Journal of Agricultural and Resource Economics 50(1):39–61
ISSN: 1068-5502 (Print); 2327-8285 (Online)

doi: 10.22004/ag.econ.344682

Drivers of the Likelihood to Consume Carbon-Friendly Beef and Plant-Based Meat Alternatives in the United States

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Understanding behavioral and demographic factors determining the consumption of sustainable meat and meat alternatives is critical in the context of sustainability. We used a sample of 430 US consumers to collect data on consumption behavior related to sustainable beef and plant-based meat alternatives. Results show that opinions and beliefs, past actions, and consideration of future consequences are behavioral factors, and age and political affinity are demographic factors that affect the likelihood of eating carbon-friendly beef and plant-based meat alternatives. The findings highlight the need for increasing environmental awareness of beef production and targeted marketing for growing consumption of such alternatives to conventional meats.

Key words: behavior, climate change concern, sustainable consumption

Introduction

In 2022, the agricultural sector contributed around 9.4% of total greenhouse gas (GHG) emissions in the United States, most of which came from the livestock sector (US Environmental Protection Agency, 2024). Methane emissions from enteric fermentation and manure management, and CO2 emissions from continuous grazing from the beef sector were major sources of livestock-sector GHG emissions. In the context of the United States, beef production accounts for 2.2% of all GHG emissions (Li et al., 2016).

Meat production and consumption have significant implications for sustainability beyond GHG emissions. Environmentally, meat production contributes to GHG emissions, larger water footprints, and biodiversity loss (Parlasca and Qaim, 2022). Steinfeld et al. (2006) reported that meat production and consumption generate 4.6 billion to 7.1 billion tons of GHGs annually. Gerbens-Leenes, Mekonnen, and Hoekstra (2013) stated that 92% of freshwater is used for agriculture; of this, one-third relates to livestock production. Machovina, Feeley, and Ripple (2015) wrote that livestock accounted for about 20% of total terrestrial biomass and consumed over half of directly used human-appropriated biomass. Economically, meat production impacts resource allocation for crop and livestock production. From a social perspective, meat production and consumption are associated with ethical and social welfare issues (Alonso, González-Montaña, and Lomillos, 2020). Global meat consumption trends show that total meat intake has increased due to growing population and per capita income. This trend toward increased meat consumption is expected to put pressure on various sustainability dimensions (Parlasca and Qaim, 2022), and leading experts warn that this pressure will have serious consequences for global food security and human health (Li, 2020).

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Deepthi Kolady acknowledges financial support from South Dakota Agricultural Experiment Station for the study.

Review coordinated by Simanti Banerjee.

Changing meat-eating habits have been cited as an affordable strategy to help mitigate climate change (de Boer, Schösler, and Boersema, 2013). Clune, Crossin, and Verghese (2017) reported that reducing the consumption of ruminant meat and dairy products had the highest impact on GHG emissions compared to other foods. If the crops grown for animal feed and biofuel were instead directly consumed by humans, about 70% more calories would be available in the global food system, and 4 billion more people could be fed (Stoll-Kleemann and Schmidt, 2017). In this regard, Tilman and Clark (2014) asserted that a vegetarian diet could reduce GHG emissions from food production by 55%, and Springmann et al. (2016) predicted that a transition toward more plant-based diets could reduce global food-related GHG emissions by 29%–70% in 2050 while lowering human mortality by 6%–10%. Yet, demand for meat is inelastic, which means that in addition to making efforts to reduce meat consumption or switching entirely to a vegetarian diet, it is necessary to offer meat that is produced more sustainably, as well as plant-based meat alternatives (PBMAs).

In this context, sustainable meat alternatives are produced with reduced environmental impacts (e.g., GHG emission, water footprint, biodiversity loss); PBMAs are food products made from vegetarian or vegan ingredients and eaten as a replacement for meat. Life cycle assessment studies show that PBMAs (e.g., impossible burger) reduce GHG emissions by 89% and land use by 96% compared to conventional meat (e.g., beef burger patties) (Khan et al., 2019). However, regular meat consumers are much less likely than those declaring an alternative diet, such as vegan/vegetarian/other, to select a PBMA item when a beef item is available (Tonsor, Lusk, and Schroeder, 2023). Further, loyal beef consumers in the United States are less sensitive to beef price changes (Tonsor, Lusk, and Schroeder, 2018). It is therefore important to produce beef in a sustainable way that reduces GHG emissions through either improved genetics, feed additives, manure management, or grazing management. A comparison of carbon sequestration rates between conventional and environment-friendly grazing (e.g., rotational/prescribed grazing) shows an increased sequestration rate for the latter, implying reduced GHG emissions from sustainably produced meat (Bosch et al., 2008).

Transitioning the global food system toward the consumption of more sustainably produced meat and meat alternatives requires a wide range of activities to evoke technical changes from producers and behavioral changes from consumers (Bendz et al., 2023). A shift toward low-meat diets (de Boer, Schösler, and Aiking, 2017); consumption of alternatives to farm-grown meat, such as PBMAs (Slade, 2018); and wide adoption of sustainably produced meat, such as carbon-friendly beef (Li et al., 2016), have received considerable attention for their potential to address climate change concerns associated with meat production and consumption.

Most previous research has studied the effects of sustainability labels on meat consumption, hypothesizing that sustainability concerns influence meat consumption (Van Loo et al., 2014; Apostolidis and McLeay, 2019). Van Loo et al. (2014) showed that consumers prefer animal welfare aspects more than organic and carbon footprint labels on meat. Previous studies have reported that food consumption overall is inelastic to taxes to reduce GHG emissions (Afshin et al., 2017), but beef consumption declined when GHG taxes were applied in the European Union (Biasini et al., 2021). Related to this, a recent study from the United States showed that policies targeting a reduction of GHG emissions are likely more cost-effective for reducing beef consumption than limiting vehicle use, another major source of GHG emissions (McFadden, Ferraro, and Messer, 2022).

Given this, it is imperative to gain an understanding of the factors influencing the consumption of sustainably produced meat and meat alternatives. To inform food policies and develop market and outreach efforts, this study analyzes behavioral and sociodemographic factors that affect US consumers' readiness to consume sustainably produced beef and PBMAs. To do so, we collected data from 430 US consumers and employed a logistic regression model to estimate the effect of behavioral and demographic factors on the willingness to consume beef raised carbon-friendly (RCF) and PBMAs. Results suggest that opinions and beliefs, past actions, consideration of future consequences, age, and political affinity affect the likelihood of eating RCF beef and PBMAs.

Drivers of Consumption of Sustainable Meat and Meat Alternatives

Behavioral Factors

Consumers' behavior is affected by factors related to the individual, including physical factors (e.g., health), personal and emotional factors (e.g., personality, beliefs, emotions, attitudes, expectations), life experiences (e.g., family, culture, friends), and context. This section summarizes previous studies that examined the effect of behavioral factors on sustainable meat consumption, which includes consumption of sustainably produced meat and meat alternatives.

Dietary Habits

Studies examining the effect of dietary habits on consumers' willingness to replace conventional meat with meat alternatives show mixed evidence. For example, Slade (2018) studied preferences for different types of burgers and found that frequent meat eaters were less likely to buy plant-based burgers. Positive reactions toward meat alternatives in terms of taste, texture, appearance, and smell were shown for regular consumers of meat alternatives, suggesting that current consumption patterns influence the acceptance of meat alternatives (Michel, Hartmann, and Siegrist, 2021). However, Hwang et al. (2020) found that the frequency of meat consumption did not influence the decision to purchase plant-based alternatives.

Meat Attachment

Meat attachment is a positive bond toward meat, measured using hedonism, affinity, entitlement, and dependence. Previous studies showed that those who were strongly attached to meat were less willing to reduce meat consumption or buy PBMAs (Graça, Calheiros, and Oliveira, 2015). Profeta et al. (2020) found significant and negative associations with meat attachment and meat substitution in Germany. A comparative study of the United States, China, and India by Bryant et al. (2019) showed a negative effect of meat attachment on the likelihood of purchasing PBMAs in the United States, a positive effect in China, and no effect in India.

Environmental Concerns

Several studies show that concerns related to climate change and the environment can influence food purchase decisions (Bryant et al., 2019; Circus and Robison, 2019; Hwang et al., 2020; Szejda et al., 2021). Consumers who endorse the value of caring for the environment are more likely to prefer plant-based substitutes than consumers who do not (de Boer and Aiking, 2022; Hoek et al., 2011). Li et al. (2016) showed that consumers who were more concerned with climate change, the environment, and local food were willing to pay more for RCF beef. However, some studies report that environmental concerns do not affect consumers' decisions on consuming meat or sustainably produced meat. For example, Arora, Brent, and Jaenicke (2020) did not find any effect of environmental concern on meat purchase decisions, and Ishaq, Kolady, and Grebitus (2023) did not find any effect of climate change concern on willingness to pay for sustainable meat alternatives, such as RCF beef.

Time Preference

Numerous studies have identified time preference as a significant driver of health-related behavior, but very few have examined the effect of time preference on food choice behavior. De Marchi et al. (2016) used the Consideration of Future Consequences (CFC) scale adopted from Joireman et al. (2012) to measure time preference and its effect on food choice behavior. The study found that CFC

significantly influenced consumer valuation for the USDA organic label. Tórtora and Ares (2018) found that respondents with a higher CFC made more healthful food choices, and Dassen, Houben, and Jansen (2015) concluded that the CFC scale has a strong relationship with healthy eating.

Perceptions and Knowledge

Perceptions regarding health and nutrition aspects of food are expected to drive consumer food choices (Rimal, 2005). Studies show that health-related perceptions and information influence preferences for meat alternatives (Van Loo, Caputo, and Lusk, 2020; International Food Information Council, 2021; Smart Protein Project, 2021). Sogari et al. (2021) analyzed factors affecting the intention to purchase meat–mushroom blended burgers and found that a positive perception of a sustainable diet, a positive attitude toward food innovation, and a positive motivation to process sustainability and nutrition information were significant drivers. Peschel et al. (2016) found that both subjective and objective knowledge influence environmentally sustainable food choices.

Food Labels

Food labels play an important role in determining consumers' food choices. Several studies have examined the role of food labels on meat and meat alternatives consumption (Apostolidis and McLeay, 2016, 2019; Edenbrandt and Lagerkvist, 2021; Carlsson, Kataria, and Lampi, 2022; Marshall, Bano, and Banas, 2022; Ortega, Sun, and Lin, 2022). However, the usefulness of these food labels depends on consumers' attention and trust (Pieniak, Aertsens, and Verbeke, 2010). While Mosier (2023) showed that consumers are willing to pay a premium for sustainable products if they trust the information on food labels and the information provider, Ishaq, Kolady, and Grebitus (2023) found no significant influence of trust on the willingness to pay for sustainable ribeye beef steak.

Sociodemographic Factors

This section briefly summarizes prior research on the effects of key sociodemographic factors on sustainable meat consumption.

Age

Evidence of the effect of age on the willingness to consume PBMAs and other meat alternatives is mixed. Some studies have found a negative association of age with meat alternatives (Slade, 2018; Van Loo, Caputo, and Lusk, 2020), and others have found no significant effect (Arora, Brent, and Jaenicke, 2020; Hwang et al., 2020; Szejda et al., 2021).

Gender

Bryant et al. (2019) found that women are more likely to buy PBMAs in China and in the United States. A study conducted in Europe found among older adults that women are more eco-friendly compared to men (Broeckhoven et al., 2021). However, other studies have found no significant differences in gender for purchasing decisions of meat alternatives (Slade, 2018; Bryant et al., 2019; Arora, Brent, and Jaenicke, 2020; Szejda et al., 2021).

Education

Similar to age and gender, evidence on the effects of education on consumers' willingness to eat sustainable meat alternatives is mixed. Some studies have shown a positive effect of education on

preferences for meat alternatives (International Food Information Council, 2020, 2021; Van Loo, Caputo, and Lusk, 2020), and others have found a negative relationship between education and the willingness to buy PBMAs (Hwang et al., 2020; Szejda et al., 2021).

Income

Evidence on the effect of income on willingness to consume meat alternatives is also mixed. In a US survey, the International Food Information Council (International Food Information Council, 2020) found a positive association between income and the likelihood of trying plant-based alternatives. However, this association was negative in India, and no significant association was found in China (Bryant et al., 2019). In addition, Bryant et al. (2019) and Van Loo, Caputo, and Lusk (2020) did not find significant income effects on the purchase intention of meat alternatives or on market shares of meat alternatives; and Slade (2018) found no significant effect of income on willingness to pay for plant-based burgers among Canadian consumers.

Deriving Research Questions

The previous studies discussed here highlight many factors that may affect the consumption of sustainably produced meat and meat alternatives. Nevertheless, research that has analyzed several behavioral and sociodemographic factors together is scarce, especially in the US context. Hence, this study investigates the influence of behavioral and demographic factors on consumers' willingness to consume sustainably produced beef (RCF beef) and plant-based meat alternatives (PBMAs). Specifically, we pose two research questions:

1. What are the behavioral characteristics of those who are willing to consume RCF beef and PBMAs?

2. What are the demographic characteristics of those who are willing to consume RCF beef and PBMAs?

To answer these research questions, we collected data on consumer behavioral and demographic characteristics (see Figure 1). We then used descriptive analysis to examine similarities and differences between consumers willing to consume RCF beef and PBMAs. Afterward, we employed a logistic regression model to estimate the marginal effects of behavioral and demographic characteristics on the likelihood of being willing to eat RCF beef and/or PBMAs.

Materials and Methods

Data Collection

We used an online survey facilitated by Qualtrics to collect the data.[1] The study received Institutional Review Board approval from South Dakota State University before conducting the survey. We collected data from 430 US consumers. Screening questions related to age, meat shopping, and meat consumption were asked in the beginning of the survey to ensure participants were at least 18 years of age and are primary shoppers who purchase and consume meat. The authors developed the survey instrument to include questions related to demographic and behavioral characteristics, including age, gender, education, income, marital status, place of residence, and political ideology. We also collected information about behavioral factors following those described in the previous section. A review of the literature informed the development of the survey instrument described below.

[1] Part of the dataset has been previously used by Ishaq, Kolady, and Grebitus (2023, 2024).

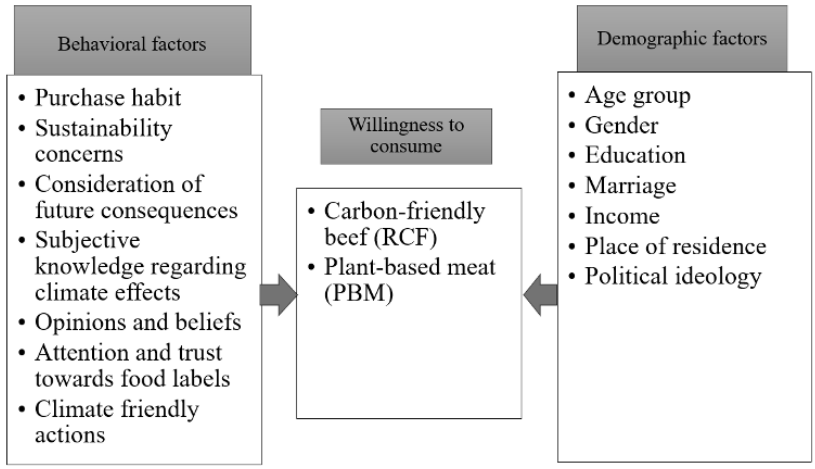

Figure 1. Conceptual Framework: Sociobehavioral Factors of Willingness to Consume Sustainable Meat Options and Meat Alternatives

Willingness to Consume Carbon-Friendly Beef and Plant-Based Meat Alternatives

Willingness to consume RCF beef was measured with a binary variable with a yes/no question on participants' willingness to consume beef produced using the rotational grazing approach. The willingness to consume PBMAs was measured using a 3-point scale ("very likely," "somewhat likely," and "not likely"), which was then converted into a binary variable by coding "very likely" and "somewhat likely" as 1 and "not likely" as 0.[2]

Meat Purchase Habits

To assess meat purchase habits, respondents were asked about their beef purchasing frequency. The answers provided were daily (6), twice per week (5), weekly (4), once in 2 weeks (3), monthly (2), a few times per year (1), and never (0).

Sustainability Concerns

To measure sustainability concerns, we designed a climate change concern scale comprised of 11 statements, such as "Global climate change is happening," and "I am concerned about the climate change consequences." Each of the items were rated on a 7-point Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree). Appendix Table A1 reports the complete list of statements. To include participants' level of concern in the analysis, we calculated an index by summing up the scores for all items and dividing the sum by 11. This was then standardized by subtracting the mean and dividing it by the standard deviation when used in the subsequent regression analysis.

Consideration of Future Consequences

Consideration of future consequences was measured using the statement "I try to think how my actions will impact others long term" on a 5-point Likert scale from 1 (strongly disagree) to 5 (strongly agree).

[2] We framed the questions for carbon-friendly beef and plant-based meat differently because the study respondents were meat consumers. Hence, we felt comfortable asking them a simple yes/no question regarding their willingness to consume carbon-friendly beef. Although meat alternatives are already in the market, we did not expect all respondents to be familiar with plant-based meat. Hence, we framed the response as a 3-point Likert scale.

Subjective Knowledge Regarding Climate Effects

Subjective knowledge regarding climate effects of products and services was assessed using three items, measured on a 7-point Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree). The items included "I consider myself knowledgeable about the climate effects of products and services," "I consider myself equipped to compare and evaluate the climate friendliness of different products and services," and "I am considered an expert in the field of climate effects of products and services by people who know me." To include participants' subjective knowledge in the analysis we calculated an index by summing up the scores for all items and dividing the sum by 3. This was then standardized by subtracting the mean and dividing it by the standard deviation to be used in subsequent regression analysis.

Climate-Friendly Behavior

Climate-friendly behavior was elicited using four questions measured as binary variables (Yes = 1/No = 0) to be used in subsequent regression analysis. These questions were (i) "Have you ever recycled or reused any product due to concern for climate change?" (ii) "Have you ever carpooled or rode a bike to reduce carbon emissions?" (iii) "Have you purchased a food item that is labeled as sustainable in the last 3 months?" and (iv) "Have you reduced beef consumption or tried plant-based meat to mitigate climate change?"

Beliefs

We elicited beliefs related to the contribution of beef production to GHG emissions by asking "Do you believe beef production is contributing to Green House Gas (GHG) Emission?" Answers were given on a 5-point Likert scale ranging from 1 (strongly disbelieve) to 5 (strongly believe). We also asked, "How positive or negative is your opinion about sustainable beef production practices?" This was measured on a 5-point Likert scale ranging from 1 (very negative) to 5 (very positive).

Attention and Trust Toward Food Labels

Attention to food labels was measured with the question "How much attention do you pay to labels on food packages?" The options provided were 1 (never), 2 (somewhat), and 3 (very much). Trust toward food labels was measured by asking "Do you trust labels on food packaging?" where "Yes" was coded as 1 and "No" as 0.

Data Analysis

We used two separate binary logit regression models to analyze drivers of consumers' willingness to consume beef raised carbon friendly (*RCF*), a sustainably produced meat, and plant-based meat alternatives (*PBMA*). The binary models take the following forms:

$$Y^*_{iRCF} = \beta \boldsymbol{X}_i + \varepsilon_i; \tag{1}$$

$$Y^*_{iPBMA} = \beta \boldsymbol{X}_i + \varepsilon_i; \tag{2}$$

where Y^*_i is the expected utility for individual i (for *RCF* in equation 1 and *PBMA* in equation 2), $\boldsymbol{X}_i$ is a matrix of covariates for individual i, and ε_i is a random error term with mean 0 and variance

$\pi^2/3$. The distribution of Y_i^* is unobserved; we observe the discrete variable Y_i such that

$$y_{iRCF} = \begin{cases} 1, \text{if willing to consume carbon-friendly meat} \\ 0, \text{otherwise} \end{cases} \tag{3}$$

$$y_{iPBMA} = \begin{cases} 1, \text{ if most or somewhat likely to consume plant-based meat} \\ 0, \text{otherwise} \end{cases} \tag{4}$$

The equations take the following forms (for willingness/likeliness to consume RCF beef and PBMAs, respectively):

$$\begin{aligned} \Pr(y_{iRCF} = 1) = {} & \beta_0 + \beta_1 BFREQ_i + \beta_2 CCCS_i + \beta_3 CFCS_i + \beta_4 KNOW_i \\ & + \beta_5 RECYCLE_i + \beta_6 CARPOOL_i + \beta_7 PSUS_i + \beta_8 TPBMA_i + \beta_9 BELIEF_i \\ & + \beta_{10} OPINION_i + \beta_{11} ATTN_i + \beta_{12} TRUST_i + \beta_{13} AGE_i + \beta_{14} GENDER_i \\ & + \beta_{15} EDU_i + \beta_{16} MARRY_i + \beta_{17} INCOME_i + \beta_{18} URBAN_i + \beta_{19} DEMO_i \\ & + \beta_{20} REPUB_i + \varepsilon_i; \end{aligned} \tag{5}$$

$$\begin{aligned} \Pr(y_{iPBMA} = 1) = {} & \beta_0 + \beta_1 BFREQ_i + \beta_2 CCCS_i + \beta_3 CFCS_i + \beta_4 KNOW_i \\ & + \beta_5 RECYCLE_i + \beta_6 CARPOOL_i + \beta_7 PSUS_i + \beta_8 TPBMA_i + \beta_9 BELIEF_i \\ & + \beta_{10} OPINION_i + \beta_{11} ATTN_i + \beta_{12} TRUST_i + \beta_{13} AGE_i + \beta_{14} GENDER_i \\ & + \beta_{15} EDU_i + \beta_{16} MARRY_i + \beta_{17} INCOME_i + \beta_{18} URBAN_i + \beta_{19} DEMO_i \\ & + \beta_{20} REPUB_i + \varepsilon_i; \end{aligned} \tag{6}$$

where β_0 is the intercept term and β_1–β_{20} are the coefficients to be estimated by maximizing the log-likelihood function with respect to each variable. Table 1 fully defines the explanatory variables and their summary statistics. Appendix Table A3 presents the correlation matrix for the behavioral variables included in the analysis.

Results

Sample Characteristics

The study sample characteristics of age, income, and ethnicity were closely comparable with the US population (Humes, Jones, and Ramirez, 2011; Ryan and Bauman, 2016; Proctor, Semega, and Kollar, 2016). The median age of respondents was 35–44 years, which corresponds with the 37.2-year average for the US population. Most of the respondents in the study sample were White (59.53% vs. 72.4 % of the US population), followed by Hispanic or Latino (18.14% vs. 16.30%), Black or African American (13.72% vs. 12.6%), and Asian ethnic groups (5.81 % vs. 4.8%). Native American/Alaska Natives constituted the smallest ethnic group in the sample (0.47% vs. 0.90%). Education ranged from a college degree or higher (50% vs. 32.50%) to high school graduate (46.51% vs. 55.90%) or associate degree (4%). The median income of the respondents was \$50,000–\$74,999, which corresponded closely with the median income of the US population (\$56,516). Of the 430 respondents, about 65.81% were female, higher than the 50.80% share for the US population. The higher sample share of female participants, however, is in line with women being over-proportionally responsible for grocery shopping and should not present a negative bias.

Table 1. Variable Definitions, Hypothesized Signs, and Summary Statistics of Explanatory Variables in Regression

Variables	Definition	Hypothesized Sign RCF	Hypothesized Sign PBMA	Mean
Behavioral characteristics				
BFREQ	Beef purchasing frequency (scale of 1–6)	–	–	3.94 (1.37)
CCCS	Climate change concern (scale of 1–7)	+	+	4.94 (1.08)
CFCS	Consideration of future consequences (scale of 1–5)	+	+	3.63 (1.03)
KNOW	Subjective knowledge regarding climate effects (scale of 1–7)	+	+	4.19 (1.43)
RECYCLE	1 if consumer recycles/reuses, 0 otherwise	+	+	0.78 (0.41)
CARPOOL	1 if consumer carpools, 0 otherwise	+	+	0.50 (0.50)
PSUS	1 if consumer purchases food items labelled as sustainable, 0 otherwise	+	+	0.54 (0.50)
TPBMA	1 if consumer has reduced meat consumption or tried plant-based meat alternatives to mitigate climate change, 0 otherwise	+	+	0.43 (0.50)
BELIEF	Belief about beef production and GHG emissions (scale of 1–5)	+	+	3.18 (1.13)
OPINION	Opinion about sustainable beef production (scale of 1–5)	+	+	3.89 (0.91)
ATTN	Attention to labels on food packaging (scale of 1–3)	+	+	2.40 (0.60)
TRUST	1 if consumer trusts labels on food packaging, 0 otherwise	+	+	0.77 (0.42)
Demographic characteristics				
AGE	1 = 18–24, 2 = 25–34, 3 = 35–44, 4 = 45–54, 5 = 55–64, 6 ≥ 65 (in years)	+	–	3.78 (1.67)
GENDER	1 if female, 0 otherwise	+	+	0.66 (0.47)
EDU	1 = below high school, 2 = high school graduate/associate degree and 3 = college degree or higher	+	+	2.47 (0.57)
MARRY	1 if married, 0 otherwise	+	+	0.56 (0.50)
INCOME	1 ≤ \$10, 000–\$24,999, 2 = \$25, 000–\$49,999, 3 = \$50, 000–\$74,999, 4 = \$75, 000–\$99,999, 5 ≥ \$100, 000	+	+	2.88 (1.38)
URBAN	1 if consumer lives in urban area, 0 otherwise	+	+	0.73 (0.44)
DEMO	1 if consumer identifies as Democrats, 0 otherwise	+	+	0.53 (0.50)
REPUB	1 if consumer identifies as Republicans, 0 otherwise	–	–	0.24 (0.43)

Notes: Values in parentheses are standard deviations. RCF = willingness to consume carbon-friendly beef; PBMA = willingness to consume plant-based meat alternatives.

Behavioral Characteristics

Purchasing Habits

Table 2 shows purchasing habits in terms of beef purchasing frequency for the total sample, as well as for those who are willing to consume RCF beef and are likely to eat PBMAs. Of the total sample, 31% purchased beef weekly, 23% purchased beef twice per week, and 14% purchased it daily. The beef purchasing habits of those willing to consume RCF beef are comparable to the full sample: 31% purchased beef weekly, 22% purchased it twice per week, and 14% purchased it daily. Among those willing to consume PBMAs, 27% purchased beef weekly, 27% purchased it twice per week, and 20% purchased it daily. The results indicate that a majority of the study sample were frequent meat purchasers who were likely to eat RCF beef or PBMAs.

Sustainability Concerns

Table 2 reports the mean sustainability concern for consumers willing to consume PBMAs and RCF meat. The overall score for the climate change concern scale was 4.94, indicating that, on average,

Table 2. Descriptive Statistics of Behavioral Factors Affecting Willingness to Consume (WTC) Sustainable Meat

Variables	Full Sample (N = 430)	WTC RCF (Yes = 370)	WTC PBMA (Yes = 267)
Beef purchasing frequency (%)			
A few times per year	4.19	4.32	3.00
Monthly	14.19	13.51	11.24
Once in two weeks	14.65	15.14	12.36
Weekly	30.70	30.81	27.34
Two times per week	22.56	22.16	26.59
Daily	13.72	14.05	19.48
Sustainability concerns			
Climate change concern scale (mean score on 7-point agreement scale)	4.94	5.02	5.07
Consideration of future consequences			
I try to think how my actions will impact others in long term (mean score on 5-point agreement scale)	3.62	3.66	3.88
Subjective knowledge			
Knowledge regarding climate effects of products and services (mean score on 7-point agreement scale)	4.19	4.24	4.68
Opinion about sustainable beef production (%)			
Very negative	1.16	0.54	0.37
Somewhat negative	3.26	2.97	2.25
Neutral	30.47	28.38	21.35
Somewhat positive	35.35	35.14	41.20
Very positive	29.77	32.97	34.83
Belief about contribution of beef production to GHGs (%)			
Strongly disbelieve	9.77	8.65	4.12
Somewhat disbelieve	15.35	15.14	11.61
Neutral	33.02	30.27	32.21
Somewhat believe	30.70	33.24	38.95
Strongly believe	11.16	12.70	13.11
Attention to food labels (%)			
Never	5.81	5.14	0.75
Somewhat	48.60	49.19	41.57
Very much	45.58	45.68	57.68
Trust labels on food packaging (%)			
Yes	76.98	78.92	82.77
No	23.02	21.08	17.23
Climate friendly actions (%)			
Done recycling/reusing	78.14	81.89	85.77
Carpooled or rode a bike to reduce carbon emission	50.00	52.16	62.17
Purchased food item labelled as sustainable	53.85	56.91	68.8
Reduced beef consumption or tried plant-based meat alternatives to mitigate climate change	42.56	44.05	57.68

Notes: RCF = carbon-friendly beef and PBMA= plant-based meat alternatives.

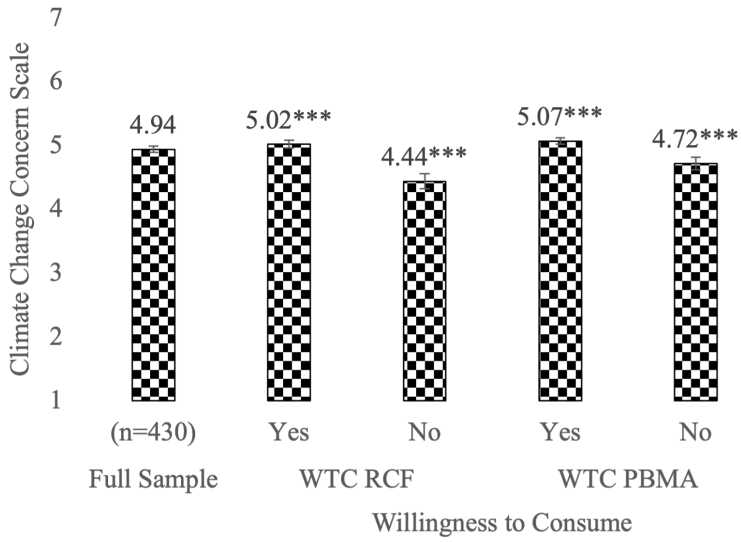

Figure 2. Relationship Between Climate Change Concern and Willingness to Eat Sustainable Meat and Meat Alternatives

Notes: Scale: 1 = strongly disagree to 7 = strongly agree. Triple asterisks (***) denote statistical significance at the 1% level. Mean values of willing and not willing to consume RCF beef and PBMA were compared using an independent sample *t*-test. WTC RCF = Willingness to consume carbon-friendly beef and WTC PBMA = Willingness to consume plant-based meat alternatives.

participants were concerned about climate change. The items were internally consistent, as suggested by a Cronbach's alpha of $\alpha = 0.84$ (Table A1). As shown in Figure 2, consumers who are likely to eat RCF beef and PBMAs were more concerned than the full sample and those not likely to eat these alternatives. Consumers likely to eat PBMAs and RCF beef had comparable levels of climate change concerns. Mean differences of the climate change concern scale for likely eaters and noneaters of RCF and PBMA were significant at the 1% level of significance (see Figure 2).

Consideration of Future Consequences

Table 2 reports meat consumers' consideration of future consequences (i.e., thinking about long-term consequences of present actions). Overall, the sample scored slightly higher than neutral (3.6) on the consideration of future consequences agreement score, showing that, on average, participants care somewhat about future consequences of their actions. The relatively higher mean score for those likely to eat PBMAs implies that they care more about the long-term consequences of their actions than those willing to eat RCF beef. We observe that consumers who are likely to eat sustainable meat alternatives think more about the long-term consequences of present actions (consideration of future consequences score of 3.9) than those not likely to eat these alternatives (consideration of future consequences score of 3.2) (see Figure 3). The mean difference of the scores for likely eaters and noneaters of PBMA was significant at the 1% level.

Subjective Knowledge on Climate Effects of Products and Services

Table 2 reports the mean value for subjective knowledge of participants regarding the climate effects of products and services. The overall knowledge score of 4.2 with an acceptable Cronbach's alpha of 0.76. (Appendix Table A2 implies that survey respondents were somewhat knowledgeable regarding climate effects of products and services.) Consumers likely to eat RCF beef and PBMAs considered themselves to be more knowledgeable about the climate effects of products and services than those who were not likely to eat these options (see Figure 4). The mean difference of subjective knowledge

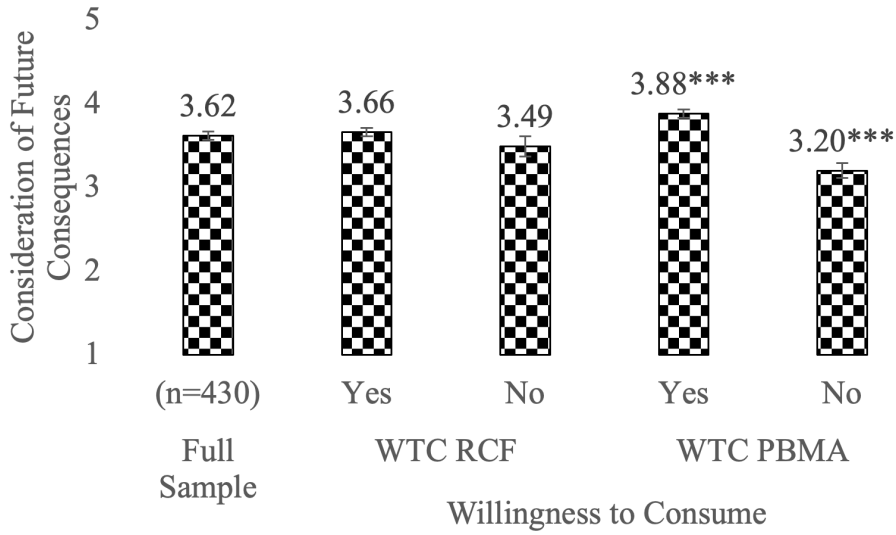

Figure 3. Relationship Between Consideration of Future Consequences and Willingness to Eat Sustainable Meat and Meat Alternatives

Notes: Scale: 1 = strongly disagree to 5 = strongly agree. Triple asterisks (***) denote statistical significance at the 1% level. Mean values of willing and not willing to consume RCF beef and PBMA were compared using an independent sample *t*-test. WTC RCF = Willingness to consume carbon-friendly beef and WTC PBMA = Willingness to consume plant-based meat alternatives.

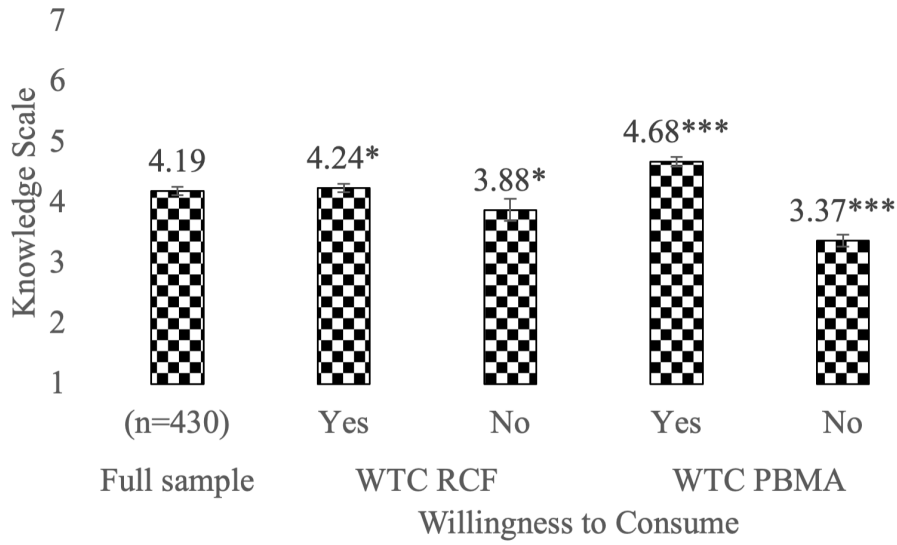

Figure 4. Subjective Knowledge on Climate Effects and Willingness to Consume Sustainable Meat and Meat Alternatives

Notes: Scale: 1 = strongly disagree to 7 = strongly agree. Single and triple asterisks (*, ***) denote statistical significance at the 10% and 1% level, respectively. Mean values of willing and not willing to consume RCF beef and PBMA were compared using an independent sample *t*-test. WTC RCF = Willingness to consume carbon-friendly beef and WTC PBMA = Willingness to consume plant-based meat alternatives.

for willingness to consume RCF beef and PBMA was statistically significant at the 10% and 1% levels, respectively.

Opinions and Beliefs

Table 2 summarizes respondents' opinions and beliefs regarding sustainable beef production and beef production's contribution toward GHG emissions. Most respondents likely to eat sustainable meat and meat alternatives hold positive opinions about sustainable beef production. Very few consumers had negative opinions about sustainable beef production. Many consumers also belonged to the neutral categories for likely eaters of sustainable meat alternatives. Regarding consumers' beliefs about the contribution of beef production to GHG emissions, 33% of the total sample (the largest share) fell under the neutral category, followed by those who somewhat believed (31%). About 30% and 32% of the neutral category were likely to eat RCF beef and PBMAs. Almost 33% and 39% of the somewhat believe category were likely to eat RCF beef and PBMAs.

Attention and Trust Toward Food Labels

The results for attention to food labels in Table 2 show that, on average, most respondents pay some attention to food labels (49% somewhat and 46% very much). The share of consumers who never pay attention to food labels is small (6%). A larger portion of those who paid attention to food labels were likelier to eat RCF beef and PBMAs. Regarding trust in food labels, most of the respondents (77%) trusted labels on food packaging. The share of consumers who trust food labels was higher for PBMAs (83%) than for RCF beef (79%).

Climate-Friendly Behavior

Table 2 reports climate-friendly behavior adopted by respondents to mitigate the effects of climate change. Respondents likely to eat sustainable meat and meat alternatives had mostly adopted climate-friendly behavior in the past: 78% indicated recycling or reusing, 50% carpooled or rode a bike to reduce GHG emissions, 54% purchased food items labeled as sustainable, and 43% reduced beef consumption or tried PBMAs to mitigate climate change. Overall, respondents who were likely to eat PBMAs engaged in more climate-friendly behavior than those who were likely to eat RCF beef.

Demographic Characteristics of Consumers

Table 3 displays the similarities and differences in demographic characteristics of the total sample and respondents likely to eat RCF beef and PBMAs. Since we summarized the demographic characteristics of the total sample earlier, we focus on the characteristics of consumers who are willing to consume (i.e., likely to consume) RCF beef and PBMAs. The results show that a greater percentage of consumers were likely to eat RCF beef (86%) than PBMAs (62%). Women accounted for a larger share of the total sample (66%) and were likely consumers of both RCF beef (65%) and PBMAs (63%).

When looking at the age of consumers, we observe that the older age group (65+ years) of consumers consisted of the largest share (26%) of likely eaters of RCF beef. Consumers 25–34 years old held the second largest share of likely eaters of RCF beef. Younger consumers (25–34 years) were the most likely eaters of PBMAs (32%). Consumers 35–44 years old were the second largest group of likely eaters of PBMAs (26%).

More than 50% of the likely eaters of RCF beef and PBMAs had college degrees or higher-level education. Very few consumers of either sustainable alternative had less than high school-level education.

Table 3. Demographic Characteristics of Consumers Willing to Consume Carbon-Friendly Beef (RCF) and Plant-Based Meat Alternatives (PBMAs)

Variables	Full Sample (N = 430)	WTC RCF (%) (Yes = 370, 86%)	WTC PBMA (%) (Yes = 267, 62%)
Gender			
Male	34.19	34.59	37.08
Female	65.81	65.41	62.92
Age group			
18–24 years	5.58	5.14	6.37
25–34 years	23.95	24.32	32.21
35–44 years	21.40	21.62	26.22
45–54 years	11.63	12.16	11.61
55–64 years	10.93	10.81	9.74
≥65 years	26.51	25.95	13.86
Education			
Below high school	3.49	2.97	3.75
High school graduate/associate degree	46.51	45.95	40.07
College degree or higher	50.00	51.08	56.18
Income			
< $10,000–$24,999	20.70	18.65	17.60
$25,000–$49,999	21.86	21.35	16.85
$50,000–$74,999	24.19	25.95	23.97
$75,000–$99,999	15.58	15.41	19.85
≥$100,000	17.67	18.65	21.72
Residence			
Urban	73.49	74.59	78.28
Rural	26.51	25.41	21.72
Marriage status			
Married	56.28	58.11	62.92
Unmarried	43.72	41.89	37.08
Political ideology			
Republican	23.78	23.85	18.80
Democrat	52.68	53.66	63.53
Independent	23.54	22.49	17.67

Notes: WTC RCF = willingness to consume carbon-friendly beef and WTC PBMA= willingness to consume plant-based meat alternatives.

Consumers with income levels of $50,000–$74,999 constituted the largest share (24%) of potential consumers for sustainable options. Consumers with income levels of $25,000–$49,000 accounted for the second largest share of likely eaters for RCF beef, and those with income levels of $75,000–$99,999 accounted for the smallest share. In contrast, consumers with an income level of $100,000 or more accounted for the second largest group of likely eaters of PBMAs, and those with an income level of $25,000–$49,999 accounted for the smallest share.

Regarding consumers' residence, urban residents were more likely to eat RCF beef (75%) and PBMAs (78%). A greater number of married consumers were willing to eat both sustainable options. With respect to political ideology, a higher number of respondents who identified as Democrats were more likely to eat sustainable options (54% for RCF beef and 64% for PBMAs) than those who identified as Republicans or Independents.

Table 4. Marginal Effects of Behavioral and Demographic Factors on Willingness to Consume Sustainable Meat Options

Variables	WTC RCF dy/dx	WTC PBMA dy/dx
Purchasing habit		
Purchase frequency	−0.02 (0.01)	0.01 (0.01)
Sustainability concerns		
Climate change concern scale	0.01 (0.02)	−0.02 (0.02)
Time preference		
I try to think how my actions will impact others long term	−0.03* (0.02)	0.05*** (0.02)
Subjective knowledge		
Knowledge regarding climate effects of products and services	0.00 (0.02)	0.04 (0.02)
Opinion and belief		
Opinion about sustainable beef production	0.07*** (0.02)	−0.01 (0.02)
Belief about contribution of beef production to GHGs	0.03** (0.02)	0.05*** (0.02)
Attention and trust toward food label		
Attention to labels on food package	−0.06** (0.03)	0.11*** (0.03)
Trust labels on food packages	0.05 (0.04)	0.02 (0.04)
Climate friendly actions		
Done recycling/reusing	0.11*** (0.04)	0.00 (0.05)
Carpooled or rode a bike to reduce carbon emission	0.01 (0.04)	0.02 (0.04)
Purchased food item labelled as sustainable	0.07* (0.04)	0.10*** (0.04)
Reduced beef consumption or tried plant-based meat alternatives to mitigate climate change	−0.02 (0.04)	0.18*** (0.04)
Sociodemographic characteristics		
Age group	0.01 (0.01)	−0.05*** (0.01)
Gender (Female)	0.00 (0.03)	−0.05 (0.04)
Education	−0.01 (0.03)	0.01 (0.03)
Married	−0.01 (0.04)	0.01 (0.04)
Income	0.02 (0.02)	−0.01 (0.01)
Residence (urban)	0.03 (0.04)	0.05 (0.04)
Democrat	−0.03 (0.04)	0.15*** (0.04)
Republican	0.03 (0.05)	0.03 (0.05)
LR χ^2	56.38***	229.44***
Pseudo-R^2	0.16	0.40

Notes: Values in parentheses are standard errors. Single, double, and triple asterisks (*, **, ***) denote statistical significance at the 10%, 5%, and 1% level, respectively. WTC RCF = willingness to consume carbon-friendly beef and WTC PBMA= willingness to consume plant-based meat alternatives.

Sociobehavioral Drivers of Willingness to Consume Sustainable Meat

Table 4 presents the findings from two separate binary logistic regressions for willingness to consume RCF beef and likelihood to eat PBMAs. Results show that behavioral factors, including beliefs about the contribution of beef production to GHG emissions and engaging in climate-friendly actions of purchasing food items labeled as sustainable, increase the likelihood of consuming RCF beef and PBMAs in the future. Respondents who have strong positive opinions about sustainable beef production and have done recycling in the past are more likely to eat RCF beef, while no such effect is present for PBMAs. Respondents who have a reduced beef consumption or tried PBMAs in the past are more likely to eat PBMAs, while no such effect is present for RCF beef. With respect to

attention to food packaging labels, results showed that more attentive respondents were more likely to eat PBMAs but less likely to eat RCF beef. Respondents who reported that they care about the long-term impact of their actions were more likely to eat PBMAs but less likely to eat RCF beef.

Among the demographic characteristics, only age and political affiliation were associated with respondents' willingness to consume sustainable options. According to the results, younger consumers and those who identified as Democrats were more likely to eat PBMAs, while no such effect was present for RCF beef.

Discussion and Policy Implications

A thorough understanding of the factors that may hinder or encourage a dietary transition toward sustainability enables the development of more effective policies and strategies to reduce high levels of meat consumption (Apostolidis and McLeay, 2016). Wolstenholme et al. (2021) asserted that identifying psychological variables associated with behavior can be useful in maximizing positive attitudes, subjective norms, and perceived behavioral control that encourage behavior change toward more sustainable diets. However, behavioral factors are often neglected, even though they are important drivers of food choices. Therefore, in this study we examined the effect of both behavioral and demographic characteristics related to future consumption decisions of beef raised carbon-friendly (RCF) and plant-based meat alternatives (PBMAs).

Descriptive analysis of behavioral characteristics shows that most of the consumers willing to eat both sustainable alternatives purchased meat more frequently (mostly weekly followed by twice per week and daily). This suggests that there is an opportunity to reduce unsustainable meat consumption by decreasing purchase frequency of conventionally produced beef. Replacing the purchase of such beef with RCF beef and PBMAs could reduce the possible GHG emission impact.

Consumers who are more likely to eat sustainable meat options are characterized by higher levels of concern regarding climate change, care about long-term consequences of consumption, feel more knowledgeable about climate effects of products, hold positive opinions about sustainable production, believe that beef production emits GHG, and adopt climate-friendly actions. Overall, consumers more likely to eat PBMAs showed more climate-friendly behavior than those who were more likely to eat RCF beef.

The descriptive analysis of demographic characteristics shows that women were more likely to eat sustainable meat alternatives than men. These findings complement previous findings that women opt for more eco-friendly options than men (Bryant et al., 2019; Broeckhoven et al., 2021). For RCF beef, the 65+ age group dominated the share of those more likely to eat sustainably produced beef. In contrast, as reported by Slade (2018) and Van Loo, Caputo, and Lusk (2020), younger consumers, particularly the 25–34 age group, were the largest consumer segment indicating a likelihood to eat PBMAs. This finding suggests that consumers' preferences for sustainable options differ based on age and gender. Results also suggest that consumers with higher education levels, living in urban areas, and identifying as Democrats are a dominant consumer group that is more likely to eat both sustainable alternatives.

Our econometric analysis showed that several factors were associated with the willingness to consume RCF beef and PBMAs. The analysis highlights that behavioral factors were more important drivers of the likelihood to eat sustainable meat options in our study than demographic factors. Similar to Bradford et al. (2018) and Schaub (2022), this research provides evidence that those who were more concerned about long-term consequences of their actions were more likely to eat PBMAs and less likely to eat RCF beef. This finding highlights that concerns about future consequences are important in shaping consumer choices. Therefore, this ought to be considered while developing strategies and outreach efforts to encourage sustainable food choices, such as the consumption of sustainably produced meat and meat alternatives.

Our results also highlighted the significance of opinions and beliefs in determining green consumption behavior. Consumers with a stronger belief in the contribution of beef production to

GHG emissions were more likely to eat both sustainable meat alternatives. Those who had positive opinions about sustainable beef production were more likely to eat RCF beef. Another important determinant of sustainable meat consumption is attention to and trust in food labels. Findings show that those who pay attention to food labels are more likely to eat PBMAs and less likely to consume RCF beef. In line with Wang, Shen, and Chu (2021), our study found that consumers' attitude toward green consumption has a positive impact on their intention to consume sustainable meat alternatives. This underscores the importance of using food labels with reliable information to cultivate positive opinions, beliefs, and attitudes toward sustainable products, thereby enhancing the intention to consume green products.

Lacroix and Gifford (2019) opined that the identification of consumer segments helps predict dietary patterns and consumers' willingness to change their dietary patterns, which could be useful in designing conventional meat-reduction interventions. Hence, all these characteristics can be used for the targeted marketing of more sustainable meat alternatives. Our findings suggest that blanket marketing strategies and policy interventions will likely not work to reach all consumers. Rather, these strategies should be targeted in accordance with their characteristics. The strategies should focus on addressing consumers' knowledge level, opinions, and beliefs. Further, labeling can be instrumental in promoting sustainable meat products. Therefore, the food industry could consider these demographic and behavioral factors when designing appropriate marketing strategies.

Our results indicated that recycling had a positive effect on the likelihood of eating RCF beef. Similarly, past purchases of sustainable food items had a positive effect on the likelihood of eating PBMAs and RCF beef. In line with the findings by de Boer and Aiking (2022), our study found that those who reduced beef consumption or tried sustainable food items were more likely to eat PBMAs. The findings emphasize the importance of leveraging consumers who display more climate-friendly behavior in efforts to scale up the consumption of sustainable meat alternatives. Results also revealed that consumers who are younger and identify as Democrats were more likely to eat PBMAs.

This research is not without limitations. One of the potential caveats of our study is that we did not use validated scales for the measurement of behavioral factors. Future studies could use validated scales to analyze the effect of these constructs on the consumption of sustainably produced meat. In addition, we used subjective knowledge (self-reported knowledge) and did not test how much participants really know (objective knowledge). While previous studies have shown subjective knowledge to affect choice (Peschel et al., 2016), future studies could test the effect of objective knowledge as well. Our results showed that climate change concern does not influence willingness to consume both alternatives. This finding contradicts the results of Yue et al. (2020) but is in line with findings of Arora, Brent, and Jaenicke (2020) and Ishaq, Kolady, and Grebitus (2023). This implies that although consumers are concerned about climate change issues, this may not be enough to change their consumption patterns. Therefore, translating environmental concern into actual green consumption behavior requires more attention. This opens an avenue for future research regarding the factors that affect this green attitude-behavior gap (ElHaffar, Durif, and Dubé, 2020) and designing appropriate marketing strategies, such as the use of information nudges, to close this gap. Finally, we estimated logit regression models to identify the factors influencing consumption decisions. Future research could employ latent class analysis to observe whether or how behavioral characteristics and demographics interact.

[First submitted March 2024; accepted for publication August 2024.]

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Appendix A

Table A1. Climate Change Concern Scale of Meat Consumers

Serial Number	Items	Scale (1–7)
1	Global climate change is happening	5.51
2	I am concerned about the climate change consequences	5.37
3	Climate change is a serious problem, and its effects are likely to be catastrophic for future generation and environment	5.22
4	The seriousness of climate change has been exaggerated	4.46
5	Human activities cause global climate change	5.26
6	Climate change is inevitable and has nothing to do with human activity	4.48
7	Climate change is a problem to be solved by future generation	4.51
8	We should burden future generation as little as possible with the consequences of climate change	4.70
9	Knowing about environmental problems and issues are important to me	5.12
10	I can do my part to make the world a better place for future generations	5.33
11	There is not much I can do that will help solve environmental problems	4.38
	Cronbach's alpha	0.84

Notes: 1 = strongly disagree to 7= strongly agree. Items 4, 6, 7, and 11 were reverse coded to maintain consistency in the direction.

Table A2. Relationship Between Subjective Knowledge and Willingness to Consume Sustainable Meat and Meat Alternatives

Items	Full Sample	WTC RCF	Not WTC RCF	WTC PBMA	Not WTC PBMA
"I consider myself knowledgeable about the climate effects of products and services"	4.52 (1.45)	4.58 (1.42)	4.13 (1.61)	4.90 (1.27)	3.90 (1.52)
"I consider myself equipped to compare and evaluate the climate friendliness of different products and services"	4.50 (1.56)	4.57 (1.56)	4.08 (1.57)	4.95 (1.39)	3.77 (1.56)
"I am considered an expert in the field of climate effects of products and services by people who know me"	3.55 (1.86)	3.57 (1.89)	3.42 (1.62)	4.21 (1.79)	2.46 (1.39)
Mean knowledge	4.19 (1.43)	4.24 (1.43)	3.88 (1.40)	4.68 (1.26)	3.37 (1.30)
Cronbach's alpha = 0.76					

Notes: Scale: 1= strongly disagree to 7= strongly agree. Values in parentheses are standard deviations. WTC PBMA = willingness to consume plant-based meat alternatives and WTC RCF = willingness to consume carbon-friendly beef.

Table A3. Correlation Matrix of Behavioral Variables Included in the Regression Analysis

Variables	*PBMA*	*RCF*	*BFREQ*	*CCCS*	*CFCS*	*KNOW*	*RECYCLE*	*CARPOOL*	*PSUS*	*TPBMA*	*BELIEF*	*OPINION*	*ATTN*	*TRUST*
PBMA	1	0.11	0.26	0.16	0.32	0.45	0.24	0.31	0.38	0.39	0.31	0.26	0.37	0.18
RCF	0.11	1	0	0.19	0.05	0.09	0.23	0.10	0.16	0.08	0.18	0.21	0.03	0.11
BFREQ	0.26	0	1	−0.07	0.12	0.37	0.09	0.20	0.11	0.12	0.03	0.23	0.25	0.16
CCCS	0.16	0.19	−0.07	1	0.26	0.15	0.42	0.19	0.26	0.16	0.43	0.23	0.10	0.15
CFCS	0.32	0.05	0.12	0.26	1	0.36	0.27	0.14	0.23	0.19	0.20	0.31	0.27	0.17
KNOW	0.45	0.09	0.37	0.15	0.36	1	0.22	0.31	0.35	0.34	0.23	0.39	0.47	0.28
RECYCLE	0.24	0.23	0.09	0.42	0.27	0.22	1	0.26	0.31	0.34	0.20	0.21	0.18	0.14
CARPOOL	0.31	0.10	0.20	0.19	0.14	0.31	0.26	1	0.24	0.28	0.15	0.23	0.21	0.13
PSUS	0.38	0.16	0.11	0.26	0.23	0.35	0.31	0.24	1	0.34	0.23	0.21	0.20	0.08
TPBMA	0.39	0.08	0.12	0.16	0.19	0.34	0.34	0.28	0.34	1	0.22	0.15	0.20	0.07
BELIEF	0.31	0.18	0.03	0.43	0.20	0.23	0.20	0.15	0.23	0.22	1	0.31	0.15	0.16
OPINION	0.26	0.21	0.23	0.23	0.31	0.39	0.21	0.23	0.21	0.15	0.31	1	0.36	0.16
ATTN	0.37	0.03	0.25	0.10	0.27	0.47	0.18	0.21	0.20	0.20	0.15	0.36	1	0.26
TRUST	0.18	0.11	0.16	0.15	0.17	0.28	0.14	0.13	0.08	0.07	0.16	0.16	0.26	1