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Does food processing mitigate consumers' concerns about crops grown with recycled water?

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ABSTRACT

This paper presents results from a field experiment designed to evaluate whether food processing alleviates consumers' concerns about crops grown with recycled water. Recycled water has emerged as a potentially safe and cost-effective way to replace or supplement traditional irrigation water. However, adoption of recycled water by U.S. agricultural producers has been modest, in part, because of concerns that consumers will be reluctant to accept their products. Our results suggest that simple processing of foods such as drying or liquefying can relieve some of consumers' concerns about use of recycled irrigation water. While consumers of processed foods are indifferent between irrigation with recycled and conventional water, they are less willing to pay for fresh foods irrigated with recycled water relative to conventional water. We also found that consumers would experience a welfare gain from a labeling policy communicating the use of recycled irrigation water on both processed and fresh foods. Our analysis further reveals that informational nudges that provide consumers with messages about benefits, risks, and both the benefits and risks of using recycled water have no statistically significant effect on consumers' willingness to pay for fresh and processed foods irrigated with recycled water relative to a no-information control group.

1. Introduction

Water scarcity is a growing concern in many regions of the U.S. and across the world. Currently, 4 billion people worldwide, including 130 million people in the U.S., experience severe water shortages at least part of the year (Mekonnen and Hoekstra, 2016). Projected growth in populations and food demand, coupled with rising temperatures and changing weather patterns, will further strain available water resources. These issues pose a serious challenge for the agricultural sector, which currently uses more than 70% of the world's fresh water resources for irrigation (World Water Assessment Programme, 2016). In the U.S., the agricultural sector is responsible for 80% of the country's total water consumption and 90% of total water consumption in most western states (U.S. Department of Agriculture, 2017). Furthermore, global agricultural output is projected to double in the next 30 years (World Bank, 2014), and therefore alternative sources of irrigation water are critically needed.

Recycled water[1] has emerged as a safe and cost-effective way to provide for the growing demand for irrigation water around the world (Chen et al., 2013). Countries such as Israel and Australia have been using recycled irrigation water for decades, but its use by U.S. agricultural producers has been modest. Though 32 billion gallons of municipal wastewater are produced daily in the U.S. (National Research Council, 2012), only California, Florida, Arizona, and Texas augment their irrigation supplies with recycled water (McNabb, 2017). Perhaps the most significant hurdle to using recycled water in the U.S. is consumers' lack of acceptance of it, particularly for products that are ingested (e.g. food) or come into direct contact (e.g. bathing), despite technological advances that can treat the water so it meets both potable and non-potable standards (Dolnicar and Saunders, 2006; Haddad et al., 2009; Hurlimann and Dolnicar, 2016; Kecinski et al., 2016, 2018a, 2018b; Po et al., 2005; Rozin et al., 2015; Savchenko et al., 2019; Schmidt, 2008; Kecinski and Messer, 2018; Ellis et al., 2018). This aversion to recycled water also extends to fresh produce irrigated

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[1] According to the California Department of Water Resources (2018), "recycled water is highly treated wastewater from various sources, such as domestic sewage, industrial wastewater and storm water runoff." This type of water has been referred to by several names, including reclaimed water, reused water, treated wastewater, repurified water, tertiary treated wastewater, advanced purified water, NEWater (Ellis et al., 2018; Lee and Tan, 2016; Rock et al., 2012; Menegaki et al., 2009).

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Fig. 1. Photo of the front of a package of blueberries labeled with information on water source, emphasis added.

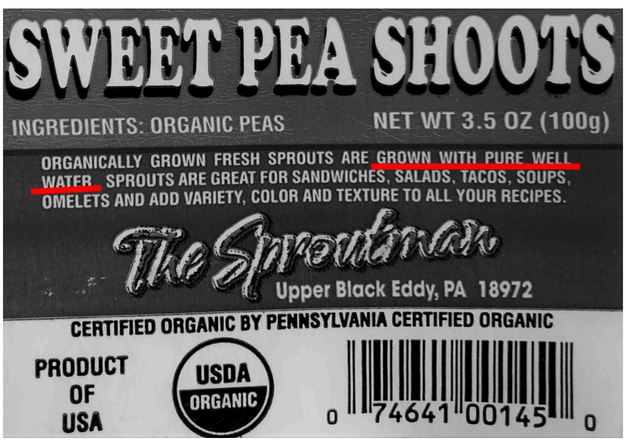

Fig. 2. Photo of the label on sweet pea shoots with information on water source, emphasis added.

with recycled water (Savchenko et al., 2018). Because of the stigma associated with recycled water, some producers have started to advertise their use of fresh irrigation water on product labels (see Figs. 1 and 2 for examples). Therefore, it is important for policymakers and agricultural producers to find ways to mitigate consumers' concerns about food grown with recycled water and to "nudge" them toward accepting this safe and sustainable resource.

We use an incentive-compatible framed field experiment involving 329 adult participants from the mid-Atlantic region of the U.S. to study whether processing of fresh foods relieves consumers' concerns about crops irrigated with recycled water (Table 1 summarizes research questions, hypotheses and results). To our knowledge, food processing has not been previously explored for its potential to mitigate consumer stigma. Using a dichotomous-choice experimental design that is both theoretically (Satterthwaite, 1975) and empirically (Taylor et al., 2001) demand-revealing, we elicit consumers' willingness to pay (WTP) for fresh and processed foods irrigated with recycled water. Participants in the experiment used US dollars to make purchase decisions for grapes and olives presented fresh and after two types of processing: drying, represented by dried grapes (raisins) and olives, and liquid extraction, represented by grape juice and olive oil. These foods were labeled as produced with recycled water, produced with conventional water, or had no specification regarding the irrigation water used. The data collected in the experiment and a survey of participants' demographic characteristics and buying behaviors is then used in an econometric analysis to reveal consumers' responses to use of recycled water for irrigation of fresh and processed food products. We also test a set of information treatments designed to nudge consumers' perceptions of foods produced with recycled water, providing important insight for policymakers, producers, and other organizations interested in better strategies for recycled water programs: information about (1) benefits of recycled water, (2) risks associated with recycled water, and (3) the benefit and risk information combined. Finally, we examine the effect of several demographic characteristics and behavioral attitudes on consumers' WTP for the foods offered in the experiment.

Our results indicate that food processing can alleviate some consumers' concern associated with recycled irrigation water. We find that consumers of processed foods are indifferent between recycled and conventional irrigation water but are less willing to pay for fresh foods grown with recycled water than for fresh foods grown with conventional water. This heterogeneity in response suggests that consumers are less sensitive to the use of recycled irrigation water for foods that are processed. Our analysis also reveals that consumers still prefer processed foods irrigated with unspecified water to those that were irrigated with recycled or conventional water. This suggests that consumers may generally not think about how their foods are produced and becoming aware of the types of irrigation water used on their foods may lead to a different set of consumption choices, which is consistent with some previous literature (see Li et al., 2018). A value of information analysis supports these results and suggests that a labeling policy communicating recycled irrigation water use on both processed and fresh foods would lead to gains in consumer welfare compared to a no label scenario as it would enable consumers to make more informed choices. In addition, we find that the informational nudges tested in the experiment have no statistically significant effects on consumers' WTP for fresh and processed foods irrigated with recycled water (relative to the experimental control. This finding may be due to a lack of negative publicity or media attention on the use of recycled water irrigation; or perhaps, that the nature of this topic was too technical for participants. Of the demographic characteristics and behavioral attributes analyzed, only age has a statistically significant effect on WTP and then only for processed foods irrigated with recycled water. We find that older consumers are less likely than younger consumers to purchase processed foods irrigated with recycled water, possibly because they perceive a greater degree of risk given the greater prevalence of health concerns among older adults.

The rest of this paper is organized as follows. Section 2 provides a brief review of the relevant literature. Section 3 describes experimental design. Analysis and results are discussed in Section 4, and Section 5 summarizes findings and provides concluding remarks.

2. Review of relevant literature

A growing body of literature has documented public resistance toward the use of recycled water (Fielding et al., 2018; Savchenko et al., 2019; Whiting et al., 2019). Most prior studies, however, have primarily relied on survey methodologies to understand consumers' responses to recycled water. Those studies showed that consumers are generally concerned about recycled irrigation water used on edible crops (Po et al., 2005; Menegaki et al., 2007; Rock et al., 2012) and found that providing consumers with information about recycled water can increase their acceptance of its use (Hills et al., 2002; Hurlimann, 2007; Dolnicar et al., 2010; Fielding and Roiko, 2014; Simpson and Stratton, 2011; Hui and Cain, 2018). Research designed to identify socio-demographic drivers of acceptance of recycled water has produced mixed results. Menegaki et al. (2007), for example, found that younger respondents were more likely than older respondents to consume produce irrigated with recycled water. In contrast, Dolnicar and Schäfer (2009), found that older consumers were more receptive to recycled water than younger consumers and Po et al. (2005) found that age had no significant effect. In analyses of education level, Rock et al. (2012) reported that higher levels of education were associated with increased acceptance of recycled water

Table 1
Summary of research questions, hypothesis tests, and results.

Research Question	Hypothesis Test*	Results
Irrigation Water Type and Food Type		
(1) Does consumers' WTP for *processed foods* change when they know it has been irrigated with *recycled water* relative to their WTP for the same processed foods irrigated with *conventional* type of water?	H_0: $WTP_P^R = WTP_P^C$ H_A: $WTP_P^R \neq WTP_P^C$	Fail to Reject H_0. Consumers of processed foods were indifferent between recycled and conventional water types.
(2) Does consumers' WTP for *processed foods* change when they know it has been irrigated with *unspecified water* relative to their WTP for the same food products irrigated with a *conventional* type of water?	H_0: $WTP_P^U = WTP_P^C$ H_A: $WTP_P^U \neq WTP_P^C$	Reject H_0. Consumers had higher WTP for processed foods irrigated with unspecified water relative to conventional water baseline.
(3) Does consumers' WTP for *fresh foods* change when they know it has been irrigated with *recycled water* relative to their WTP for the same processed foods irrigated with *conventional* type of water?	H_0: $WTP_F^R = WTP_F^C$ H_A: $WTP_F^R \neq WTP_F^C$	Reject H_0. Consumers lowered their WTP for fresh foods irrigated with recycled water relative to conventional water baseline.
(4) Does consumers' WTP for *fresh foods* change when they know it has been irrigated with *unspecified water* relative to their WTP for the same food products irrigated with a *conventional* type of water?	H_0: $WTP_F^U = WTP_F^C$ H_A: $WTP_F^U \neq WTP_F^C$	Fail to Reject H_0. Consumers of fresh food were indifferent between conventional and unspecified water types.
Information Treatment Effects		
(3) Does exposure to information about *benefits* of recycled water change consumers' WTP for food products irrigated with *recycled* water?	H_0: $WTP^{Benefit} = WTP^{Control}$ H_A: $WTP^{Benefit} \neq WTP^{Control}$	Fail to Reject H_0. Information treatment was not significant.
(4) Does exposure to information about *risks* associated with recycled water change consumers' WTP for food products irrigated with *recycled* water?	H_0: $WTP^{Risk} = WTP^{Control}$ H_A: $WTP^{Risk} \neq WTP^{Control}$	Fail to Reject H_0. Information treatment was not significant.
(5) Does exposure to information about *both benefits and risks* associated with recycled water change consumer's WTP for food products irrigated with *recycled* water?	H_0: $WTP^{Both} = WTP^{Control}$ H_A: $WTP^{Both} \neq WTP^{Control}$	Fail to Reject H_0. Information treatment was not significant.

* For recycled water (R), conventional water (C), processed food (P), and fresh food (F).

while Hui and Cain (2018) found that it had no significant effect on consumers' willingness to use recycled water. Several studies have found that income and gender (Menegaki et al., 2007; Dolnicar et al., 2010) can influence acceptance of recycled water. Women were found to be less likely than men to prefer recycled water (Dolnicar and Schäfer, 2009; Rock et al., 2012; Savchenko et al., 2019). The lack of consistency in the findings of these studies makes it difficult to draw conclusions. Survey questions generally do not present an incentive-compatible decision environment or allow participants to observe and consider purchasing foods irrigated with recycled water (Russell and Hampton, 2006). Thus, the participants in these studies may not necessarily reveal their true demand for such products. Unlike these prior studies, we use non-hypothetical demand-revealing framed field experiments that involve participants making real decisions about purchasing food products irrigated with recycled water.

The few studies that have used data from economic experiments found that consumers were less willing to pay for wine made from grapes irrigated with recycled water than for grapes irrigated with conventional water (Li et al., 2018) and less willing to pay for fresh produce grown with recycled water than for produce with no description of the irrigation water used (Savchenko et al., 2018). Ellis et al. (2018) also showed that the use of recycled water decreased consumers' demand for food products by 87% in the U.S. and that this reduction was dependent upon the type of recycled water used (recycled gray, recycled black and recycled produced). Disgust, safety concerns and neophobia were identified as the three primary drivers of consumers' acceptance or rejection of recycled water (Savchenko et al., 2019). These three factors can lead to stigmatization of recycled water and foods produced with this water.

Stigma is generally difficult to eliminate, particularly for products that are ingested (Rozin, 2001). Studies that use economic experiments to explore stigma associated with recycled water found that several stigma-reducing treatments can be more effective than one specific mitigation step (Kecinski et al., 2016). Social preferences and communication can also help reduce stigma related to recycled drinking water (Kecinski and Messer, 2018). Further, the terms used to refer to recycled water also matter. Ellis et al. (2019) found that the names traditionally used to refer to recycled water such as reclaimed, treated wastewater, nontraditional and reused water are least preferred by consumers. On the other hand, branding recycled water with names such as eco-friendly water, advanced purified water or pure water generate a more favorable perception of recycled water.

Consumer perceptions of food safety can play an important role in their acceptance of foods irrigated with recycled water. Prior studies have documented substantial reductions in consumers' WTP for foods that may be perceived as unsafe or produced using risky food processing technologies (Hayes et al., 1995, 2002; Lusk et al., 2005, 2015; Messer et al., 2017). For example, using data from non-hypothetical experimental auctions, Hayes et al. (1995) found that consumers' WTP decreased as the risk of food-borne illness increased. Likewise, McFadden and Huffman (2017) demonstrated that individuals' WTP for potato chips and French fries decreased once they received information that these foods may contain acrylamide, a potential carcinogen. The majority of studies of food processing have focused primarily on the negative consumer responses and stigmatization of foods processed using technologies such as genetic engineering, irradiation, growth hormones, and antibiotics (Kanter et al., 2009; Costanigro and Lusk, 2014; Lusk and Murray, 2015; Messer et al., 2015, 2017; Payne et al., 2009). A *meta*-analysis of twenty-five studies that included fifty-seven different food products showed that consumers' WTP for genetically modified (GM) foods was 23%-28% lower relative to non-GM foods (Lusk et al., 2005). In a study of consumer preferences for food irradiation, Hayes et al. (2002) also reported that negative information about irradiation from activist groups dominated positive scientific information about this food technology. Consumers' acceptance of food technologies, has been also shown to be heterogeneous across fresh and processed food categories (He and Bernard, 2011; Lusk et al., 2015). Lusk et al. (2015) found that genetic engineering leads to a greater decrease in desirability of fresh than processed food. However, the potential of food processing to reduce stigma associated with a new food technology such as recycled irrigation water, or heterogeneity in consumer responses to fresh and processed foods irrigated with recycled water has not been considered in the literature before.

3. Experimental design

In this framed field experiment (Harrison and List, 2004), we use a single-bounded dichotomous choice format that includes elements of within-subject and between-subject designs to elicit consumers' WTP for processed and fresh foods (see Table 2 for a summary of experiment design). Dichotomous-choice mechanisms are often used in experimental economics due to their incentive-compatible and demand-

Table 2
Experimental design.

			Number of Participants	Total
Between-subject Treatments				
	No Information Control		82	
	Benefit		81	
	Risk		86	
	Benefit and Risk		80	329
Within-subject Treatments				
Processed Foods	Raisins	No Specification Conventional Recycled	40	
	Dried Olives	No Specification Conventional Recycled	66	
	Olive Oil	No Specification Conventional Recycled	66	
	Grape Juice	No Specification Conventional Recycled	58	
Fresh Foods	Grapes	No Specification Conventional Recycled	47	
	Olives	No Specification Conventional Recycled	52	329

revealing[2] properties (Taylor et al., 2001; Satterthwaite, 1975) and the ease by which participants understand the purchase decision setting. A number of recent articles have used either single- or double-bounded dichotomous choice models to elicit consumer preferences (See Gabrielyan et al., 2014; Kecinski et al., 2018a, 2018b; Mamadzhanov et al., 2019). A dichotomous choice design with take-it-or-leave-it prices provides participants with a simple decision-making setting that closely resembles actual purchasing environments consumers face in the market. Therefore, participants are more familiar with this elicitation format than with other formats including experimental auctions or a Becker–DeGroot–Marschak (BDM) mechanism. This, in turn, facilitates easier and quicker implementation compared to other elicitation mechanisms that often require time-consuming instruction, training, practice rounds and comprehension quizzes that increase cognitive load and lengthen experiments. To understand whether food processing can alleviate consumers' concerns about the use of recycled irrigation water, we designed the experiment to answer a series of research questions related to consumers' demand for processed and fresh foods irrigated with recycled, conventional and no specification water (a summary of research questions, hypotheses and results is provided in Table 1).

In the experiment, 329 adult participants were randomly recruited from the mid-Atlantic region of the U.S. at a farmer's market. The subjects were each given a $10 participation payment and were told that they could use the money to purchase food products in the experiment at posted prices and that they would keep whatever portion of the $10 they did not spend. Each participant was seated in front of a tablet computer placed at individual work stations with dividers attached to ensure participants' privacy. After reading the on-screen instructions, participants were presented with a series of opportunities to make binary yes/no purchase decisions regarding fresh and processed foods labeled as having been irrigated with recycled water, irrigated with conventional water, or no information about irrigation water. All purchasing choices were presented on a single page of a participant's screen. The purchase decisions were presented to each participant in random order to avoid order effects. Pictures of the food products were included next to the purchasing options. The posted price for each product presented was randomly drawn from a normal distribution with the mean equal to the average market price for the product and standard deviation of one-half of the mean:

Grapes (1 lb): $P \sim N(3, 1.5^2)$
Olives (8 oz): $P \sim N(3.4, 1.7^2)$
Raisins (1 lb): $P \sim N(3.4, 1.7^2)$
Dried Olives (8 oz): $P \sim N(2.7, 1.35^2)$
Grape Juice (1 bottle) : $P \sim N(2.7, 1.35^2)$
Olive Oil (1 bottle): $P \sim N(4.4, 2.2^2)$.

The products offered to the participants in the course of the experiment were selected to represent different types of food processing so that we could test whether the type of processing, such as drying or liquefying, is effective for mitigating the stigma associated with the use of recycled irrigation water. For example, grape juice and raisins represent liquid and dried forms of processed grapes. Similarly, olive oil and dried olives are the liquid and dried forms of fresh olives. The choice of products was also dependent on our ability to find fresh and processed foods that were actually irrigated with recycled water. Each of the products offered through the experiment were displayed to participants in a designated area where they could easily examine them. All branding information and identifying labels were removed from the products prior to display.

Before proceeding to the purchase decisions, the software interface provided participants with the following formal definitions of recycled and conventional water. These definitions also appeared on the page that displayed purchasing options.

Conventional Water: "Conventional water comes from a variety of sources. Typical sources of conventional water include: surface water, groundwater from wells, rainwater, impounded water (ponds, reservoirs, and lakes), open canals, rivers, streams, and irrigation ditches." (Centers for Disease Control and Prevention, 2016).
Recycled Water: "Recycled water is highly treated wastewater from various sources, such as domestic sewage, industrial wastewater and storm water runoff." (California Department of Water Resources, 2018).

To maintain incentive-compatibility, participants were further informed that their choices were not hypothetical and that one of their decisions would be randomly selected for implementation at the end of the experiment. Therefore, if the participant had chosen to purchase the product offered in the selected decision, the posted price of that product would be subtracted from the $10 participation fee and the participant would receive the product and whatever money remained. If the participant had rejected the product offered in the selected decision, the participant simply received the entire $10 payment and no food. Thus, participants would choose to purchase a food item only when their WTP for the item is greater than or equal to the posted price:

$$D = \begin{cases} 0 WTP < P(No) \\ 1 WTP \geq P(\text{Yes}), \end{cases} \tag{1}$$

where D = {0,1} and (D = 1) represents a "yes" decision, (D = 0) represents a "no" decision, and *WTP* represents individual *i*'s willingness to pay for food product *j*.

After participants made their purchasing decisions, they answered a short survey presented on the screens of their tablet computers. The survey consisted of twenty-two questions designed to collect information about participants' socio-demographic characteristics, food and water preferences. In terms of socio-demographic characteristics, the participants were asked to report their age, education level,

[2] For information on stated preferences research see for example Menegaki et al. (2016).

employment status, income category, political affiliation and whether children were present in their household. The survey also included questions about whether participants' were a primary shopper in the household, participants' preferences for different food characteristics (e.g. local, organic), and awareness of the sources of their drinking water. For a complete list of questions and the visual representation of each question, refer to Appendix A.

Participants were not allowed to communicate with each other during the experiment to ensure that their decisions were not influenced by preferences of others. Each participant took about fifteen minutes to make their purchasing decisions and complete a survey. Then, the software interface randomly selected one of each participant's decisions for implementation.

3.1. Behavioral interventions

To explore whether consumers' WTP for fresh and processed foods changes in response to different kinds of information about recycled water, the participants were randomly assigned to one of three information treatments (benefit information, risk information, and both benefit and risk information) or to the control group in a between-subject design. This random assignment to treatment groups ensured that the participants' observed and unobserved characteristics were independent of the treatment received and, therefore, that a causal relationship could be established between the estimated effects and the treatment. The treatments presented the participants with the following information about recycled water:

Treatment 1 – Benefits of Recycled Water: "According to the United States Environmental Protection Agency (EPA), 'In addition to providing a dependable, locally controlled water supply, water recycling provides tremendous environmental benefits. By providing an additional source of water, water recycling can help us find ways to decrease the diversion of water from sensitive ecosystems. Other benefits include decreasing wastewater discharges and reducing and preventing pollution. Recycled water can also be used to create or enhance wetlands and riparian habitats.'" (Environmental Protection Agency, 2017).

Treatment 2 – Risks of Recycled Water: "According to cropscience.org, 'There have been a number of risk factors identified for using recycled waters for purposes such as agricultural irrigation. Some risk factors are short term and vary in severity depending on the potential for human, animal or environmental contact (e.g., microbial pathogens), while others have longer term impacts which increase with continued use of recycled water (e.g., salt effects on soil).'" (Fourth International Crop Science Congress, 2004).

Treatment 3 – Benefits and Risks of Recycled Water: The information from both treatments 1 and 2 presented in random order.

Participants assigned to the *Control Group* received no information prior to making their purchasing decisions.

3.2. Data

Table 3 summarizes the demographic characteristics and behavioral attributes of the 329 adult participants.[3] The average age of the participants was 41 years, 55% were female and 45% were male, and there were one or more children under age 18 in 35% of the households. Approximately 49% of the participants had a bachelor's or graduate degree and slightly more than half reported annual household incomes of less than $50,000. In terms of political affiliation, 26% of participants identified as liberal, 21% as conservative, and 43% as moderate. The majority of participants (73.3%) were their households' primary food shoppers, 61.7% preferred to buy local foods, and almost 40% reported that at least half of the food they consumed was organic. Overall, the participants were mostly aware of recycled water use (69%) before taking part in the experiment.

Table 3
Summary of respondents' demographic characteristics and behavioral attributes.

Variable	
Number of respondents	329
Average age (years)	41.1
	Percentage of participants
Female	55.6
Children under 18 in the household	35.9
Education	
Some high school	2.7
High school graduate	18.2
Some college	19.5
Associate degree	10.6
Bachelor's degree	27.7
Graduate degree/Professional degree	21.3
Household Income	
Less than $10,000	10.9
$10,000–$14,999	5.8
$15,000–$24,999	12.2
$25,000–$34,999	9.7
$35,000–$49,999	13.1
$50,000–$74,999	19.2
$75,000–$99,999	10.3
$100,000–$149,999	10.9
$150,000–$199,999	4.9
$200,000–$249,999	2.1
$250,000 and above	0.9
Prefer Local Food	61.7
Primary Food Shopper	73.3
Know the Source of Water at Home	59.3
Heard of Recycled Water	69.3
Organic food comprises at least half of food consumption	38.6

Table 4 compares the socio-demographic characteristics of our sample to that of the general population of the South Atlantic region of the U.S., where most of our participants resided, and the entire U.S. The participants in our sample are generally comparable to the South Atlantic region of the U.S. and also to the entire U.S. in terms of gender distribution, median age, income distribution, and the number of children under 18 present in households. However, our sample exceeded the general population of the South Atlantic U.S. and the entire U.S. in terms of education.

4. Analysis and results

Each of the 329 participants in the experiment made nine yes/no purchase decisions, yielding 2961 observations. The participants chose to purchase a food item in 801 of the decisions (27%) and purchased foods irrigated with recycled water in 288 of those purchases (36%).

4.1. Random effects logit models

We use a random effects logistic model that controls for within-subject comparisons to determine which factors influence participants' WTP for fresh and processed foods irrigated with recycled water:

$$log\frac{D_{ij}}{1-D_{ij}} = \beta_0 + \beta_1 B_{ij} + \beta_2 I_{ij}^{R} + \beta_3 I_{ij}^{U} + \beta_4 T_{ij}^{1} + \beta_5 T_{ij}^{2} + \beta_6 T_{ij}^{3} + \beta_7 (I_{ij}^{R} * T_{ij}^{1}) + \quad (2)$$

[3] The initial sample included 375 participants. We excluded observations for eight of those participants because of missing data on their incomes, education level, and ages. And to ensure that our sample included only adults, we excluded 38 participants younger than 22 and who identified themselves as students.

Table 4
Comparison of the experiment sample and 2010 Census statistics for South Atlantic and the U.S.

	Sample	2010 Census	
	Experiment Participants	South Atlantic	U.S.
Number of respondents/ population	329	59,777,037	308,746,965
Median age (years)	39	38.3	37.2
Female	55.6%	51.2%	50.8%
Children under 18 in the household	35.9%	28.6%	29.8%
Education			
Percent high school graduate or higher	97.3%	87.2%	87.0%
Percent bachelor's degree or higher	49.0%	30.5%	30.0%
Household Income (2015)			
Less than $10,000	10.9%	7.6%	7.2%
$10,000–$14,999	5.8%	5.4%	5.3%
$15,000–$24,999	12.2%	10.9%	10.6%
$25,000–$34,999	9.7%	10.6%	10.1%
$35,000–$49,999	13.1%	13.9%	13.4%
$50,000–$74,999	19.2%	17.8%	17.8%
$75,000–$99,999	10.3%	11.6%	12.1%
$100,000–$149,999	10.9%	12.3%	13.1%
$150,000–$199,999	4.9%	4.8%	5.1%
$250,000 and above	2.1%	5.0%	5.3%

$$\beta_8(I_{ij}^R * T_{ij}^2) + \beta_9(I_{ij}^R * T_{ij}^3) + \beta_{10}P_{ij} + \beta_{11}(I_{ij}^R * P_{ij}) + \beta_{12}O_{ij} + \nu_i + \varepsilon_{ij},$$

where $\nu_i \; N(0, \sigma_\nu^2), \quad \varepsilon_{ij} \; N(0, \sigma^2)$.

D_{ij} is the probability that participant i will choose to purchase food product j. B_{ij} is the posted price for participant i and food product j. I_{ij}^R and I_{ij}^U are dummy variables indicating foods irrigated with recycled water and unspecified water respectively, with foods irrigated with conventional water as the omitted category. T_{ij}^1, T_{ij}^2, and T_{ij}^3 are dummy variables that represent the three information treatments that include benefit information (T_{ij}^1), risk information (T_{ij}^2) and both the benefit and risk information (T_{ij}^3), with no information (T_{ij}^4) as the omitted variable. P_{ij} is a dummy variable that represents processed foods, with fresh foods as the omitted category. O_{ij} is a dummy variable that represents olive products, with grape products as the omitted category. $I_{ij}^R * T_{ij}^1$, $I_{ij}^R * T_{ij}^2$, $I_{ij}^R * T_{ij}^3$ capture the interaction effects between foods irrigated with recycled water and the information treatments. $I_{ij}^R * P_{ij}$ is the interaction effect between foods irrigated with recycled water and processed foods.

Table 6 presents estimates from the random effects logit model (Eq. (2)) for the likelihood of purchasing the various food choices presented in the experiment. We used separate regressions to estimate the likelihood of purchasing decision with the four processed foods treated as a single variable (column 1) and with the two types of processing used in the experiment (drying and liquid extraction) as separate variables (column 3). In columns 2 and 4, both regressions were extended to include a set of the demographic and behavioral characteristics (variable definitions are provided in Table 5).

As expected, we find that price has a significant negative impact on consumers' likelihood of purchasing food products across all models. Relative to the conventional-water baseline, consumers are less likely to purchase foods irrigated with recycled water. They also prefer the items that did not specify the type of irrigation water to the conventional-water products.

Our results also show that the behavioral interventions represented by the information treatments had no statistically significant effects on purchasing decisions for foods irrigated with recycled water relative to purchasing foods in the no-information control group. These findings are in line with other studies that also reported insignificant effects of information on acceptance of recycled water (Ellis et al., 2018; Hui and Cain, 2018). The fact that information about benefits of recycled water is unlikely to increase consumers' acceptance of products irrigated with recycled water has important policy implications. This result is consistent with a few other studies that found similar effects (Ellis et al., 2018; Savchenko et al., 2018). However, our findings do not support the results of prior research that showed consumers lowered their willingness to pay for fresh produce irrigated with recycled water when they received negative information about recycled water and that both positive and negative information increased acceptance of foods irrigated with recycled water (Savchenko et al., 2018).

Table 5
Description of explanatory variables.

Variable	Description
Price	Randomly posted price
Recycled	Equals 1 for foods irrigated with recycled water
Unspecified	Equals 1 for foods irrigated with unspecified water
T1: Benefits	Equals 1 if participant is in the group that received information only about benefits of recycled water
T2: Risks	Equals 1 if participant is in the group that received information only about risks associated with recycled water
T3: Benefits and Risks	Equals 1 if participant is in the group that received a balanced information treatment that includes information about benefits and risks
Processed	Equals 1 for processed foods
Olive	Equals 1 for olive foods
Liquid	Equals 1 for liquid foods
Dried	Equals 1 for dried foods
Demographic Characteristics	
Age	Participants' age
Female	Equals 1 for female participants
Income	Categorical (1–lowest, 11– highest)
Education	Equals 1 for participants with a bachelor or graduate/ professional degree
Children	Equals 1 if a child under 18 in the household
Behavioral Attributes	
Local Food	Equals 1 for participants who prefer local food
Primary Shopper	Equals 1 for primary food shopper
Water Source	Equals 1 for participants who know the source of water in their household
Heard	Equals 1 for participants who heard about recycled water
	Equals 1 if organic food comprises at least half of food consumption
Organic	Organic food comprises at least half of total food consumption

The results in Table 6 also indicate that consumers generally prefer fresh versions of the foods to processed foods at their respective market prices (columns 1). From the estimates for processed foods separated into dried and liquid categories (columns 3 of Table 6), we find that consumers' preferences for the dried products drive their preference for fresh over processed food.

In terms of demographic and behavioral characteristics, the estimates indicate that consumers' likelihood of purchasing both fresh and processed foods irrigated with recycled water is greater among relatively educated consumers and consumers who express a preference for local foods. Participants with relatively high incomes are less likely to purchase than participants with relatively low incomes, as are households with children. Age is the only demographic characteristic that had a statistically significant impact on likelihood to purchase foods irrigated with recycled water (*Recycled* × *Age*, -0.0199, $p < 0.058$).[4] This effect may be driven by greater concern among older adults about health risks potentially associated with recycled water.

To gain insight into whether processing can alleviate consumers' concerns about food irrigated with recycled water, we analyze the

[4] Interaction effects of *Recycled* with the other demographic and behavioral characteristics were not statistically significant. Those results are available from the authors upon request.

Table 6
Comparison of likelihood of purchasing food products at the posted price.

Decision (yes/no)	All Processed Foods Represented by a Single Variable				Liquid and Dried Processed Foods Represented by Separate Variables			
	(1)		(2)		(3)		(4)	
	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.
Price	−0.464***	0.049	−0.462***	0.049	−0.487***	0.048	−0.485***	0.048
Recycled	−0.698**	0.340	−0.703**	0.339	−0.715**	0.347	−0.719**	0.346
Unspecified	0.230*	0.132	0.229*	0.132	0.232*	0.134	0.231*	0.134
T1: Benefits	0.0535	0.318	−0.0569	0.328	0.0565	0.324	−0.058	0.333
T2: Risks	−0.160	0.330	−0.218	0.323	−0.163	0.335	−0.222	0.327
T3: Benefits & Risks	−0.409	0.324	−0.472	0.313	−0.406	0.328	−0.470	0.318
Recycled × T1	0.0846	0.420	0.0899	0.418	0.095	0.429	0.099	0.427
Recycled × T2	−0.135	0.431	−0.138	0.432	−0.132	0.439	−0.137	0.440
Recycled × T3	0.0536	0.442	0.0488	0.441	0.0746	0.451	0.068	0.451
Processed	−0.277**	0.118	−0.277**	0.118				
Recycled × Processed	0.191	0.192	0.196	0.192				
Olive	−0.129	0.212	−0.123	0.205	−0.0904	0.217	−0.0845	0.209
Liquid					0.0462	0.145	0.044	0.145
Recycled × Liquid					0.244	0.239	0.248	0.239
Dried					−0.611***	0.138	−0.609***	0.138
Recycled × Dried					0.161	0.228	0.164	0.228
Age			−0.001	0.007			−0.0013	0.007
Female			0.017	0.216			0.0074	0.220
Income			−0.061*	0.032			−0.0605*	0.033
Education			0.779***	0.226			0.785***	0.229
Children			−0.383*	0.230			−0.392*	0.233
Local Food			0.534**	0.227			0.540**	0.230
Primary Shopper			−0.010	0.222			−0.007	0.227
Water Source			0.113	0.206			0.110	0.210
Heard			0.131	0.244			0.128	0.247
Organic			0.075	0.212			0.081	0.215
Constant	0.442	0.315	0.165	0.551	0.480	0.315	0.207	0.556
Observations	2961		2961		2961		2961	

Note: Robust standard errors are shown in parentheses. *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.1$.

likelihood of purchasing fresh and processed foods separately using the random effects logistic model. We also compute marginal willingness to pay (WTP) values for processed and fresh foods irrigated with different types of water from the estimates of the random effects logistic model. These WTP values capture the differences between participants' WTP for foods irrigated with conventional water baseline and their WTP for foods irrigated with recycled and unspecified water types. Estimation results and marginal WTP values are summarized in Table 7 for proceed foods and in Table 8 for fresh foods.

The results presented in Tables 7 and 8 point to important heterogeneity in consumers' responses to processed and fresh foods irrigated with recycled water. We find no statistically significant difference in likelihood of purchasing processed foods based on recycled versus conventional irrigation water. For fresh food, however, consumers are less willing to purchase products irrigated with recycled water than products irrigated with conventional water. In fact, participants were willing to pay $1.23 less for fresh foods irrigated with recycled water relative to the conventional water baseline. These findings suggest that processing can mitigate some of the concern associated with recycled water found in previous studies. Consumers' lack of acceptance of fresh foods irrigated with recycled water may be related to aversion (Kecinski et al., 2016, 2018a, 2018b; Kecinski and Messer, 2018; Savchenko et al., 2019; Wester et al., 2016) and/or its actual and perceived risks as discussed previously. Food processing may provide consumers with a degree of physiological separation between the recycled water and their food, making them less sensitive to its use.

We also find that consumers of processed foods still prefer no specification regarding water to products labeled as having recycled and conventional irrigation water. Participants were willing to pay a premium of $0.87 for processed foods irrigated with unspecified water relative to the conventional water baseline. This result suggests that consumers do not necessarily think about how their food is produced in a detailed way and that raising the question of the type of water used may lead to concerns about agricultural water in general. This finding is consistent with Li et al. (2018) in their study of the effect of information about recycled water on demand for wine. The authors found that consumers lowered their WTP for wine when they received information about the source of irrigation water used in wine production.

Our analysis of the demographic and behavioral drivers of consumers' purchasing decisions related to processed (column 2 of Table 7) and fresh foods (column 2 of Table 8) shows that a higher level of education and a preference for local food increases consumers' willingness to purchase fresh and processed food, while a relatively high income decreases the likelihood. We find that presence of a child in the household has a negative effect on purchasing fresh foods. As with the previous analysis, age is the only demographic characteristic that has a statistically significant effect on consumers' decisions with older consumers less willing to buy processed foods irrigated with recycled water (*Recycled × Age*, -0.0264, $p < 0.016$).[5]

4.2. Value of information and implications of a labeling policy

Consumers today are exposed to an ever growing number of food labels. Food labels help consumers better assess the quality of the foods

[5] The interaction effects of *Recycled* with the other demographic and behavioral characteristics were not statistically significant.

Table 7
Comparison of likelihood of purchasing processed foods at the posted price.

	(1)		(2)			
Decision (yes/no)	Coeff.	S.E.	Coeff.	S.E.	WTP	95% CI
Price	−0.423***	0.051	−0.420***	0.0507		
Recycled	−0.388	0.370	−0.384	0.371	−$0.92	[−2.65 0.81]
Unspecified	0.369**	0.151	0.371**	0.151	$0.87**	[0.16 1.59]
T1: Benefits	0.0802	0.331	−0.0093	0.339		
T2: Risks	−0.0335	0.336	−0.0599	0.330		
T3: Benefits & Risks	−0.462	0.328	−0.489	0.322		
Recycled × T1	0.117	0.452	0.115	0.451		
Recycled × T2	−0.223	0.462	−0.234	0.463		
Recycled × T3	0.244	0.471	0.233	0.473		
Dried	−0.635***	0.149	−0.630***	0.149		
Recycled × Dried	−0.0957	0.250	−0.095	0.251		
Olive	0.197	0.217	0.185	0.211		
Age			−0.0002	0.00711		
Female			−0.0677	0.221		
Income			−0.0406	0.0328		
Education			0.645***	0.221		
Children			−0.334	0.231		
Local Food			0.506**	0.229		
Primary Shopper			−0.0835	0.229		
Water Source			0.146	0.212		
Heard			0.146	0.251		
Organic			0.0859	0.216		
Constant	0.149	0.312	−0.189	0.562		
Observations	1,974		1,974			

Note: Robust standard errors are shown in parentheses. *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.1$. Marginal WTP 95% confidence intervals are obtained using delta method.

Table 8
Comparison of likelihood of purchasing fresh foods at the posted price.

	(1)		(2)			
Decision (yes/no)	Coeff.	S.E.	Coeff.	S.E.	WTP	95% CI
Price	−0.657***	0.090	−0.653***	0.087		
Recycled	−0.805*	0.433	−0.837*	0.428	−$1.23*	[−2.47 0.02]
Unspecified	−0.0715	0.194	−0.0815	0.192	−$1.09	[−0.69 0.47]
T1: Benefits	−0.115	0.38	−0.208	0.389		
T2: Risks	−0.488	0.393	−0.573	0.386		
T3: Benefits & Risks	−0.295	0.387	−0.359	0.375		
Recycled × T1	−0.0929	0.588	−0.0723	0.581		
Recycled × T2	0.109	0.571	0.126	0.571		
Recycled × T3	−0.332	0.591	−0.317	0.587		
Olive	−0.464*	0.249	−0.450*	0.241		
Age			−0.00235	0.008		
Female			0.172	0.260		
Income			−0.0946***	0.037		
Education			0.781***	0.261		
Children			−0.508*	0.261		
Local Food			0.498*	0.256		
Primary Shopper			0.142	0.271		
Water Source			−0.0501	0.238		
Heard			0.123	0.267		
Organic			−0.00485	0.239		
Constant	1.498***	0.403	1.506**	0.637		
Observations	987		987			

Note: Robust standard errors are shown in parentheses. *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.1$. Marginal WTP 95% confidence intervals are obtained using delta method.

they purchase and reduces the asymmetry of information about food production between producers and consumers. Although valuable to increase transparency in food production, some labels may stigmatize foods produced using technologies (e.g. genetic modification) perceived as risky by the consumers despite the existing scientific evidence of their safety (Messer et al., 2017). Given the tradeoffs of satisfying consumers' desire for more information about how their foods are produced and the potentially damaging effects of labels on food demand, there has been a considerable debate over which labels should be used or mandated. To inform policy makers on whether consumers would benefit from a labeling policy communicating the use of recycled irrigation water, we estimate changes in consumer welfare resulting from such a policy. Specifically, we calculate the value of information (VOI) consumers would derive from a label that informs them of the use of recycled water to irrigate their fresh and processed foods.

Foster and Just (1989) developed the theoretical foundation of VOI calculation, while Leggett (2002) applied it to a discrete-choice random utility framework. Unlike the traditional consumer welfare calculation that assumes consumers have perfect knowledge of the changes in product attributes resulting from a policy (Hanemann 1983, 1985), the VOI approach allows for the case when a policy only provides new information about a product without changing its underlying quality. VOI has been used to calculate welfare changes for a range of labeling policies related to genetically modified foods (Hu et al., 2005), antibiotic-free pork (Lusk et al., 2006), cloning technology in beef production (Lusk and Marette, 2010), and calorie information on restaurant menus (Ellison et al., 2014).

Following Leggett (2002) and Lusk and Marette (2010), we estimate the change in welfare as

$$\Delta CS = \frac{1}{-\rho_{price}}\left\{\left[\ln\left(\sum_{j=1}^{J} e^{(\beta' X_j^L)}\right) - \ln\left(\sum_{j=1}^{J} e^{(\beta' X_j^{NL})}\right)\right] - \left[\sum_{j=1}^{J} P_j^{NL}(\beta' X_j^L - \beta' X_j^{NL})\right]\right\}, \tag{3}$$

where X_j^{NL} and X_j^L are vectors of produce attributes before and after the labeling policy, respectively, and P_j^{NL} is the probability that alternative j is selected before the policy change. The term in the first brackets represents the anticipated change in consumer surplus due to a labeling policy that communicates the use of recycled irrigation water and is the traditional welfare measure that uses compensating variation. The term in the second brackets represents the potential loss resulting from consumers making the same choices about purchasing fresh or processed foods when uninformed of the type of irrigation water used. Therefore, Eq. (3) accounts for the situations in which the available information about a product improves but the attributes of the product do not change.

To perform the calculation in Eq. (3), we used the estimated parameters from Tables 7 and 8, respectively, and the average prices across the four categories of processed and across the two categories of fresh foods at the time of our analysis. Given that the policy only provides information about recycled irrigation water and does not change the quality of the products, we assume that the price of processed and fresh foods does not change in response to the policy.

The welfare effects of a policy that would label processed and fresh foods as irrigated with recycled water are presented in Table 9. Specifically, the gain for this type of labeling is \$0.75 per choice for processed foods and \$0.19 per choice for fresh foods, respectively. This suggests that although consumers are less concerned about recycled water use on processed foods, they still benefit from having this information. Although VOI estimates are not directly comparable across studies, our results confirm the positive gains from a labeling policy communicating recycled irrigation water use on fresh produce found by Savchenko et al. (2018). Prior studies that calculated VOI of food policies related to genetically modified foods reported similar magnitude of VOI estimates (Hu et al., 2007; Rousu et al., 2007).

Table 9
Value of information for recycled irrigation water labels for processed and fresh foods.

Food Type	Mean VOI	Confidence Interval
Processed Food	0.749**	
	(0.2382)	[0.2820, 1.2157]
Fresh Food	0.187**	
	(0.0869)	[0.0167, 0.3574]

Note: Standard errors are in parentheses. 95% confidence intervals are in square brackets.
*** $p < 0.01$, ** $p < 0.05$, and * $p < 0.1$.

5. Conclusion

As water shortages become increasingly common in the U.S. and around the world, recycled wastewater can provide a valuable and sustainable source of water for irrigation of agricultural crops, which currently consume about 80% of the U.S. water supply. Current technologies can purify wastewater not only for non-potable uses but to meet standards for safe drinking water. However, numerous studies have shown that consumers in the U.S. are reluctant to accept recycled water when used for products that are ingested or involve personal contact because of its "yuck factor" (Kecinski et al., 2016, 2018a, 2018b; Rozin et al., 2015; Savchenko et al., 2019). Consumers' aversion extends to produce from plants irrigated with recycled water (Savchenko et al., 2018), presenting a serious barrier to widespread adoption of recycled water by U.S. agricultural producers. Therefore, it is important for policymakers, producers and the food industry to thoroughly understand this stigma and ways to mitigate it.

Using an incentive-compatible, dichotomous-choice, framed field experiment involving 329 adult consumers, this study explores the potential for processing to relieve some of the stigma associated with foods produced using recycled water. We find that consumers are equally accepting of processed foods irrigated with recycled and conventional water but are less accepting of fresh foods irrigated with recycled water relative to the conventional-water baseline. A welfare analysis suggests that providing information about recycled water irrigation use to consumers through labelling on both types of foods would lead to gains in consumer welfare relative to a scenario where this information is not known. Coupled with our other results, this implies that although consumers are less sensitive to the use of recycled irrigation water on processed foods than on fresh foods, they would benefit from the information about recycled irrigation water use on both types of foods because they would be able to make more informed consumption choices. Our results suggest that compared to a no-information control, messages about benefits, risks or both benefits and risks associated with recycled water do not have statistically significant effects on consumers' likelihood of purchasing processed or fresh foods irrigated with recycled water. Finally, though most of the demographic and behavioral characteristics tested in the experiment had no statistically significant effects, age was a factor for processed foods labeled as irrigated with recycled water. Older consumers were less likely than younger consumers to purchase those products.

The findings of this study suggest that processing can alleviate some of consumers' concern about food products irrigated with recycled water, providing important insight for policymakers and producers interested in promoting its use in U.S. agriculture. These results suggest, as well, that crops such as grains irrigated with recycled water may be more acceptable to consumers as ingredients in highly processed foods such as baked goods or that consumers may be less concerned about eating meat from animals that grazed on pastures irrigated with recycled water. These ideas would be potentially fruitful areas of future study.

The results of the information treatments tested in this study are also important because they indicate that positive information about the type of water used for food products meant to relieve concerns about recycled water may be unlikely to succeed. The three information treatments used in this study had no statistically significant effect on WTP for fresh or processed foods irrigated with recycled water. However, the regressions did identify reductions in likelihood of purchasing food products bearing labels that identified the source of irrigation water used relative to products with no such labeling. These results suggest that labeling products as irrigated with fresh water could backfire and reduce consumers' desire to purchase those products.

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Appendix A. Survey questions

Please answer the following questions:

1. What is your age?

2. What is your zip code?

3. What is your gender?
   - Male
   - Female
   - Other (please specify)

4. Which one of the following categories best describes your employment status:
   - Government
   - Education
   - Business
   - Agriculture
   - Student
   - Other (please specify)

5. Are you:
   - Politically liberal
   - Politically moderate
   - Politically conservative
   - Other (please specify)

6. Which category best describes your household income (before taxes) in 2015?
   - Less than $10,000
   - $10,000-$14,999
   - $15,000-$24,999
   - $25,000-$34,999
   - $35,000-$49,999
   - $50,000-$74,999
   - $75,000-$99,999
   - $100,000-$149,999
   - $150,000-$199,999
   - $200,000-$249,999
   - $250,000 and above

7. What is the highest level of education that you have completed?
- Grade school
- Some high school
- High school graduate
- Some college credit
- Associate degree
- Bachelor's degree
- Graduate degree/Professional

8. Do you have a child/children under the age of 18 years old in your household?
- Yes
- No

9. How often do you consume the following produce:

Fresh Grapes

[ ] times per month

Grape Juice

[ ] times per month

Raisins

[ ] times per month

Fresh Olives

[ ] times per month

Olive Oil

[ ] times per month

Dried Olives

[ ] times per month

10. Are you the primary shopper in your household?
- ◯ Yes
- ◯ No

11. What is the percentage of organic foods in your overall vegetable and fruit consumption?

Non-Organic (50%) Organic (50%)

12. Do you grow your own food?
- ◯ Yes
- ◯ No

13. Which do you prefer?
- ◯ Local Food
- ◯ Non-Local Food
- ◯ Don't care

14. How important are the following produce characteristics to you?

Taste: **5**
Not Important (1) **Very Important (9)**

Appearance: **5**
Not Important (1) **Very Important (9)**

Smell: **5**
Not Important (1) **Very Important (9)**

Price: **5**
Not Important (1) **Very Important (9)**

Organic: **5**
Not Important (1) **Very Important (9)**

Non-Genetically Modified Organisms: **5**
Not Important (1) **Very Important (9)**

Growing Location: **5**
Not Important (1) **Very Important (9)**

Brand: **5**
Not Important (1) **Very Important (9)**

15. Have you ever heard of recycled/reclaimed/reused water before today?
- ◯ Yes
- ◯ No

16. How do you drink your water?
- ◯ Bottled Water
- ◯ Filtered Tap Water
- ◯ Tap Water
- ◯ Other (please specify)

17. Please check the areas in which you're concerned about water availability.

- ☐ Your Community
- ☐ Your State
- ☐ United States
- ☐ Worldwide
- ☐ I'm not concerned.

18. Are you concerned about water availability in the following time periods?

Present: **5**
Not At All (1) **Very Concerned (9)**

Next 10 Years: **5**
Not At All (1) **Very Concerned (9)**

Next 30 Years: **5**
Not At All (1) **Very Concerned (9)**

Greater than 30 years: **5**
Not At All (1) **Very Concerned (9)**

19. How concerned are you about climate change in...

Your Community: **5**
Not At All (1) **Very Concerned (9)**

Your State: **5**
Not At All (1) **Very Concerned (9)**

United States: **5**
Not At All (1) **Very Concerned (9)**

Worldwide: **5**
Not At All (1) **Very Concerned (9)**

20. How do you feel about these different types of non-traditional waters for irrigation?

Grey Water: **5**

It generally refers to the wastewater generated from household uses like bathing and washing clothes.

Dislike (1) **Like (9)**

Black Water: **5**

Also described as Brown Water. It generally refers to the wastewater generated from toilets.

Dislike (1) **Like (9)**

Brackish Water: **5**

It is typically defined as distastefully salty but less saline than seawater (between 1,000 to 10,000 ppm [parts per million] in total dissolved solids [TDS]). In addition to certain surface water settings such as estuaries, brackish water can be found in aquifers.

Dislike (1) **Like (9)**

Industrial Water: **5**

It generally means process and non-process wastewater from manufacturing, commercial, mining, and silvicultural (forestry) facilities or activities, including the runoff and leachate from areas that receive pollutants associated with industrial or commercial storage, handling or processing, and all other wastewater not otherwise defined as domestic wastewater.

Dislike (1) **Like (9)**

Rain Water: **5**

Generally, the term rain water refers to water coming from rooftops and other aboveground surfaces.

Dislike (1) **Like (9)**

Storm Water: **5**

Generally, the term storm water refers to rainwater collected from non-roof surfaces, such as parking lots, hardscapes, and landscapes surrounding urban buildings.

Dislike (1) **Like (9)**

21. Do you reuse waste wate at home?

- Yes
- No

22. What is your attitude towards these different types of recycled water?

Primary Treated Recycled Water : **5**

Use of mechanical or physical systems such as sedimentation to treat wastewater is generally referred to as primary treatment.

Dislike (1) **Like (9)**

Secondary Treated Recycled Water : **5**

Use of biological processes such as biological oxidation and disinfection to provide further treatment is generally referred to as secondary treatment.

Dislike (1) **Like (9)**

Tertiary Treated Recycled Water : **5**

Use of more advanced processes such as chemical coagulation, filtration and disinfection to provide further treatment is generally referred to as tertiary treatment.

Dislike (1) **Like (9)**

Finish and Submit

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