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Tennessee Consumer Willingness to Pay for Disposable Dinnerware Molded from Wheat Straw

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Abstract

Wheat straw, a wheat byproduct, can be used in making disposable dinnerware. This study uses a contingent valuation survey to measure consumer willingness to pay (WTP) for wheat straw dinnerware bowls (WSB). Consumers would pay a premium ($1.33) for a 25-count package of molded WSB over the same size package of conventional bowls. Target markets include those who spend more on disposable dinnerware but also those who have greater concern about reducing greenhouse gas (GHG) emissions and climate change. Recyclability, no plastic, USDA Certified Biobased, and compostability are more important attributes to consumers than no tree cellulose being used in making the disposable dinnerware.

Keywords: consumer, disposable dinnerware, preferences, wheat straw

Introduction

An estimated 1,740 million bushels of wheat were produced in the United States for 2017/2018 on 37.5 million acres (U.S. Department of Agriculture, 2018). Wheat straw—what remains after the wheat kernel is removed to make flour and cereal products—is a byproduct of producing wheat. An acre of wheat yields 1.5–2 tons of wheat straw (Gross, 2016). Most wheat straw is incorporated back into the soil, burned in the field, or perhaps used as animal bedding (U.S. Department of Agriculture, 1994).

Like trees, wheat straw can be broken down into several components—lignin, cellulose, and hemicellulose—with additional uses. Cellulose can be used to produce biofuels and can also be used to make other biobased products. One example is molded dinnerware products that can serve as substitutes for those made from tree cellulose or from plastic. In 2016, the U.S. paper cup and paper plate market was valued at $104 billion (Wood, 2017). In 2015, paper plates and cups represented 1,360,000 tons of municipal solid waste (MSW) (U.S. Environmental Protection Agency, 2018). For nondurable paper goods (including paper plates and cups), around 40% ends up landfilled. About 1,050,000 tons of MSW was generated from plastic plates and cups, of which 840,000 tons was landfilled (U.S. Environmental Protection Agency, 2018). If consumers substitute from plastic or paper disposables toward compostable disposable dinnerware and then compost this waste, landfilled plastic or paper disposable dinnerware could be reduced. Davis and Song (2006) suggested that some of the most significant impacts of substitution could be from changes in habits in developed countries, such as the United States, where per capita consumption of plastics is highest. Increasing consumer options for biodegradable disposable dinnerware could provide consumers with choices to substitute away from conventional paper or plastic disposable dinnerware.

The market for molded dinnerware that uses cellulose alternatives to tree cellulose is emerging. One type of molded cellulose dinnerware uses wheat straw as the source of its cellulose. A few dinnerware (plates, trays, and bowls) products have been registered through the USDA Bio-

Preferred Program (U.S. Department of Agriculture, 2019). These include products sourced from bamboo, sugarcane, palm leaves, and wheat straw. Molded wheat dinnerware tends to be heavyweight and sturdy. It also uses no trees for cellulose and is compostable, which likely appeals to environmentally concerned market segments. However, the market for molded wheat dinnerware is still not yet well developed and studies measuring consumer preferences for these products are lacking. In addition, few studies have examined how consumers perceive molded dinnerware made from crop-based cellulose sourced from byproducts compared with dedicated crops grown specifically for their use in making molded cellulose fiber products.

This study provides the emerging industry that uses alternative fibers to make molded dinnerware with market information about product pricing and market segments most likely to be interested in purchasing these products. The objectives of this study are to

- provide a measure of consumer WTP for disposable dinnerware (specifically bowls) molded from wheat straw;
- provide estimates of how demographics, expenditure patterns, and attitudes influence this WTP;
- provide measures of the importance of additional attributes in making disposable dinnerware purchase decisions (including whether the wheat straw is sourced from a dedicated crop or as a byproduct to grain production); and
- ascertain whether shoppers would exhibit differences in WTP across retail shopping outlet types.

Previous Research

Little research exists on disposable dinnerware made from alternative fibers, but several studies have examined consumer preferences for packaging and biobased products made from renewable sources. The following studies' findings include environmental attitudes, preferred attributes, and examples of premiums that are relevant to the research presented in this study.

Herbes, Beuthner, and Ramme (2018) studied consumer attitudes toward biobased packaging across the United States, France, and Germany. The recyclable material and bioplastics rated most highly by U.S. respondents were those made from renewable resources (other than bio-methane) that were biodegradable, while plastic made from bio-methane rated lowest. Herbes, Beuthner, and Ramme found that Germans raised ethical concerns about the use of agricultural land to produce biogas (Herbes, Beuthner, and Ramme, 2018). These results suggest that U.S. consumers may be receptive to recyclable products and have limited concerns about the use of agricultural land to produce inputs for biobased packaging. Barnes et al. (2011) studied Hawaiian consumers' preferences and WTP for nonplastic food containers. They separated responses into four classes based on stated preferences for attributes of the nonplastic food container. Some segments were found to prefer lower prices and water-resistant food containers, but certain classes more highly valued the containers being microwavable and/or locally produced. Barnes et al. hypothesized that respondents who most highly valued the nonplastic container (i.e., were willing to pay $0.37 more for the product being locally produced) were those that understood the local economic impacts of using sugarcane to produce food containers. Generally, respondents preferred an alternative food

container that was made with sugarcane material (66.49%), microwavable (88.94%), water resistant (100%), locally produced (51.23%), and competitively priced. In addition, 97% of respondents stated that they would recycle or compost the container if given the choice, and 81% supported a ban on expanded polystyrene plastic. These relatively high percentages may be influenced by the fact that Hawaii is dealing with an issue of limited landfill space and experiences the impacts of marine plastic pollution firsthand. With widespread increased awareness of single-use plastic pollution, into the near future, consumer attitudes and preferences for product attributes may be influenced by this awareness (Barnes et al., 2011).

Kainz (2016) examined the impact of educating consumers about durable biobased plastic alternatives and associated labelling on their WTP for such a product. After conducting a series of experimental auctions, the investigators used a regression analysis to estimate consumer WTP. Kainz found that the information given to the consumer only partially influenced their WTP and that adding a label to the biopolymer during the auction experiment was most impactful and suggested that using raw materials that were collected locally and then labeling the product accordingly may increase consumer WTP.

Yue et al. (2010) examined consumer preferences for biodegradable plant containers. They evaluated price premiums consumers would pay for containers made from wheat starch, rice hulls, straw, coir, peat, and other materials. Yue et al. found that consumers were willing to pay 19.5 cents more for wheat starch containers than recyclable plastic containers. This suggests that containers from crop-based products are appealing to consumers. They found that female participants were willing to pay more for the biodegradable pots than for conventional plastic pots.

Kurka and Menrad (2009) conducted a survey on European consumers' attitudes toward and WTP for several biobased products, including orange juice packaged in a biobased container and soap labeled as biobased. The investigators found that consumers who indicated highest WTP for biobased soap had high sensitivity toward ecological issues, sustainability, and personal health. Consumers ranked their top reasons for purchasing bioplastics in order as: to be more ecofriendly, to conserve resources for future generations, for health reasons, to strengthen the regional economy, to get it for a low price, to set an example for others, and to ease one's conscience (Kurka and Menrad, 2009).

The results from each of the aforementioned studies provide insight into consumer preferences for environmentally friendly containers and packaging, but none directly examined consumer preferences for disposable dinnerware with ecofriendly attributes. Some results from prior research suggest that age will likely have a negative influence on WTP (Yue et al., 2010; Martinho et al., 2015), while other studies suggest age will exert a positive influence (Kainz, 2016). Findings from prior research also suggest that being female will have a positive influence on WTP (Casadesus-Masanell et al., 2009; Yue et al., 2010; Martinho et al., 2015; Kainz, 2016). Previous research suggests that residing in an urban area will have a negative influence on WTP (Casadesus-Masanell et al., 2009). The presence of children in the household and household size were previously found to positively impact WTP (Yue et al., 2010; Kainz, 2016). Some studies found education to positively impact WTP (Yue et al., 2010; Martinho et al., 2015), while others found

education to have a negative impact (Casadesus-Masanell et al., 2009). Similarly, some studies found household income to positively impact WTP (Casadesus-Masanell et al., 2009; Yue et al., 2010), while others observed a negative impact (Kurka and Menrad, 2009; Kainz, 2016). Previous product knowledge was found to positively impact WTP (Kainz, 2016), as did a history of previously purchasing the product type investigated (Casadesus-Masanell et al., 2009). Overall, having positive environmental attitudes and positive attitudes toward sustainable products increased WTP (Kurka and Menrad, 2009; Martinho et al., 2015; Kainz, 2016). These findings provide a conceptual starting point for possible factors to be included in a WTP analysis of biodegradable WSB. A WTP analysis on consumer preferences for disposable dinnerware made from biobased materials is missing from the existing literature; the current study intends to fill this gap in the literature.

Economic Model

A referendum-style contingent valuation method was used to determine WTP for molded wheat bowls. The contingent valuation follows a random utility framework (McFadden, 1974). Let U_{CBi} represent the *i*th consumer's utility from choosing the conventional bowls and U_{WSBi} represent the *i*th consumer's utility from choosing the bowls molded from wheat straw (WSB). The *i*th consumer will choose WSB if $U_{WSBi} > U_{CBi}$. If these preferences are influenced by price (P_{WSBi}, P_{CBi}) as well as nonprice variables such as demographics, shopping patterns, or attitudes represented by the vector $\boldsymbol{X}_i$, then the *i*th consumer will choose WSB if

$$\text{UiWSB}\,(\text{Xi}, P_{WSBi}) > \text{UiCB}\,(\text{Xi}, P_{CBi}). \tag{1}$$

The probability of the *i*th respondent choosing the WSB is

$$\Pr[WSB_i = 1] = F\left(\alpha + \boldsymbol{X}_i\beta + \beta_{PSWB} \times P_{WSBi}\right), \tag{2}$$

where α is a constant, β_{PWSB} is the price parameter, $\boldsymbol{\beta}$ is a vector of parameters on nonprice variables, and assuming a logit model, and *F* is the logistic distribution function (Greene, 2018).

The marginal effect of the *j*th variable X_{ij} on the probability of the *i*th respondent selecting the WSB over the conventional bowls is

$$\frac{\Pr\left[WSB_i = 1\right]}{\partial X_{ij}} = f_i \times \beta_j, \tag{3}$$

where β_j is the parameter on X_{ij} and f_i is the logistic density function. The mean marginal effects and their associated standard errors are calculated using the Krinsky–Robb (1986) method with 5,000 replications.

WTP for WSB can be expressed as $\widehat{WTP}_{WSBi} = -\left(\alpha + \boldsymbol{X}_i\beta\right)/\beta_{PWSB}$. The means of the WTP and associated standard errors are also calculated using the Krinsky–Robb (1986) method with 5,000 replications. Further, the effects of each variable on WTP and their associated standard errors are calculated using the Krinsky–Robb. The effect of the *j*th nonprice explanatory variable on estimated WTP is calculated as

$$\frac{\partial \widehat{WTP}_{WSB}}{\partial X_j} = -\frac{\beta_j}{\beta_p}. \tag{4}$$

Survey Data

An online survey was administered through Qualtrics to 217 Tennessee respondents statewide aged 18 or older in late August 2018. The survey was reviewed through Internal Review Board procedures prior to administration. A pretest was conducted prior to administration of the full survey. The survey contained several sections, including information about wheat straw and its uses (see Figure 1).[1]

What is Wheat Straw?

Wheat straw is a byproduct of producing wheat. After the wheat kernel is removed to make flour and cereal products, the wheat straw remains. Hence, wheat straw is a renewable resource that is a byproduct of the wheat crop.

Figure 1. Wheat Straw Information Screen

This was followed by a screen regarding wheat straw's uses for its components, lignin, cellulose, and hemicellulose (Figure 2). In the next screen, respondents were informed they would be choosing between two 25-count packages of molded disposable dinnerware bowls. Note that

[1] Copies of the survey instrument are available from the authors upon request.

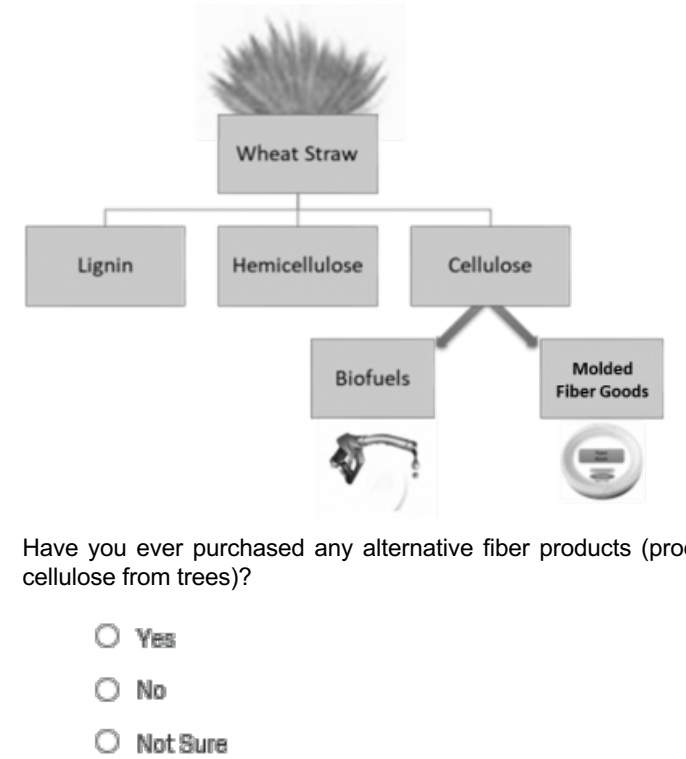

Figure 2. Information Screen about Wheat Straw Uses

online surveys present respondents with a hypothetical choice; these surveys may therefore be subject to bias compared with actual purchase decisions.n order to reduce this bias, respondents were asked to consider their choices as realistically as possible (Blamey, Bennett, and Morrison, 1999) and reminded of their budget (Cummings and Taylor, 1999) (Figure 3).

These screens were followed by a choice set between two 25-count packages of molded disposable dinnerware bowls, one made from conventional cellulose from trees and the other from wheat straw cellulose (Figure 4). In this choice set, the respondents were asked to suppose they were shopping for disposable dinnerware bowls. The respondent could choose the WSB, the conventional bowls, or neither. The two product choices and a neither choice option were presented in tabular format. Adamowicz, Lloyd-Smith, and Zawojskia (2018) suggested an advantage of using a table format of information presentation over a text format. In our study, respondents were presented with a table choice from which they could choose the conventional product, wheat straw product, or neither (Carson et al., 1996).

The next screen is going to ask you to choose which of two 25 count packages of disposable dinnerware bowls you might purchase if given the opportunity.

Responses to questions like this one can sometimes be biased. For example, sometimes people respond how they believe is socially responsible instead of how they would actually behave.

So, in answering this question, **we ask that you take a moment to consider your household budget and the fact that paying more for a package of disposable dinnerware bowls would mean you would have less to spend on other items.** Remember, it is possible to support an issue related to a product without being willing to pay more for the product itself.

Figure 3. Budget Reminder Screen

The sample was divided into five equal price groups ($2.25, $3.25, $4.25, $5.25, $6.25) for a 25-count package of disposable dinnerware bowls molded from wheat straw, with 20% of the participants seeing each of the respective price points. The price of the base product was held constant at $2.25. The base price was derived from conventional molded dinnerware prices at major retailers at the time of the survey. The range of higher prices was based on specialty and alternative fiber molded dinnerware bowls sold through major online retailers (information collected in June/July 2018).

A "neither" choice was offered in order to identify if the respondent was unwilling to choose either product. The "neither" respondents are not included in the WTP estimation because they were unwilling to participate in the market even at the conventional product price. For example, a high percentage of "neither" respondents could indicate that the product pricing for both products, including the conventional product, was too high. In the case of this study, about 17% of participants selected neither product.

As a follow-up, respondents were asked about importance of additional potential attributes that might influence purchase decisions for disposable dinnerware. They were first provided an information screen about the USDA Certified Biobased designation (Figure 5). The respondents

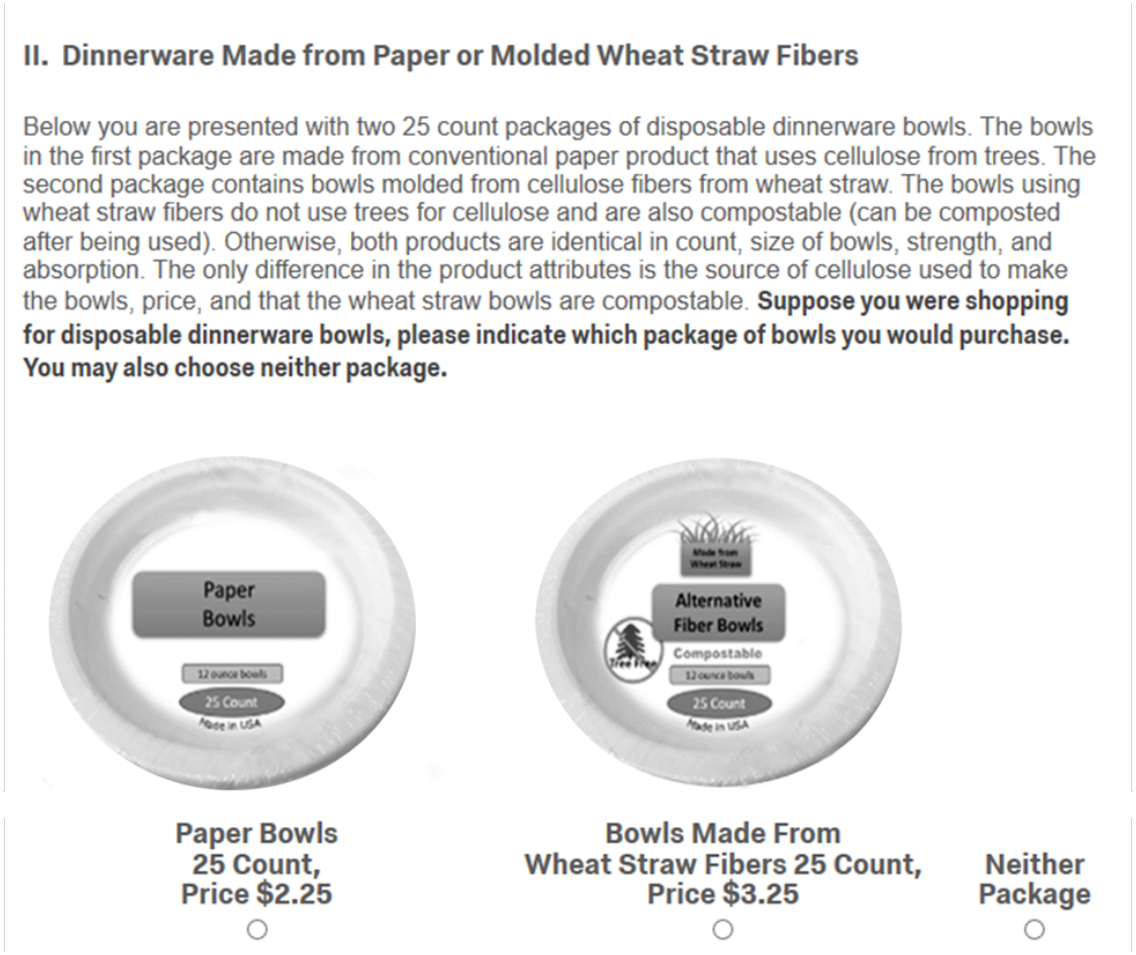

Figure 4. Labels on Disposable Dinnerware Bowls in Choice Set

were then asked about importance of the product not using trees, being USDA Certified Biobased, made in the United States, recyclability, compostability, the source of the cellulose being from agricultural crop grown for its cellulose, the source of the cellulose being from a byproduct of agricultural grain production, the product not being made from plastic, and the cellulose being organic. A 5-point Likert scale was used to measure respondents' importance rating for each attribute (from 1 = not important at all to 5 = extremely important). Table 3 reports the means of these ratings and means comparisons *t*-tests across whether respondents selected the WSB.

In addition, WTP estimates are also calculated using the individual response and the coefficients from the estimated logit model. To examine whether respondents who most often shop at particular retail outlet types might have differing WTP for the WSB, means of these WTP estimates were compared across where the respondent indicated they usually shopped for disposable dinnerware. *T*-tests were used to compare mean WTP across retail outlet types.

Questions asked in later sections of the survey included expenditure patterns on disposable dinnerware, attitudes, and demographics. The attitude questions assessed respondents' agreement

Figure 5. Information Screen for USDA Certified Biobased Labeling

with statements about the environment and climate change on a five-point Likert scale (where 1 = strongly disagree to 5 = strongly agree), including:

- Protecting the world's forests is critical to the environment,
- We have a responsibility to future generations to protect the environment,
- Responses to this survey could cause dinnerware manufacturers to offer more alternative products that don't use trees,
- Consumers can influence the environment with their product choices,
- There is urgent need to take measures to prevent climate change, and
- There is urgent need to reduce greenhouse gas emissions.

To reduce the number of opinion variables, we calculated indices for the opinion variables with high correlations between each other. Cronbach's alpha is used to test for validity of using an index (average of the Likert rating scales) of the correlated opinion variables. Cronbach's alpha assesses the reliability of using a rating scale, such as an average, of multiple Likert variables to represent that variable list (Cronbach, 1951). If the reliability score, α, is at least 0.80, then the average of the scale is considered to be a reliable representation of the variables in the list. These resultant indices are discussed in the results section.

Results

Sample Demographics

The average age of respondents included in the logit model was 43.42 years, and 78% were female (Table 1). About 67% had attended college or were college graduates and the pretax household income for 2017 was $52,080. Compared with Tennessee residents generally, our respondents are on average somewhat older than Tennessee residents generally and a larger percentage were female relative to the state population of 52% (U.S. Census Bureau, 2019). However, this could in part be due to the nature of the survey, which is more likely to be completed by a primary food shopper due to the subject matter. We did not select for primary food shoppers, but there was likely some self-selection bias toward primary food shoppers. This could have been the result of the title of the survey, which was "Your Views of Dinnerware Made from Wheat Straw." The median household income for the state in 2017 was $51,340 (U.S. Census Bureau, 2019), while the sample average was $52,080. About 67% of the sample had attended college or were college graduates, somewhat higher than for the state's population. Hence, the sample tended to be a higher percentage female, somewhat older, and higher percentage college graduates than the overall Tennessee population.

Indices for Environmental and Climate Change Opinion Variables

Agreement with each of the following statements was highly correlated:

- Protecting the world's forests is critical to the environment,
- We have a responsibility to future generations to protect the environment,
- Responses to this survey could cause dinnerware manufacturers to offer more alternative products that don't use trees, and
- Consumers can influence the environment with their product choices.

The Cronbach's scale reliability coefficient, α, is equal to 0.87 for this grouping of four opinion variables. Hence, an average rating scale is created from these variables, the Environmental Concern Index.

Agreement with each the following two statements was highly correlated:

- There is urgent need to take measures to prevent climate change, and
- There is urgent need to reduce greenhouse gas emissions.

The Cronbach's scale reliability coefficient, α, is equal to 0.79 for this pair of statements. Hence, an average rating scale is created from these variables, the GHG/Clim Chng Concern Index. These two indices (Environmental Concern Index and GHG/Clim Chng Concern Index) are used as explanatory variables in the logit model of WTP for the disposable dinnerware bowls made from wheat straw fibers.

Logit Model of WTP

Of the 217 who participated in the product choice question, 17% chose neither molded dinnerware product. Of the remaining 179 who did select between the two products, 41% chose the WSB,

Table 1. Variable Names, Definitions, and Means for the Logit Model of Probability of Choosing Wheat Straw Molded Dinnerware Bowls

Variable Name	Variable Definition	Variable Means (N = 173)
ChooseWheat	=1 if chose 25-count package of wheat straw molded bowls, 0 otherwise	0.410
Price	Price of 25-count package of disposable dinnerware bowls, $2.25, $3.25, $4.25, $5.25, $6.25	4.244
Age	Age in years	43.416
Female	=1 if female, 0 otherwise	0.780
Urban	=1 if resides in urban area, 0 otherwise	0.197
Middle	=1 if resides in Middle Tennessee, 0 otherwise	0.312
Children	=1 if have children under 18 in household, 0 otherwise	0.428
College	=1 if attended college or graduated from college, 0 otherwise	0.671
Household Income Thous	2017 household income (pre-tax) in thousands of dollars	52.080
Ann Expend Disp Dinnerware	Annual expenditures on disposable dinnerware in dollars	98.150
Heard of Wheat Straw	=1 if have heard of wheat straw before, 0 otherwise	0.595
Purch Alt Fiber Prod	=1 if have purchased alternative fiber products before, 0 otherwise	0.197
Heard of Wheat Straw× *Purch Alt Fiber Prod*	=1 if have heard of wheat straw and purchased alternative fiber products before, 0 otherwise	0.150
Environ. Concern Index	Index from Cronbach's alpha on environmental concern Likert variables (1 = strongly disagree to 5 = strongly agree)	4.260
GHG/Clim Chng Concern Index	Index from Cronbach's alpha on GHG/climate change concern Likert variables (1 = strongly disagree to 5 = strongly agree)	3.711

while 59% chose the conventional bowls. A total of 173 respondents answered all questions needed to estimate the logit model (Table 2). The likelihood ratio statistic suggests that the covariates included in the model explain the purchasing decision. The model correctly classified 78% of the observations. Variables with significant influences on selection of the WSB include *Price* (-), *College* (-), *Household Income Thous* (-), *Ann Expend Disp Dinnerware* (+), *Heard of Wheat Straw* (+), *Heard of Wheat Straw*×*Purch Alt Fiber Prod* (+), and *GHG/Clim Chng Concern Index* (+). Some studies found that education positively impacts WTP (Yue et al., 2010; Martinho et al., 2015), while other studies have found negative impacts (Casadesus-Masanell et al., 2009) on purchasing decisions for environmentally friendly packaging or containers. Similarly, findings regarding the effects of income have been mixed as both positive (Casadesus-Masanell et al., 2009; Yue et al., 2010) and negative (Kurka and Menrad, 2009; Kainz, 2016). The effects of prior knowledge about wheat straw and the effects of alternative fiber products purchases align with prior research findings (Casadesus-Masanell et al., 2009; Kainz, 2016). The finding regarding the

Table 2. Logit Results: Probability of Choosing Wheat Straw Molded Dinnerware Bowls (N = 173)

Variable	Est. Coeff.	Marginal Effect on Pr WheatStraw=1	Est. Effect on WTP ($)
Intercept	**1.271**		
Price	**-1.189*** **	**-0.163*** **	
Age	0.007	0.001	0.006
Female	0.310	0.043	0.260
Urban	-0.163	-0.022	-0.137
Middle	0.033	0.005	0.028
Children	-0.151	-0.021	-0.127
College	**-1.006** **	**-0.138** **	**-0.846**
Household Income Thous	**-0.011** *	**-0.002** *	-0.009
Ann Expend Disp Dinnerware	**0.005** **	**0.001*** **	**0.004**
Heard of Wheat Straw	**1.138** **	**0.156** **	**0.957**
Purch Alt Fiber Prod	-1.303	-0.179	-1.100
Heard of Wheat Straw×Purch Alt Fiber Prod	**2.413** *	**0.331** *	2.030
Environ. Concern Index	0.202	0.028	0.170
GHG/Clim Chng Concern Index	**0.467** **	**0.064*** **	**0.393**
LLR Test (14 df)	**87.25*** **		
Pseudo-R^2	0.3725		
Percentage correctly classified	78.03		
Est. WTP $3.58 Mean $3.14 LCL $3.94 UCL			

Note: Single, double, and triple asterisks (*, **, ***) indicate significance of α at the 10%, 5%, and 1% level. Estimated effects on WTP that are significantly different from 0 at the 95% confidence level are bolded.

positive effect of GHG/climate change concern on WTP is similar to those from other studies (Kurka and Menrad, 2009; Martinho et al., 2015; Kainz, 2016).

The marginal effects in the third column of Table 2 show the effects of each variable on the probability of choosing the WSB. Notably, a $1 increase in price decreases the probability of choosing the WSB by 0.16. Being college educated (*College*) decreases the probability by 0.14. While a $1,000 increase in household income (*Household Income Thous*) decreases the probability of choosing the WSB by 0.002, a $1 increase in expenditures on disposable dinnerware (*Ann Expend Disp Dinnerware*) increases this probability by 0.001. If the respondent had heard of wheat straw (*Heard of Wheat Straw*), this increases the probability of choosing the WSB by 0.16. Further, if the respondent had both heard of wheat straw and purchased an alternative fiber product in the past (*Heard of Wheat Straw×Purch Alt Fiber Prod*), the probability increase by an added 0.33. Greater importance of reducing GHG and climate change (*GHG/Clim Chng Concern Index*) to the respondent increases the probability of choosing the WSB by 0.06.

The effects of each of the variables on WTP are shown in the fourth column of Table 2. Those that are bolded have confidence intervals showing a significant difference from 0 at the 95% confidence level. If the respondent had at least attended college (*College*), this decreased their WTP by nearly

$0.85. An increase in annual expenditures on disposable dinnerware (*Ann Expend Disp Dinnerware*) of $1 increases WTP by $0.004, and a $10 per year increase would increase WTP by $0.04. If the respondent had heard of wheat straw (*Heard of Wheat Straw*), their WTP increases by nearly $0.96. Further, if GHG and climate change reduction (*GHG/Clim Chng Concern Index*) were of greater importance to them, WTP increases by $0.39.

The mean WTP is estimated to be $3.58, a premium over the base price of $2.25. The 95% confidence interval was calculated using the Krinsky–Robb method at 5,000 iterations and has a lower bound of $3.14 and an upper bound of $3.94. A histogram of the WTP values is shown in Figure 6 (Krinsky and Robb, 1986). This WTP estimate is for the 83% of respondents who would at least pay the base price of $2.25. Note that if those who chose neither product were included in the dependent variable as 0s, the estimated WTP value would decline from $3.58 to $3.13.

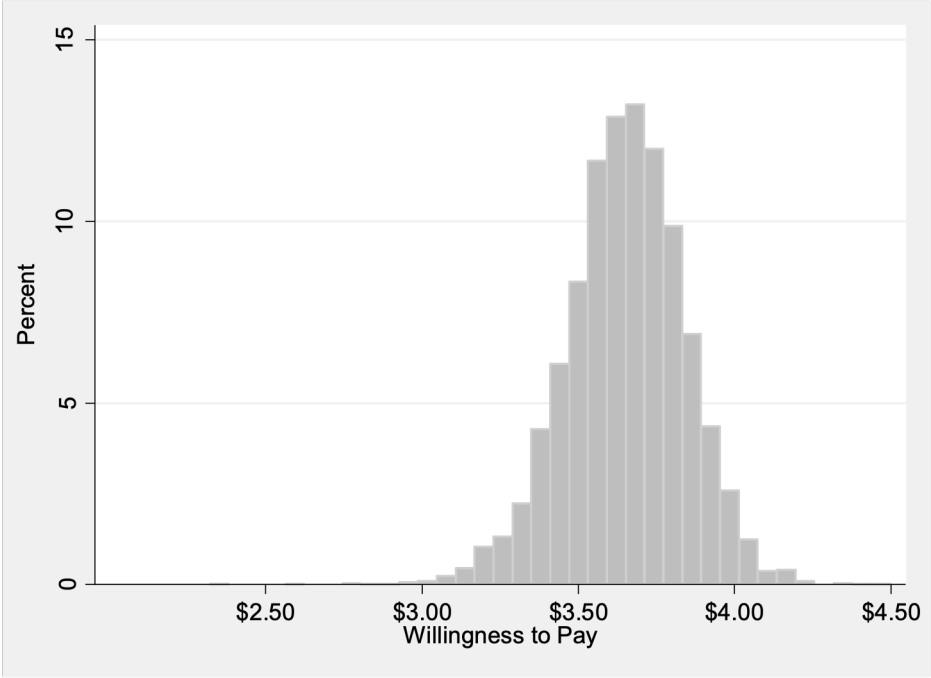

Figure 6. Estimated WTP for WSB

Responses among Those Who Did Not Choose the WSB or Chose Them at the Same Price as Conventional Bowls

The respondents who chose a package of bowls but either did not choose the WSB or chose the WSB at $2.25, were asked whether they would pay any amount more for the WSB. Among this group, 34% would pay some amount more, while 60.90% supported development of wheat straw disposable dinnerware but would not pay any more, and only 5% did not support development of wheat straw disposable dinnerware. Among those who said they would not pay any more, the most commonly cited reason was that they could not afford to pay any more, followed by that they did not purchase disposable dinnerware bowls enough to pay attention to the materials from which they are made.

Importance of Disposable Dinnerware Attributes

In general, the respondents who chose the WSB felt the potential disposable dinnerware attributes were more important than those who did not select the WSB (Table 3). However, statistical difference in the mean ratings at the 95% confidence level was found only for disposable dinnerware being compostable. In this case, the group that selected the WSB felt this attribute to be of greater importance than the group that did not select the WSB.

Table 3. Importance of Disposable Dinnerware Attributes across Respondents Who Chose and Did Not Choose the WSB

	Mean Rating of Importance (1 = Not at All, …, 5 = Extremely)	
Attribute	**Did Not Choose WSB (*N* = 102)**	**Chose WSB (*N* = 71)**
Does not contain trees	2.58[b]	2.89[b]
USDA Certified Biobased	2.82[ab]	3.15[a]
U.S. made	3.04[a]	3.08[ab]
Recyclable	3.04[a]	3.22[a]
Compostable	2.80[ab]	3.14**[a]
Cellulose from dedicated ag crop	2.99[a]	3.10[ab]
Cellulose from byproduct of a crop	2.94[a]	3.00[ab]
Does not contain plastic	2.94[a]	3.18[a]
Cellulose organically produced	3.00[a]	2.97[ab]

Note: Double asterisks (**) indicate significant difference in means across the two groups at 95% confidence level. Within each group, means followed by the same letter indicate no significant difference between the means at the 95% confidence level.

In addition to comparing the means across the two groups, mean ratings were compared within each group. The same letter beside two means in Table 3 indicates that these two means are not statistically different from each other at the 95% confidence level. For those who did not select the WSB, the mean importance ratings of attributes in disposable dinnerware are not significantly different from each other except for the product attribute of "no trees." This attribute is rated significantly lower than the product being U.S. made, recyclable, made from cellulose that is organically produced, made from cellulose from a dedicated energy crop or a byproduct of crops, and not being made from plastic. For those who selected the WSB, products being recyclable, not containing plastic, USDA Certified Biobased, and compostable are rated significantly higher in importance than the product containing no cellulose from tree fibers. The relative importance of each potential attribute is shown in bar charts for the two groups in Figure 7. Interestingly, for both groups of respondents, the mean importance rating of the product being made from cellulose from a dedicated crop is not statistically different from mean importance rating of the crop being made from cellulose as byproduct of grain production. This result is similar to those reported by Herbes, Beuthner, and Ramme (2018) that U.S. consumers are less likely to express concerns about agricultural land use for bioenergy production.

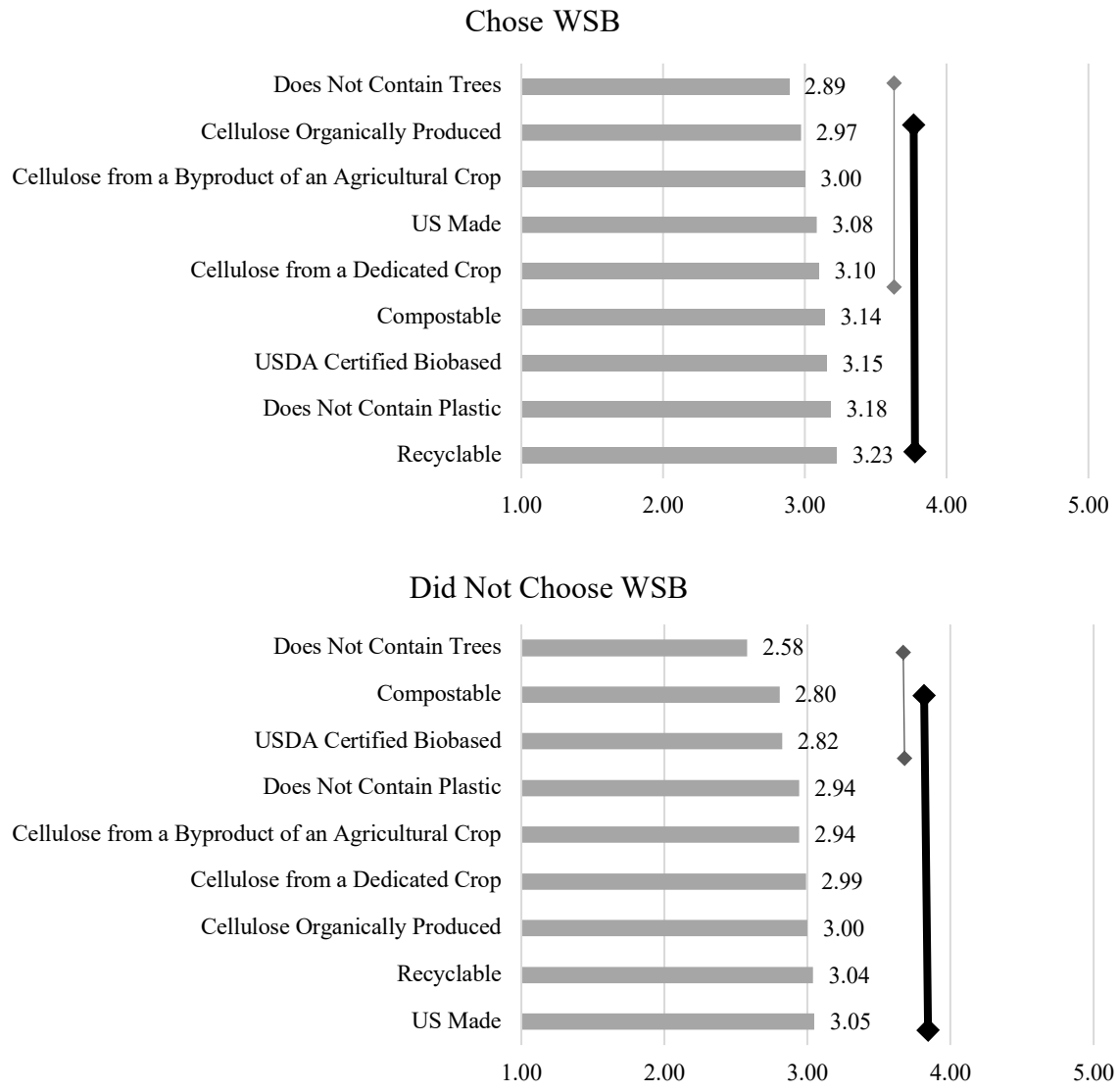

Figure 7. Importance of Disposable Dinnerware Attributes, Respondents Who Chose and Did Not Choose the WSB

= No significant difference among means at 95% confidence level.

= No significant difference among means at 95% confidence level.

WTP and Retail Outlet Type

One question inquired where respondents usually shopped for disposable dinnerware. About 41.1% most often shopped for disposable dinnerware at big box type stores (e.g., WalMart or Target). About 28% most often shopped for the product at grocery stores, while 24% most often purchased disposable dinnerware at warehouse clubs (e.g., Sam's Club or Costco). Less than 10% purchased at other outlets, which included online, convenience stores, and other sources. To ascertain whether shoppers at different types of retail outlets might exhibit differing WTPs for the

WSB, the average WTP for the WSB was compared across where the respondent most often shopped for disposable dinnerware. Average WTP differed across those who usually purchased disposable dinnerware at grocery stores and those who purchase it at other sources such as online or in convenience stores (Table 4). However, for most of the retail types, no significant differences in average WTP were found, suggesting that the molded dinnerware from wheat straw could be marketed at the same price across a variety of retail outlet types. The exception is grocery store outlets, for which those respondents who usually purchase at grocery stores would be willing to pay less for the WSB than those who purchased through other sources.

Table 4. Willingness to Pay and Importance of Attributes across Type of Store Where Most Often Shop for Disposable Dinnerware

	Average WTP (in dollars) if Most Often Shop at Store Type (N = 173)	
Type of Store Where Most Often Purchase Disposable Dinnerware	**Yes**	
Other (Warehouse Clubs, Online, Convenience)	\$4.24	a
Big Box (WalMart, Target, etc.)	\$3.75	a,b
Discount (Dollar General, Dollar Tree, etc.)	\$3.68	a,b
Grocery (Kroger, Publix, etc.)	\$3.37	b

Note: Like letters indicate no significant difference found in means at the 90% confidence level.

Conclusions and Implications

Results from this study suggest that consumers would pay a premium price of \$3.58 for a 25-count package of bowls molded from wheat straw fiber compared with a price of \$2.25 for the same size package of conventional molded bowls from tree cellulose. Results from this study also show certain market segments would be more likely to choose the WSB. These include those who spend more on disposable dinnerware, have heard of wheat straw, have purchased alternative fiber products in the past, and are more concerned about reducing GHG and climate change. These results suggest consumers who spend more on disposable dinnerware but are still more concerned about the environment may be target markets. Respondents who have heard of wheat straw or have purchased alternative fibers in the past are likely to choose the wheat straw molded disposable dinnerware. This could indicate that educating consumers about wheat straw as a cellulosic fiber could be helpful in marketing wheat straw cellulosic fiber products. The results could also indicate that repeat customers of "alternative fiber" products may be an additional target market. Surprisingly, lower education and income levels have positive influences. These results are somewhat perplexing. Research examining drivers of expenditures on disposable dinnerware (for example convenience and time constraints) and then subsequently the potential for purchasing wheat straw molded dinnerware among the differing levels of disposable dinnerware expenders may provide additional explanation for these results.

The results from this study suggest that among those choosing the WSB or not choosing them, the attribute with the least importance was that the product contains no cellulose fibers from trees.

This result suggests that "tree free" labeling may be of little value in building premiums. The result could also suggest that consumers believe cellulose from trees can be sustainably sourced. However, additional research would be needed to further investigate these motivations. The result that the respondents viewed cellulose from agricultural crops similarly whether it comes from a dedicated crop or a crop byproduct may suggest that consumers are about equally receptive to planting dedicated crops as sources of cellulose for disposable products as they are to cellulose sourced as a crop byproduct.

For those who selected the WSB, the products not containing plastic and being recyclable, USDA Certified Biobased, and compostable were rated significantly higher in importance than the product containing no cellulose from tree fibers. Adding these attributes could bring additional premiums among those willing to purchase a WSB. However, measuring the relative WTP for these attributes is beyond the scope of this study. Additional research might incorporate multiple attributes into choice sets through a conjoint or best-worst analysis.

As to what types of retail outlets through which WSB's might be marketed, it does not appear that consumers exhibited a large difference in WTP across various types of shopping outlets. An exception is that grocery shoppers are willing to pay less than those who usually buy their disposable dinnerware through sources other than grocery, big box, or discount stores.

This study has several limitations. First, the study was conducted in a limited region, Tennessee. Consumers' preferences for disposable dinnerware from wheat straw fibers could vary greatly across regions of the United States. Additional research should be conducted across a wider geographic region to provide a better understanding of the product's national market potential.

A second limitation of this study is that the survey was conducted online and involved a hypothetical choice. With private goods, survey respondents have an incentive to overstate their WTP for a private good in hopes it will influence the market offering (Carson and Groves, 2007, 2011). We did provide information screens to remind respondents to answer as realistically as possible, however, the potential for this bias remains. It should be noted that we asked for respondents' level of agreement with a statement about survey consequentiality ("responses to this survey could cause disposable dinnerware manufacturers to offer more alternative fiber products that don't use trees") (Vossler and Watson, 2013), but a dummy variable representing their agreement with this statement was not found to be significant in the model. Additional research should likely evaluate consumer preferences for disposable dinnerware from wheat straw fibers via in-store experiments. However, this type of analysis was beyond the scope of this study.

An additional limitation was that the WSB labels contained several attribute components (e.g., compostable, no trees, and made from wheat straw fibers) shown on the hypothetical product label. In some cases, attributes are combined by virtue of the nature of the product; for example, if a product is completely made from wheat straw fibers, it would contain no tree fibers. Also, it should be noted that some paper-based disposable dinnerware can be compostable. Additional research would be needed to truly elicit the values that each of these attributes contributed to consumers' WTP for the WSB.

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