 2011).

1.2 Roles of Date Labels in Consumer Food Waste

In the United States, consumer confusion around food product date labels is considered to be a leading driver of household level food waste as well. Date labeling refers to the posted dates and accompanying language that food manufacturers and retailers print on packaged food products. In the United States, these date labels are commonly referred to as “expiration dates”, but their meaning is less straightforward (Davenport et al., 2019). There are currently no federal regulations regarding food date

labeling (other than for infant formula), which has resulted in a proliferation of date label language used in the market. While some states require date labels on specific products, date labels are generally applied on a voluntary basis at both the federal and state level. Examples include “use by” , “best by”, “sell by”, “best if used by”, “expires on”, “best before”, and “fresh until”, among others (FSIS; Reiley, 2019) In the absence of standard federal regulation, these date labels do not have consistent legal definitions (if any) across states, and consumers are not provided with a clear understanding of their meaning. This inconsistency in regulation contributes to consumer confusion regarding date labels, with many consumers believing that date labels carry meanings that they are not legally required to carry, especially meanings about food product safety. When consumers mistakenly believe date labels communicate specific information about food product quality/freshness or food product safety, they may discard products which are past their posted date but still wholesome and safe to consume. To combat this, industry groups like the Food Waste Reduction Alliance (FWRA) and NGOs like ReFED have advocated for standardizing and simplifying the food product date labeling regime in the United States by utilizing only 2 date labels, one to communicate food safety and one to communicate food quality (ReFED, 2016; Consumer Brands Association, 2017). Since 2019, the Food and Drug Administration (FDA) has advocated for a single date label phrase, “Best if Used By”, to clearly communicate product quality to consumers. However, it is clear that food manufacturers and retailers currently have the freedom to apply date labels to their products however they see fit in the United States (Reiley, 2019).

In the United Kingdom, the food date labeling environment has less complexity and potential for confusion. Food product date labeling is regulated at the national level according to Regulation (EU) No. 1169/2011 and requires all food products to be labeled with a date of minimum durability, with some exceptions for

fresh produce, baked goods, and alcoholic beverages. This can be either a quality-based “Best Before” date or a safety-based “Use By” date. While manufacturers have the choice of deciding which date label to apply to their products, “Use By” dates are recommended only for products that pose specific microbiological food safety risks. In the UK, food products are not permitted to be sold or donated after their printed “Use By” date. Recent efforts by WRAP have focused on encouraging food manufacturers and retailers to reduce the use of “Use By” dates on products that do not pose a specific microbiological food safety risk (WRAP, 2019).

1.3 Intelligent Packaging Technology

With consumer confusion about date label meanings for food quality and safety leading to waste of otherwise wholesome food, there is a marked need to improve food packaging information and reduce information asymmetry between food manufacturers/retailers and consumers. In particular, there is a need for clear, real-time information regarding food product quality and microbiological safety (Extabide et al., 2021). Intelligent packaging technology improves food packaging through the use of sensors and indicators that provide dynamic information about food products after they have passed from manufacturers to retailers and consumers (Yam et al., 2005). While there are many different types of intelligent packaging technologies, they typically communicate information to consumers using visual indicators, such as color changing dots, that are easy to understand. While ongoing research is focused on the development and application of new intelligent packaging technologies for commercial use, consumers are not yet familiar with these types of technologies and research is needed to investigate potential consumer response.

1.4 Research Question and Contribution

This study seeks to understand the effect of food date labeling on consumer likelihood to waste. We developed a combined within-subject and between-subject experimental survey, in which we ask participants from the United States (US) and United Kingdom (UK) to report their anticipated likelihood of discarding 15 different food products under different date label treatments. We introduce a novel set of experimental treatments using an on-package Freshness Indicator combined with date label language to provide participants with additional information. A mixed effects ordered logit model is used to estimate and calculate average adjusted probabilities (AAPs) of likelihood to discard under each of the date label treatments. We find similar likelihood to discard across the US (n=579) and the UK (n=583) samples in the control treatment (no date label), with 26.35% and 23.40% of participants predicted to be likely to discard food products one day past the posted date. Our results show that participants in both the US and UK are predicted to have a similar likelihood to discard under the "Use By" and "Best if Used By" / "Best Before" date labels commonly seen in the market. The novel Freshness Indicator treatments show the greatest change in predicted likelihood to discard from the control treatment in both the US and UK samples. While our results find meaningful differences in predicted likelihood to waste across different types of food products, the date label treatment effects are relatively consistent across products in both countries overall.

CHAPTER 2

LITERATURE REVIEW

2.1 Food Product Date Labeling Regulations - United States

In the United States, there are no federal regulations that formalize legal definitions or standardize the use of food date labels across products. At the federal level, there are no regulations that require food products to be labeled with an open date that is visible to consumers, other than for infant formula. Under the Infant Formula Act of 1980, the Food and Drug Administration (FDA) set standard nutrition requirements for infant formula and required infant formula to be labeled with a "Use By" date, determined based on how long the product would maintain an adequate concentration of nutrients (The Dating Game, 2013). Notably, these requirements do not specify any meaning related to product freshness or food safety. According to the FDA, food manufacturers are not required to include quality-based date labels on packaged food, so there are no standard descriptions for use on food labels. As a result, there are wide variety of phrases used on food product date labels (FDA, 2019).

In a 2019 report, the FDA explicitly states that "manufacturers apply date labels at their own discretion and for a variety of reasons. The most common is to inform consumers and retailers of the date to which they can expect the food to retain its desired quality and flavor" (FDA, 2019). The United States Department of Agriculture (USDA), which has federal regulatory authority over poultry, meat, and certain egg products, does not generally require date labels on regulated products. However, they do require that food producers who choose to include an open date, either voluntarily or according to state law, accompany the date with a date label

phrase to indicate the meaning of the date. While USDA requires the date label phrase to be either “packing”, “sell by”, or “use before”, no distinction is made between the three phrases to indicate a difference in meaning or how each phrase is meant to be applied (The Dating Game, 2013).

In the absence of federal regulation, many states have adopted their own laws and regulations regarding food product date labeling. In most cases, labels are only required on certain types of food products that carry specific food safety risks, such as shellfish, and voluntary labeling guidance is provided for the remainder of products. Broad Leib et al. classify states into 4 categories “(1) Those that regulate the presence of date labels on certain foods but do not regulate sales after those dates; (2) Those that do not regulate the presence of date labels but broadly regulate sales after such dates if date labels are voluntarily applied; (3) Those that regulate both the presence of date labels and, broadly, the sale of products after those dates; and (4) Those that do not require or regulate date labels at all.” This diverse range of date labeling regulations across states only adds to consumer confusion and the potential for misunderstanding of the various date labels that exist in the market. For example, Alabama state law does not require date label on food products, but allows for 26 different date labeling phrases to be used interchangeably with no distinction in meaning if open dates are voluntarily applied (Ala. Admin. Code r. 80- 1-22-.33, 2013).

The Food Safety Inspection Service (FSIS) of the USDA explicitly states “it is important that consumers understand that the dates applied to food are for quality and not for safety. Food products are safe to consume past the date on the label, and

regardless of the date, consumers should evaluate the quality of the food product prior to its consumption" (FSIS). Industry groups and NGOs like ReFED have advocated for standardizing and simplifying the food product date labeling regime at the federal level in the United States by utilizing only two date labels, one to communicate food safety and one to communicate food quality. These advocacy efforts have recently been codified in the proposed Food Date Labeling Act of 2019, HR 3981 before the United States Congress. This proposed legislation calls for using "Use By" as an indicator of food safety ("discard date") and using "Best if Used By" as an indicator of food quality ("quality date"). Under this proposed legislation, open dating would remain voluntary at the federal level, but all open dates printed on food product packaging would be required to be preceded by "Use By" or "Best if Used By". Food product manufacturers and retailers would maintain the power to decide which of the two proposed labels to apply to their products and to set the open dates. This proposed legislation explicitly does not "prohibit or restrict the use of time-temperature indicator labels or similar technology that is in addition to or in lieu of any uniform quality date label phrase or uniform discard date label phrase".

2.2 Food Product Date Labeling Regulations - United Kingdom

In the United Kingdom, food product date labeling has been regulated at the national level, with a requirement for food products to carry a date of minimum durability in some form, since the enactment of the Food Labelling Regulations 1980 / No 1849 in January 1983. Currently, food product date labeling is regulated at the national level according to Regulation (EU) No 1169/2011 of the European Parliament and of the Council that requires all food products to be labeled with a date of

minimum durability accompanied by the “Best Before” label (with some exceptions for fresh, unpackaged food). “The ‘date of minimum durability of a food’ means the date until which the food retains its specific properties when properly stored”. For foods that are highly perishable and pose an increased risk of a microbiological health hazard, the date of minimum durability is required to be replaced by a “Use By” date. It is illegal to sell a food product after it has passed its “Use By” date, as it is deemed unsafe for human consumption (Regulation (EU) No 1169/2011). This legislation went into effect in the United Kingdom in December 2014.

While this legislation reduces the number of food product date labels present in the market and improves the clarity of the 2 permitted date labels, it does not provide specific definitions for the “Use By” or “Best Before” labels. Food manufacturers and retailers have the freedom to decide how they apply these labels to their products and how they determine ranges for the posted dates that accompany them. Notably, neither of these date labels provide any information regarding food safety as a result of product handling or storage conditions. WRAP’s recent guidance and efforts with retailers have focused on reducing “Use By” dates to being used only on products that pose a specific microbiological safety risk and removing date labels from products like fresh, uncut produce that do not require them under current law (WRAP, 2019).

2.3 Consumer Perception of Food Product Date Labels

Overall, there is substantial evidence that some consumers are confused by food product date labels. In particular, consumers are confused about the differences in meaning between different date labels and whether they communicate information about food product quality, freshness, or safety. In the United States, consumers

assume that certain date labels have specific meanings, for example “Use By”, as being indicative of food safety, while the FSIS has stated that no date labels in the United States communicate any information about microbiological safety. Despite confusion regarding date label meanings, most consumers check date labels to help inform their decision-making. In an online survey on household food behaviors, Davenport et al. find that about 70% of participants frequently check “expiration dates” (Davenport et al., 2019).

Survey results from this study find that concerns relating to food safety and food quality are among the most important factors consumers consider when deciding to keep or discard food, with consumers paying most attention to odor, appearance, and date labels (Davenport et al., 2019). A national survey on consumer perception of date labels conducted by the Harvard Law School Food Law and Policy Clinic found that “Best if Used By”, “Best By”, and “Freshest By” were perceived as indicators of food quality by about two-thirds of respondents and that “Expires On” was perceived as an indicator of food safety by just over half of respondents. Survey respondents were more confused by “Use By”, with 42% perceiving this label as an indicator of food safety and 40% perceiving it as an indicator of food quality. This survey also found that younger consumers (age 18-34) were most likely to mistakenly perceive all date labels as indicators of food safety (Broad Leib et. al., 2016). Further, about one-third of consumers surveyed mistakenly believe that date labels are federally regulated in the United States (Broad Leib et. al., 2016).

Wilson, Miao, and Weis (2018) provide additional evidence that consumers are confused by current date labels. In this study, survey respondents are asked to indicate

their agreement with the meaning of "Best By" and "Use By" date labels across 4 different attributes (safety, quality, taste, nutrition). They find that respondents associate "Use By" more with safety and nutrition, when compared to "Best By", and associate "Best By" more with taste, when compared to "Use By". "Use By" and "Best By" are both associated with quality at levels that are not statistically significantly different from each other. Overall, differences across the two date labels ("Use By" and "Best By") are small in magnitude, suggesting that consumers have a difficult time distinguishing between their meanings. This result is not surprising, as there are no clear or distinct meanings for these labels in the two states (Alabama and New York) where the respondents were surveyed.

2.4 Review of Research on Household Food Waste in Response to Date Labels

Consumers make decisions to keep or discard food products based on date labels. In a nationally representative survey examining U.S. consumers' behaviors concerning food waste, Neff et al. (2015) find that "91% of respondents said they pay attention to date labels". Research in experimental economics has gone beyond basic survey data to further analyze how consumers make decisions around food waste in response to changes in date labels and other variables. In an experiment using milk, Roe et al. (2018) find that consumer discard intentions differ for milk bottles with "Sell By" dates, compared to milk bottles with no date label. In this experiment, participants are given identical milk in separate bottles (one group with "Sell By" dates) and asked to report their discard intentions upon sensory evaluation of the milk. Each flight of milk contained one container of milk bottled 15 days, 25 days, 30 days and 40 days prior to the study date. The "Sell By" date for the commercial bottler

providing the containers was 18 days after the day of bottling, meaning that the containers with a date label would appear as 3 days prior, 7 days post, 12 days post and 22 days post the “Sell By” date, respectively. Discard intentions were lower for milk with a “Sell By” date compared to milk without a date label when the milk was still within its posted date. However, for past date samples, discard intentions were significantly higher for the samples with a “Sell By” date, compared to those without a date label. These results suggest that consumers do waste food products at different rates in the presence of date labels than they would without date labels. However, the results do not explicitly measure the direction or magnitude of the effects.

Wilson et al. (2017) go further to investigate the role of date labels on food waste levels, looking at differences across product package size and product category. In this experiment they used four date labels that each used different language. One date label was more suggestive of a food safety concern (‘‘Use by”), two were more suggestive of a food quality concern (‘‘Fresh by” and ‘‘Best by”), and one was suggestive of retailer responsibilities rather than a label directed at the final consumer (‘‘Sell by”). They find that ‘‘Use by”, which consumers perceive to be more about food safety, may lead to more expenditures on food waste relative to date labels about quality or other attributes (‘‘Best by”, ‘‘Fresh by” or ‘‘Sell by”). These findings suggest that consumer perception of date label meanings can lead to increased waste, especially when consumers mistake date labels to have meanings related to food safety.

Ellison and Lusk (2018) use a vignette approach to describe a series of scenarios to consumers in which they are asked to state their food discard intentions.

With a vignette focused on milk, they found that a subset of consumers chose to discard the milk simply due to the posted date being one day past, even when given sensory confirmation that the product had not degraded in quality. (Ellison and Lusk, 2018). These findings suggest that some consumers respond to past product dates by wasting, even in the absence of date label phrases. Open dates can override sensory evaluation as a decision factor in the choice to consumer or discard a food product.

2.5 Smart Labels and Intelligent Packaging Technology

Intelligent packaging technology offers a solution for improving the information that is available for consumers regarding food product quality and safety. Intelligent packaging technology can be defined as a "packaging system that is capable of carrying out intelligent functions (such as detecting, sensing, recording, tracing, communicating, and applying scientific logic) to facilitate decision making to extend shelf life, enhance safety, improve quality, provide information, and warn about possible problems" (Yam et al., 2005). Increasing the use of smart labels, like time-temperature indicators, could provide consumers with more clear information regarding food quality and safety and contribute to the reduction of food waste (Broad Leib et al., 2013).

Vanderroost et al. (2014) provide an overview of current intelligent packaging technologies, categorizing these technologies into sensors, indicators, and radio frequency identification (RFID). Indicators are regarded as the most commercially mature and viable type of intelligent packaging technology, especially in the context of food packaging. Indicators "provide immediate visual, qualitative (or semi-quantitative) information about the packaged food by means of a color change, an

increase in color intensity or diffusion of a dye along a straight path" (Kerry et al., 2006). Indicators tend to be classified either as freshness indicators or time-temperature indicators. "Freshness indicators provide immediate product quality information resulting from microbial growth or chemical changes within a food product" (Vanderroost et al., 2014). Examples of this technology include thermochromic inks, which change color to indicate when a food product has passed a specified level of quality or freshness (Newsome et al., 2014).

Different freshness indicators work in different ways, depending on their applications, but typically detect metabolites from microbial growth or volatile organic compounds. Lee et al. (2019) have developed and tested a freshness indicator that changes color from yellow to green to indicate real-time degradation of quality (spoilage) in chicken breast. Time-temperature indicators communicate information about the temperature history of food products. Proper handling and storage temperature conditions are among the most important factors for maintaining food safety. Vanderroost et al. (2014) describe other applications of freshness indicators and time temperature indicators in various countries, with most applications focusing on high value products like fish, meat, and dairy. While intelligent packaging technology has not been widely utilized in consumer-facing food packaging in the United States and United Kingdom, this technology provides an opportunity to provide consumers with more accurate, real-time information regarding the quality, freshness, and microbial safety of the food products they are deciding to purchase, keep, or discard. Increasing the application of this technology can reduce consumer

uncertainty about food products and enable consumers to better avoid discarding wholesome food.

Fortin et al. (2009) find that US consumers value freshness indicators and are willing to pay for the increased information provided by freshness indicators. Consumers have a less elastic demand for freshness indicators included on fresh meat products compared to salad greens, suggesting that food safety and quality information is most desired for products with increased safety risks. While consumer willingness to pay estimates may vary across food products, the estimated cost of including the freshness indicators is less than $0.05 per package (Fortin et al, 2009). These findings suggest that with further research and commercialization, consumers are likely to not only accept but deliberately choose food products with freshness indicators at prices they are already used to paying in the near future.

CHAPTER 3

METHODS – SURVEY AND EMPIRICAL APPROACH

3.1 Experimental Design and Survey

We designed a survey to elicit consumer's anticipated likelihood to discard 15 different food and beverage products under different date label treatments. In all, we collected data from 579 participants in the United States (US) and 583 participants in the United Kingdom (UK). Separate surveys were used for participants from each country in order to take into account differences in food choice environments and product familiarity between the two countries. In both of the surveys, participants were asked to report their likelihood to discard 15 different food products on a 5-point Likert scale (1 = "Extremely Unlikely", 5 = "Extremely Likely"). In order to reduce bias, participants were also given the option to choose a "Do Not Consume" option if they do not consume the product presented for any reason. The same 15 food products were used in each country, with slight naming and package size differences to mimic market conditions in each country. The 15 products were: Bread, Butter, Chicken, Cookies / Biscuits, Eggs, Fruit, Ham, Jam, Juice, Milk, Nuts, Salad, Soda / Fizzy Drink, Soup, Yogurt. We used product names and package sizes to describe the products, rather than product images, in order to eliminate any brand-level bias or confusion amongst the participants.

We use a combined between-subject and within-subject experimental design. All participants see 2 date label treatments, the control treatment (with no date label / posted date only) and one experimental treatment. All participants see all 15 products in each of the treatments they are placed in, for a total of 30 likelihood to discard

questions. Treatment order and product order were randomized to reduce ordering bias. However, by nature of this randomization, some participants are shown an experimental treatment before the control treatment. We have accounted for this with an "order" dummy variable in the model.

Participants were asked to report their anticipated likelihood to discard the entire product under each date label treatment, given that the product's on-package posted date is one day past (yesterday's date). In the United States, there were a total of 10 experimental date label treatments. Four of the date labels included language that is commonly seen on food product date labels in the United States: "Use By", "Best If Used By", "Best By", and "Sell By". The remaining six date label treatments included a Freshness Indicator, paired with either "Use By" or "Best if Used By" language. These two date labels ("Use By" and "Best If Used By") were chosen for the Freshness Indicator treatments because they are the two date labels advocated for by policymakers and industry groups in efforts to reduce date label confusion. The Freshness Indicator was described to participants as signaling the freshness of the product using a color-coded system. The Freshness Indicator treatments include date label language currently seen in the market, combined with a Freshness Indicator color dot. This color dot is a visual representation of product freshness, with 3 different colors indicating different levels of freshness. Green represents "fresh", blue represents "less fresh" and purple represents "past fresh" (Appendix Exhibit 1). The 10 date label treatments for the United States sample are "Use By", "Best if Used By", "Best By", "Sell By", "Use By – Green Freshness Indicator", "Use By – Blue Freshness Indicator", "Use By – Purple Freshness Indicator", "Best if Used By –

Green Freshness Indicator", "Best if Used By – Blue Freshness Indicator", "Best if Used By – Purple Freshness Indicator".

In the United Kingdom, there were a total of 8 date label treatments, in addition to the control. There are fewer date label treatments than in the United States because all food products with date labels in the United Kingdom are required to include either "Use By" or "Best Before" language. The 8 date label treatments are "Use By", "Best Before", "Use By – Green Freshness Indicator", "Use By – Blue Freshness Indicator", "Use By – Purple Freshness Indicator", "Best Before – Green Freshness Indicator", "Best Before – Blue Freshness Indicator", "Best Before – Purple Freshness Indicator".

In the experiment task, participants were shown a food product and a posted date (one day past today's date) and asked to imagine a scenario in which they must decide whether to discard the product. Participants are asked to report the likelihood that they will discard each product variation they are shown. It is important to note that in this scenario, participants were told that they had paid full retail price for the product, the posted date is one day past (yesterday's date), the food product is commercially packaged and unopened, the participants have stored the product in their own home, and the participant confirms that the food product does not taste, smell, or look unusual. These informational conditions are constant across all date label and food product variations. Thus, the only variables that change from scenario to scenario are the date label seen and the type of food product. After the experiment task, participants receive some "attention check" questions as a way to monitor the validity

of responses. Participants are then asked a series of sociodemographic questions, followed by questions about their household food behavior.

This survey was designed in the Qualtrics survey platform and distributed to participants online via Prolific, a UK-based research distributor. Prolific maintains regular samples of research participants and requires minimum compensation of $6.50 / hour for survey tasks. Respondents in this survey completed the task in an average of 15 minutes. The United States survey data was collected in May 2018, and the United Kingdom survey data was collected in November 2018.

3.2 Empirical Model

Following Ellison and Lusk (2018), we estimated an ordinal logit model for the likelihood to discard question to analyze the effects of the date label treatments and food product types on the likelihood to discard a product one day past its posted on-package date. The ordinal logit model is ideal to model scale-response questions (Likert-scale), like the outcome variable in our experimental survey task (UCLA). As the outcome variable scales from “Extremely Unlikely” (1) to “Extremely Likely” (5), positive coefficients can be interpreted as increasing the likelihood of waste, and negative coefficients can be interpreted as decreasing the likelihood of waste (discarding the product). In the model, there are 4 intercepts to accommodate the 5-point-scale outcome variable. Likelihood to discard (Discard) is modeled as a function of date label treatment (Label) and food product type (Product). The model also includes the binary indicator variables, *Order* and *Attention,* which are used to capture ordering effects in date label treatments and attention check responsiveness. When *Order* = 0, participants saw the control treatment first. Observations have an *Order* =1

value when participants were shown an experimental date label treatment first, before the control. In the survey, participants were shown an attention check question, which required them to read a full set of instructions in order to answer correctly. Participants who answered correctly take on an *Attention* = 0 value. Participants who answered incorrectly were then shown an additional attention check question, which they were required to answer correctly in order to complete the survey, and take on an *Attention* = 1 value. Participants who were shown the second attention check question and answered incorrectly were dropped from the survey and are not included in the data model.

LABEL is a categorical variable that represents the different date label treatments participants are shown in the two surveys. The control treatment is the base level for the variable and all regression coefficients represent a change from or comparison to the control treatment. In the United States survey, *LABEL* has 10 levels in addition to the control. In the United Kingdom survey, *LABEL* has 8 levels in addition to the control.

PRODUCT is a categorical variable that represents the different food product types participants are shown. *PRODUCT* takes on 15 levels, with soda / fizzy drink as the base level in both the US and UK surveys. All coefficients are interpreted as a change from or comparison to soda / fizzy drink.

The ordinal logit model is an extension from the traditional binary choice logit model. In the binary logit model, coefficient values represent a change in the log-odds of the outcome associated with each variable and are interpreted to represent a change in the probability of the choice outcome. The ordinal logit model extends this logic to

model an ordinal outcome variable. Thus, coefficient values for each independent variable represent a change in the log-odds of the outcome variable taking on a higher level. In this model, Discard is the outcome variable and is ordered from 1-5 ("Extremely Unlikely" – "Extremely Likely"). As higher levels of the outcome variable represent an increase in the likelihood to discard, positive regression coefficients are associated with an increase in likelihood to discard and negative coefficients with a decrease in likelihood to discard. Since the independent variables in the model are categorical variables, changes in likelihood to discard are relative to the base levels for each of the independent variables. For the *LABEL* variable, the control treatment with no date label is the base level. Coefficients for the different date label treatments represent changes in likelihood to discard compared to the control treatment. For the *PRODUCT* variable, soda / fizzy drink is the base level, as it was the product with the lowest frequency of "Extremely Likely" to discard responses. This means that all other levels of the *PRODUCT* variable are expected to have positive coefficients, representing an increase in the likelihood to discard compared to soda / fizzy drink.

Likelihood to discard for a given respondent, i, is modeled as a function of *LABEL*, t, and *PRODUCT*, a. Model 1 includes the effect of only the *LABEL* variable; Model 2 includes both *LABEL* and *PRODUCT* variables; and Model 3 includes *LABEL*, *PRODUCT*, and a full interaction between *LABEL* and *PRODUCT* variables. Z_i is an individual-specific fixed-effect included in the mixed-effects ordinal logit model. This fixed-effect parameter accounts for the correlation in responses that is created by all respondents providing multiple likelihood to discard responses.

Model 1: $LTD_{it} = f(LABEL_t; \boldsymbol{Z_i})$

Model 2: $LTD_{ita} = f(LABEL_t, PRODUCT_a; \boldsymbol{Z_i})$

Model 3: $LTD_{ita} = f(LABEL_t, PRODUCT_a,\ LABEL_t\ x\ PRODUCTt_a; \boldsymbol{Z_i})$

From the model specifications, we propose the four hypotheses to investigate the effects of *LABEL* and *PRODUCT* variables on likelihood to discard.

Hypothesis 1: $LTD(LABEL_t) \neq LTD(LABEL_0)$

Likelihood to discard for all date label treatments will be different from likelihood to discard under the control treatment.

Hypothesis 2: $LTD(PRODUCT_a) \neq LTD(PRODUCT_0)$

Likelihood to discard for all product types will be different from likelihood to discard in the case of the base-level product (soda / fizzy drink).

Hypothesis 3: $LTD(LABEL_{UB-Green}) < LTD(LABEL_{UB})$

$LTD(LABEL_{BIUB-Green}) < LTD(LABEL_{BIUB})$

$LTD(LABEL_{BBF-Green}) < LTD(LABEL_{BBF})$

Likelihood to discard for the Green Freshness Indicator date label treatments will be less than likelihood to discard for the corresponding date label treatments without a Freshness Indicator.

Hypothesis 4: $LTD(LABEL_{UB-Purple}) > LTD(LABEL_{UB})$

$LTD(LABEL_{BIUB-Purple}) > LTD(LABEL_{BIUB})$

$LTD(LABEL_{BBF-Purple}) > LTD(LABEL_{BBF})$

Likelihood to discard for the Purple Freshness Indicator date label treatments will be greater than likelihood to discard for the corresponding date label treatments without a Freshness Indicator.

3.3 Calculating Average Adjusted Probabilities (AAPs) and High Adjusted Probability to Waste (HAPW)

As the regression coefficients are expressed in terms of log-odds, it can be difficult to interpret coefficients in terms that are appropriate for choice scenarios. To improve the ease of interpreting the model, coefficient values are used to calculate average adjusted probabilities (AAPs) with the margins command in Stata 15.1. Average adjusted probabilities represent the estimated probability/likelihood of each response value (1-5) at given treatment levels for the independent variables. Coefficient estimates from Model 2 are used to calculate average adjusted probabilities, as interaction effects from Model 3 cannot be properly accommodated by the estimation process in Stata (Williams, 2012).

Average adjusted probabilities for "Somewhat Likely" (4) and "Extremely Likely" (5) are combined to represent the High Adjusted Probability to Waste (HAPW). HAPW represents the likelihood of respondents to have a high probability to discard the product. For each date label treatment, we compare the estimated HAPW to the control. These treatment effects represent the estimated increase or decrease in HAPW from the control treatment for each date label treatment, averaged across all products. We also estimate the HAPW for each food product type under the control date label treatment (no date label). Finally, we show results for the change (compared to control) in HAPW for each food product type under each date label treatment.

CHAPTER 4

DATA AND RESULTS

4.1 Descriptive Statistics

Table 1 shows likelihood to discard frequencies by date label treatment, including the control treatment, for the US sample. These frequencies represent the reported likelihood to discard the entire product one day past the printed date, across all products (average product), for each date label treatment. For the control treatment, with no date label, the largest share of respondents are "Extremely Unlikely" to discard the product (40.42%). 25.56% of participants were either "somewhat likely" or "extremely likely" to discard the entire product. For the Use By with Purple Freshness Indicator (Use By – Purple FI) treatment, 38.32% of participants were either "somewhat likely" or "extremely likely" to discard the entire product, the highest amongst all treatment groups. For the Best if Used By with Green Freshness Indicator (BIUB – Green FI) treatment, 61.30% of participants were "extremely unlikely" to discard the entire product, the most of any treatment group.

These preliminary results suggest that respondents are more unlikely to discard a product than they are likely to discard a product, just one day past the posted date. Further, the Purple Freshness Indicator treatments are associated with a higher likelihood to discard and the Green Freshness Indicator treatments with a lower likelihood. The date label treatments currently present in the market (Use By, Best If Used By, Best By, Sell By) have smaller differences from the frequencies in the control treatment that cannot be understood in the preliminary analysis.

Table 2 shows the descriptive results for the survey data from the UK experiment. For the control treatment, the largest share of respondents were "extremely unlikely" to discard the average product (42.87%), while 23.11% of participants were either "somewhat likely" or "extremely likely" to discard the product. For the Best Before with Purple Freshness Indicator (BBF – Purple FI) treatment, 33.73% of participants were "somewhat likely" or "extremely likely" to discard the entire product, the most of any treatment group. For the Use By with Green Freshness Indicator (Use By – Green FI), 54.24% of participants were "extremely unlikely" to discard the entire product, the most of any treatment group.

These preliminary results show that UK respondents are more unlikely to than likely to discard a product just one day past its on-package date. Further, there is evidence that participants respond to Freshness Indicators, with Green / "fresh" indicators decreasing the likelihood to discard and Purple / "past fresh" indicators decreasing the likelihood to discard. Best Before, the quality label, has a lower frequency of "Extremely Likely" to discard responses than Use By, the safety label.

Table 3 shows descriptive statistics for sociodemographic variables from the US survey, summarized by date label treatment. All participants are included in the control treatment and then randomly assigned to one of the 10 experimental treatments shown. Overall, the treatment groups are relatively similar to the control across the variables included. The BIUB – Blue FI treatment group has more males than average, and BIUB – Green FI has fewer. Best By has a larger share of non-white participants than average, while Best if Used By has a smaller share than average. Use By – Blue FI is less educated than average, and Best if Used By is more educated than average.

Use By – Blue FI has a slightly lower mean income than average. Sociodemographic variables are helpful to understand the sample population, but are not included in the regression models as explanatory variables for changes in likelihood to discard.

Table 4 presents descriptive statistics for sociodemographic variable for the UK survey, summarized by date label treatment for comparison across treatment groups. All participants are included in the control treatment and then randomly assigned to one of the 8 experimental treatments shown. Overall, the 8 treatment groups are relatively similar to the control group that includes all participants. BBF – Blue FI has a larger share of males than average. BBF – Green FI is slightly more educated than the average UK respondent, and Use By is slightly less educated. Mean age and mean income levels do not differ greatly across date label treatment groups. Overall, respondents in the US and UK report a similar likelihood to discard, with respondents in each country being more unlikely to discard than likely to discard. Respondents in the US (33) and UK (37) are similar in terms of average age, but US respondents report a higher mean income than UK respondents. The US sample has a larger share of male respondents (56%) than the UK sample (35%).

4.2 Regression Results from Ordinal Logit Model

The ordinal logit model is a mixed effects ordinal logit model with the dependent / outcome variable as reported likelihood to discard (1-5) (extremely unlikely - extremely likely). Independent variables are discrete/categorical variables representing date label treatment, food product treatment, attention check, and control/treatment order. There is a fixed effect on Participant ID, as each participant answers multiple likelihood to discard questions.

Table 5 and Table 6 show coefficient measures from 3 model specifications (Model 1, Model 2, Model 3) for the US and UK samples, respectively. Model 1 includes only date label treatment effects and does not include food product type as an independent variable. Model 2 includes both date label treatment effects and product-level effects. Model 3 is a full interaction model that includes date label treatment effects, product-level effects, and full interaction between label and product variables. In the table, coefficients for interaction terms have been omitted, as there are too many to list and all coefficients are not statistically significant. I will use Model 2 for all interpretation and future analysis, as the model without interaction terms allows for the calculation of marginal effects and predicted probabilities (Williams, 2012). Also, adding interaction terms in Model 3 results in very similar Log Likelihood and Chi-square measures to Model 2, suggesting that both models have similar explanatory power. Given this, I chose to use the simpler model specification (Model 2).

4.2.1 Ordinal Logit Model – United States

Table 5 shows ordinal logit regression results for the US sample. For the label variables, the control treatment is used as the base-level, so coefficients can be interpreted compared to the control treatment. As the coefficients correspond to a latent variable, the interpretation is in direction and comparative scale only. The outcome variable measured (Discard) is the reported likelihood to discard the entire food product given. (Extremely Unlikely = 1; Extremely Likely = 5). Therefore, positive coefficients can be interpreted as increasing the likelihood to discard ("more likely"), while negative coefficients represent a decrease in likelihood to discard ("less likely") compared to the base-level. For the product variables, soda is chosen as the

base-level since it had the highest frequency of "Extremely Unlikely" likelihood to discard responses, meaning that all product variable coefficients should be positive ("more likely" to discard than base case).

Additionally, the model contains the binary variables Order and Attention. These variables control for the effect of treatment presentation order and attention check, but are not statistically significant. For label variables, Use By – Green FI, Use By – Purple FI, BIUB – Green FI, BIUB – Purple FI, Best By, and Sell By are significantly different from the control treatment at the $p < 0.001$ level. Use By – Green FI, BIUB – Green FI , Best By, and Sell By all have negative coefficients, representing a decreased likelihood to discard compared to the control treatment with no date label. Use By – Purple FI and BIUB – Purple FI have positive coefficients, representing an increased likelihood to discard compared to the control treatment. Use By and Best If Used By are not significantly different from the control treatment, suggesting that respondents may not meaningfully differentiate between these labels. Use By – Blue FI and BIUB - Blue FI are also not significantly different from the control treatment, suggesting that "less fresh" does not add meaningful information to the Use By and BIUB labels. Interestingly, the Green and Purple Freshness Indicator treatments have coefficient values about 3 times larger than the Best By and Sell By treatments, suggesting that reported likelihood to discard is more affected by these new FI treatments than the Best By and Sell By treatments that participants may already be familiar with. Also, the FI treatments carry more information about product freshness.

For product variables, all coefficients are significant (at $p < 0.001$) and positive, suggesting that there is a meaningful role played by food product type in reported likelihood to discard. Coefficient values for most food products are greater than those seen for treatment variables, with chicken having the highest coefficient value (4.239). However, coefficient values can only be interpreted as a relative change from the variable base level, so the magnitude of label and product coefficients cannot be meaningfully compared.

4.2.2 Ordinal Logit Model - UK

Table 6 shows ordinal logit regression results for the UK sample. For label variables, Use By – Green FI, Use By – Blue FI, Use By – Purple , BBF – Green FI, BBF – Blue FI, and BBF – Purple FI are significantly different from the control treatment at the $p < 0.001$ level; and Best Before is significantly different from the control treatment at the $p < 0.01$ level. Use By – Green FI, BBF – Green FI, and Best Before have negative coefficients, representing a decreased likelihood to discard compared to the control treatment with no date label. Use By – Blue FI, Use By – Purple FI, BBF – Blue FI, and BBF – Purple FI have positive coefficients, representing an increased likelihood to discard compared to the control treatment with no date label. Use By is the only date label treatment that is not statistically different from the control treatment, suggesting that respondents may interpret Use By as the default date label.

It is important to note that food products in the UK are required to feature a date label phrase, so consumers may be unfamiliar with seeing food products with no date label, like in the control treatment. In this case, respondents may be cautious and

treat a product with no date label phrase as they would a product with a Use By date label. Respondents in the UK are more sensitive to the Freshness Indicator treatments than those in the US sample, with Blue / "less fresh" treatments increasing the likelihood to discard. Label treatments with Purple Freshness Indicators represent larger increases in likelihood to discard than treatments with Blue Freshness Indicators.

For product variables, all coefficients are significant at the $p < 0.001$ level, other than biscuits ($p < 0.05$) and nuts ($p < 0.01$). Fizzy drink is the base-level. All coefficients are positive, representing an increase in likelihood to discard compared to the base level (fizzy drink). Chicken has the greatest coefficient value (4.669), representing the greatest increase in likelihood to discard compared to fizzy drink.

4.3 Average Adjusted Probabilities (AAPs) – Date Label Treatments

Average Adjusted Probabilities (AAPs) are calculated from the regression coefficients in Table 5 (US) and Table 6 (UK) and represent the estimated likelihood of a single respondent choosing an outcome variable level or the estimated share of total respondents choosing an outcome variable level. AAPs are calculated for date label treatments, including the control, and represent the average effect of the date label treatment across all 15 products.

4.3.1 Average Adjusted Probabilities – US Date Label Treatments

Table 7 shows Average Adjusted Probabilities (AAPs) for each date label treatment for the "average" product (across all products) for the US sample. All date label treatments are shown, although the "Use By", "Best if Used By", "Use By – Blue FI", and "BIUB – Blue FI" treatments are not significantly different from the

control treatment. Under the control treatment, we estimate that respondents have a 41.54% chance of being "extremely unlikely" to discard the average food product and a 12.27% chance of being "extremely likely" to discard. To improve understanding and comparisons between date label treatments, Table 9 combines the AAPs for "extremely likely" and "somewhat likely" responses to create what will be referred to as High Adjusted Probability of Waste (HAPW) and represents the estimated share of respondents that will have a high probability to discard a product. HAPW is then shown as a treatment effect (compared to the control) in the last column.

Under the control treatment, HAPW is 26.35%. US treatment effects are shown graphically in Figure 1. Treatment effects are in the same direction as the regression coefficient values suggest. "Use By – Green FI" has the largest decrease in HAPW from the control treatment (-40.65%). BIUB – Green FI has a similarly large decrease in HAPW at 37.19% less than under the control treatment. "Best By" (-14.12%) and "Sell By" (-14.46%) also show decreases in HAPW from the control treatment with no date label. "Use By – Purple FI" (+45.20%) and "BIUB- Purple FI" (+47.40%) are the only date label treatments that show increases in HAPW compared to the control. Notably, HAPW is predicted to be in the same range for both Green Freshness Indicator treatments and for both Purple Freshness Indicator treatments.

This suggests that respondents may assign more meaning to the freshness information communicated by the Freshness Indicators, rather than the information they perceive to be communicated by the date label phrases. Further, Green Freshness Indicator treatments represent roughly the same decrease in HAPW from the control as Purple Freshness Indicator treatments represent an increase in HAPW.

4.3.2 Average Adjusted Probabilities – UK Date Label Treatments

Table 8 shows Average Adjusted Probabilities (AAPs) for each date label treatment for the "average" product (across all products) in the UK sample. All date label treatments are shown, although the "Use By" treatment is not significantly different from the control treatment. AAPs are calculated from the regression coefficients in Table 6. Under the control treatment, we estimate that respondents have a 43.60% of being "extremely unlikely" to discard the average food product and a 12.40% chance of being "extremely likely" to discard. Notably, these estimates are in line with the estimates in the United States sample. Table 9 combines the AAPs for "extremely likely" and "somewhat likely" responses to create HAPW. HAPW is then shown as a treatment effect (compared to the control) in the last column.

Under the control treatment, HAPW is 23.40%. Treatment effects are shown graphically in Figure 2. Treatment effects are in the same direction as the regression coefficient values from the ordinal logit model suggest. "BBF – Green FI" has the largest decrease in HAPW compared to the control (-29.06%). "Use By – Green FI" has a similarly large decrease in HAPW of 24.79%. "Best Before" also shows a decrease in HAPW compared to the control (-11.54%), although it is about half the decrease estimated for the two Green Freshness Indicator treatments. "Use By – Purple FI" (+38.89%) and "BBF – Purple FI" (+38.03%) are estimated to substantially increase HAPW compared to the control treatment. "Use By – Blue FI" and "BBF – Blue FI" are also predicted to increase HAPW compared to the control treatment by 14.10% and 18.80%, respectively. As in the US sample, the two Green Freshness Indicator treatments and the two Purple Freshness Indicator treatments have estimated

treatment effects in the same range, providing more evidence that respondents react to the freshness information provided by the FIs regardless of date label phrase.

4.4 Average Adjusted Probabilities and Treatment Effects by Product

To investigate product type effects, we calculate average adjusted probabilities for each product type from the regression coefficients in Table 5 (US) and Table 6 (UK). AAPs are calculated under the control treatment in order to eliminate any date label treatment interaction bias.

4.4.1 Average Adjusted Probabilities by Product (Control Treatment) - US

For the US sample, Table 10 shows AAPs by product under the control treatment, with HAPW in the last column. Overall, we find large differences in predicted HAPW across food products. In the US sample, soda is the base/control product used in the model, as it had the highest frequency of "Extremely Unlikely" responses in the preliminary analysis. Soda has the lowest HAPW of only 6.81%.

Participants are most likely to discard chicken, milk, and ham. Participants are least likely to discard soda, nuts, and cookies. For chicken, HAPW is estimated at 48.97%, the highest of all food products in the study. Participants are predicted to have a similarly high HAPW for milk (45.33%) and ham (43.03%). Compared to soda (6.81%), participants are predicted to have a similarly low HAPW for nuts (8.76%) and cookies (10.10%). HAPW for the average product under the control treatment is 26.35%.

4.4.2 Average Adjusted Probabilities by Product (Control Treatment) – UK

For the UK sample, Table 11 shows AAPs by product under the control treatment, with HAPW in the last column. In the UK sample, fizzy drink is the

base/control product used in the model, as it had the highest frequency of "Extremely Unlikely' responses in the preliminary analysis. Fizzy drink has the lowest HAPW of only 5.78%. Participants are most likely to discard chicken, ham, and milk. Participants are least likely to discard fizzy drink, biscuits, and nuts. For chicken, HAPW is estimated at 53.13%, the highest across all food products in the study.

Participants are predicted to have a similarly high HAPW for ham (42.21%) and milk (40.56%). Compared to fizzy drink (5.78%), participants are predicted to have a similarly low HAPW for biscuits (6.93%) and nuts (7.15%). In the UK sample, HAPW for the average product under the control treatment is 23.40%. In both the US and UK samples, participants experience similar product type effects and exhibit similar differences across product types. In both samples, participants are most likely to discard chicken, ham, and milk and least likely to discard soda/fizzy drink, nuts, and cookies/biscuits. Further, participants from each sample are predicted to have a similar likelihood to discard the same products. Product type effects are consistent from the US to the UK.

4.4.3 Date Label Treatment Effects by Product – US

Table 12 shows date label treatment effects for all significant treatments across all products for the US sample. These treatment effects are changes in HAPW compared to the control treatment. Product-specific treatment effects can be compared to the average date label treatment effects shown in Table 9 and Figure 1. Figure 3 shows date label treatment effects for selected products from Table 12, which had the highest and lowest HAPW under the control treatment. All product-specific effects are in the same direction (increase or decrease) as the average treatment effects. In

general, products that have higher estimates for HAPW under the control treatment have smaller magnitude date label treatment effects compared to the average date label treatment effects across all products, and products with lower HAPW under the control treatment have larger magnitude date label treatment effects compared to the average across all products. For example, the average treatment effect for "Use By – Green FI" is -40.65%. The treatment effect for chicken (highest HAPW) for "Use By – Green FI" is -32.98%, and the treatment effect for soda (lowest HAPW) under this date label is -55.65%. It is interesting to see that date label treatment effects are larger for food products with a lower base-level HAPW. This provides evidence that even when consumers have a low likelihood to waste a food product in general, they are still affected by date labels.

4.4.4 Date Label Treatment Effects by Product – UK

Table 13 shows date label treatment effects for all significant treatments across all products for the UK sample. These treatment effects are changes in HAPW compared to the control treatment for each product. Product-specific treatment effects can be compared to the average date label treatment effects shown in Table 9 and Figure 2. Figure 4 shows date label treatment effects for selected products from Table 13. As in the US sample, all product-specific effects are in the same direction as the average date label treatment effects. Products that have higher estimates for HAPW under the control treatment have smaller magnitude date label treatment effects compared to the average date label treatment effects across all products, and products with lower HAPW under the control treatment have larger magnitude date label treatment effects compared to the average across all products. For example, the

average treatment effect for “Use By – Purple FI” is +38.89%. The treatment effect for ham (second highest HAPW) is +29.12% under this date label, and the treatment effect for nuts (second lowest HAPW) is +69.37%. This provides evidence that date labels affect HAPW across all products, even for products that consumers are less likely to waste in general.

CHAPTER 5

DISCUSSION AND CONCLUSIONS

5.1 Discussion

Overall, we find strong evidence that consumer's reported likelihood to discard varies across date labels and across food product types in both the United States and the United Kingdom. We find evidence in strong support of Hypothesis 1, with statistically significant differences in likelihood to discard for 6 out of 10 date label treatments in the US sample and 7 out of 8 date label treatments in the UK sample. We also find evidence in support of Hypothesis 2 in both countries, with significant differences in likelihood to discard across all 15 products. Further, we find evidence in support of Hypothesis 3 and Hypothesis 4, with all Green FI treatments having lower HAPW than their respective comparison treatments and all Purple FI treatments having higher HAPW than their respective comparison treatments.

Despite different food product date label regulatory regimes in the US and UK, we find relatively similar likelihood to discard between our two samples. Under the control treatment with no date label, the HAPW for an average food product one day past its posted date is 26.35% in the United States and 23.40% in the United Kingdom. This finding is in line with WRAP's 2011 estimate that as much as 20% of household food waste can be attributed to confusion around date labels. In the United States, we find that consumers respond to "Use By" and "Best if Used By" no differently than they respond to the control treatment with no date label. This suggests that consumers do not derive any additional meaning for food product quality or food product safety from either of these date labels. Perhaps most of the meaning for these most common

date labels is communicated by the posted date alone. For the other two date labels commonly seen in the US that we included in our study ("Best By" and "Sell By"), we estimate HAPW about 14% lower than the control treatment. This finding suggests that consumers are aware that these date labels, in particular "Sell By", are primarily used by food manufacturers and retailers to manage inventory rotation (Broad Leib et al., 2013).

In the United Kingdom, where regulations require date labels and specify that "Best Before" is an indicator of product quality and "Use By" is an indicator of product safety, we find that "Use By" is the only date label not significantly different from the control treatment. This suggests that respondents may behave cautiously in the presence of no date label and be more likely to waste. Our finding that HAPW is 11.54% lower under the "Best Before" label adds more evidence in support of this claim, as respondents are likely aware that this label does not carry meaning related to food safety.

In both countries, we find large treatment effects in response to the novel Freshness Indicator treatments, which provide clear information on food product quality ("fresh", "less fresh", "past fresh"). When respondents in both countries are provided information that a given product is "fresh" despite being past its posted date (Green FI), they are significantly less likely to waste. However, when respondents are told that the product is "past fresh" (Purple FI), they are significantly more likely to waste. In the United Kingdom, respondents are more likely to waste even when the product is "less fresh", although we do not find this behavior in the United States. The large effects under the Freshness Indicator treatments suggest that current date labels

do not provide consumers with the information they desire to make decisions on keeping or discarding food products past their posted dates.

We find evidence in both countries that HAPW is more dependent on food product type than date labels. HAPW is highest for fresh animal-derived products that may have a higher spoilage or microbiological safety risk and lowest for shelf-stable products like soda / fizzy drink that pose little to no food safety risk under normal conditions. Despite these differences, date labels have consistent treatment effects across products. This result is surprising because date labels have meaningful effects on likelihood to discard even for products that have a very low HAPW under the control treatment.

5.2 Limitations and Suggestions for Further Research

As this study was conducted via an online survey which asked participants about their anticipated behavior, there is a chance that these results are biased and do not reflect the actual behavior of the participants included in the survey. We also employed a combined within-subject and between-subject design in which each respondent only saw the control treatment and one of the experimental date label treatments. A larger study in which each respondent saw all of the date label treatments may provide more robust data, but could also result in respondent fatigue.

Overall, our samples in both countries included less than 600 respondents each. A larger sample, even with the same study design, could be beneficial for future research and increasing the reliability of estimates. Further, we use novel Freshness Indicators that consumers most likely have never encountered in their typical food choice environments. While this study is intended to explore the potential applications

of these technologies, it is possible that the participants' lack of familiarity could bias responses.

Another limitation is that all of the date label treatments showed the date of one day past (yesterday's date). Future research could involve date labels with a range of dates to investigate changes in discard intentions in the presence of Freshness Indicators as products move further than one day beyond their posted date. As our findings suggest that Freshness Indicators have the potential to reduce consumer-level food waste, further research is needed to improve and commercialize freshness indicators and other types of intelligent packaging technologies. Reliability of freshness indicators will be a key factor affecting implementation and use, as malfunctions or errors carry the risk of increasing food waste levels.

5.3 Conclusion

Overall, we find that consumer behavior in response to date labels is a significant contributor to household food waste in both the United States and United Kingdom. While much debate has focused on date label language, we find evidence that suggests consumer likelihood to waste is driven mostly by posted on-package dates alone. In the United States, we estimate that 26.35% of consumers will have a high likelihood to discard (HAPW) a product just one day past its posted date (with no date label). In the presence of a "Use By" or "Best if Used By" date label phrase, there is no significant difference in likelihood to discard from the case with no date label.

When clear information is added about product quality through color-coded Freshness Indicators, we estimate the share of consumers with a high likelihood to discard will decrease when they are assured of product quality being "fresh" and will

increase when they are told the product is “past fresh”. According to the FSIS and FDA, most food products in the United States should not experience any degradation in quality within a short range of passing the posted on-package date, so the potential for Freshness Indicators to reduce food waste is promising.

In the United Kingdom, we estimate that 23.40% of consumers will have a high likelihood to discard (HAPW) a product just one day past its posted date (with no date label). A “Use By” date label phrase does not result in a statistically significant change in HAPW. Accompanying the posted date with a “Best Before” date label is estimated to reduce the share of consumers with a high likelihood to discard by 11.54%. Freshness Indicators represent a potential to reduce household food waste in the UK as well, with the potential to reduce the share of consumers with a high likelihood to discard by as much as 29%.

This paper provides evidence to support the continued improvement of food product labeling in the United States and United Kingdom. Providing consumers with easy access to real-time information about the quality and safety of food products they have the opportunity to consume can improve choice outcomes in the favor of consumers. Freshness Indicators are a new technology with the potential to reduce unnecessary household food waste, with benefits for consumers, their communities, and the environment.

TABLES

Table 1. US Sample - Likelihood to Discard Frequency (%) by Date Label Treatment

Treatment	Discard					
	Extremely Unlikely	Somewhat Unlikely	Neither likely or unlikely	Somewhat likely	Extremely likely	Total
Control	40.42	26.18	7.84	14.46	11.1	100
Use By - Green FI	57.19	20.35	6.9	7.02	8.54	100
Use By - Blue FI	36.91	28.69	6.29	14.63	13.49	100
Use By - Purple FI	24.62	25.89	11.17	18.02	20.3	100
BIUB - Green FI	61.3	17.01	5.02	8.45	8.22	100
BIUB - Blue FI	38.19	23.84	7.41	16.78	13.77	100
BIUB - Purple FI	29.63	24.65	11.11	19.54	15.07	100
Use By	37.5	27.71	9.28	13.79	11.73	100
Best If Used By	40.91	23.11	9.15	12.73	14.09	100
Best By	46.47	24.43	8.02	13.17	7.9	100
Sell By	48.22	21.96	6.75	14.97	8.1	100
Total	41.4	24.94	7.94	14.14	11.57	100

Table 2. UK Sample - Likelihood to Discard Frequency (%) by Date Label Treatment

Treatment	Discard					
	Extremely Unlikely	Somewhat Unlikely	Neither likely or unlikely	Somewhat likely	Extremely likely	Total
Control	42.87	25.78	8.25	11.19	11.92	100
Use By - Green FI	54.24	21.85	7.61	8.68	7.61	100
Use By - Blue FI	32.35	28.64	11.32	12.84	14.84	100
Use By - Purple FI	35.87	23.46	7.43	14.96	18.28	100
BBF - Green FI	52.48	21.71	6.52	9.44	9.83	100
BBF - Blue FI	33.96	29.04	10.14	14.27	12.6	100
BBF - Purple FI	32.26	23.78	10.23	15.89	17.84	100
Use By	43.06	22.93	8	12.52	13.49	100
Best Before	50.19	27.39	6.92	8.09	7.41	100
Total	42.33	25.32	8.39	11.64	12.33	100

Table 3. US Sample - Sociodemographic Variables by Date Label Treatment Group

	age (mean)	male = 1 (mean)	nonwhite = 1 (mean)	college = 1 (mean)	income $ (mean)
Control	33.837	0.563	0.186	0.543	60,375.22
Use By - Green FI	32.751	0.564	0.17	0.529	64,251.46
Use By - Blue FI	34.739	0.656	0.193	0.387	47,965.71
Use By - Purple FI	35.225	0.466	0.152	0.572	55,600.26
BIUB - Green FI	34.382	0.418	0.218	0.58	55,930.64
BIUB - Blue FI	34.243	0.706	0.183	0.579	62,714.12
BIUB - Purple FI	32.797	0.598	0.198	0.562	66,387.01
Use By	33.324	0.541	0.226	0.51	67,952.76
Best If Used By	34.314	0.645	0.098	0.624	67,087.77
Best By	32.648	0.448	0.262	0.562	55,790.42
Sell By	33.79	0.6	0.153	0.541	62,697.20

Table 4. UK Sample - Sociodemographic Variables by Date Label Treatment Group

	Age (mean)	Male = 1 (mean)	Non-white = 1 (mean)	College = 1 (mean)	Income $ (mean)
Control	37.017	0.35	0.09	0.548	40,483.07
Use By - Green FI	37.604	0.325	0.15	0.58	41,768.23
Use By - Blue FI	35.882	0.294	0.051	0.525	35,621.85
Use By - Purple FI	37.473	0.354	0.1	0.538	44,721.01
BBF - Green FI	35.614	0.379	0.12	0.655	42,882.58
BBF - Blue FI	37.779	0.512	0.067	0.508	40,141.85
BBF - Purple FI	35.771	0.288	0.052	0.637	36,479.71
Use By	37.635	0.325	0.108	0.426	42,810.55
Best Before	38.767	0.323	0.07	0.519	40,220.60

Table 5. US Sample - Mixed Effects Ordinal Logit Model of Likelihood to Discard

	(1) Model 1	(2) Model 2	(3) Model 3
Discard			
Use By - Green FI	-0.936***	-1.193***	-1.127*
	[0.0993]	[0.106]	[0.486]
Use By - Blue FI	0.0489	0.0235	0.494
	[0.0926]	[0.0981]	[0.349]
Use By - Purple FI	0.779***	1.049***	1.294***
	[0.0940]	[0.0996]	[0.341]
BIUB - Green FI	-0.868***	-1.074***	-0.475
	[0.104]	[0.111]	[0.486]
BIUB - Blue FI	0.110	0.130	0.195
	[0.0919]	[0.0974]	[0.385]
BIUB - Purple FI	0.837***	1.097***	1.525***
	[0.0955]	[0.101]	[0.359]
Use By	0.1000	0.117	-0.0510
	[0.0973]	[0.103]	[0.397]
Best If Used By	0.00247	-0.00716	0.385
	[0.0977]	[0.104]	[0.397]
Best By	-0.311**	-0.374***	-0.0890
	[0.0971]	[0.102]	[0.373]
Sell By	-0.328***	-0.383***	0.0948
	[0.0986]	[0.105]	[0.401]
order=1	0.313*	0.377	0.378
	[0.154]	[0.194]	[0.195]
attention=1	-0.106	-0.136	-0.133
	[0.286]	[0.358]	[0.360]
bread		1.900***	2.038***
		[0.104]	[0.147]
butter		1.655***	1.751***
		[0.105]	[0.149]
chicken		4.239***	4.512***

Table 5 (Continued)

		[0.107]	[0.149]
cookies		0.626***	0.704***
		[0.109]	[0.155]
eggs		2.678***	2.798***
		[0.104]	[0.147]
fruit		2.968***	3.220***
		[0.103]	[0.145]
ham		3.821***	4.068***
		[0.106]	[0.149]
jam		1.567***	1.610***
		[0.105]	[0.150]
juice		2.206***	2.373***
		[0.103]	[0.146]
milk		3.984***	4.147***
		[0.106]	[0.148]
nuts		0.396***	0.457**
		[0.111]	[0.158]
salad		3.208***	3.380***
		[0.104]	[0.146]
soup		2.090***	2.217***
		[0.105]	[0.148]
yogurt		3.473***	3.647***
		[0.105]	[0.148]
Observations	16565	16565	16565
Adjusted R-squared			
Pseudo R-squared			
AIC	40147.5	35227.6	35394.7
BIC	40278.7	35466.7	36713.9
ll	-20056.8	-17582.8	-17526.3
chi2	331.1	4251.6	4325.5
Standard errors in brackets			
="* p<0.05	** p<0.01	*** p<0.001"	

Table 6. UK Sample - Mixed Effects Ordinal Logit Model of Likelihood to Discard

	(1) Model 1	(2) Model 2	(3) Model 3
Discard			
Use By - Green FI	-0.472***	-0.631***	-0.143
	[0.0899]	[0.0962]	[0.374]
Use By - Blue FI	0.243**	0.319***	0.571
	[0.0822]	[0.0876]	[0.303]
Use By - Purple FI	0.619***	0.846***	0.478
	[0.0870]	[0.0926]	[0.333]
BBF - Green FI	-0.553***	-0.756***	-0.382
	[0.0899]	[0.0964]	[0.376]
BBF - Blue FI	0.351***	0.425***	0.650*
	[0.0840]	[0.0905]	[0.329]
BBF - Purple FI	0.595***	0.826***	0.870**
	[0.0840]	[0.0886]	[0.294]
Use By	0.0112	0.0151	-0.437
	[0.0863]	[0.0914]	[0.362]
Best Before	-0.216*	-0.286**	-0.308
	[0.0868]	[0.0923]	[0.368]
order=1	-0.0748	-0.0926	-0.0958
	[0.142]	[0.182]	[0.184]
attention=1	1.003***	1.268***	1.280***
	[0.238]	[0.306]	[0.308]
biscuits		0.274*	0.178
		[0.107]	[0.156]
bread		1.891***	1.941***
		[0.101]	[0.144]
butter		2.020***	2.109***
		[0.101]	[0.144]

Table 6 (Continued)

chicken		4.669***	4.743***
		[0.108]	[0.150]
eggs		2.900***	2.944***
		[0.103]	[0.145]
fruit		2.313***	2.383***
		[0.102]	[0.144]
ham		3.917***	3.987***
		[0.105]	[0.147]
jam		1.077***	1.074***
		[0.104]	[0.149]
juice		2.255***	2.253***
		[0.101]	[0.144]
milk		3.799***	3.867***
		[0.103]	[0.144]
nuts		0.321**	0.254
		[0.110]	[0.157]
salad		2.572***	2.618***
		[0.101]	[0.143]
soup		1.932***	1.963***
		[0.102]	[0.144]
yogurt		3.351***	3.442***
		[0.102]	[0.144]
Observations	16464	16464	16464
Adjusted R-squared			
Pseudo R-squared			
AIC	40257.9	35013.1	35103.2
BIC	40373.6	35236.7	36190.2
ll	-20114.0	-17477.6	-17410.6
chi2	216.8	4398.3	4464.0
Standard errors in brackets			
="* p<0.05	** p<0.01	*** p<0.001"	

Table 7. US Sample - Average Adjusted Probability (%) of Likelihood to Discard by Date Label Treatment for Average Product

	Discard				
Treatment	Extremely Unlikely	Somewhat Unlikely	Neither likely nor unlikely	Somewhat likely	Extremely likely
Control	0.4154	0.2439	0.0773	0.1408	0.1227
Use By - Green FI	0.5649	0.2202	0.0585	0.0944	0.062
Use By - Blue FI	0.4125	0.244	0.0776	0.1417	0.1242
Use By - Purple FI	0.2931	0.2376	0.0867	0.1797	0.2029
BIUB - Green FI	0.55	0.2239	0.0606	0.0988	0.0667
BIUB - Blue FI	0.3995	0.2445	0.0789	0.1459	0.1312
BIUB - Purple FI	0.2879	0.2368	0.0869	0.1812	0.2072
Use By	0.401	0.2444	0.0787	0.1454	0.1304
Best if Used By	0.4162	0.2438	0.0772	0.1405	0.1223
Best By	0.4619	0.2399	0.072	0.1259	0.1004
Sell By	0.463	0.2398	0.0718	0.1255	0.0999

Table 8. UK Sample - Average Adjusted Probability (%) of Likelihood to Discard by Date Label Treatment for Average Product

	Discard				
Treatment	Extremely Unlikely	Somewhat Unlikely	Neither likely nor unlikely	Somewhat likely	Extremely likely
Control	0.436	0.25	0.079	0.11	0.124
Use By - Green FI	0.517	0.237	0.069	0.089	0.087
Use By - Blue FI	0.396	0.253	0.084	0.121	0.146
Use By - Purple FI	0.333	0.252	0.09	0.137	0.188
BBF - Green FI	0.533	0.234	0.066	0.085	0.081
BBF - Blue FI	0.383	0.254	0.085	0.124	0.154
BBF - Purple FI	0.335	0.252	0.09	0.137	0.186
Use By	0.434	0.251	0.08	0.111	0.125
Best Before	0.473	0.246	0.075	0.101	0.106

Table 9. High Adjusted Probability to Waste Treatment Effects by Date Label Treatment (Total)

US Sample			UK Sample		
Treatment	HAPW	% Change from Control HAPW	Treatment	HAPW	% Change from Control HAPW
Control	26.35%		Control	23.40%	
Use By - Green FI	15.64%	-40.65%	Use By - Green FI	17.60%	-24.79%
Use By - Blue FI	26.59%	0.91%	Use By - Blue FI	26.70%	14.10%
Use By - Purple FI	38.26%	45.20%	Use By - Purple FI	32.50%	38.89%
BIUB - Green FI	16.55%	-37.19%	BBF - Green FI	16.60%	-29.06%
BIUB - Blue FI	27.71%	5.16%	BBF - Blue FI	27.80%	18.80%
BIUB - Purple FI	38.84%	47.40%	BBF - Purple FI	32.30%	38.03%
Use By	27.58%	4.67%	Use By	23.60%	0.85%
Best if Used By	26.28%	-0.27%	Best Before	20.70%	-11.54%
Best By	22.63%	-14.12%			
Sell By	22.54%	-14.46%			

Table 10. US Sample - Average Adjusted Probability (%) of Likelihood to Discard by Product (Control Treatment) and High Adjusted Probability of Waste (%)

	Discard					
Product	Extremely Unlikely	Somewhat Unlikely	Neither likely nor unlikely	Somewhat likely	Extremely likely	HAPW
Bread	46.31	26.12	7.28	12.42	7.86	20.28
Butter	49.82	25.28	6.91	11.27	6.72	17.99
Chicken	18.53	22.59	9.90	21.80	27.17	48.97
Cookies	64.07	20.81	5.02	6.76	3.34	10.10
Eggs	35.69	27.31	8.53	15.85	12.62	28.47
Fruit	32.07	27.04	9.01	17.02	14.86	31.88
Ham	22.59	24.41	9.97	20.31	22.72	43.03
Jam	51.08	24.95	6.77	10.86	6.34	17.20
Juice	42.00	26.90	7.76	13.83	9.52	23.35
Milk	20.96	23.72	10.00	20.92	24.41	45.33
Nuts	66.97	19.73	4.54	5.93	2.83	8.76
Salad	29.24	26.54	9.38	17.95	16.89	34.84
Soda	71.65	17.80	3.74	4.71	2.10	6.81
Soup	43.62	26.64	7.58	13.30	8.86	22.16
Yogurt	26.26	25.74	9.72	18.98	19.30	38.28

Table 11. UK Sample - Average Adjusted Probability (%) of Likelihood to Discard by Product (Control Treatment) and High Adjusted Probability of Waste (%)

	Discard					
	Extremely Unlikely	Somewhat Unlikely	Neither likely nor unlikely	Somewhat likely	Extremely likely	HAPW
Biscuits	69.57	19.33	4.17	4.26	2.67	6.93
Bread	47.23	26.92	7.74	9.85	8.25	18.1
Butter	45.35	27.33	7.99	10.38	8.96	19.34
Chicken	14.51	21.82	10.54	19	34.13	53.13
Eggs	33.2	28.35	9.55	13.8	15.1	28.9
Fizzy Drink	72.83	17.79	3.61	3.62	2.16	5.78
Fruit	41.14	28.03	8.52	11.57	10.74	22.31
Ham	21.46	25.49	10.83	17.13	25.08	42.21
Jam	59.01	23.51	5.99	6.69	4.79	11.48
Juice	41.96	27.91	8.42	11.34	10.37	21.71
Milk	22.69	25.99	10.76	16.78	23.78	40.56
Nuts	68.98	19.6	4.27	4.38	2.77	7.15
Salad	37.55	28.36	8.98	12.58	12.52	25.1
Soup	46.63	27.06	7.82	10.02	8.47	18.49
Yogurt	27.68	27.54	10.26	15.35	19.17	34.52

Table 12. US Sample - Date Label Treatment Effects (% Change in HAPW from Control) by Product (Significant Treatments Only)

	Treatment					
Product	Use By - Green FI	Use By - Purple FI	BIUB - Green FI	BIUB - Purple FI	Best By	Sell By
Bread	-47.68	56.0	-43.84	58.88	-17.01	-17.41
Butter	-49.25	59.92	-45.41	62.98	-17.90	-18.29
Chicken	-32.98	29.79	-29.98	31.06	-10.90	-11.15
Cookies	-53.66	79.90	-49.80	84.26	-20.79	-21.29
Eggs	-42.11	46.51	-38.43	48.89	-14.40	-14.75
Fruit	-40.09	43.63	-36.54	45.80	-13.68	-13.96
Ham	-35.14	34.67	-32.00	36.23	-11.85	-12.13
Jam	-49.77	61.51	-45.87	64.59	-18.20	-18.60
Juice	-45.61	51.69	-41.80	54.39	-15.93	-16.32
Milk	-34.30	32.78	-31.22	34.22	-11.49	-11.78
Nuts	-54.45	84.13	-50.46	88.81	-21.23	-21.58
Salad	-38.52	41.30	-35.13	43.28	-13.12	-13.43
Soda	-55.65	90.46	-51.84	95.74	-21.88	-22.32
Soup	-46.44	53.25	-42.60	56.00	-16.34	-16.74
Yogurt	-36.96	38.56	-33.67	40.36	-12.57	-12.85

Table 13. UK Sample - Date Label Treatment Effects (% Change in HAPW from Control) by Product (Significant Treatments Only)

	Treatment						
Product	Use By - Green FI	Use By - Blue FI	Use By - Purple FI	BBF - Green FI	BBF - Blue FI	BBF - Purple FI	Best Before
Biscuits	-34.92	22.94	69.99	-40.40	31.46	67.97	-17.32
Bread	-29.28	17.29	49.12	-34.31	23.43	47.79	-14.14
Butter	-28.70	16.75	47.36	-33.66	22.65	46.17	-13.81
Chicken	-17.30	8.68	22.34	-20.65	11.52	21.83	-7.89
Eggs	-24.43	13.56	37.79	-28.82	18.27	36.82	-11.49
Fizzy Drink	-35.81	23.53	72.66	-41.35	32.35	70.59	-17.99
Fruit	-27.34	15.55	43.79	-32.14	21.02	42.67	-13.00
Ham	-20.21	10.85	29.12	-23.95	14.52	28.41	-9.41
Jam	-32.40	20.47	60.28	-37.72	27.87	58.71	-16.03
Juice	-27.64	15.75	44.45	-32.47	21.28	43.30	-13.22
Milk	-20.64	11.14	30.13	-24.46	14.94	29.39	-9.66
Nuts	-34.69	22.80	69.37	-40.28	31.19	67.41	-17.34
Salad	-25.98	14.66	41.00	-30.60	19.76	39.96	-12.27
Soup	-29.15	17.14	48.57	-34.07	23.15	47.27	-14.01
Yogurt	-22.39	12.28	33.89	-26.51	16.51	33.05	-10.52

FIGURES

Figure 1. US Sample – Date Label Treatment Effects (% Change from Control) on High Adjusted Probability of Waste (HAPW) for Average Product

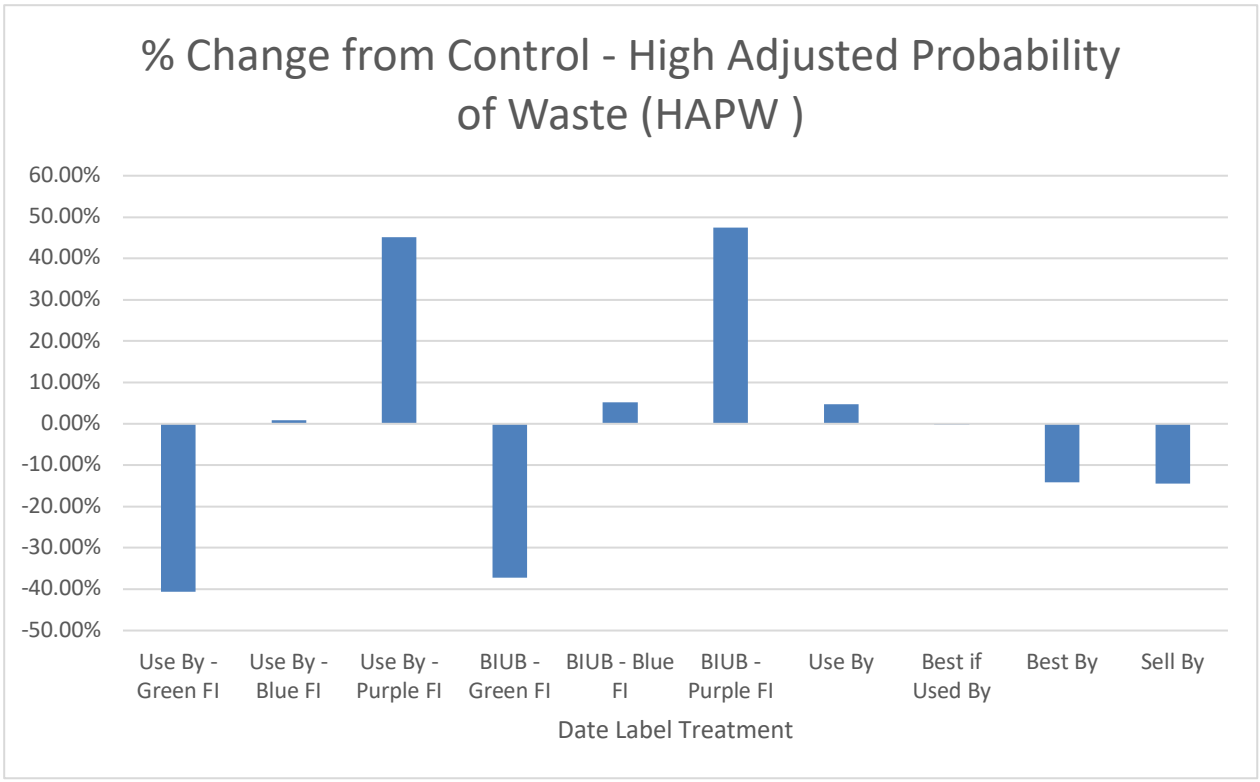


Figure 2. UK Sample – Date Label Treatment Effects (% Change from Control) on High Adjusted Probability of Waste (HAPW) for Average Product

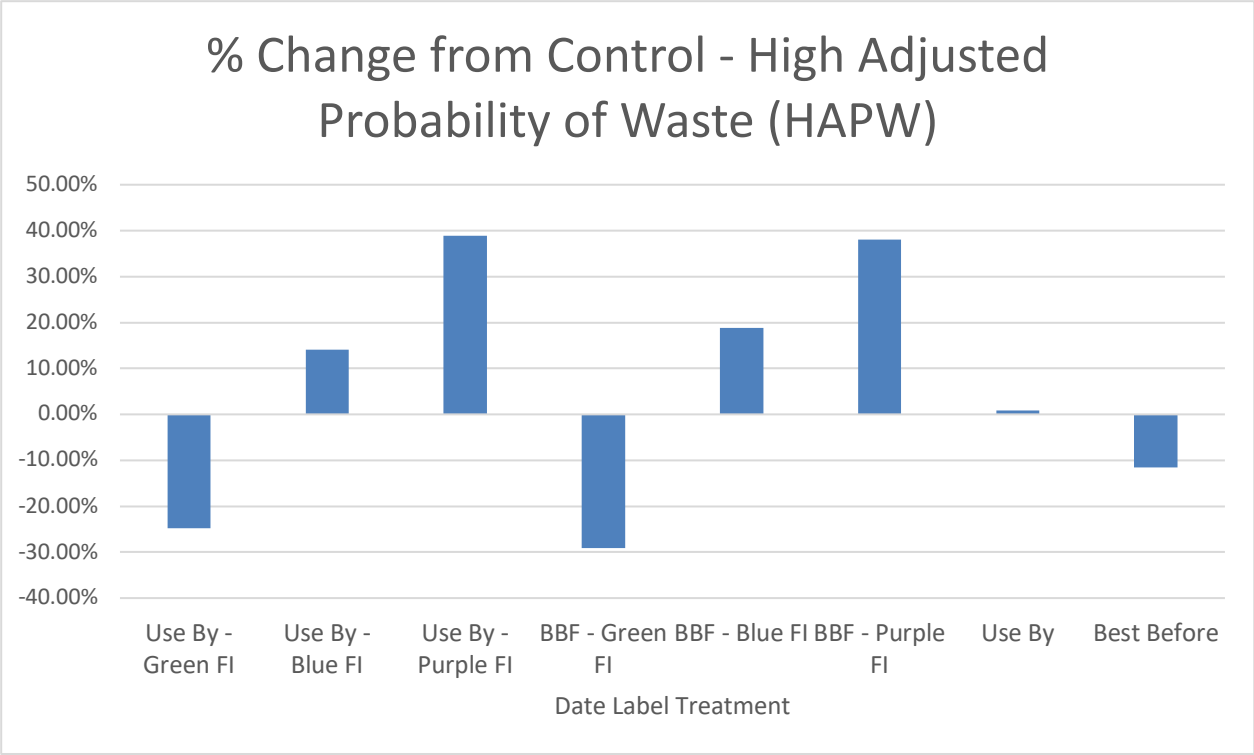


Figure 3. US Sample – Date Label Treatment Effects (% Change in HAPW from Control) for Selected Products (Significant Treatments Only)

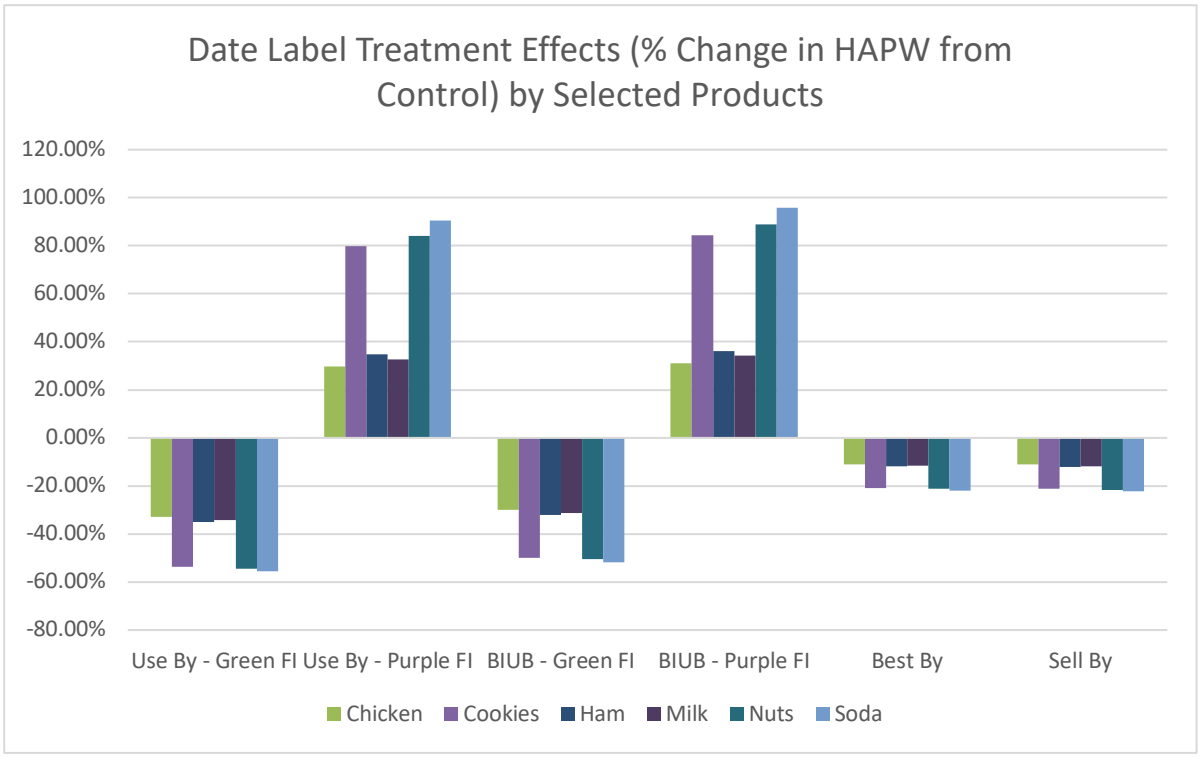
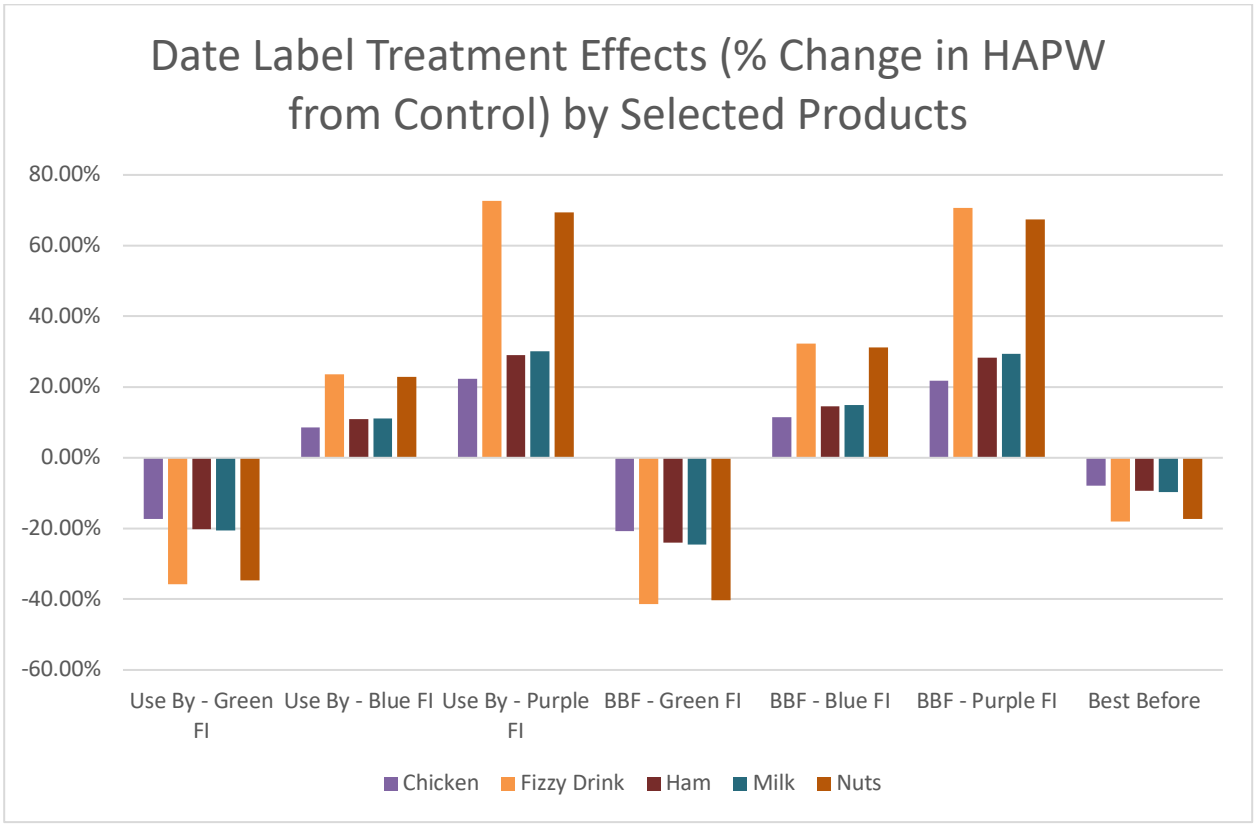
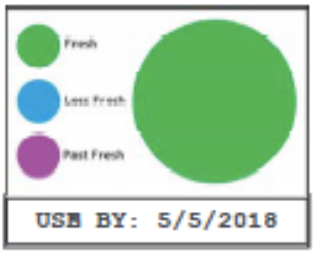


Figure 4. UK Sample – Date Label Treatment Effects (% Change in HAPW from Control) by Selected Products (Significant Treatments Only)



APPENDIX

Exhibit 1. Sample Survey Question with Freshness Indicator



6-pack of 12-ounce soda

Remember this product does not appear contrary to your expectations.

How likely is it that you will discard all of this product due to the date label above?

- » Extremely likely
- » Somewhat likely
- » Neither likely nor unlikely
- » Somewhat unlikely
- » Extremely unlikely
- » I do not consume this product.

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