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Canning cannabis: Consumer preferences for CBD- and THC-infused beverages

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Abstract

Cannabis regulatory reform has opened areas for product innovation and entrepreneurship. One dimension that has so far been understudied is the potential for cannabidiol (CBD) and tetrahydrocannabinol (THC) beverages. This study uses double-bounded contingent valuation techniques and parametric and nonparametric estimation procedures to assess consumer demand and willingness to pay (WTP) for various cannabis-infused beverages. By targeting a nationally representative sample of U.S. adults, the study finds that roughly half of consumers are willing to try cannabis-infused beverages. Among these respondents, cannabis-infused juices and sweetened iced tea elicit the highest mean WTP, though the WTP for other beverage options varies across demographics and consumer preferences. On average, the mean WTP for THC-infused beverages is 12.5% higher per 12 oz can than its CBD-infused counterpart, and younger consumers are willing to pay more for each of these products. These results have important implications for entrepreneurial decision-making, product development, and marketing strategies.

Keywords: beverages; cannabis; consumer preference; double-bounded dichotomous choice; contingent valuation; willingness to pay

JEL classifications: Q11; Q13

I. Introduction

Cannabis policies are rapidly evolving (Miller et al., 2024), opening unexplored avenues for entrepreneurship in food and beverage manufacturing (Stevens and Pahl, 2021). One area garnering tremendous interest is the market for cannabidiol (CBD) and tetrahydrocannabinol (THC) beverages (Brewbound, n.d.).[1] For example, Nielsen (2022a) reports that CBD-infused beverages eclipsed $19 million in sales in 2022, up 42% from the year prior and 106% from two years earlier. Meanwhile, in states that have legalized recreational cannabis, several craft beverage manufacturers have partnered

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[1]CBD is a nonintoxicating component of cannabis commonly associated with soothing effects that reduce anxiety, chronic pain, and insomnia (Grinspoon, 2021). Alternatively, THC is the intoxicating component of cannabis more commonly associated with recreational purposes.

with cannabis companies to produce and sell THC-infused drinks in state-licensed dispensaries (Kendall, 2019; Villa, 2021; Walsh, 2024). There are also loopholes in current federal laws stemming from the 2018 Farm Bill that allow the sale of certain types of THC beverages in states without recreational cannabis (Leas, 2021). Despite these initial insights and partnerships, the market potential of these novel beverage categories has remained understudied.

This study uses double-bounded contingent valuation (DBCV) procedures (Hanemann et al., 1991) from an online survey of 2,010 U.S. adults to evaluate demand and willingness to pay (WTP) for various cannabis-infused beverages. The experiment includes 12 oz cans of CBD- and THC-infused juice, sparkling water, iced coffee, sweetened tea, sports drinks, and non-alcoholic (NA) versions of beer, wine, and cocktails. Parametric and nonparametric approaches are then used to estimate mean WTP and identify the consumer characteristics associated with elevated consumer WTP. In conducting this analysis, the study provides key statistics on the CBD- and THC-infused beverage market to inform entrepreneurial decision-making, product development, and marketing strategies.

The present study most closely resembles Charlebois et al. (2020), who evaluated Canadian consumer willingness to purchase cannabis-infused edibles. Their results suggest that 40–46% of consumers are willing to purchase edibles, with 15% willing to substitute a cannabis-infused beverage for a conventional beverage, and 16% for an alcoholic beverage. This study extends this analysis by focusing exclusively on cannabis-infused beverages, considering market pricing, and assessing preferences for several CBD- and THC-infused options.

The study offers three primary contributions for academic researchers and industry stakeholders. First, in sampling a nationally representative panel of U.S. adults 21+ with respect to key demographics, the study identifies the share of the population that is willing to try cannabis-infused beverages and the demographics of this group. Second, the study presents mean WTP estimates for 16 different cannabis-infused drinks: eight CBD-infused and eight THC-infused alternatives. In doing so, the study discusses the products that appeal to the broadest range of consumers and evaluates what price the market could potentially bear. This information is valuable for beverage manufacturers, who can compare estimated WTP against production costs to determine whether it is a market worth pursuing.[2] Finally, the study discusses the factors correlating with WTP, providing valuable marketing insights into which demographic characteristics, personal habits, etc., best predict WTP for each product.

In previewing the results, over half of the sample is or may be willing to try cannabis-infused beverages, with CBD- and THC-infused juice, sweetened iced tea, and iced coffee appealing to the broadest range of consumers. The mean WTP estimates vary quite substantially across products, ranging from a lower-bound estimate of $1.44 per 12 oz can of CBD-infused NA beer to an upper-bound estimate of $4.63 per 12 oz can of THC-infused juice. On average, the mean WTP for THC-infused alternatives is approximately $0.30–$0.40 higher (or 12.5% greater) than CBD-infused counterparts.

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[2]Engaging in this market would also clearly depend on the legal statutes of the state the manufacturer operates within. As discussed later, this study does not speak to the legality of the product, and any stakeholder should consult their legal team before pursuing cannabis-infused beverage manufacturing.

Considering the demographics influencing WTP, age is the best predictor of elevated WTP levels for all products, while other characteristics and habits correlate well for some products. Ultimately, these results highlight the importance of defining a target audience during product development and considering how these factors will influence demand and WTP.

The remainder of this paper is structured as follows. Section II presents the methodology, including an overview of the product offerings, survey design, and estimation procedures. Section III presents the results of the DBCV analysis, including mean WTP estimates and a discussion of the factors influencing WTP. Section IV concludes with a summary of the marketing implications, limitations, and areas for future research.

II. Methodology

A. *Experimental design*

This study utilizes DBCV techniques to evaluate consumer WTP for CBD- and THC-infused beverages (Hanemann et al., 1991).[3] In a DBCV study, respondents are presented with a good or service and asked whether they would be willing to purchase it at a given price. They are then asked a follow-up question about whether they would be willing to pay a new price conditional upon their initial response. Respondents who state they would be willing to pay the original price see a higher price; those unwilling to pay the original price see a lower price.

Eight beverage types are included in this project, creating 16 total (hypothetical) cannabis-infused alternatives: eight CBD-infused and eight THC-infused beverages. These include 12 oz cans of juice, sparkling water, iced coffee, sweetened tea, sports drinks, and NA versions of beer, wine, and ready-to-drink (RTD) cocktails. These options reflect real-world alternatives and potential opportunities based on consumer demand. For example, sparkling water, tea, and fruit drinks represent some of the top-growing CBD-infused beverage categories (Nielsen, 2022a). Meanwhile, NA beer, wine, and RTD cocktails reflect growing consumer and producer interest in NA beverage markets (Lee-Weitz, 2023). Nielsen (2022b) reports that the category expanded by 20% from 2021 to 2022, while Lee-Weitz (2023) highlights how the number of beverage manufacturers operating in this space has blossomed. Additionally, there is a budding curiosity among producers in cannabis-infused beverages that mimic NA beer, wine, and spirits (e.g., Villa, 2021).

Given the broad beverage categories, respondents are asked to envision that the products are of their favorite flavor or type.[4] Each CBD-infused option has 25 mg CBD per 12 oz can, while the THC-infused options have 5 mg THC, representing standard industry serving sizes.[5] Figures 1 and 2 present the CBD- and THC-infused beverages.

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[3]Preferences are assessed separately for CBD and THC because the target populations and market segments could vary given their differing degrees of legality, stigmas, and expected reasons for use (Staples et al., 2022). Thus, a holistic assessment requires an understanding of CBD and THC preferences.

[4]For example, if the respondent's favorite flavor of sparkling water is strawberry, they should see a strawberry cannabis-infused sparkling water; if their favorite juice is orange juice, then they should see orange juice; etc.

[5]Daytrip is a fast-growing CBD-infused beverage brand (Nielsen, 2022a), and their products have 25 mg CBD: https://wearedaytrip.com/ [accessed May 14, 2024]. Levia is a popular THC-infused beverage brand

Figure 1. CBD-infused beverage options.

It is worth highlighting the warning label on the THC-infused alternatives but not the CBD-infused ones. CBD-infused alternatives are widely available, nonintoxicating, and generally come from federally legal hemp. As such, it does not require a warning label. Alternatively, THC comes from recreational cannabis and is intoxicating, so states with legal recreational cannabis require THC-infused food and drink products to be labeled with a warning label similar to the one used here (Kosa et al., 2017; Villa, 2021).

Market prices for a single 12 oz can of each CBD- and THC-infused alternative are then gathered for the bidding procedures. Based on the available information,[6] $2.99 per 12 oz can is selected as the average price for all products. Following Gabrielyan et al. (2014), each respondent sees this initial $2.99 bid for each product in the first part of the DBCV. To cover the range of available prices and obtain additional variation in the

whose seltzer includes 5 mg of THC: https://levia.buzz/products/cannabis-infused-seltzer/ [accessed May 14, 2024].

[6]Market prices for CBD- and THC-infused beverages are challenging to evaluate in online searches for a few reasons. First, though CBD-infused beverages are widely available, they are often sold in multi-unit packs (e.g., 6-pack or 12-pack), and price varies quite noticeably by brand and retail location. For THC-infused beverages, product availability is the main concern. Additionally, while cannabis-infused sparkling waters are common, other alternatives included in the design are not. Thus, the market prices for these products are not well known.

Figure 2. THC-infused beverage options.

Table 1. Bidding blocks for each product

#	Initial bid (b^m)	Discounted bid (b^d)	Premium bid (b^p)
1.	$2.99	$1.99	$4.99
2.	$2.99	$1.99	$3.99
3.	$2.99	$0.99	$4.99
4.	$2.99	$0.99	$3.99

Note: Respondents were randomly placed into one of the four blocks for each product. This means that, for example, they could be placed in Block 1 for the first product but Block 3 for the second product.

choice data, two discounted prices and two premium prices are included for the follow-up question. If respondents say they are unwilling to pay the original price, they are randomly presented with a discounted price of $0.99 or $1.99. Respondents willing to pay the original price are shown a premium price of $3.99 or $4.99. Table 1 summarizes the bidding blocks that respondents could be placed in for each product.

B. Survey instrument and sampling strategies

The DBCV study is embedded in an online survey constructed and distributed through Qualtrics targeting a nationally representative sample of U.S. adults 21+ with respect to key demographics. Since there is limited literature on the demographics

What's the difference?

CBD	**THC**
Cannabidiol	Tetrahydrocannabinol
▪ **Non-psychoactive** compound of the cannabis plant	▪ **Psychoactive** compound in the cannabis plant
▪ Commonly associated with **hemp**	▪ Commonly associated with **marijuana**
▪ NOT a federally controlled substance	▪ A federally controlled substance
▪ Widely available across the United States	▪ Available in states with legalized marijuana
▪ Common reasons for use: to reduce anxiety, help with sleep problems and stress levels, and improve general health and well-being	▪ Common reasons for use: for fun or recreation, to reduce stress and anxiety levels, to stimulate appetite, and for better sleep

Figure 3. Information provided to respondents before they state whether they would be willing to try CBD- and THC-infused beverages.

of cannabis-infused beverage consumers, the study elects for a nationally representative sample. That way, by asking each respondent whether they would be willing to try cannabis-infused beverages, the study identifies the share of the population and the consumer segments most likely to try these products. Outside of demographics, the survey includes questions on household characteristics, alcohol and cannabis consumption patterns, etc.

Before engaging in the DBCV portion of the study, respondents are provided with information on CBD- and THC-infused beverages. This includes real-world examples of these products and a summary of the differences between the two cannabinoids (Figure 3). They are then asked whether they had heard of CBD- and THC-infused beverages, whether they had consumed CBD- and THC-beverages, and if they would be willing to try them in the future. Each question is asked separately for CBD and THC.

Respondents who state they are unwilling to try these beverages in the future skip the DBCV portion of the study. In other words, these individuals are assumed to have a WTP of $0.00 for the products included in the study. Removing these respondents acts as a screening criterion, as researchers generally constrain their sample when analyzing WTP to ensure the proper target population. Of course, including these respondents in the estimation would reduce WTP.

Those who say they would or may be willing to try these products then participate in the DBCV. Rather than randomizing across all 16 beverages, respondents randomly see the eight CBD-infused or eight THC-infused options first. This reduces the cognitive burden and prevents confusion over the different cannabinoids (i.e., CBD and THC). However, bidding across the eight products within each set is randomized to prevent ordering effects (Boyle et al., 1993; Day et al., 2012). Once the respondent finishes their first set of eight tasks, they repeat the same questions for the other cannabinoid (if they said they would consume both types of cannabis-infused beverages). Figure 4 summarizes the DBCV survey flow for respondents.
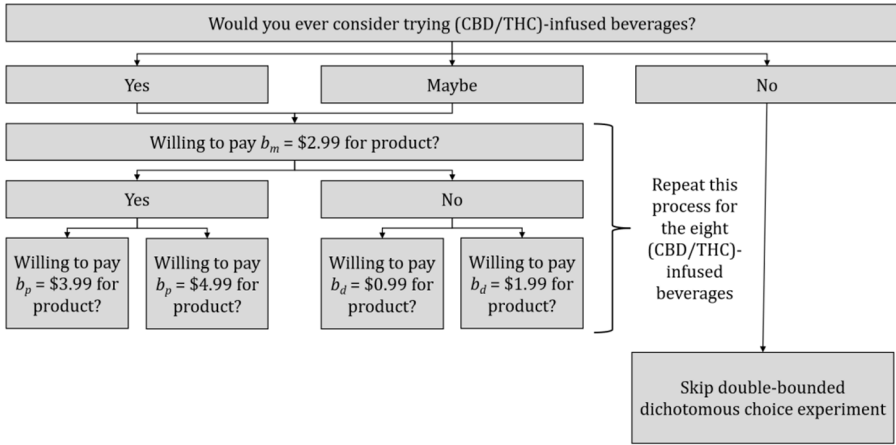
Figure 4. Experimental design flow for the double-bounded contingent valuation (DBCV) portion of the experiment.

C. Estimation

The study uses DBCV methods (Hanemann et al., 1991) and parametric and non-parametric modeling to determine consumer WTP for cannabis-infused beverages. Following approaches outlined in past empirical studies (e.g., Gabrielyan et al., 2018, 2014; Tozer et al., 2015), respondent i sees two bids for each product j. The initial market price bid b^m is presented to all respondents, and respondents are asked whether they would be willing to pay b^m for product j. The second bid is then conditional upon whether respondents are willing to pay the initial bid price. Those willing to pay b^m are then shown a premium price $b_i^p > b^m$, where the premium bid varies by i (Table 1). Respondents unwilling to pay b^m see a discounted price $b_i^d < b^m$, which also varies across i.

As WTP is a latent variable, this framework constructs bounds on the WTP for each product j. Let WTP_{ij} denote individual i's true WTP for product j. Then, the four possible outcomes (y_{ij}) are responding: no to both bids (NN); (ii) no to the first and yes to the second (NY); yes to the first and no to the second (YN); and yes to both (YY). Mathematically, this is represented as:

$$Y_j = \begin{cases} \text{NN if} & WTP_{ij} < b_i^d \\ \text{NY if} & b_i^d \leq WTP_{ij} < b^m \\ \text{YN if} & b^m \leq WTP_{ij} < b_i^p \\ \text{YY if} & WTP_{ij} \geq b_i^p \end{cases} \quad . \tag{1}$$

The probability of membership in each bound is then predicted as a function of the bids and respondent characteristics using maximum likelihood procedures, assuming the random variables follow some assumed cumulative distribution function.

We follow procedures outlined in López-Feldman (2012), where respondent i's WTP for product j is modeled as the linear function:

$$WTP_{ij} = z_{ij}\beta_j + \epsilon_{ij} \tag{2}$$

where z_{ij} is a vector of bid prices, respondent demographics, and personal characteristics, β_j is the set of parameters, and $\varepsilon_{ij} \sim N(0, \sigma^2)$. Demographic characteristics include gender, age, household income, and education. Other personal characteristics include political affiliation, past cannabis use, preferred alcoholic beverage (if any), knowledge of cannabis-infused beverages before this study, and the state legal policy of recreational cannabis. Additionally, the environmental and choice modeling literature suggests that the presentation order could impact WTP (Powe and Bateman, 2003; Stewart et al., 2002). As respondents consider several products in the study, a series of dummy variables are included to control for possible ordering effects (Boyle et al., 1993; Day et al., 2012). The model is estimated using the "doubleb" command (López-Feldman, 2012) in Stata 18.0 (StataCorp LLC., n.d.), which allows the parameter vector to be directly interpretable as marginal effects. This follows similar DBCV methods to those described in past empirical studies, such as Tozer et al. (2015), Sun and Zhu (2014), and Budhathokia et al. (2019).

Understanding that mean WTP estimates can be sensitive to distributional assumptions, the study also employs nonparametric techniques (Carson and Hanemann, 2005). Specifically, the Turnbull estimator is used to estimate the Kaplan–Meier mean WTP and survival function for each of the 16 cannabis-infused beverages. These estimates are generally considered a lower-bound estimate of mean WTP (Carson and Hanemann, 2005), and thus serve as a more conservative estimate for the present study. Nonparametric modeling is done using the "turnbull.db" function (Aizaki et al., 2022) in R Studio (R Core Team, 2021).

III. Results

A. Willingness to try CBD- and THC-infused beverages

Figure 5 gauges general awareness, previous consumption, and willingness to try CBD- and THC-infused beverages. Roughly half of the survey respondents had heard of CBD-infused drinks before the survey, whereas just 42% had heard of THC-infused beverages. The higher familiarity with CBD-infused beverages is unsurprising given the legal status of the two cannabinoids and the broad availability of CBD-infused beverages in traditional retail outlets.

Approximately 35% of the respondents who had heard of CBD-infused beverages before the survey, or 20% of the entire sample, previously consumed a CBD-infused beverage. For THC, 44% of those familiar with THC-infused beverages had previously tried them, equating to roughly 20% of the sample. Thus, while CBD-infused beverages are more well-known among the general population, they have similar overall consumption rates based on past exposure. It is also worth noting that there is significant overlap in the sample regarding who has tried CBD- and THC-infused beverages (correlation coefficient of 0.69).
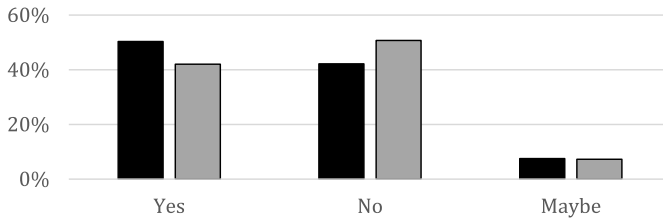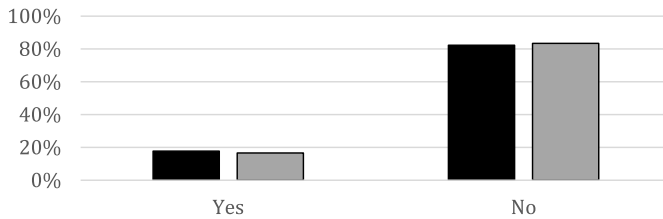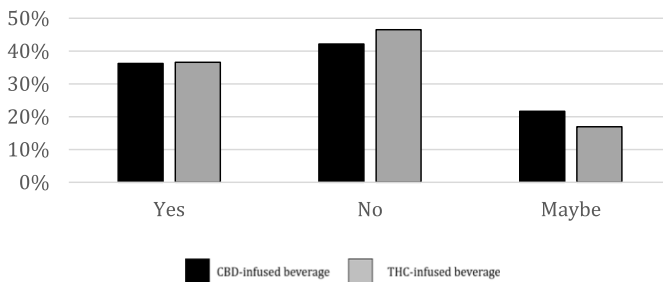
Panel A. Have you heard of these cannabis-infused beverages before the survey?

Panel B. Have you ever consumed these cannabis-infused beverages before?

Panel C. Would you be willing to try these cannabis-infused beverages?

Figure 5. Response rates to questions on cannabis-infused beverage familiarity, past consumption, and willingness to try (*n* = 2,010). Note: The sample size for CBD beverages is *n* = 1,163. The sample size for THC-infused beverages is *n* = 1,075, except for THC-infused juice (*n* = 967) due to an error in the survey coding during data collection.

In comparing the responses to the willingness to try questions to the overall sample (Table 2), respondents who are willing to try CBD-infused beverages are, on average, younger and more likely to have reported recent alcohol and cannabis use. There are less notable differences among the other demographic characteristics. For THC-infused beverages, similar yet more pronounced trends emerge. Younger respondents who have recently used alcohol and cannabis are more likely to try these beverages. Males are also more likely to state a willingness to try THC-infused beverages.

B. Mean WTP for cannabis-infused beverages

1. CBD-infused beverages

Of the 2,010 respondents completing the survey, 1,163 (58%) state that they would or may be willing to try CBD-infused beverages in the future. Figure 6 presents the mean

Table 2. Sample demographics, broken down by their willingness to try CBD- and THC-infused beverages

| Characteristic	Sample	Sub-sample analysis: Willingness to try	
		CBD-infused beverages	THC-infused beverages
Gender			
Male	49.3%	50.6%	55.6%
Female	49.9%	48.3%	43.4%
Non-binary/self-describe	0.9%	1.1%	0.9%
Age			
21–34	29.6%	36.0%	37.7%
35–54	31.6%	37.6%	38.7%
55 or older	38.9%	26.4%	23.6%
Income			
Less than $40K	38.8%	38.0%	38.1%
$40K–$79K	34.0%	32.8%	32.4%
$80K or more	27.2%	29.2%	29.5%
Education			
High school or less	30.3%	30.9%	31.2%
Some college, no degree	33.4%	34.4%	36.1%
College or advanced degree	36.3%	34.7%	32.7%
Region			
Midwest	21.6%	21.8%	20.9%
Northeast	17.6%	16.3%	16.7%
South	39.5%	40.9%	41.2%
West	21.3%	21.0%	21.1%
Political party			
Democratic	34.3%	38.3%	39.4%
Republican	29.3%	25.8%	23.6%
Independent or other	36.4%	35.9%	36.9%
Consume _____ in the past year			
Alcohol	72.2%	81.5%	84.9%
Cannabis	35.7%	50.8%	60.1%
Preferred alcoholic beverage			
Beer	24.4%	28.3%	31.2%
Cider or seltzer	6.8%	9.0%	9.0%
Distilled spirits	23.4%	27.4%	29.2%
Wine	15.2%	15.0%	14.0%
None	30.1%	20.3%	16.7%
N	**2,010**	**1,163**	**1,075**
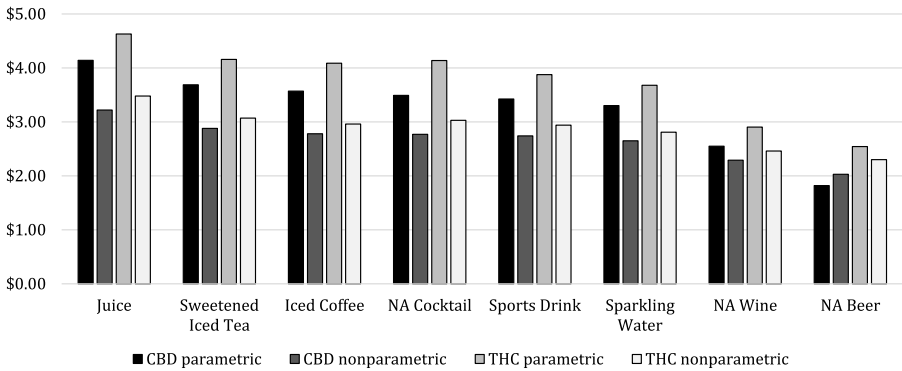
Figure 6. Mean willingness to pay (WTP) per 12 oz can

WTP estimates of these 1,163 respondents under the parametric and nonparametric approaches.[7]

Across the eight CBD-infused beverages, the juice has the highest mean WTP, ranging from \$3.22–\$4.14 per 12 oz under the different estimation strategies. Indeed, the mean WTP is at least \$0.34 larger than the second most preferred CBD-infused product: sweetened iced tea (\$2.88–\$3.69 per 12 oz can). The iced coffee and NA cocktail are also popular alternatives, with mean WTP estimates of \$2.78–\$3.57 and \$2.77–\$3.49 per 12 oz can, respectively. Alternatively, NA beer (\$1.82–\$2.03) and NA canned wine (\$2.29–\$2.55) have the lowest mean WTPs, which was anticipated given their appeal to fewer consumers than more conventional beverages (e.g., juice). Put differently, if someone does not like the taste of beer, their WTP may be \$0.00 even if they are interested in purchasing CBD-infused beverages. This limited appeal to a broad consumer base ultimately reduces the mean WTP for these products. Interestingly, the mean WTP for the NA cocktail is nearly double that of NA beer in the parametric approach and \$0.48–0.94 larger than the mean WTP for NA wine. This traditional alcoholic product may not suffer the same reduction in appeal because it would essentially be a mix of fruit juices, soft drinks, and other natural flavorings.

2. THC-infused beverages

Figure 6 also shows the average WTP for THC-infused beverages under the parametric and nonparametric approaches, where 1,075 (53%) of the 2,010 respondents stated that they would or may be willing to try these beverages. Generally, the mean WTP estimates follow a similar preference ordering to the CBD-infused alternatives. THC-infused juice appeals to the broadest range of consumers, with the highest mean WTP estimates of \$3.48–\$4.63 per 12 oz can. THC-infused sweetened iced tea (\$3.07–\$4.16), NA cocktails (\$3.03–\$4.14), and iced coffee (\$2.96–\$4.09) round out the top four products with the highest mean WTP.

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[7]As previously stated, respondents who are unwilling to try CBD- and/or THC-infused beverages are excluded from the analysis, as their responses do not provide useful insights into what potential consumers are willing to pay for cannabis-infused beverages (i.e., their WTP is \$0.00).

While NA beer remains the alternative with the lowest mean WTP, the THC-infused version sees a notable increase in mean WTP: $2.30–$2.54 per 12 oz can (up from $1.82 to $2.03 in the CBD-infused scenario). Indeed, this premium of switching from the CBD- to THC-infused option is the largest among the eight beverage categories. Gender differences in the two samples may drive this trend, as males are more likely to be willing to try THC-infused beverages (Table 2) and state that beer is their preferred beverage (Auter, 2016).

The pattern of higher WTP in the THC setting exists across each beverage category. On average, the mean WTP is $0.36 per 12 oz can for THC-infused options than the CBD-infused counterpart. This amounts to roughly a 12.5% premium, on average. However, there is some variation across beverage types, ranging from $0.35 to $0.72 under the parametric approach and $0.16 to $0.27 under the nonparametric approach. Besides NA beer ($0.50), the NA cocktails ($0.45) and juice ($0.37) have the greatest average differences between CBD- and THC-infused options, while canned wine ($0.26) and sparkling water ($0.27) have the smallest.

3. Considering potential hypothetical bias

DBCV offers a straightforward procedure to generate WTP estimates for various products based on just two questions. However, one common critique of contingent valuation and online surveys more broadly is the potential for hypothetical bias and inflated mean WTP estimates (Carson and Hanemann, 2005). Several steps were taken to reduce this potential bias, following best practices offered by Penn and Hu (2018) and Caputo and Scarpa (2022). This includes providing respondents with a cheap talk script (Cummings and Taylor, 1999), a consequentiality script (Carson and Groves, 2007; Vossler and Evans, 2009), and a solemn oath script (Jacquemet et al., 2013) before the experiment.[8] However, given the hypothetical nature of the experiment and the lack of consequences for suboptimal decision-making, this bias could persist. For example, a recent meta-analysis in the marketing literature suggests that the average hypothetical bias in online WTP studies is 21% (Schmidt and Bijmolt, 2020). As such, Table 3 presents deflated mean WTP estimates alongside

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[8]The **cheap talk script** was presented to the respondents before answering both the CBD and THC questions. The script read, "In online, hypothetical settings, survey respondents have been shown to state a higher willingness to pay than what they really are. This phenomenon is known as hypothetical bias. Although this survey scenario is purely hypothetical, we ask you to please carefully consider your true willingness to pay." The **consequentiality script** was included in an earlier portion of the survey, stating, "Before we begin, we want to once again stress the importance of providing truthful answers, as these results will be used to inform policymakers and industry groups." Finally, the **solemn oath script** was included as a question at the beginning of the survey, stating, "This survey will include questions on alcohol and cannabis use and preferences. These are sensitive topics, and we understand that you may be hesitant to provide this information. However, we want to stress that your results will be strictly anonymous, and there will be no way for us to trace these results back to you. Even if you do not use these products and never plan on using them, your responses are important to us. It is important that you provide honest responses and answer the questions to the best of your ability. The results of this survey will be used to shape policy decisions and industry decision-making. Do you commit to providing your best and most honest answers to the questions in this survey?" Respondents then could respond that (i) they would provide their best answers, (ii) they would not provide their best answers, or (iii) they cannot promise either way. Individuals who answered with (ii) or (iii) were removed from the survey.

Table 3. Deflated mean willingness to pay (WTP) estimates accounting for potential hypothetical bias

Product	CBD-infused beverages		THC-infused beverages	
	Original estimate	Deflated estimate	Original Estimate	Deflated estimate
Juice	$3.22–$4.14	$2.54–$3.27	$3.48–$4.63	$2.75–$3.66
Sweetened iced tea	$2.88–$3.69	$2.28–$2.91	$3.07–$4.16	$2.43–$3.28
Iced coffee	$2.78–$3.57	$2.20–$2.82	$2.96–$4.09	$2.34–$3.23
NA cocktail	$2.77–$3.49	$2.19–$2.76	$3.03–$4.14	$2.39–$3.27
Sports drink	$2.74–$3.43	$2.16–$2.71	$2.94–$3.88	$2.32–$3.06
Sparkling water	$2.65–$3.30	$2.09–$2.61	$2.81–$3.68	$2.22–$2.91
NA wine	$2.29–$2.55	$1.81–$2.01	$2.46–$2.90	$1.94–$2.29
NA beer	$1.82–$2.03	$1.44–$1.60	$2.30–$2.54	$1.82–$2.01

Note: The range in the "Estimate" columns denotes the values from the parametric and nonparametric approaches (Figure 6). The "Deflated" columns take the range and scale the estimates down by 21% according to the recent review study by Schmidt and Bijmolt (2020) on the prevalence of hypothetical bias in online surveys.

the original estimates presented earlier (Figure 6), where the initial range is deflated by 21%.

This procedure simply scales each mean WTP estimate down by the same factor, so preference ordering remains the same. For CBD-infused beverages, the deflated mean WTP estimates range from a low of $1.44–$1.66 per 12 oz can for NA beer to a high of $2.54–$3.27 for juice. Similarly, for THC-infused beverages, NA beer has the lowest deflated mean WTP of $1.82–$2.01, while juice has the highest at $2.75–$3.66. As before, when comparing the deflated CBD- and THC-infused estimates, the average consumer is willing to pay $0.28 (12.5%) more for THC-infused beverages than their CBD-infused counterpart.

C. Demographics influencing WTP

Under the parametric approach, we used average consumer demographics and characteristics to calculate the mean WTP for the 16 cannabis-infused beverage alternatives. However, from a marketing perspective, it is also valuable to understand the characteristics associated with an increased WTP for each product. The following two subsections explore the factors associated with a higher WTP for each CBD- and THC-infused beverage.

1. CBD-infused beverages

Table 4 presents the DBCV output for CBD-infused beverages. Across all eight CBD-infused alternatives, age was a statistically significant predictor of WTP. Specifically, respondents ages 21–34 and 35–54 are, on average, willing to pay more for CBD-infused beverages than respondents above the age of 55. The premium is highest among respondents in the youngest age bracket. Males also have a higher average WTP for NA beer and sports drink; for the other six beverages, gender is an insignificant predictor of WTP. The higher WTP for males for these two CBD-infused products follows from

the fact that males are more likely to consume beer (Auter, 2016) and traditional sports drinks (Grand View Research, 2019). Household income above $80K positively correlates with WTP, with statistically significant estimates in four of the eight beverages. Educational attainment, political affiliation, and residing in states with legal recreational cannabis are relatively weak predictors of WTP, with a few spurious statistically significant estimates across the eight products.

2. THC-infused beverages

Table 5 presents the results of the WTP estimation for THC-infused beverages. Many of the results for the factors influencing consumer WTP for THC-infused beverages follow from the previous section on CBD-infused beverages. Specifically, age is a clear predictor of WTP, where younger consumers are willing to pay more for each of the eight product alternatives, on average. This is true across all eight product options, with statistically significant point estimates for 21–34- and 35–54-year-olds relative to the baseline (55+). Higher-income households are also willing to pay higher prices, on average, where the point estimate for $80K+ is significant at the 5% level for five of eight beverages. Alcohol consumption is also associated with an increased WTP for THC-infused beverages, as depicted through the point estimates on the preferred alcohol types. For example, consumers who prefer cider or seltzer are willing to pay more for THC-infused sparkling water, while those who prefer beer are willing to pay more for THC-infused beer. As with CBD-infused beverages, males are also willing to pay more for THC-infused sports drinks and NA beer, on average.

IV. Discussion and conclusion

Entrepreneurs and key stakeholder groups are wondering about the market extent of cannabis products as U.S. policies continue evolving. While some studies have evaluated consumer cannabis product preferences, less is known about the market for CBD- and THC-infused beverages. This gap in the literature is critical as it represents an area for potential innovation in beverage manufacturing (Stevens and Pahl, 2021).

This study uses survey and DBCV data from a panel of U.S. adults to provide three key takeaways on consumer demand and WTP for CBD- and THC-infused beverages. First, there is broad interest in cannabis-infused beverages among consumers, with 58% and 53% of survey participants saying they would or may be willing to try CBD- and THC-infused beverages, respectively. Second, the study expresses substantial variation in preferences and WTP for cannabis-infused beverages, where the mean WTP for THC-infused alternatives is approximately 12.5% higher than CBD-infused counterparts, on average. Preference ordering is consistent across categories, with CBD- and THC-infused juice, sweetened iced tea, NA cocktails, and iced coffee appealing to the broadest range of consumers. Finally, the study determines the demographics correlating with higher WTP. Across all 16 cannabis-infused beverages, age is a statistically significant predictor of WTP, while income, gender, and preferred alcoholic beverage (if any) are sometimes insightful. These results highlight the importance of market segmentation and considering the target population, as products with lower mean WTP estimates could still appeal to select demographic groups. For example, while

Table 4. Predicting willingness to pay for CBD-infused beverages as a function of demographic and personal characteristics

Variable	Coefficient (std. error)							
	Juice	Iced tea	Iced coffee	NA cocktail	Sports drink	Spark. water	NA wine	NA beer
Male	−0.15 (0.18)	0.08 (0.22)	−0.25 (0.25)	−0.20 (0.22)	**0.88 (0.22)**	−0.10 (0.22)	0.15 (0.27)	**1.19 (0.31)**
Age								
21–34	**1.68 (0.24)**	**1.73 (0.29)**	**2.84 (0.34)**	**2.11 (0.30)**	**2.53 (0.29)**	**1.73 (0.30)**	**2.61 (0.38)**	**3.56 (0.45)**
35–54	**1.22 (0.23)**	**1.61 (0.28)**	**2.28 (0.32)**	**1.82 (0.29)**	**2.00 (0.28)**	**1.58 (0.28)**	**1.93 (0.36)**	**2.76 (0.42)**
Household income								
$40K–79K	−0.06 (0.20)	**−0.69 (0.25)**	−0.23 (0.28)	0.26 (0.25)	−0.13 (0.24)	−0.13 (0.25)	−0.15 (0.31)	0.37 (0.35)
$80K+	0.23 (0.22)	−0.12 (0.28)	0.31 (0.31)	**1.08 (0.28)**	0.12 (0.27)	**0.93 (0.28)**	**1.16 (0.35)**	**1.29 (0.39)**
Education								
Some college, no degree	−0.10 (0.21)	−0.20 (0.25)	−0.06 (0.28)	0.17 (0.26)	0.06 (0.25)	0.01 (0.25)	−0.20 (0.32)	−0.35 (0.36)
College degree	−0.07 (0.23)	−0.02 (0.28)	0.23 (0.31)	**0.56 (0.28)**	0.47 (0.27)	**0.72 (0.28)**	0.63 (0.35)	**0.86 (0.39)**
Political party								
Democratic	−0.03 (0.22)	0.24 (0.26)	−0.02 (0.30)	0.05 (0.27)	0.17 (0.26)	−0.19 (0.27)	0.42 (0.33)	−0.17 (0.37)
Independent or other	**−0.46 (0.22)**	−0.25 (0.26)	−0.47 (0.30)	−0.28 (0.27)	−0.31 (0.26)	**−1.16 (0.27)**	−0.20 (0.33)	**−0.85 (0.38)**
Rec cannabis use	**0.40 (0.19)**	0.25 (0.23)	**0.66 (0.26)**	0.40 (0.23)	**0.69 (0.22)**	0.32 (0.23)	0.14 (0.29)	0.62 (0.32)
Preferred alcohol type								
Beer	0.47 (0.25)	**1.14 (0.31)**	**1.41 (0.35)**	**1.16 (0.31)**	**0.94 (0.30)**	0.21 (0.31)	**1.25 (0.39)**	**1.94 (0.45)**
Wine	0.24 (0.28)	**0.74 (0.35)**	0.71 (0.39)	**0.94 (0.36)**	0.61 (0.35)	−0.15 (0.35)	**1.98 (0.45)**	0.93 (0.52)
Cider/seltzer	**0.98 (0.35)**	**1.52 (0.42)**	**1.76 (0.47)**	**1.00 (0.42)**	**1.63 (0.42)**	0.43 (0.41)	**1.40 (0.52)**	**1.26 (0.58)**
Distilled spirits	**0.87 (0.25)**	**0.95 (0.31)**	**0.89 (0.35)**	**0.90 (0.31)**	**0.75 (0.30)**	−0.11 (0.31)	**0.81 (0.39)**	0.84 (0.45)

(Continued)

Table 4. (*Continued.*)

Variable		Coefficient (std. error)						
	Juice	Iced tea	Iced coffee	NA cocktail	Sports drink	Spark. water	NA wine	NA beer
Prior knowledge								
CBD beverages	−0.07 (0.23)	0.26 (0.28)	0.44 (0.32)	0.39 (0.29)	0.31 (0.28)	0.47 (0.29)	0.38 (0.36)	**0.81 (0.41)**
THC beverages	**0.63 (0.24)**	**0.61 (0.28)**	0.88 (0.32)	0.33 (0.29)	**0.56 (0.28)**	0.46 (0.29)	**0.90 (0.36)**	0.44 (0.49)
Legal rec cannabis	−0.07 (0.17)	−0.07 (0.20)	−0.28 (0.23)	0.09 (0.21)	**−0.53 (0.20)**	−0.18 (0.21)	**−0.56 (0.26)**	0.21 (0.29)
Constant	**2.29 (0.37)**	0.77 (0.46)	−0.31 (0.55)	−0.87 (0.51)	−0.66 (0.49)	**1.39 (0.46)**	**−2.27 (0.64)**	**−4.22 (0.76)**
σ	**2.46 (0.10)**	**3.01 (0.13)**	**3.33 (0.15)**	**3.04 (0.13)**	**2.93 (0.13)**	**3.04 (0.13)**	**3.68 (0.18)**	**4.04 (0.21)**
N	1,163							
Ordering effects	Yes							
Log-likelihood	−1,392.5	−1,448.3	−1,381.6	−1,447.8	−1,407.8	−1,444.5	−1,380.3	−1,270.1

Note: **Boldface** represents statistical significance at the 5% level or greater.
Ordering effects are controlled for by the inclusion of dummy variables corresponding to the position in which the respondent saw each of the beverages.

Table 5. Predictors of willingness to pay for THC-infused beverages

Variable	Coefficient (std. error)							
	Juice	Iced tea	Iced coffee	NA cocktail	Sports drink	Spark. water	NA wine	NA beer
Male	0.08 (0.21)	0.31 (0.26)	−0.49 (0.31)	0.04 (0.28)	**0.79 (0.26)**	−0.03 (0.27)	0.21 (0.31)	**1.00 (0.31)**
Age								
21–34	**1.84 (0.29)**	**1.92 (0.35)**	**3.14 (0.42)**	**2.15 (0.37)**	**3.21 (0.36)**	**1.83 (0.36)**	**3.22 (0.44)**	**3.18 (0.44)**
35–54	**1.59 (0.28)**	**2.04 (0.34)**	**2.89 (0.40)**	**1.91 (0.36)**	**2.78 (0.34)**	**2.04 (0.35)**	**2.97 (0.42)**	**2.77 (0.42)**
Household income								
$40K – 79K	0.00 (0.24)	−0.29 (0.29)	−0.10 (0.35)	0.09 (0.31)	0.08 (0.29)	0.08 (0.30)	0.45 (0.35)	0.17 (0.35)
$80K+	0.46 (0.27)	0.07 (0.33)	**1.06 (0.39)**	**1.05 (0.35)**	0.17 (0.33)	**1.14 (0.35)**	**1.19 (0.40)**	**1.50 (0.40)**
Education								
Some college, no degree	−0.28 (0.24)	−0.27 (0.30)	−0.20 (0.35)	−0.17 (0.31)	−0.26 (0.29)	−0.36 (0.31)	−0.39 (0.36)	−0.53 (0.35)
College degree	0.17 (0.28)	0.43 (0.34)	−0.01 (0.39)	0.63 (0.36)	0.41 (0.33)	**1.05 (0.35)**	**0.83 (0.40)**	0.51 (0.40)
Political party								
Democratic	−0.13 (0.26)	0.19 (0.32)	−0.23 (0.38)	−0.47 (0.34)	−0.27 (0.32)	−0.28 (0.33)	−0.35 (0.38)	−0.19 (0.38)
Independent or other	−0.47 (0.27)	−0.16 (0.32)	−0.74 (0.38)	**−0.75 (0.36)**	**−0.74 (0.33)**	**−0.69 (0.34)**	**−0.79 (0.39)**	**−1.27 (0.39)**
Rec cannabis use	0.21 (0.22)	0.15 (0.27)	0.55 (0.32)	0.04 (0.28)	**0.78 (0.27)**	0.20 (0.28)	−0.26 (0.32)	0.10 (0.32)
Preferred alcohol type								
Beer	**0.62 (0.30)**	**0.99 (0.37)**	**1.18 (0.44)**	**1.38 (0.40)**	**0.93 (0.37)**	0.55 (0.39)	**1.24 (0.45)**	**1.42 (0.45)**
Wine	−0.12 (0.36)	0.58 (0.45)	0.55 (0.52)	0.71 (0.47)	0.39 (0.44)	−0.06 (0.46)	**1.63 (0.54)**	0.17 (0.55)
Cider/seltzer	**0.87 (0.41)**	0.84 (0.50)	**2.07 (0.61)**	**1.76 (0.54)**	**1.26 (0.51)**	**1.41 (0.53)**	**1.91 (0.61)**	1.04 (0.60)
Distilled spirits	**0.84 (0.31)**	**0.89 (0.38)**	0.79 (0.44)	**1.27 (0.40)**	0.52 (0.37)	−0.44 (0.39)	0.58 (0.46)	0.57 (0.46)

(Continued)

Table 5. (*Continued.*)

				Coefficient (std. error)				
Variable	Juice	Iced tea	Iced coffee	NA cocktail	Sports drink	Spark. water	NA wine	NA beer
Prior knowledge								
CBD beverages	0.19 (0.27)	**0.91 (0.33)**	**0.99 (0.40)**	**1.05 (0.35)**	0.45 (0.33)	**1.06 (0.35)**	0.51 (0.41)	0.65 (0.40)
THC beverages	**0.86 (0.27)**	0.36 (0.33)	0.56 (0.40)	0.18 (0.35)	0.51 (0.33)	0.16 (0.35)	**0.88 (0.40)**	0.43 (0.40)
Legal rec cannabis	−0.38 (0.20)	−0.22 (0.24)	−0.32 (0.29)	−0.44 (0.26)	−0.44 (0.24)	−0.18 (0.25)	−0.32 (0.29)	0.06 (0.29)
Constant	**1.81 (0.48)**	0.56 (0.60)	0.20 (0.69)	0.63 (0.64)	−0.04 (0.61)	0.75 (0.61)	**−1.72 (0.75)**	**−1.99 (0.76)**
σ	**2.59 (0.12)**	**3.40 (0.16)**	**3.95 (0.21)**	**3.58 (0.18)**	**3.34 (0.16)**	**3.53 (0.17)**	**4.03 (0.21)**	**3.96 (0.21)**
N	1,075							
Ordering effects	Yes							
Log-likelihood	−1,074.9	−1,297.2	−1,231.5	−1,274.2	−1,239.3	−1,298.3	−1,269.5	−1,232.3

Note: **Boldface** represents statistical significance at the 5% level or greater.
The sample size for THC-infused juice is 967 due to an error in the survey coding during data collection. Specifically, the skip logic insufficiently placed 108 respondents into the proper location following their first response (whether they would be willing to pay $b_m = \$2.99$). For example, some respondents saw a higher despite being unwilling to pay the initial price, while others were not asked a follow-up question altogether. This error was detected and corrected during data collection. Its effect is limited to only these 108 responses for the THC-infused juice option. Ordering effects are controlled for by the inclusion of dummy variables corresponding to the position in which the respondent saw each of the beverages.

cannabis-infused NA beers have the lowest mean WTP, beer manufacturers could still pursue this route knowing that beer drinkers are willing to pay above the mean for these products.

This study is not without limitations. The first comes from possible self-selection into treatment. While the sampling strategy targeted a nationally representative sample of U.S. consumers with respect to key demographic characteristics, some potential respondents may have been more likely to complete the survey than others. Alcohol and cannabis consumption can be sensitive topics, and regular consumers of these substances may have been more likely to complete the survey than those who strongly oppose them.[9] Thus, the estimate on the share of consumers who are willing to try cannabis-infused beverages may serve as an upper-bound approximation. However, by constraining the DBCV procedures to potential consumers and controlling for alcohol and cannabis use in the regression analysis, the main WTP findings are free of this concern.

The more prominent limitations of the WTP estimates stem from the reliance on DBCV techniques. The method has known shortcomings in incentive compatibility (Carson and Hanemann, 2005), potentially leading to inflated WTP estimates due to hypothetical bias (Murphy et al., 2005). Best practices are used to mitigate these concerns (Caputo and Scarpa, 2022; Penn and Hu, 2018), including combining a cheap talk script (Cummings and Taylor, 1999), consequentiality script (Carson and Groves, 2007; Vossler and Evans, 2009), and a solemn oath script (Jacquemet et al., 2013) before the experiment. Knowing that the bias could persist, the study also presents deflated WTP estimates following the study by Schmidt and Bijmolt (2020). These deflated estimates can be thought of as the most conservative estimates of mean WTP for each product.

Other critiques of the DBCV are that the WTP estimates can be sensitive to starting bids and bid design (Chien et al., 2005; Cooper, 1993; Veronesi et al., 2011; Vossler et al., 2004), ordering effects (Boyle et al., 1993; Day et al., 2012), and the distributional assumptions made about true WTP (Borzykowski et al., 2018; Veronesi et al., 2011). Measures were taken to overcome these drawbacks. First, regarding the starting bid levels, we follow procedures outlined in Gabrielyan et al. (2014); (2018), where the same initial bid level is given to each respondent for all products. Available market data informed the initial bid price, and the discounted and premium prices were selected to cover the range of prices at equivalent intervals. This creates a well-balanced and symmetric design, which minimizes biases even if anchoring is strong (Veronesi et al., 2011).[10] As for ordering effects, randomizing product appearance in the experiment and controlling for positioning in the empirical estimation mitigates these concerns (Cai et al., 2011). Finally, the nonparametric approach provides an estimate that is free of the concern over the distributional assumption. While these DBCV drawbacks may persist despite these mitigation efforts, the paper provides a necessary first set of

[9]Indeed, 36% of the sample states that they had consumed cannabis in the past year, which is larger than the national average of less than 20% reported by the CDC in 2019 (CDC, n.d.).

[10]Moreover, given that the initial bid level was the same for all products, and randomization was used for the conditional discounted and premium prices, any bias from bid level selection (if any) should be similar in magnitude across all products options. The implication of this is that the relative ranking or preference ordering across alternatives should remain the same.

estimates of consumer WTP for various cannabis-infused beverages. These insights, particularly when paired with considering the preference ordering of each beverage category and the information on demographic characteristics correlating with WTP, should be valuable to stakeholders on the potential market and consumer base of these cannabis-infused beverages.

This is a new and emerging market with several avenues for future research. Most notably, future research should build upon these results and consider expected consumption patterns of cannabis-infused beverages relative to alcohol or traditional cannabis options. That is, questions remain over whether consumers would substitute away from traditional alcohol or cannabis with this novel product option, or whether they would expect to consume them on the same occasion. This is important from both a marketing and public health perspective.[11] It could also be useful to gauge demand elasticities and perform market segmentation for frequent versus infrequent users to analyze optimal packaging options and per-unit pricing. A final avenue for future research is to explore and clarify the legal gray area in which cannabis-infused beverages operate (Schuster and Wroldsen, 2018; Villa, 2021). In no way should the results of this paper be considered guidance on the legal framework, and additional work is needed to better understand the legislative frameworks regulating the labeling, materials/input sourcing, distribution, etc., of cannabis-infused beverages.

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[11] As with any intoxicating or potentially harmful product, it is important to consider the potential adverse health and societal outcomes from their expansion in the market. While this lies outside the scope of this study, future studies could consider how consumers perceive cannabis-infused alternatives relative to alcohol.

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