

Segmenting U.S. consumers by food waste attitudes and behaviors: Opportunities for targeting reduction interventions

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ABSTRACT

In order to achieve U.S. food waste reduction goals, changing the behavior of consumers will be essential as ~50 % of wasted food occurs in residential settings. Segmenting consumers by their food waste patterns can help direct consumer campaigns, however no such analysis has been conducted in the United States. We analyze the food waste attitudes and behaviors of 1086 U.S. consumers who responded to an online survey by using *k*-means clustering and post-hoc sample weighting to ensure national representativeness. We identify four distinct consumer segments: Conscientious Conservers (22 % of households, 10 % of total food waste generated), Harried Profligates (26 % of households, 38 % of waste), Unrepentant Drink Wasters (21 % of households, 10 % of waste), Guilty Carb Wasters (31 % of households, 33 % of waste). For each segment we identify and discuss the constellation of attitudes, behaviors and characteristics that distinguish them from other groups and then postulate intervention and communication strategies that may prove fruitful for targeting messages in a manner that advance national food waste reduction goals in a cost-effective manner. For example, we recommend targeting campaign resources on the Harried Profligates segment, who report 45 % more wasted food than the sample average yet hold multiple attitudes conducive to supporting food waste reduction so long as the interventions can support this cluster's lack of planning skills in a manner that does not exacerbate the time pressure they report facing in day to day life.

1. Introduction

In 2015 the United States announced a goal to reduce food waste by 50 % by 2030 (USDA, 2015). In order to achieve this goal, changing the behavior of US consumers will be essential as 48 % of the food wasted in the United States in 2021 occurred in residential settings (ReFED, 2023). Reducing food waste in households can be accomplished by changing several types of behavior (e.g., meal planning, food shopping, food storage, food preparation, leftover management) and by leveraging several sources of consumer motivation (financial, environmental, norm adherence) with extant research identifying >100 specific drivers of wasted food across several points in typical in-home food routines (National Academies of Science, Engineering, and Medicine, 2020).

This broad array of possible motivations and action points creates a dilemma when attempting to formulate and prioritize behavior change interventions as people may respond to interventions differently. Similar challenges arise in settings as diverse as consumer goods marketing, public health behavior campaigns, and pro-environmental behaviors, which have led to the development of consumer targeting tactics

(Weinstein, 1994) and their adaptation to public health practice (Donovan et al., 1999) with calls for extending such approaches to campaigns to encourage pro-environmental behaviors (Nielsen et al., 2021).

The aim of this paper is to identify segments of U.S. consumers with similar food waste attitudes and behaviors and to understand how these segments differ in terms of the potential for reducing their household food waste and in terms of the issues that would need to be addressed in order to achieve reductions in waste. Answering these questions will provide information that can guide the formation of communication campaigns or other interventions that support the U.S. food waste reduction goal. To accomplish these aims, we analyze the food waste attitudes and behaviors of 1086 US consumers who responded to an online survey during November or December of 2022. In the survey, consumers provide responses to an array of questions designed to elicit awareness, attitudes, and behaviors toward food and food waste, including a detailed reporting of food wasted during a 7-day period preceding the survey. We apply *k*-means clustering to these responses to identify four distinct segments or clusters of consumers and then assess

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differences across clusters in terms of their demographic characteristics and their responses to questions.

2. Literature review

Numerous studies identify consumer segments designed to inform food waste management approaches. Each measures attitudes, behaviors, and other critical information about consumers relevant to their food and food waste related habits, including one or more indicators of food that is wasted in the household. These studies employed a diverse array of segmentation techniques with the most prevalent methods being *k*-means clustering and hierarchical clustering. Furthermore, the variables utilized for consumer segmentation include socio-demographic information (Kutlu, 2022; Marek-Andrzejewska and Wielicka-Regulska, 2021), food waste attitudes (Gaiani et al., 2018; Pocol et al., 2020), food waste causes (Di Talia et al., 2019; Närvänen et al., 2023), food waste behaviors (Romani et al., 2018; Borg et al., 2022), and broader food-related lifestyle factors (Aschemann-Witzel et al., 2018; Aschemann-Witzel et al., 2021; Delley and Brunner, 2017; Mallinson et al., 2016; Richter, 2017). The number of segments identified in these studies range from two to seven with distinct profiles relevant to understanding household food waste patterns.

We summarize these extant efforts in Table 1. While each study produces a slate of named consumer segments, it is crucial to recognize the methodological challenges inherent in these studies. The utilization of diverse statistical approaches (column 3, Table 1) and the selection of varying variables for consumer segmentation make it challenging to compare findings and draw conclusive insights. Even when such comparisons are feasible, we observe only limited similarities among segments from different studies. This observation underscores the significance of recognizing the substantial influence of geographic and cultural factors on the identified consumer segments, thus emphasizing the importance of region-specific insights.

It's worth noting that none of these studies feature consumers from the United States or elsewhere in the Americas. Roe et al. (2022)'s study does feature consumers from the United States but, rather than identifying consumer segments, they develop food waste reduction interventions adaptively tailored to individual respondents. Hence, while segmentation analyses are readily available to guide campaigns and other interventions in Australia and select European countries, it is not well-known or understood how applicable these characterizations may be in the U.S. context. In the Results section we contrast the segments identified in Table 1 with those identified from the U.S. study which is detailed next.

3. Materials and methods

3.1. Participants

Residents who participate in consumer panels managed by the commercial vendor Prolific were invited to participate in a two-part online survey during November and December of 2022 with 1217 completing the first part of the survey and 1086 (89.2 %) providing complete responses to both parts of the survey. All participants provided informed consent and received compensation. Inclusion criteria included age 18 years or older and performance of at least half of the household food preparation. No data was collected during the week of or the week following Thanksgiving and data collection ended prior to the Christmas holiday. Participants were drawn from all 50 states and the District of Columbia. Recruitment quotas were implemented to ensure sufficient representation by geographical region, household size, race, and age group. Post-hoc sample weights were constructed and applied in all analyses to assure national representativeness of the sample with respect to age, income, and household size, which are critical characteristics often associated with household food waste. The protocol was approved by the local Internal Review Board.

Table 1
Previous segmentation studies.

Study	Sample	Methods	Segments (% of sample)
Annunziata et al. (2022)	Italy (N = 530), national web-based survey	Principal Component Analysis and a two-step cluster analysis	1. Self-Indulgent (20 %) 2. Proactive (55 %) 3. Discouraged (25 %)
Aschemann-Witzel et al. (2018)	Denmark (N = 848), national web-based survey	Factor analysis and a two-step cluster analysis	1. Cooking involved and spontaneous* 2. Price vs quality-orientated and dislikes cooking 3. Very involved and cooking engaged 4. Good food involved and price dismissive 5. Least concerned, normative and social
Aschemann-Witzel et al. (2021)	5 EU countries (N = 4214), national web-based surveys	Factor analysis and a two-step cluster analysis	1. Well-planning cook and frugal food waste avoider** 2. Young foodie 3. Established 4. Uninvolved young male waster 5. Convenience and price-oriented low income
Bilska et al. (2020)	Poland (N = 1115), national computer-assisted personal interviews	k-means cluster analysis	1. Saving food (41.8 %) 2. Wasting vegetables and fruit (46.3 %) 3. Wasting food (11.9 %)
Borg et al. (2022)	Australia (N = 2803), national web-based survey and waste audit	Two-step cluster analysis	1. Over providers (23 %) 2. Under planners (32 %) 3. Considerate planners (45 %)
Coskun (2021)	Turkey (N = 150), city-level in-person survey	Agglomerative hierarchical cluster analysis	1. Conservers (50 %) 2. Considerates (28 %) 3. Reluctants (16 %) 4. Prodigals (6 %)
Delley and Brunner (2017)	Switzerland (N = 681), national mail-based survey	Hierarchical cluster analysis	1. Conservative (24 %) 2. Self-indulgent (8 %) 3. Short-termist (21 %) 4. Indifferent (27 %) 5. Consumerist (14 %) 6. Eco-responsible (6 %)
Di Talia et al. (2019)	Italy (N = 213), rural town-level face-to-face interview	Multiple Correspondence Analysis (MCA) and hierarchical cluster analysis	1. Non-aware consumer (45 %) 2. Consumers unaware but not wasteful (26 %) 3. Conscious consumers (29 %)
Flanagan and Priyadarshini (2021)	Ireland (N = 2155), national web-based survey	Factor analysis and a two-step cluster analysis	1. Uncaring consumers (63 %) 2. Caring consumers (37 %)
Gaiani et al. (2018)	Italy (N = 3087), national web-based survey	Multiple Correspondence Analysis (MCA) and hierarchical cluster analysis	1. Conscious fussy (22 %) 2. Conscious-forgetful (20 %) 3. Frugal consumer (23 %)

(continued on next page)

Table 1 (continued)

Study	Sample	Methods	Segments (% of sample)
			4. Confused (about labelling) (3 %) 5. Exaggerated cook (22 %) 6. Exaggerated shopper (3 %) 7. Unskilled cook (5 %)
Kutlu (2022)	Turkey (N = 301), national web-based survey	Confirmatory factor analysis and Chi-Square Automatic Interaction Detector analysis (CHAID)	1. Frugal believers (18 %) 2. Frugal seculars (23 %) 3. Conscientious individuals (20.3 %) 4. Casual females (19.9 %) 5. Casual males (17.6 %)
Mallinson et al. (2016)	United Kingdom (N = 928), national web-based survey	k-means cluster analysis	1. Epicures (15 %) 2. Traditional consumers (28 %) 3. Casual consumers (27 %) 4. Food detached consumers (16 %) 5. Kitchen evaders (15 %)
Marek-Andrzejewska and Wielicka-Regulska (2021)	Poland (N = 369, age 20–34 years), national web-based survey	Component factor analysis and k-means cluster analysis	1. Control-Conscious Young Men from Urban Areas (27 %) 2. Positive-Attitude Young Women from Urban Areas (45 %) 3. Planning-Seeking Young Women from Rural Areas (28 %)
Närviäinen et al. (2023)	Finland (N = 12,187), national web-based survey	Hierarchical cluster analysis	1. No food waste (13 %) 2. Trust in date labels (19 %) 3. Safety first (9 %) 4. Occasional wasters (18 %) 5. Overpurchasers and overpreparers (32 %) 6. Family first (9 %)
Pocol et al. (2020)	Romania (N = 2379), national web-based survey	k-means cluster analysis	1. Careless (22 %) 2. Precautious (40 %) 3. Ignorant (38 %)
Richter (2017)	Germany (N = 1023), national web-based survey	Factor analysis, hierarchical cluster analysis, and k-means cluster analysis	1. Guilty food wasters (26 %) 2. Unwitting food wasters (42 %) 3. Careless food waster (32 %)
Romani et al. (2018)	Italy (N = 456), Local shopping malls face-to-face interview	A two-step cluster analysis	1. Virtuous (35 %) 2. Moderate (49 %) 3. Waster (16 %)
Vittuari et al. (2020)	Italy (N = 938), residential suburb of city face-to-face interview	Principal component analysis (PCA), hierarchical (single, average, complete, weighted-average, median, centroid, and Ward's linkage) and partition (k-means and k-medians) cluster analysis	1. Pragmatic consumers (22 %) 2. Thrifty altruists (45 %) 3. Aware wasters (33 %)

Notes: * % of sample in each cluster not provided. ** % of sample in each clustered reported for each country separately.

3.2. Questionnaire and data analysis

We followed the survey instrument developed by Shu et al. (2021) where the details of the survey origins and approach are provided. In brief, participants complete an initial online survey that collects demographic and certain behavioral characteristics and ends with an announcement that a follow-up survey will arrive in about one week, and that for the next 7 days, participants should pay close attention to the amounts of different foods their household throws away, feeds to animals, or composts because the food is past date, spoiled, or no longer wanted for other reasons. They are told to exclude items they would normally not eat, such as bones, pits, and shells. Approximately 7 days later they receive a follow-up online survey, which elicits the amount of wasted during the past 7 days in up to 24 categories of food (see supplemental information) and includes other questions including detailed attitudinal and behavioral questions upon which the segmentation analysis depends (see supplemental information for survey question wording).

Waste amounts in each category are reported by selecting from one of several ranges of possible amounts. The gram weight for categories with volumetric ranges (e.g., listed in cups) were derived by assigning an appropriate mass to the midpoint of the selected range consistent with the food category. For the categories with highly variable weight per volume (e.g., a cup of raw asparagus weighs about 7 times more than a cup of raw chopped arugula), we use the profile of items most consumed in the United States to determine the appropriate gram weight (USDA, 2021 – see Shu et al., 2021 for details). For purposes of analysis, the 24 categories are consolidated into 6 categories: produce, meat & fish, carbs (potatoes, pasta, beans, bread, rice and cereal), dairy & eggs, drinks (including milk), and all others. Total weekly household food waste is calculated by summing up reported gram amounts across all categories. We divide this total by the number of household members to generate the per person weekly food waste amount.

After respondents provide waste amounts in each category, they respond to a series of questions that elicit attitudes about food waste and daily time pressure and assess behaviors of the respondent with respect to food purchasing, storage, preparation, and waste. Respondents provide their agreement or disagreement with each statement using a 5-point Likert scale, ranging from 'Strongly agree' to 'Strongly disagree.' The questions were adapted from similar questions used by WRAP (2022) and then pre-tested on a small sample of respondents (N = 30) to assess their clarity and enhance data quality with U.S. respondents. Finally, respondents are allocated to segments based upon their responses to these questions (Table 2). These variables were chosen as the focus of the cluster analysis because these attitudes, behaviors and characteristics were considered most useful for guiding food waste interventions, e.g., respondents who hold similar attitudes about the source and implications of food waste and have similar suites of food management practices may be more likely to respond to a particular intervention than would respondents that simply have similar levels of food waste or similar demographic profiles. Respondents are allocated to segments by applying k-means clustering (Kodinariya and Makwana, 2013) as implemented in R (kmeans function, version 4.2.2). The goal of k-means clustering is to minimize the within-cluster variation and maximize the between-cluster variation with respect to the segmentation variables, which means that the respondents within a cluster should be as similar as possible with respect to these variables while differences between clusters should be distinct. To achieve this, the Euclidean distance was utilized to measure both within-cluster and between-cluster variation. Subsequently, the elbow criterion was applied, which recommended four clusters.

We then contrasted respondents across these clusters based upon the amount and types of food they report is wasted in their household; self-assessment of additional food purchasing, storage, management, and preparation skills; concerns with food-related issues; and demographic characteristics. Several variables related to political and personal

Table 2
Respondent food waste attitudes.

	All			Cluster 1			Cluster 2			Cluster 3			Cluster 4		
				Conscientious conservers			Harried profligates			Drink wasters			Carb wasters		
	Mean	SD		Mean	SD		Mean	SD		Mean	SD		Mean	SD	
Attitudes (Agree = 1)															
FW is important national issue	0.84	0.37		0.92	0.28	a [†]	0.92	0.28	ab	0.49	0.50	c	0.96	0.20	abd
Everyone has responsibility to reduce FW	0.90	0.29		0.96	0.19	a	0.95	0.21	ab	0.65	0.48	c	0.99	0.09	abd
FW is bad for environment	0.68	0.47	2*	0.81	0.40	a	0.68	0.47	b	0.36	0.48	c	0.79	0.40	ad
Feel guilty about FW	0.81	0.39	1	0.83	0.38	a	0.86	0.35	ab	0.56	0.50	c	0.93	0.26	d
Minimizing FW is my priority	0.65	0.48	2	0.73	0.44	a	0.70	0.46	ab	0.18	0.38	c	0.87	0.34	d
No time to worry about FW	0.10	0.29		0.00	0.00	a	0.14	0.34	b	0.21	0.41	c	0.05	0.22	d
I currently feel time pressure	0.39	0.49		0.16	0.37	a	0.57	0.50	b	0.27	0.45	c	0.48	0.50	d
Have made effort to reduce FW	0.65	0.48	12	0.60	0.49	a	0.64	0.48	ab	0.38	0.49	c	0.88	0.33	d
More FW due to bulk/sale items	0.56	0.50	34	0.31	0.46	a	0.74	0.44	b	0.56	0.50	c	0.60	0.49	cd
FW can decrease risk of illness	0.63	0.48	23	0.46	0.50	a	0.66	0.47	b	0.68	0.47	bc	0.70	0.46	bcd
FW can help meals taste fresh	0.39	0.49	4	0.19	0.39	a	0.44	0.50	b	0.53	0.50	c	0.39	0.49	bd
Forget food in freezer	0.27	0.44		0.07	0.25	a	0.71	0.45	b	0.13	0.34	c	0.11	0.32	acd
Confident about freezing food	0.65	0.48	3	0.82	0.38	a	0.37	0.48	b	0.64	0.48	c	0.75	0.43	ad
Fully aware of food in fridge	0.82	0.39	3	0.99	0.09	a	0.56	0.50	b	0.82	0.38	c	0.91	0.29	d
Fridge is a disaster	0.22	0.41		0.03	0.18	a	0.70	0.46	b	0.06	0.23	ac	0.04	0.20	acd
Purchase more food than needed	0.21	0.41		0.04	0.19	a	0.48	0.50	b	0.12	0.32	c	0.17	0.37	cd
FW is major source of wasting money	0.47	0.50		0.04	0.19	a	0.68	0.47	b	0.15	0.36	c	0.82	0.39	d
It would be difficult to reduce FW	0.28	0.45		0.55	0.50	a	0.15	0.36	b	0.34	0.47	c	0.17	0.37	bd
My HH wastes more than others	0.05	0.23	4	0.00	0.00	a	0.14	0.35	b	0.02	0.12	ac	0.04	0.20	cd
N	1086			233			273			238			342		
Weighted % of Sample Waste	100 %			10 %			38 %			19 %			33 %		
Weighted % of Sample Observations	100 %			22 %			26 %			21 %			31 %		

Notes: Weighted figures based upon post-hoc sample weights to adjust for age, income and household size. *Cluster numbers that appear in this column have mean values that are not significantly different from the mean value for all other clusters for the variable in this row at the 5 % level. E.g., for ‘Food waste is bad for the environment’ the mean value for cluster 2 is not significantly different than the mean value pooled across clusters 1, 3 and 4. † Clusters that share a letter within the same row have means that are not statistically different from one another at the 5 % level.

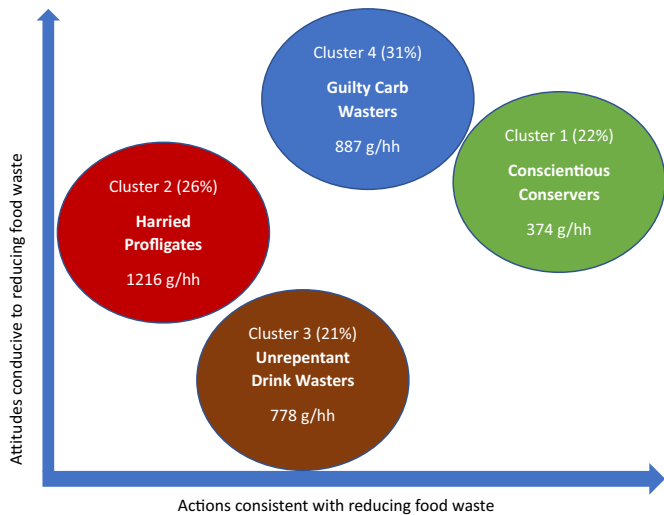


Fig. 1. Cluster positions on attitude and action dimensions with average weekly self-reported food waste.

philosophies and typical communications channels were not collected from a subset of 790 respondents due to an administrative error; values for these respondents were predicted based upon respondent answers to other survey questions. Statistical significance is set at the 5 % level and test results yielding *p*-values between 0.05 and 0.10 are deemed marginally significant.

4. Results

The first empirical result features the number of clusters selected to segment the sample. We selected four (*k* = 4) determined by elbow

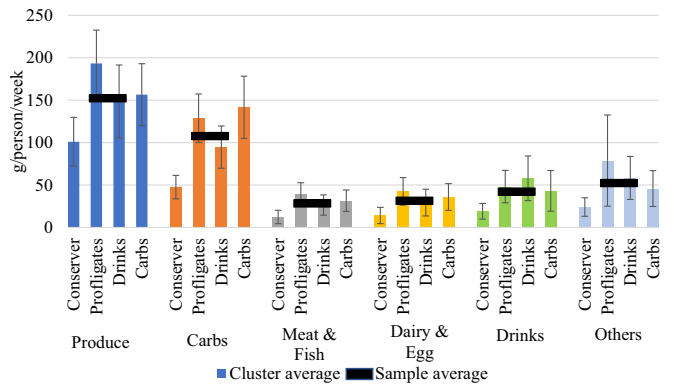


Fig. 2. Waste by category and cluster
Notes: *N* = 1086. Conserver – Cluster 1, Conscientious Conservers (22 %); Profligates – Cluster 2, Harried Profligates (26 %); Drinks – Cluster 3, Unrepentant Drink Wasters (21 %); Carbs– Cluster 4, Guilty Carb Wasters (31 %). 95 % confidence intervals depicted. Carbs– potatoes, pasta, beans, bread, cereal & rice.

criterion as increasing beyond 4 clusters did not result in a significant reduction of within-cluster variation.¹ Fig. 1 provides an overview of the four clusters in two dimensions. The vertical dimension relates to the ‘Attitude’ panel of Table 2 and clusters positioned higher on the vertical axis report attitudes more conducive to reducing food waste (e.g., more strongly agree with the statement that ‘Everyone has a responsibility to reduce food waste’). The horizontal dimension relates to the ‘Behavior’

¹ Increasing from 1 to 4 clusters reduced within-cluster variation by 13.94 %, 7.41 %, and 4.60 %, while increasing from 4 to 5 clusters reduced within-cluster variation by only 2.93 %.

panel of Table 2 and clusters further to the right report behaviors more conducive to reducing food waste (e.g., more likely to report being good at ‘Checking what you already have in the fridge before shopping’). The ovals identify the four clusters, the percent of sample respondents that belong to the cluster, and the overall self-reported food waste level on a per household basis. Fig. 2 breaks out the overall food waste for each cluster into the six constituent categories detailed in the Materials and Methods section and provides the sample-wide average as a visual point of reference.

4.1. Cluster overview

We have identified and labeled four distinct clusters based on a combination of attitudes, behaviors, and waste levels. Cluster 1 comprises respondents who consistently report attitudes and behaviors strongly aligned with food waste reduction efforts. Their self-reported waste levels align with these positive attitudes and behaviors, leading us to label this the ‘**Conscientious Conservers**’ segment. They account for 22 % of sample observations but, given their modest levels of reported waste, only 10 % of sample wide wasted food.

Moving to Cluster 2, respondents in this group share some positive attitudes with Cluster 1 but also are more likely to agree with some statements negatively associated with food waste reduction. Their reported behaviors exhibit the least support for food waste reduction. Their self-reported levels of waste align with these behaviors as they report waste levels above the sample average for each of the six categories, leading us to dub this the ‘**Harried Profligates**’ segment. While they represent only 26 % of sample households, due to their relative waste levels, they generated 38 % of overall sample waste.

Cluster 3 respondents exhibit the least supportive attitudes toward food waste reduction, and many of their self-reported behaviors are similar with the sample average. Their waste levels closely aligned with sample average except a higher waste level in drinks category, leading us to call them the ‘**Unrepentant Drink Wasters**’ segment, representing 21 % of sample households and contributing to 19 % of sample waste.

In Cluster 4, respondents hold attitudes comparable to or stronger than Clusters 1 and 2 in terms of food waste reduction. While their self-reported behaviors fall slightly behind those in Cluster 1, they outperform Clusters 2 and 3. Their reported waste levels are very similar to sample average, with exceptions of higher waste in the carb category and lower waste in the drinks category. This leads us to dub them the ‘**Guilty Carb Wasters**’ segment, comprising 31 % of sample observations and contributing to 33 % of sample waste. The next sections explore each cluster in greater detail.

4.2. Food waste attitudes

Cluster 1 (Conscientious Conservers) respondents report attitudes that are nearly universally supportive of food waste reduction (Table 2) when compared to the sample average. For example, respondents in this cluster are very likely to agree with statements that assert food waste as an important issue (‘Food waste is an important national issue,’ ‘Minimizing my food waste deserves to be one of my top priorities’) and less likely to agree with reasons that are often proffered for food waste creation but lack scientific backing (‘Throwing away food if the package date has passed reduces the chance someone will get sick from eating the food,’ ‘Some food waste is necessary to make sure meals taste fresh and good’). They are also more likely to agree with statements concerning perceived awareness of food in their home (‘I am fully aware of what food is in my refrigerator’).

Respondents in Cluster 2 (Harried Profligates) hold similar attitudes as Cluster 1 in terms of seeing food waste as an important issue that warrants societal and personal priority and causes them personal guilt (Table 2). However, they are more likely than Cluster 1 to agree with standard excuses for food waste creation (can decrease risk of foodborne illness, help meals taste fresh, more waste due to bulk/sale items) and

are more pre-disposed to a key motivation to reduce food waste (saving money). Respondents in this cluster generally agree that they lack control of certain aspects of their home food environment (forgetting food in freezer, fridge is a disaster, their household wastes more than other similarly sized households). This cluster is the most likely to report feeling time pressure in day-to-day life with a majority (57 %) registering agreement with this sentiment.

Cluster 3 (Unrepentant Drink Wasters) respondents are the least likely to agree that food waste is an important national issue that warrants societal and personal priority, holds negative effects for the environment, or drives personal guilt (Table 2). However, they are no more likely than the sample average to agree with several standard excuses for food waste creation (food safety, bulk/sale purchases), though they are less likely than all other clusters (except Cluster 1) to view food waste as a source of financial waste. Respondents in this cluster are as good or better than the sample average in terms of their perceived control of their home food environment (not forgetting food in freezer, saying fridge is a disaster, confident in freezing food). Other than Cluster 1, Cluster 3 respondents are most likely to agree that it would be difficult to reduce food waste further and the least likely to feel much day-to-day time pressure.

Respondents in Cluster 4 (Guilty Carb Wasters) hold very similar or stronger attitudes as Clusters 1 and 2 in terms of seeing food waste as an important issue that warrants societal and personal priority (Table 2). More than any other cluster, Cluster 4 respondents report a higher level of agreement with the statements ‘You feel guilty when you throw away food’ and ‘I have been making more of an effort lately to reduce my food waste.’ However, they are more likely than Cluster 1 to agree with standard but potentially spurious reasons for food waste creation (decrease the risk of illness, help meals taste fresh, waste due to bulk/sale items). They are more pre-disposed to a key motivation to reduce food waste (saving money) than any other cluster. Cluster 4 respondents think they have more room to reduce food waste further than any other cluster except Cluster 2 as only 17 % agree that it would be difficult to further reduce food waste.

4.3. Food waste behaviors

Respondents in cluster 1 (Conscientious Conservers) are more likely than other clusters to report behaviors consistent with greater control of home food preparation (making and following meal plans, checking current food stocks before shopping, avoiding buying too much and unplanned purchases, tracking food once brought home, making meals with unused ingredients and leftovers, confidence in freezing food, creating portion sizes that reduce the odds of waste, see Table 3). They are the most likely of all clusters to say that it would be difficult to further reduce food waste and least likely to agree that they waste more than other households or that they think their food waste leads to a major source of lost money in their household.

Compared to all other clusters, cluster 2 (Harried Profligates) respondents’ self-reported behaviors are the least supportive of food waste reduction: they are less likely to make and stick to meal plans, check food in storage before shopping, create and adhere to shopping lists, avoid overbuying/unplanned purchases, track food once in storage, use leftovers and unused ingredients, and monitor portion sizes (Table 3).

Many of Cluster 3 (Unrepentant Drink Wasters) respondents’ self-reported behaviors are quite similar to the sample average in terms of meal planning, checking food in storage before shopping, creating/adhering to shopping lists, avoiding overbuying/unplanned purchases, tracking food once in storage, using up leftovers and unused ingredients, and monitoring portion sizes (Table 3).

Respondents in cluster 4 (Guilty Carb Wasters) falls short of Cluster 1 in avoiding overbuying and unplanned purchases, tracking purchased foods, preparing appropriate portion sizes and using up leftovers, though they are better than Clusters 2 and 3 (Table 3).

Table 3
Respondent food waste behaviors.

	All			Cluster 1			Cluster 2			Cluster 3			Cluster 4		
				Conscientious conservers			Harried profligates			Drink wasters			Carb wasters		
	Mean	SD		Mean	SD		Mean	SD		Mean	SD		Mean	SD	
Behavior (Adherent = 1)															
Plan meals ahead of time	0.56	0.50	3	0.66	0.47	a	0.44	0.50	b	0.53	0.50	c	0.61	0.49	acd
Follow previously made meal plan	0.61	0.49	3	0.71	0.45	a	0.50	0.50	b	0.56	0.50	bc	0.67	0.47	ad
Check fridge before shopping	0.87	0.34		0.98	0.14	a	0.68	0.47	b	0.92	0.28	c	0.92	0.27	cd
Check freezer before shopping	0.80	0.40	3	0.94	0.24	a	0.54	0.50	b	0.85	0.36	c	0.90	0.31	acd
Make and stick to shopping list	0.76	0.43	3	0.91	0.29	a	0.57	0.50	b	0.77	0.42	c	0.81	0.40	cd
No overbuying	0.76	0.43	4	0.95	0.23	a	0.55	0.50	b	0.83	0.37	c	0.76	0.43	d
Avoid unplanned purchases	0.60	0.49	34	0.84	0.37	a	0.39	0.49	b	0.62	0.49	c	0.61	0.49	cd
Track food in fridge	0.81	0.40	3	0.99	0.09	a	0.52	0.50	b	0.84	0.37	c	0.90	0.3	d
Track food in freezer	0.74	0.44		0.94	0.23	a	0.33	0.47	b	0.83	0.37	c	0.88	0.33	cd
Check label for storage info	0.74	0.44	3	0.84	0.37	a	0.58	0.49	b	0.71	0.46	c	0.83	0.38	ad
Use up food before package date	0.82	0.39	3	0.97	0.17	a	0.62	0.49	b	0.83	0.38	c	0.87	0.33	cd
Label food before storage	0.54	0.50	34	0.65	0.48	a	0.42	0.49	b	0.54	0.50	c	0.57	0.50	cd
Track opened food	0.78	0.42		0.96	0.20	a	0.52	0.50	b	0.85	0.36	c	0.82	0.38	cd
Freeze food	0.88	0.32	3	0.95	0.21	a	0.76	0.43	b	0.90	0.30	ac	0.92	0.27	acd
Defrost food	0.69	0.46	34	0.79	0.41	a	0.56	0.50	b	0.71	0.46	c	0.73	0.44	acd
Check fridge temp	0.62	0.49	34	0.75	0.44	a	0.45	0.50	b	0.64	0.48	c	0.64	0.48	cd
Make meals with unused ingredients	0.79	0.41		0.91	0.28	a	0.63	0.48	b	0.74	0.44	c	0.86	0.34	ad
Prepare appropriate portion sizes	0.81	0.39	3	0.95	0.21	a	0.61	0.49	b	0.83	0.38	c	0.86	0.34	cd
Use up leftovers	0.85	0.35	34	0.96	0.19	a	0.73	0.45	b	0.85	0.36	c	0.88	0.32	cd
Batch cooking	0.62	0.49	4	0.75	0.44	a	0.56	0.50	b	0.56	0.50	bc	0.62	0.49	bcd
N	1086			233			273			238			342		
Weighted % of Sample Waste	100 %			10 %			38 %			19 %			33 %		
Weighted % of Sample Observations	100 %			22 %			26 %			21 %			31 %		

Notes: Weighted figures based upon post-hoc sample weights to adjust for age, income and household size. *Cluster numbers that appear in this column have mean values that are not significantly different from the mean value for all other clusters for the variable in this row at the 5 % level. E.g., for 'Food waste is bad for the environment' the mean value for cluster 2 is not significantly different than the mean value pooled across clusters 1, 3 and 4. † Clusters that share a letter within the same row have means that are not statistically different from one another at the 5 % level.

4.4. Self-reported food waste amounts

We observe a strong alignment between the self-reported waste levels and the exhibited attitudes and behaviors in Cluster 1 (Conscientious Conservers). Respondents in this cluster report waste levels below the sample average both overall (55 % less) and for each of the six categories (Fig. 2). In Cluster 2 (Harried Profligates), respondents' self-reported levels of waste align with these behaviors as they report waste levels above the sample average both overall (45 % more) and for each of the six categories (Fig. 2). For respondents in Cluster 3 (Unrepentant Drink Wasters), their self-reported levels are very similar to the sample average overall (7 % less) though the distribution across categories differs from average with below average waste in all categories except drinks, where waste is 24 % greater than average (Fig. 2). In Cluster 4 (Guilty Carb Wasters), we find that their self-reported levels of waste are very similar to the sample average (6 % more) though they are 23 % higher in the carb category and 14 % below average for drinks (Fig. 2).

4.5. Demographics characteristics

Conscientious Conservers in Cluster 1 skew toward the older age categories (e.g., 82 % are 45+ vs. 63 % for the sample) and are the most likely cluster to report being retired (Table 4). Respondents tend to report lower incomes and smaller household sizes than the overall sample with few reporting young children in their households (4 % vs. 9 % sample average). Respondents were the least likely of all clusters to report an unexpected issue leading to unusual amounts of wasted food during their reporting week (Table 4), the least likely to report relying upon social media for news coverage (Table 4), and the most likely to have reported hearing about food waste as an issue prior to taking this survey (Table 4). In terms of guiding life principles (Table 4), Cluster 1 respondents assigned significantly lower importance than other clusters to the values of power and hedonism and significantly higher importance to the values of universalism, self-direction and security.

Harried Profligates in Cluster 2 skew younger and higher income and live in households with more total people including young children (age 5 or less, see Table 4). They are the cluster most likely to report that an unexpected issue led to unusual amounts of food waste during their reporting week (Table 4). Compared to other clusters, they are more likely to receive news via TV and social media. In terms of personal values, they place lower importance on self-direction (creativity, freedom, curiosity, independence, choosing one's own goals) than those in all other clusters.

Unrepentant Drink Wasters in Cluster 3 are the least likely to identify as female and, after Cluster 1, are more likely to consist of single-person households (Table 4). They are the least likely of all clusters to have heard of food waste as a topic prior to this survey. After Cluster 1, they were the least likely to report an unexpected issue that caused unusual food waste levels during their week of reporting. Along with Cluster 1, they tend to rely less upon social media for receiving news than Clusters 2 and 4.

The Guilty Carb Waster (Cluster 4) segment contains the highest fraction of respondents identifying as female (63 %) and as Hispanic or Latino (6 %, Table 4). Respondents skew a little younger and report less formal education than both the sample mean and Cluster 1. They also tend to have larger households and are more likely to have young children than Cluster 1. Guilty Carb Wasters are the most likely to be working full time among all clusters and, after Cluster 2, most likely to report that an unexpected issue caused unusual amounts of wasted food during their reporting week (81 %). After Cluster 2, these respondents were the most likely to rely upon social media for news.

4.6. Other characteristics

With respect to concerns about food (Table 5), Cluster 1 (Conscientious Conservers) respondents were least likely to mention food prices, food affordability, and food availability, and most likely to mention animal welfare. They reported the highest percentage of their food

Table 4
Respondent demographics.

	All			Cluster 1			Cluster 2			Cluster 3			Cluster 4		
				Conscientious conservers			Harried profligates			Drink wasters			Carb wasters		
	Mean	SD		Mean	SD		Mean	SD		Mean	SD		Mean	SD	
Female (Yes = 1)	0.55	0.50	12*	0.52	0.50	a [†]	0.55	0.50	ab	0.46	0.50	ac	0.63	0.48	bd
Age															
18–44	0.37	0.48	3	0.19	0.39	a	0.47	0.50	b	0.36	0.48	c	0.42	0.49	bcd
45–64	0.35	0.48	134	0.41	0.49	a	0.30	0.46	b	0.37	0.48	abc	0.35	0.48	abcd
65 and older	0.28	0.45	23	0.41	0.49	a	0.23	0.42	b	0.27	0.44	bc	0.22	0.42	bcd
Education															
Above bachelor	0.21	0.40	123	0.24	0.43	a	0.24	0.43	ab	0.18	0.39	abc	0.17	0.38	cd
Bachelor	0.38	0.49	1234	0.38	0.49	a	0.37	0.48	ab	0.42	0.49	abc	0.36	0.48	abcd
Below bachelor	0.42	0.49	123	0.38	0.49	a	0.39	0.49	ab	0.40	0.49	abc	0.47	0.50	cd
Household income															
<\$50 k	0.38	0.49	34	0.48	0.50	a	0.29	0.46	b	0.36	0.48	bc	0.40	0.49	acd
\$50 k–\$99 k	0.29	0.45	1234	0.25	0.44	a	0.28	0.45	ab	0.31	0.46	abc	0.30	0.46	abcd
>\$100 k	0.33	0.47	34	0.27	0.44	a	0.42	0.49	b	0.34	0.47	ac	0.31	0.46	acd
Household size															
1	0.27	0.44	3	0.40	0.49	a	0.19	0.39	b	0.29	0.46	c	0.23	0.42	bcd
2	0.38	0.48	1234	0.43	0.50	a	0.35	0.48	ab	0.37	0.48	abc	0.37	0.48	abcd
>2	0.36	0.48	3	0.18	0.38	a	0.47	0.50	b	0.33	0.47	c	0.41	0.49	bcd
Any children under 5 (Yes = 1)	0.09	0.29	2	0.04	0.20	a	0.12	0.32	b	0.05	0.23	ac	0.13	0.33	bd
Self-identified Race															
Asian	0.04	0.20	1234	0.03	0.17	a	0.05	0.21	ab	0.04	0.19	abc	0.06	0.23	abcd
Black	0.10	0.31	34	0.05	0.23	a	0.14	0.34	b	0.09	0.29	abc	0.12	0.33	bcd
White	0.81	0.39	234	0.88	0.33	a	0.78	0.42	b	0.84	0.37	abc	0.78	0.42	bcd
Multiple or Other Identifications	0.04	0.19	1234	0.04	0.19	a	0.04	0.20	ab	0.03	0.18	abc	0.04	0.21	abcd
Employment status															
Full Time	0.48	0.50	23	0.37	0.48	a	0.50	0.50	b	0.47	0.50	bc	0.54	0.50	bcd
Part time	0.17	0.38	1234	0.17	0.38	a	0.19	0.39	ab	0.18	0.38	abc	0.16	0.37	abcd
Retired	0.21	0.40	3	0.34	0.47	a	0.15	0.36	b	0.22	0.42	c	0.14	0.35	bd
Other	0.14	0.35	1234	0.12	0.33	a	0.16	0.37	ab	0.13	0.34	abc	0.15	0.36	abcd
Identify as Hispanic or Latino (Yes = 1)	0.04	0.20	123	0.03	0.17	a	0.04	0.20	ab	0.02	0.15	abc	0.06	0.24	bd
Unexpected issues led to waste (Yes = 1)	0.77	0.42	3	0.60	0.49	a	0.90	0.30	b	0.72	0.45	c	0.81	0.39	d
Following special diet (Yes = 1)	0.29	0.46	124	0.32	0.47	a	0.28	0.45	ab	0.24	0.43	abc	0.32	0.47	abd
Region															
Midwest	0.24	0.43	1234	0.24	0.43	a	0.28	0.45	ab	0.24	0.43	abc	0.22	0.41	abcd
Northeast	0.22	0.41	1234	0.20	0.40	a	0.21	0.41	ab	0.21	0.41	abc	0.24	0.43	abcd
South	0.31	0.46	1234	0.32	0.47	a	0.28	0.45	ab	0.30	0.46	abc	0.33	0.47	abcd
West	0.23	0.42	1234	0.24	0.43	a	0.22	0.42	ab	0.25	0.43	abc	0.22	0.41	abcd
Media for news (Often or sometimes = 1)															
Newspapers	0.12	0.33	1234	0.1	0.30	a	0.14	0.35	ab	0.12	0.32	abc	0.13	0.34	abcd
Radio	0.41	0.49	1234	0.43	0.50	a	0.42	0.50	ab	0.38	0.49	abc	0.40	0.49	abcd
TV	0.58	0.49	34	0.52	0.50	a	0.64	0.48	b	0.55	0.50	ac	0.59	0.49	abcd
Websites	0.94	0.24	134	0.93	0.26	a	0.96	0.19	ab	0.92	0.27	abc	0.94	0.25	abcd
Social media platforms	0.72	0.45	4	0.63	0.48	a	0.81	0.39	b	0.66	0.47	ac	0.75	0.43	bd
Political Identification															
Liberal	0.59	0.49	14	0.58	0.49	a	0.65	0.48	ab	0.51	0.50	ac	0.60	0.49	abd
Neither	0.15	0.36	1234	0.14	0.35	a	0.12	0.32	ab	0.19	0.39	ac	0.16	0.36	abcd
Conservative	0.26	0.44	1234	0.27	0.45	a	0.23	0.42	ab	0.30	0.46	abc	0.24	0.43	abcd
Schwartz principles (0–8 importance scale)															
Power	2.27	1.63	34	1.95	1.52	a	2.53	1.72	b	2.25	1.57	bc	2.30	1.64	bcd
Achievement	4.36	1.76	34	4.00	1.53	a	4.55	1.82	b	4.29	1.71	abc	4.51	1.87	bcd
Hedonism	3.78	1.73	3	3.25	1.5	a	4.03	1.81	b	3.75	1.69	bc	3.97	1.78	bcd
Stimulation	3.94	1.82	1234	3.79	1.71	a	4.07	1.67	ab	3.86	1.84	abc	4.00	2.00	abcd
Universalism	5.58	1.97	24	5.94	2.05	a	5.49	1.91	b	5.20	1.95	bc	5.66	1.92	abd
Benevolence	6.53	1.62	1234	6.66	1.63	a	6.49	1.70	ab	6.39	1.57	abc	6.58	1.56	abcd
Tradition	4.00	1.85	1234	3.93	1.84	a	4.09	1.82	ab	4.03	1.93	abc	3.97	1.85	abcd
Conformity	3.48	1.89	1234	3.44	1.93	a	3.57	1.80	ab	3.42	1.77	abc	3.49	2.00	abcd
Self-direction	6.72	1.31	34	7.07	1.09	a	6.45	1.43	b	6.70	1.39	c	6.70	1.25	cd
Security	5.14	1.70	234	5.36	1.82	a	5.00	1.58	b	4.99	1.63	bc	5.20	1.73	abcd

Notes: Weighted figures based upon post-hoc sample weights to adjust for age, income and household size. *Cluster numbers that appear in this column have mean values that are not significantly different from the mean value for all other clusters for the variable in this row at the 5 % level. † Clusters that share a letter within the same row have means that are not statistically different from one another at the 5 % level.

shopping being conducted in-person in stores and the least likely to have discarded food items from refrigerated, frozen and dry storage areas in their homes in the past 7 days.

Compared to other clusters, Cluster 2 (Harried Profligates) are more likely to report food waste as a concern and to have discarded food from their refrigerator, freezer and pantry in the past 7 days. They are also the least likely among all clusters to obtain their food via in-person shopping trips and prepared the smallest fraction of their meals at home during

the reporting week.

Cluster 3 (Unrepentant Drink Wasters) register less concern than all other clusters about animal welfare, food packaging, and the environmental impact of food production. They are the least likely of all clusters to mention food waste as a concern (Table 5).

Respondents from Cluster 4 were the most likely to report that they were concerned about food affordability and tied for the most likely to list food prices as a concern (Table 5). After Cluster 2, they tended to be

Table 5
Respondent food concerns, perceptions and behaviors.

	All			Cluster 1			Cluster 2			Cluster 3			Cluster 4		
	Mean	SD		Mean	SD		Mean	SD		Mean	SD		Mean	SD	
Heard about FW as an issue (Yes = 1)	0.38	0.48	4*	0.54	0.50	a [†]	0.32	0.47	b	0.24	0.43	bc	0.40	0.49	d
Food Concerns (concerned = 1)															
Price	0.74	0.44	234	0.61	0.49	a	0.78	0.42	b	0.78	0.42	bc	0.78	0.42	bcd
Food waste	0.35	0.48	4	0.29	0.46	a	0.45	0.50	b	0.27	0.44	ac	0.37	0.48	abd
Animal welfare	0.27	0.45	24	0.34	0.48	a	0.25	0.43	b	0.19	0.39	bc	0.29	0.46	abd
Food healthfulness	0.54	0.50	1234	0.54	0.50	a	0.52	0.50	ab	0.50	0.50	abc	0.57	0.50	abcd
Food packaging	0.20	0.40	4	0.25	0.43	a	0.26	0.44	ab	0.13	0.33	c	0.16	0.37	cd
Food availability	0.33	0.47	34	0.21	0.41	a	0.40	0.49	b	0.35	0.48	bc	0.35	0.48	bcd
Environment	0.23	0.42	24	0.31	0.46	a	0.23	0.42	b	0.16	0.37	bc	0.23	0.42	bcd
Hormones	0.31	0.46	34	0.38	0.49	a	0.23	0.42	b	0.31	0.47	ac	0.32	0.47	acd
Pesticides	0.30	0.46	4	0.42	0.49	a	0.25	0.44	b	0.25	0.43	bc	0.30	0.46	bcd
Farmers welfare	0.14	0.34	23	0.18	0.38	a	0.14	0.35	ab	0.14	0.35	abc	0.10	0.30	bcd
Food affordability	0.27	0.44	23	0.20	0.40	a	0.27	0.45	ab	0.28	0.45	abc	0.31	0.46	bcd
Food safety	0.41	0.49	1234	0.38	0.49	a	0.46	0.50	ab	0.38	0.49	abc	0.42	0.49	abcd
GMO's	0.20	0.40	1234	0.20	0.40	a	0.18	0.38	ab	0.22	0.42	abc	0.20	0.40	abcd
% of Food Obtained by															
Shopping in store	76.66	31.94	34	82.92	29.43	a	73.10	32.74	b	76.74	32.58	bc	75.13	32.05	bcd
Shopping online and pick up	10.00	21.75	234	6.65	19.29	a	12.10	23.54	b	8.65	21.44	abc	11.52	21.76	bcd
Shopping online and delivery	11.83	24.49	1234	9.86	22.37	a	12.52	24.46	ab	12.74	26.15	abc	12.06	24.85	abcd
Receive via mealkit	1.51	7.06	34	0.58	3.55	a	2.29	9.28	b	1.87	8.85	bc	1.29	5.06	abcd
% of daily non-sleep time at home	66.52	23.65	34	73.47	20.90	a	62.82	23.66	b	66.38	23.67	bc	64.78	24.53	bcd
% meals prepared at home past 7 days	76.97	22.42	34	86.19	18.46	a	68.91	23.17	b	77.37	22.37	c	76.97	21.87	cd
Unexpected issues led to waste (Yes = 1)	0.77	0.42	3	0.60	0.49	a	0.90	0.30	b	0.72	0.45	c	0.81	0.39	d
Grocery shopping frequency															
≥ 2/week	0.22	0.41	1234	0.20	0.40	a	0.25	0.43	ab	0.20	0.40	abc	0.21	0.41	abcd
1/week	0.53	0.50	1234	0.51	0.50	a	0.56	0.50	ab	0.53	0.50	abc	0.53	0.50	abcd
2–3/month	0.21	0.41	34	0.26	0.44	a	0.15	0.36	b	0.23	0.42	ac	0.23	0.42	acd
≥ 1/month	0.03	0.18	1234	0.03	0.17	a	0.04	0.19	ab	0.03	0.17	abc	0.03	0.17	abcd
Discarded food in past 7 days (Yes = 1):															
From fridge	0.80	0.40	3	0.61	0.49	a	0.89	0.32	b	0.81	0.39	c	0.86	0.35	bcd
From freezer	0.13	0.34	34	0.02	0.14	a	0.23	0.42	b	0.14	0.35	c	0.12	0.33	cd
From pantry	0.27	0.44	34	0.12	0.33	a	0.41	0.49	b	0.27	0.44	c	0.25	0.43	cd

Notes: Weighted figures based upon post-hoc sample weights to adjust for age, income and household size. *Cluster numbers that appear in this column have mean values that are not significantly different from the mean value for all other clusters for the variable in this row at the 5 % level. † Clusters that share a letter within the same row have means that are not statistically different from one another at the 5 % level.

the most likely to report that they had cleaned out refrigerated food storage areas in the past 7 days.

5. Discussion

5.1. Comparing clusters across countries

The segmentation results obtained in this paper can be compared to those of previous research in other countries. The first cluster we identified is the Conscientious Conservers, which bears a strong resemblance to the 'Virtuous' cluster identified by [Romani et al. \(2018\)](#) in Italy. Both clusters demonstrate a supportive attitude toward reducing food waste and engage in behaviors that can drive the minimization of food waste. Furthermore, the self-reported food waste level of the Virtuous cluster is consistent with their attitudes and behaviors, as this segment is found to generate the least waste. Similarities are also observed with the 'Precautious' segment identified by [Pocol et al. \(2020\)](#) in Romania, as this group displays concern about food waste and takes measures to limit it. Similarly, [Di Talia et al. \(2019\)](#)'s 'conscientious consumers' segment gives serious consideration to food waste and has strong awareness of its environmental, economic, and ethical consequences. This group also exhibits a sense of responsibility for the waste generated and demonstrates good control over food preparation at home. However, no significant demographic similarities are observed between these clusters and the cluster we identified, which may not be surprising given cultural differences between the United States and the European countries where the extant research takes place.

The second cluster we identified (Harried Profligates) displays

certain similarities with the 'Self-indulgent' cluster identified by [Annunziata et al. \(2022\)](#). Both clusters waste the most food and justify their waste using standard excuses such as safety and freshness, despite being aware of the food waste problem and showing concern about its consequences. Additionally, both clusters are motivated to reduce food waste by the prospect of saving money and are composed of younger individuals. The main differences between the 'Self-indulgent' and our Harried Profligates clusters involve self-assessment of food waste amounts and inclination to change behaviors. The Italian 'Self-indulgent' segment alleges that they waste less than others, while the U.S. Harried Profligates cluster are more likely to admit to their households wasting more than others. Additionally, Harried Profligates claim efforts have been made to reduce food waste and disagree with that it would be difficult to further reducing waste, while the 'Self-indulgent' cluster displays unwillingness to change. Another similar cluster from the received literature is the 'Aware Wasters' segment identified by [Vittuari et al. \(2020\)](#) in Italy, who also discard a significant amount of food, which is linked to their poor food-management skills at home. Like Harried Profligates, this Italian cluster is concerned about time constraints and price consciousness on special offers.

The third cluster identified in this study is Unrepentant drink wasters. This cluster is similar to the 'Consumers Unaware but not Wasteful' cluster identified by [Di Talia et al. \(2019\)](#) in Italy. This cluster does not consider food waste as a global problem, and is not aware of the environmental, economic, and ethical consequences of food waste. Nevertheless, they demonstrate a tendency to avoid food waste in their behavior, making them less wasteful than other clusters. While no demographic similarities were found between these two clusters, the

‘Consumers Unaware but not Wasteful’ segment is composed of an older population (aged 55 to 66) with less formal education and a higher income level, living in larger households with teenagers and obtaining information from TV and radio. In contrast, Unrepentant Drink Wasters tend to be younger (aged 18 to 44), with middle income levels, and living in single-person households. No prominent education level and information sources were identified for Unrepentant Drink Waster segment in our study. The ‘Uncaring Consumers’ segment in Ireland, as identified by Flanagan and Priyadarshini (2021), also exhibit similar traits to Unrepentant Drink Wasters, with a lack of concern for the ethics and environmental impact of food waste, though they have some level of waste-minimizing behavior. Both clusters have a higher percentage of males. It should be noted, however, that the ‘Uncaring Consumers’ group feels guilty when wasting food, which distinguishes them from the Unrepentant Drink Wasters.

The final cluster identified was the Guilty Carb Waster. A similar group, the ‘Discouraged’ cluster, was identified by Annunziata et al. (2022) in Italy. This cluster expresses concern about food waste and feels a strong sense of guilt about their wasteful behaviors. They aim to reduce food waste to manage their family spending but lack confidence in their ability to control their home food environment to minimize waste. The two clusters share a similar demographic profile, characterized by younger age and less formal education. Similarly, the ‘Caring Consumers’ segment identified by Flanagan and Priyadarshini (2021) in Ireland express guilt about wasting food and are motivated to minimize waste due to financial consequences. They are more likely to be older females over the age of 55, while the Guilty Carb Waster cluster tends to be younger females. Our Guilty Carb Waster cluster also shows similarities with the ‘Safety First’ cluster identified by Närvänen et al. (2023) in Finland, which frequently reports food safety and spoiled bread as drivers of food waste. Both clusters have a higher percentage of individuals with lower income levels.

This comparative analysis across studies reveals consistent archetypal segments in food management and waste reduction behaviors. The segment characterized by a conscientious commitment to minimizing waste, known under various labels like “Proactive” (Annunziata et al., 2022), “Conservers” (Coskun, 2021), “Conscious Consumers” (Di Talia et al., 2019), “Precautious” (Pocol et al., 2020), “Guilty Food Waster” (Richter, 2017), “Virtuous” (Romani et al., 2018) or our “Conscientious Conservers” demonstrates a purposeful and effective approach to reducing waste. Members of these segments are typically distinguished by their intentional actions, such as meticulous meal planning, precise shopping habits, and the resourceful utilization of leftovers. This segment’s presence across studies indicates a universal aspect of consumer behavior that transcends geographic boundaries and could serve as a focal point for global waste reduction initiatives.

Conversely, segments exhibiting a lack of control over their home food environment, such as our “Harried Profligates” and “Guilty Carb Waster”, “Over Providers” (Borg et al., 2022, Australia), “Exaggerated Cook” and “Exaggerated Shopper” (Gaiani et al., 2018, Italy), “Over-purchasers and Overpreparers” (Närvänen et al., 2023, Finland), contribute to increased levels of waste through behaviors such as overbuying, inadequate meal planning, and a general disengagement from food waste reduction practices. Addressing the educational and behavioral needs of these segments is crucial, as tailored interventions could significantly enhance their food waste management, contributing to substantial reductions in household food waste globally.

5.2. Policy implications and limitations

The segmentation results provide several insights that can guide prioritization and strategy development when devising persuasive communications campaigns or other interventions designed to help the United States meet national food waste reduction goals. Due to the national scope of the data collection and the representativeness of the results with respect to age, income and household size provided by post-

hoc weights, we have the scope to assess the relative impact of the four different segments. For example, Clusters 2 and 4 (Harried Profligates and Guilty Carb Wasters) are the largest clusters in terms of the proportion of sample households (26 % and 31 %, respectively for a total of 57 % of households). However, due to their household size and levels of per-person waste, they represent an even greater proportion of total waste food (71 %). Hence strategies that focus on changing the behavior of these two clusters hold the potential of reducing national food waste by the greatest amount.

Beyond generating the largest amount of waste of any combination of two clusters, the Harried Profligates and Guilty Carb Wasters share some key attitudinal and behavioral characteristics that suggest the potential for a campaign or intervention to induce behavior change by targeting overlapping aspects of these two clusters. For example, respondents in both of these clusters are highly pre-disposed to viewing food waste as a critical national issue, expressing guilt about creating food waste, identifying food waste as a major source of wasted money, dedicating recent activity to reducing waste, thinking it would not be too difficult to further reduce waste, agreeing that bulk/sale purchases contribute to waste in their households, and feeling higher levels of time pressure in day-to-day life. The respondents from these clusters were most likely to identify as female, be in the youngest age category, have 3 or more household members (including children 5 or younger), be employed full time (and least likely to be retired), report issues during their reporting week that led to unusual waste, and receive news from social media sources. The respondents in these clusters share some similar food-related concerns, including high food prices. Furthermore, both groups are below average in terms of reliance on traditional in-store food shopping and are above average in having discarded food from their refrigerator in the past 7 days.

While these two clusters share a number of similarities, there are some stark differences that any intervention designed to target both clusters would have to accommodate. For example, the Guilty Carb wasters (Cluster 4) reports food management habits that are much more supportive of reducing food waste than do the Harried Profligates. After Cluster 1, Cluster 4 reports some of the best habits with respect to meal planning, purchasing habits and in-home food management and storage, while Cluster 2 struggles with these aspects more than any other cluster.

Whereas Clusters 2 and 4 represent a majority of households and a supermajority of waste generated, Clusters 1 and 3 combined generate <30 % of aggregate wasted food and each presents characteristics that are obstacles to interventions designed to reduce waste. With respect to Cluster 1 (Conscientious Conservers), the obstacle is that they simply report the least waste of any cluster and report many attitudes and behavior that are already supportive of waste reduction. Respondents in this cluster are the most likely to report that it would be difficult to reduce food waste (55 %), whereas only 15 % and 17 % of Cluster 2 and 4 respondents hold this view. When it comes to Cluster 3 (Unrepentant Drink Wasters), they hold attitudes that seem to provide few motivational pathways for successfully introducing interventions. That is, they are least likely to view food waste as an import issue or a personal priority, are among the least likely to view waste as a source of financial stress or guilt, and report food management practices that are as good or better than most other clusters. The potential avenues for intervention may surround adjusting a few skewed perceptions as they share the majority view that, i.e., throwing away food after the label date decreases the risk of illness and, more than any other cluster, they agree that some food waste is needed to ensure meals taste fresh.

The segmentation analysis is also helpful in assessing characteristics that seem to have little bearing upon cluster membership. For example, membership in clusters appears to have little association with the region of the country, which suggests that those devising campaigns for particular states or regions may encounter similar segments in their focal geographic regions. Likewise, a respondent’s political identification (liberal-conservative spectrum), race, adherence to specialized diets, frequency of grocery shopping, and motivating philosophical principles

(Schwartz scale, e.g., power, achievement) appear to have little relationship to cluster membership.

We also want to note several limitations of this study. First, we lack several household characteristics that could be fruitful in devising campaigns and interventions, including if the household resides in an urban vs. suburban vs. rural area and in single-family vs. multi-family housing. Second, a larger sample collected over a broader period of time would provide more confidence in the robustness of the results, particularly as a few variables in the current data were not collected for all respondents due to an administrative error (media use, Schwartz power principles) and had to be predicted for a subset of respondents. We also recognize that the clustering analysis could be anchored to other subsets of variables, such as food shopping outlets/frequencies, the amounts and types of waste reported, or on preferred media. Undertaking such analyses would permit other avenues for targeting future interventions and campaigns that may lead to different priorities or strategies. Finally, we recognize that the levels of food waste used in the analysis are gathered by self-reported survey, which has been previously documented to under-report levels of waste compared to alternative measurement approaches (e.g., curbside audits, see [Van Herpen et al., 2019](#)). So long as the degree of bias in reporting is similar across segments, we feel the results presented here will still be useful in targeting household waste interventions, though look forward to future work similar to that of [Borg et al. \(2022\)](#) that can validate segmentation insights with more robust food waste measurement approaches.

6. Conclusions

In order to achieve U.S. food waste reduction goals, changing the behavior of consumers will be essential as ~50 % of wasted food occurs in residential settings. Reducing food waste in households can be accomplished by changing several types of behavior (e.g., meal planning, food shopping, food storage, food preparation, leftover management) and by leveraging several sources of consumer motivation (financial, environmental, norm adherence). Segmenting consumers by relevant behaviors and attitudes can help direct consumer campaigns, however no such analysis has been conducted in the United States.

We analyzed the food waste attitudes and behaviors of 1086 U.S. consumers who responded to an online survey by using *k*-means clustering and post-hoc sample weighting to ensure national representativeness. We identify four distinct consumer segments: Conscientious Conservers (22 % of households, 10 % of total food waste generated), Harried Profligates (26 % of households, 38 % of waste), Unrepentant Drink Wasters (21 % of households, 10 % of waste), Guilty Carb Wasters (31 % of households, 33 % of waste). For each segment we identify and discuss the constellation of attitudes, behaviors and characteristics that distinguish them from other groups and then postulate intervention and communication strategies that may prove fruitful for targeting messages in a manner that advance national food waste reduction goals in a cost-effective manner.

We find clusters 2 and 4 (Harried Profligates and Guilty Carb Wasters) are the largest clusters in terms of the proportion of sample households (26 % and 31 %, respectively for a total of 57 % of households) and, due to their household size and levels of per-person waste, represent an even greater proportion of total waste food (71 %). Hence, we recommend strategies that focus on changing the behavior of these two clusters because they hold the potential of reducing national food waste by the greatest amount. Furthermore, the Harried Profligates and Guilty Carb Wasters share some key attitudinal and behavioral characteristics that suggest the potential for a campaign or intervention to induce behavior change by targeting overlapping aspects of these two clusters. For example, respondents in both of these clusters are highly pre-disposed to viewing food waste as a critical national issue, expressing guilt about creating food waste, identifying food waste as a major source of wasted money, dedicating recent activity to reducing waste, thinking it would not be too difficult to further reduce waste,

agreeing that bulk/sale purchases contribute to waste in their households, and feeling higher levels of time pressure in day-to-day life.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.spc.2024.01.015>.

References

- Annunziata, A., Muca, F.L., Mariani, A., 2022. Preventing household food waste in Italy: a segmentation of the population and suggestions for action. *Sustainability* 14 (12), 7005. <https://doi.org/10.3390/su14127005>.
- Aschemann-Witzel, J., de Hooge, I.E., Almlí, V.L., Oostindjer, M., 2018. Fine-tuning the fight against food waste. *J. Macromark.* 38 (2), 168–184. <https://doi.org/10.1177/0276146718763251>.
- Aschemann-Witzel, J., de Hooge, I.E., Almlí, V.L., 2021. My style, my food, my waste! Consumer food waste-related lifestyle segments. *J. Retail. Consum. Serv.* 59, 102353. <https://doi.org/10.1016/j.jretconser.2020.102353>.
- Bilska, B., Tomaszewska, M., Kołozyn-Krajewska, D., Piecsek, M., 2020. Segmentation of Polish households taking into account food waste. *Foods* 9 (4), 379. <https://doi.org/10.3390/foods9040379>.
- Borg, K., Boulet, M., Karunasena, G., Pearson, D., 2022. Segmenting households based on food waste behaviours and waste audit outcomes: introducing over providers, under planners and considerate planners. *J. Clean. Prod.* 351, 131589. <https://doi.org/10.1016/j.jclepro.2022.131589>.
- Coskun, A., 2021. Identification of different user types for designing household food waste interventions. *Int. J. Sustain. Eng.* 14 (4), 609–617. <https://doi.org/10.1080/19397038.2021.1886372>.
- Delley, M., Brunner, T.A., 2017. Foodwaste within Swiss households: a segmentation of the population and suggestions for preventive measures. *Resour. Conserv. Recycl.* 122, 172–184. <https://doi.org/10.1016/j.resconrec.2017.02.008>.
- Di Talia, E., Simeone, M., Scarpato, D., 2019. Consumer behaviour types in household food waste. *J. Clean. Prod.* 214, 166–172. <https://doi.org/10.1016/j.jclepro.2018.12.216>.
- Donovan, R.J., Egger, G., Francas, M., 1999. TARPARE: a method for selecting target audiences for public health interventions. *Aust. N. Z. J. Public Health* 23 (3), 280–284.
- Flanagan, A., Priyadarshini, A., 2021. A study of consumer behaviour towards food-waste in Ireland: attitudes, quantities and global warming potentials. *J. Environ. Manag.* 284, 112046. <https://doi.org/10.1016/j.jenvman.2021.112046>.
- Gaiani, S., Caldeira, S., Adorno, V., Segrè, A., Vittuari, M., 2018. Food wasters: profiling consumers' attitude to waste food in Italy. *Waste Manag.* 72, 17–24. <https://doi.org/10.1016/j.wasman.2017.11.012>.
- Kodinariya, T.M., Makwana, P.R., 2013. Review on determining number of cluster in *k*-means clustering. *Int. J.* 1 (6), 90–95.
- Kutlu, M.B., 2022. A trait-based consumer segmentation for food waste reduction campaigns. *Soc. Mark. Q.* 28 (2), 130–146. <https://doi.org/10.1177/152450042210977>.
- Mallinson, L.J., Russell, J.M., Barker, M.E., 2016. Attitudes and behaviour towards convenience food and food waste in the United Kingdom. *Appetite* 103, 17–28. <https://doi.org/10.1016/j.appet.2016.03.017>.
- Marek-Andrzejewska, E.M., Wielicka-Regulska, A., 2021. Targeting youths' intentions to avoid food waste: segmenting for better policymaking. *Agriculture* 11 (4), 284. <https://doi.org/10.3390/agriculture11040284>.
- Närvalinen, E., Mesiranta, N., Saarijärvi, H., Nevalainen, J., 2023. Examining consumer food waste through grocery retailers' customer data: segments and practical implications. *Int. J. Consum. Stud.* <https://doi.org/10.1111/ijcs.12903>.

- NASEM (National Academies of Sciences, Engineering, and Medicine), 2020. A National Strategy to Reduce food waste at the Consumer Level. National Academies Press. Available online at: <https://nap.nationalacademies.org/catalog/25876/a-national-strategy-to-reduce-food-waste-at-the-consumer-level>. (Accessed 3 July 2022).
- Nielsen, K.S., Clayton, S., Stern, P.C., Dietz, T., Capstick, S., Whitmarsh, L., 2021. How psychology can help limit climate change. *Am. Psychol.* 76 (1), 130. <https://doi.org/10.1037/amp0000624>.
- Pocol, C.B., Pinoteau, M., Amuza, A., Burlea-Schiopoiu, A., Glogovețan, A.I., 2020. Food waste behavior among Romanian consumers: a cluster analysis. *Sustainability* 12 (22), 9708. <https://doi.org/10.3390/su12229708>.
- ReFED (Reducing food waste through economics and data), 2023. Data Insights Engine. Available online at: <https://insights-engine.refed.com/food-waste-monitor>. (Accessed 5 March 2023).
- Richter, B., 2017. Knowledge and perception of food waste among German consumers. *J. Clean. Prod.* 166, 641–648. <https://doi.org/10.1016/j.jclepro.2017.08.009>.
- Roe, B.E., Qi, D., Beyl, R.A., Neubig, K.E., Apolzan, J.W., Martin, C.K., 2022. A randomized controlled trial to address consumer food waste with a technology-aided tailored sustainability intervention. *Resour. Conserv. Recycl.* 179, 106121.
- Romani, S., Grappi, S., Bagozzi, R.P., Barone, A.M., 2018. Domestic food practices: a study of food management behaviors and the role of food preparation planning in reducing waste. *Appetite* 121, 215–227. <https://doi.org/10.1016/j.appet.2017.11.093>.
- Shu, Y., Roe, B.E., Bender, K., 2021. Adapting, refining and expanding a validated questionnaire to measure food waste in US households. *MethodsX* 8, 101377.
- USDA, 2015. USDA and EPA Join with Private Sector, Charitable Organizations to Set Nation's First Food Waste Reduction Goals. Available online from: http://www.usda.gov/wps/portal/usda/usdahome?contentid=2015/09/0257.xml&navid=NEWS_RELEASE&navtype=RT&parentnav=LATEST_RELEASES&deployment_t_action=retrievecontent. (Accessed 20 March 2023).
- USDA, 2021. Food Availability (Per Capita) data System. Economic Research Service. Available online at: www.ers.usda.gov/data-products/food-availability-per-capita-data-system/food-availability-per-capita-data-system/#Food%20Availability. (Accessed 20 March 2023).
- Van Herpen, E., van der Lans, I.A., Holthuysen, N., Nijenhuis-de Vries, M., Quested, T.E., 2019. Comparing wasted apples and oranges: an assessment of methods to measure household food waste. *Waste Manag.* 88, 71–84. <https://doi.org/10.1016/j.wasman.2019.03.013>.
- Vittuari, M., Falasconi, L., Masotti, M., Piras, S., Segrè, A., Setti, M., 2020. 'Not in my bin': Consumer's understanding and concern of food waste effects and mitigating factors. *Sustainability* 12 (14), 5685. <https://doi.org/10.3390/su12145685>.
- Weinstein, A., 1994. *Market Segmentation: Using Demographics, Psychographics and Other Niche Marketing Techniques to Predict Customer Behavior*, revised ed. Probus Publishing Co., Chicago, IL.
- WRAP, 2022. UK Household Food Waste tracking survey Winter 2021: Behaviours, attitudes, and awareness. Project Code: CIT022-001. Available online at: <https://wrap.org.uk/resources/report/uk-household-food-waste-tracking-survey-winter-2021>. (Accessed 18 November 2023).