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Consumer preferences for farm-raised meat, lab-grown meat, and plant-based meat alternatives: Does information or brand matter?

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ABSTRACT

Despite rising interest in and sales of innovative non-animal-based protein sources, there remains a lack of information about consumer demand for these new foods and their ultimate market potential. This study reports the results of a nationwide survey of more than 1800 U.S. consumers who completed a choice experiment in which they selected among conventional beef and three alternative burger patties, (lab-grown, plant-based with pea protein, and plant-based with animal-like protein) at different prices. Respondents were randomly allocated to treatments that varied in the presence/absence of brands and information about the competing alternatives. Results from random parameter logit models indicate that, holding prices constant and conditional on choosing a food product, 72% chose farm-raised beef and 28% chose one of the alternatives: 16% plant-based (pea protein) meat alternative, 7% plant-based (animal-like protein) meat alternative, and 5% lab-grown meat. Adding brand names (Certified Angus Beef, Beyond Meat, Impossible Foods, and Memphis Meats) increased the share for choosing farm-raised beef to 80%. Environment and technology information had minor effects on conditional market shares but reduced the share of people not buying any options, indicating information pulled more people into the market. Even if plant- and lab-grown alternatives experienced significant (e.g., 50%) price reductions, farm-raised beef maintains the majority market share. Vegetarians, males, younger, and more highly educated individuals tend to have relatively stronger preferences for the plant- and lab-grown alternatives relative to farm-raised beef. More people opposed than supported taxing conventional beef for environmental and animal welfare objectives and more opposed than supported having plant- and lab-grown alternatives use the label 'beef'

1. Introduction

There is increasing criticism of animal agriculture, from an environmental, animal welfare and public health perspectives. Livestock production is estimated to be responsible for 14.5% of the greenhouse gas emissions (Gerber et al., 2013). In the United States, all of agriculture contributes to about 9% of greenhouse gas emissions and beef cattle represent about half of that (US EPA, 2019). The rearing of farmed animals and especially the intensification of animal production systems leads to farm animal welfare concerns among consumers (Norwood and Lusk, 2011). Additionally, it has been argued that high levels of red and processed meat consumption are associated with adverse health outcomes, (Bouvard et al., 2015; GBD 2013 Risk Factors Collaborators, 2015; Godfray et al., 2018; National Institutes of Health, 2019; National Cancer Institute, 2019).[1] As a result of these concerns, many national (e.g., U.S. Dietary Guidelines 2015–2020 (HHS and USDA, 2015), German official guidelines (DGE, 2020)) and international (Gonzalez Fischer, and Garnett, 2016; Nordic Council of Ministers, 2014; Willett et al., 2019) food-based dietary guidelines advise consumers to reduce meat consumption. The introduction of plant-based and lab-grown meat alternatives in the marketplace could represent one option for consumers who wish to comply with these guidelines. This study explores US consumer demand for alternative meat products across different information settings.

U.S. consumers are among the heaviest beef consumers in the world, consuming 57.2 lb of beef per capita in 2018 (ERS-USDA, 2019), much of it in the form of ground beef. While beef burgers remain popular, and beef demand remains strong (Bekkerman et al., 2018), some consumers

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[1] There is ample debate about the quality of this evidence, and the extent to which the estimated relationships are causal (e.g., Carroll and Doherty, 2019; Johnston et al., 2019).

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report in surveys a desire to cut back on their meat consumption (Neff et al., 2018) and replace it with meat alternatives. In recent years, innovative products have emerged giving consumers new plant-based protein alternatives similar to ground beef. While there was more than 20% growth in the plant-based meat category in 2018 (Plant Based Foods Association, 2018), there is still a great deal of uncertainty about consumers' preferences for these alternative products and ample speculation about the ultimate size of this market. This trend is visible in many parts of the world including North America and Europe, where plant-based meat alternatives gained traction across the dietary spectrum. The meat substitute market in Europe is predicted to increase from €1.5 billion in 2018 to €2.4 billion in 2025 (FoodNavigator, 2019a) and in the US the market value is expected to increase from $10.1 billion in 2018 to $30.9 billion by 2026 (Statista, 2019).

There have been substantial investments in the development of plant-based and lab-grown[2] meats in recent years. Plant-based burger patties have been developed that create a meat-eating experience designed to mimic the taste and texture of beef, going beyond the veggie-burgers of the past. These plant-based meat alternatives[3] are now available in many grocery stores and are also appearing in major restaurant chains such as Burger King, Del Taco, and White Castle. In addition to the new plant-based burgers, several start-ups are currently developing meat by culturing animal cells, and it is likely that these lab-grown meat patties will become available to consumers in coming years. With burgers being one of the most popular menu items in the U.S. (PBS, 2012), it is of interest to better understand how the new burgers might affect the ground beef market.

This issue seems of particular importance as there has been much debate with respect to labeling requirements for plant-based and lab-grown meat. While some stakeholders such as Memphis Meats and North American Meat Institute (2018) refer to "cell-based meat and poultry", others (e.g., the US Cattleman's Association, 2018) argue food can only be labeled as meat when "harvested from animals raised in the traditional matter". The latter groups argue consumers might be misled or confused when products that do not come from slaughtered animals are labeled as 'meat'. In 2018, the US Cattleman's Association (USCA) filed a petition requesting USDA Food Safety and Inspection Service (FSIS) to "exclude products not derived directly from animals raised and slaughtered in the 'traditional matter' from the definition of 'beef' and 'meat'" (USCA, 2018). Missouri was the first U.S. state to ban the use of meat-related terms for plant-based or lab-grown alternatives by prohibiting the term 'meat' if it is "not derived from harvested production livestock or poultry" (Missouri State Senate, 2018, p 24). Similar bills have been introduced or announced in 25 U.S states including Arkansas, Oklahoma, Montana, South Carolina, North Dakota, and South Dakota (FoodNavigator, 2019b). These policies not only forbid the use of 'meat' and 'beef' but also the use of meat-related terms such as 'burger' and 'hot dog' when the product is not made of animal meat. These bans also apply to food made from insects and lab-grown meat. In the EU, similar debates are ongoing. In 2017, the EU banned the use of words as 'milk', 'cheese', 'butter', 'yoghurt' for products which were not made of dairy. More recently, in 2019, the EU parliament proposed to ban meat-free products from being labeled with meat-related words such as steak, sausage, burger and hamburger (FoodNavigator, 2019c) and rename vegetarian burgers and sausage as 'discs' and 'tubes'.

This paper aims to provide a better understanding of consumer acceptance, choice, and willingness to pay (WTP) for the three primary beef burger alternatives that are emerging (plant-based patty using pea protein, using animal-like proteins produced by yeast, and lab-grown beef) relative to farm-raised beef, and consumer's preferences for policies surrounding these alternatives. To our knowledge, this is one of the first studies investigating U.S. consumer preferences for the new generation of plant-based burger patties. Because there is no lab-grown meat yet on the market, and because plant-based burgers using animal-like heme proteins (i.e., the Impossible Burger) were only recently approved for grocery sale, there is no scanner data available for these products and thus no easily comparable consumer demand data for these beef substitutes. As such, this study conducts a discrete choice experiment (DCE) in which consumers make simulated retail choices between competing products at different prices under different information and branding conditions.

To our knowledge, Slade (2018) is the only prior study eliciting preferences for lab-grown meat relative to plant-based alternatives. However, this study did not discriminate between different types of plant-based meats (e.g., Beyond Meat vs. Impossible Foods) and it did not investigate the effect of information or brand on choice. Moreover, the study was conducted in 2017 in Canada. As highlighted by Bryant and Barnett (2018), there is a scarcity of studies on the effect of information about environment and animal welfare on consumer acceptance of lab-grown meat. In addition, while some studies investigated consumer willingness to try or purchase intentions for lab-grown meat (Bryant et al., 2019a; Wilks and Phillips, 2017), no study investigated the consumers' willingness-to-pay (WTP) or demand at alternative price-points in the United States.

This study addresses this research gap and investigates consumer preferences and demand for meat-like versus conventional meat burger patties using a DCE under different information treatments including information on the environmental impact or the technology used to produce the meat-like patties. Meat-like burger patties include patties made of lab-grown beef, plant-based meat using animal-like heme protein, and plant-based meat using pea protein. Given the fact that these are branded products, the sensitivity of choice to use of brand names used to market the beef alternatives was explored. Finally, respondent's preferences for different policies surrounding the alternative meat products were solicited.

2. Background

At the moment, several alternatives exist and are being developed to imitate the traditional beef burger patty. The new generation of meat-like plant-based burgers are gaining popularity as they are better at mimicking beef burger patties compared to the previous alternatives. One of the popular veggie burger patties is made with plant-based protein (pea protein) and beet juice resulting in a burger that 'bleeds' like a traditional beef burger (Beyond Burger©). Another new type of burger uses plant-based heme as the key ingredient to create a meaty flavor and appearance (Impossible Burger©). This approach uses a genetically engineered yeast to produce soy leghemoglobin, a protein which carries heme. Heme is naturally present in conventional beef and is thought to impart a distinctive meat-like flavor. While Beyond Burger© is currently offered in grocery stores, until very recently the Impossible Burger© was only available in restaurants. In addition to these new plant-based burgers, several start-ups are currently developing a burger patty by culturing animal cells, a lab-grown burger patty. For lab-grown meat, stem cells of a living cow are harvested and nurtured to create muscle tissue in the lab. Lab-grown meat is not yet available to consumers as the technology remains cost prohibitive, but it is expected to become available in the coming years.

Next to the challenge of the technical feasibility to successfully produce large quantities of affordable lab-grown meat, another major challenge is consumer acceptance of the novel products. Whether these burgers will become successful on the market depends on whether consumers will adopt a lab-grown or new plant-based burgers in their diet. Consequently, it is important to study consumers preferences for

[2] We use the term "lab-grown" throughout this manuscript. Other terms to describe this product include cultured, clean, cell-based, artificial, tissue-engineered, in-vitro, synthetic, animal-free and test tube meat.

[3] We use the term "meat alternatives" in the manuscript and specifically focus on burger patties

alternative meat products. Several peer-reviewed studies have evaluated consumer acceptance of lab-grown meat in various parts of the world (Bryant and Barnett, 2018; Gomez-Luciano et al. 2019, Mancini and Antonioli, 2019; Weinrich et al., 2020); including some with a U.S. sample (Bryant et al., 2019a,b; Bryant and Dillard, 2019; Wilks and Phillips, 2017). However, aside from Slade (2018), few attempted to estimate market share based on choice experiments and none investigated consumers' willingness to pay (WTP) using a choice experiment. Wilks and Phillips (2017) reported that 31% of U.S. consumers definitely and 34% probably would be willing to try lab-grown meat. While this study shows that 65% of U.S. consumers are willing to try the novel food product, the study also found that only one third would be willing to eat it regularly. Similarly, Bryant et al. (2019a) reported that 29.8% of U.S. consumers indicated they were very or extremely likely to purchase lab-grown meat. Slade (2018), using a choice experiment in Canada, compared market shares for different types of burgers when all were priced $4, and reported a 65% market share for beef burger, 21% for plant-based and 11% for lab-grown burgers (and 4% would buy none). However, no study to our knowledge has evaluated potential market shares under varying information or brands.

Consumer acceptance of these novel products will determine market potential, and consumers might be influenced by information about the products. Information has been shown to affect consumer acceptance of food produced with novel technologies (Corrigan et al., 2009; Lusk et al. 2004; McFadden, and Huffman, 2017). This is also true for the consumer acceptance of lab-grown meat (Hocquette et al., 2015; Siegrist et al., 2018; Verbeke et al., 2015). For example, Verbeke et al. (2015) reported that a quarter of the Belgian consumers said they were willing to try lab-grown meat, a figure which increased to 43% following the provision of additional information about the benefits of lab-grown meat. However, Hocquette et al. (2015) reported lower acceptancy rates. Only 9 to 19% of the participants who received information about the problems faced by the meat industry and the potential benefits of lab-grown meat believed that lab-grown meat would be accepted by consumers (Hocquette et al., 2015). Swiss consumers receiving non-technical descriptions on the production of lab-grown meat production had a higher willingness to purchase lab-grown meat compared to those receiving more technical descriptions (Siegrist et al., 2018). Studying as sample of Dutch students, Bekker et al. (2017) compared the effect of negative and positive information about lab-grown meat on the explicit attitude towards lab-grown meat. They found that positive (negative) information leads to a more positive (negative) explicit attitude towards lab-grown meat. These studies illustrate the importance of the information provided on consumer acceptance of lab-grown meat. Bekker et al. (2017, p 253) even concludes that information provision about cultured meat could "play a role in the commercial success of cultured meat".

With conventional beef being resource-intensive, requiring significant amounts of water, land and other resources, it is argued that plant-based and lab-grown alternatives have significantly lower environmental impacts (Heller and Keoleian, 2018; Tuomisto and Teixeira de Mattos, 2011). Producers of plant-based meat alternatives (using pea protein as well as using animal-like protein produced by yeast) already communicate the environment benefits to consumers (Beyond Meat, 2018; Impossible Food, 2018). It is expected that lab-grown meat producers will do the same when their products become available on the market. The effect of highlighting the benefits through information provision to consumers was tested experimentally.

3. Experimental design

Because plant-based burgers using heme protein produced by yeast and lab-grown burgers are not available yet in the supermarket, there is no grocery scanner data available on consumer demand for these burger patties. Consequently, this study addresses this gap and elicits consumer preferences using a U.S. nationwide survey. Consumer preferences are elicited using a DCE approach, which has been extensively used in meat demand analysis (Lusk and Schroeder, 2004; Lusk and Tonsor, 2016; Scarpa et al., 2013; Van Loo et al., 2014).

In the DCE, respondents were asked to make repeated choices between four burger patties offered at different price levels. The four burger patties are: lab-grown beef, plant-based meat animal-like heme protein, plant-based meat using pea protein, and farm-raised beef. These options were priced at six price levels ranging from $2.99/lb to $10.49/lb in $1.50 increments. This price range was selected to encompass the averages prices for ground beef from the US (US EPA, 2019) as well as the prices for plant-based and beef burger patties in actual grocery stores.

A labeled DCE design was used, meaning all choices had four alternatives corresponding to the different meats (plus a "none" alternative) at different prices. Given our experimental setting, there are 1296 (6^4) possible choice questions including every product type at every price level. To reduce the number of choice options, an orthogonal fractional factorial design was utilized (see Louviere et al., 2000) and reduced the number of choice questions to 36, which were then further reduced to nine per respondent using blocking techniques (four blocks). Participants were randomly assigned to one of the four blocks and answered nine choice questions, the order of which was randomized. Each choice question included a non-purchase (opt-out) alternative and four meat products or meat replacers offered at different prices.

In addition to assessing consumer valuation for alternative meat products, this study uses a between-subject approach to also examine the effects of brand and various information types on consumer preferences for alternative meat products. Respondents were randomly assigned to one of four treatments (see Table 1). Before the choice experiment questions, the respondents received the instructions that they should imagine themselves to be shopping in a grocery store, and instructions were provided on how to complete the DCE. We also included a cheap talk script to mitigate hypothetical bias.

Treatment 1 is the control treatment ("Control"). Respondents were not provided any information about the alternatives, which were only described/labeled using a few words. Treatment 2 ("Branding"), accounted for the effect of brand names, which mimics the retail environment consumers are likely to face. The four selected brands are Memphis Meat, Beyond Meat, Impossible Foods, and Certified Angus Beef. These brands were chosen as they are the most known brands for each of the respective products in the U.S. Fig. 1 shows the product presentation for the branded and non-branded treatments.

Producers of plant-based meat alternatives (using pea protein as well as using animal-like protein produced by yeast) provide consumers with information about the environmental and animal welfare benefits of their products as compared to conventional meat (Impossible Food, 2018; Beyond Meat, 2018) via advertisements, website, in-store flyers or signage, in-restaurant flyers, etc. In order to test for the effect of these communication messages on consumer preferences for meat alternatives, Treatment 3 ("Sustainability"), gave respondents environmental and animal welfare information that originated from the companies selling these products. More specifically, respondents were shown the reduction in water use, land use, energy use and greenhouse gas (GHG) emissions associated to each of the three beef alternatives compared to conventional beef, based on literature (Heller and

Table 1
Information treatments.

Treatment	Description	Treatment name
1	Only DCE questions	Control
2	DCE questions + Brand names	Branding
3	DCE questions + Environmental information	Sustainability
4	DCE questions + Technological information	Technology

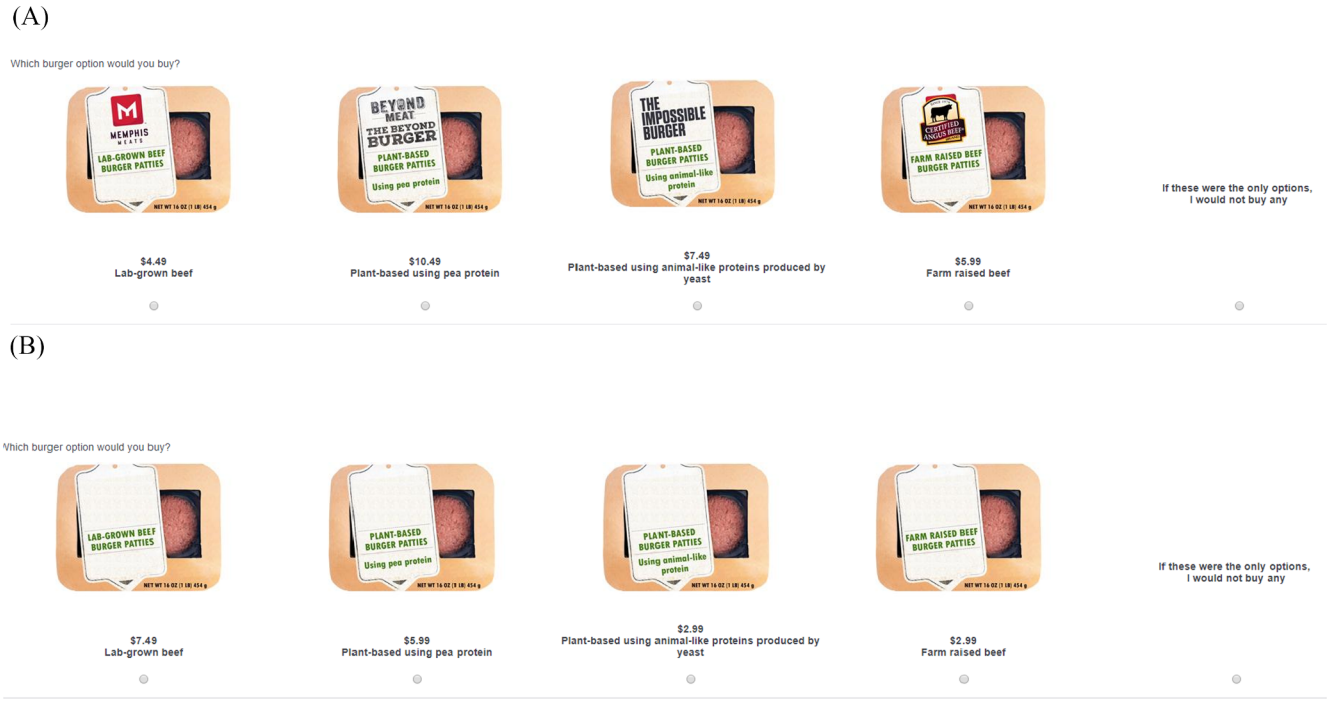


Fig. 1. Example of choice set with (A) and without (B) brand names.

Keoleian, 2018; Tuomisto and Teixeira de Mattos, 2011)[4] and company claims. Finally, Treatment 4 ("Technology"), includes information about the technology used in the production of the different products, which enables a test of whether additional information on the production of the meat alternatives has an effect on consumer preferences. Fig. 2 shows the information given in Treatment 3 and 4.

After the DCE, respondents were asked several policy-related questions. First, respondents were asked, "Should the following products be allowed to be labeled as 'beef'?" for three alternatives: lab-grown meat, plant-based meat using pea protein, and plant-based meat using animal-like proteins produced by yeast. There were two response options: "Yes, it should be allowed to be labeled as 'beef'" or "No, the USDA and FDA should prohibit the use of the word 'beef' on the labels for these products." Respondents were then asked two stand-alone questions. The first was, "Would you support or oppose a 10% tax on beef from cattle in an effort to reduce beef consumption for environmental and animal welfare objectives?" The second question was, "Would you support or oppose a policy that would require that any product labeled as 'beef' come from cattle that have been born, raised, and harvested in the traditional manner, rather than coming from alternative sources such as a synthetic product from plant, insects, or other non-animal components and any product grown in labs from animal cells?" Response categories for these two questions were simply "Support" or "Oppose."

The data were collected through a nationwide online survey conducted among U.S. food shoppers in December 2018 and January 2019. The survey was programmed in Qualtrics and participants were recruited by a market research agency considering quotas for regions (Northeast, South Midwest and West), gender, and race and ethnicity. In total, 1830 completed responses were collected. Table 2 shows the characteristics of the sample. Overall, the sample demographics in terms of gender, age, income, region of residence, and race/ethnicity are similar to the US population. Our sample contains fewer respondents from the higher income categories, less respondents with the age category between 45 and 54 years and from the West than the U.S. population.

[4] We used the values for environmental impact of lab-grown meat as reported in Tuomisto and Teixeira de Mattos (2011). Lynch and Pierrehumbert (2019) reported a less favorable environmental impact of lab-grown meat.

4. Data analysis

DCEs are consistent with random utility theory (McFadden, 1973). Within this framework, consumer n is assumed to derive the following utility from choice alternative, j: $U_{nj} = V_{nj} + \varepsilon_{nj}$; where V_{nj} is the systematic component of the utility function, and $\varepsilon_{\mathrm{nj}}$ is the random or unobservable component. V_{nj} is defined as:

$$V_{nj} = \beta_j + \alpha Price_{nj} \tag{1}$$

where β_j is an alternative-specific constant indicating utility for alternative/brand j relative to the opt-out option, which is normalized to zero for identification purpose, α is the marginal utility of price, and $Price_{nj}$ is the price of alternative j faced by consumer n.

The data are analyzed using a random parameter logit (RPL) model, which accounts for taste variation across consumers. Accordingly, the coefficients in (1) were assumed random following empirically plausible statistical distributions. The alternative specific constants were specified as random following a normal distribution because it is expected that individuals can exhibit either positive or negative values or preferences for the beef products. The price coefficient is assumed to follow a constrained (one-side) triangular distribution. The use of a constrained triangular distribution has been supported by a number of authors (Alfnes et al., 2006; Hensher and Greene, 2003; Scarpa et al., 2013) due to its finite range of variation (Hensher et al., 2015), which rules out positive price coefficients (i.e., demand curves are forced to slope downward). Formally, in the RPL, the unconditional choice probabilities of individual n choosing alternative j is expressed as follows:

$$\{P_{nj}\} = \int_{\beta_n} \int_{\alpha_n} \prod_{t=1}^{T} \frac{V_{njt}}{\sum_j e^{V_{njt}}} f(\beta_n, \alpha_n | \mu, \Omega) d\beta_n d\alpha_n \tag{2}$$

where $f(\beta_n, \alpha_n|\mu, \Omega)$is the probability density function of the vector of J random coefficients $<\beta_n, \alpha_n>$; μ is the vector of the price coefficient and

A

Conventional (farm-raised) meat such as ground beef is produced from cows, bulls, steers, and heifers grown in a variety of environments across the country and abroad. Some groups have expressed concerns about environmental and animal welfare impacts of conventional beef production.

Three meat or protein alternatives have been suggested to be more environmentally friendly and better for animal welfare.

The table below compares some estimated reductions in environmental impacts of each of the three alternatives compared to conventional beef.

	Plant-based meat using pea protein	Plant-based meat using animal-like proteins produced by yeast	Lab-grown meat
Water	99% less	75% less	96% less
Land	93% less	95% less	99% less
Energy	46% less	93% less	45% less
Greenhouse gas emissions	90% less	87% less	96% less

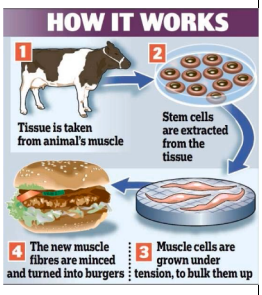
B

Plant-based meat using pea protein

The primary source of protein in this burger comes from peas. In addition, trace amounts of beet lend a beefy red color while coconut oil and potato starch ensure mouth-watering juiciness and chew. The result is an plant-based patty that mimics the taste of an animal meat burger patty.

Plant-based meat using animal-like proteins produced by yeast

The burger patty is made from plant-based heme, wheat protein, coconut oil, potato protein.
Heme is an iron-containing molecule that occurs naturally in every single plant and animal and is responsible for the characteristic of taste and aroma of meat. The plant-based heme is produced by a yeast, using fermentation. In order to have yeast producing the plant-based heme, the yeast is genetically engineered by adding the gene responsible to make heme in soy to the yeast. Since this heme is identical to the one found in animal meat, this plant-based burger patty mimics the taste of an animal meat burger.



Lab-grown beef

Lab-grown meat is produced in the laboratory (see figure). Stem cells are obtained from the muscle tissue of cows. Scientists then feed and nurture the cells so they multiply to create muscle tissue, which is the main component of the meat we eat. It is biologically exactly the same as the meat tissue that comes from a cow. The result is a patty with a similar taste, texture and composition to traditional meat.
(Figure source: Daily Mail, 2019)

Fig. 2. Sustainability (A) and technological (B) information. (See above-mentioned references for further information.)

the alternative-specific constants; Ω is the variance- covariance matrix of the vector of random parameters, for which the off-diagonals were assumed zero. The models were estimated by simulated maximum likelihood estimation techniques using 500 Halton draws (Train, 2009). The normally distributed coefficients provide information on the proportion of the population that attach a positive values to the product (Train, 2009). The share of the population with positive and negative values for each product were calculated. The mean value for willingness to pay of each product alternative was estimated as a negative ratio, where the numerator is the estimated mean value of the coefficient associated with the alternative and the denominator is the estimated price coefficient.

Further, based on the RPL estimates, the predicted conditional (conditional on buying an option) and unconditional market share for each meat product or meat alternatives were calculated, following Lusk and Tonsor (2016). The estimated coefficients from the RPL were substituted into probability equations, setting all prices equal to $5.00/lb. This allowed us to explore the market shares of the meat alternatives across different information treatments when all prices are held constant. In addition, following Lusk and Tonsor (2016), the predicted

Table 2
Socio-demographic characteristics of the sample (%).

Characteristic	Sample (N = 1830)	Population/Census
Region		
Northeast	18.6	17.5
Midwest	21.5	21.1
South	38.5	37.7
West	21.4 [a]	23.7
Gender		
Male	51.6	51.4
Female	46.8	48.6
Other	1.5	
Age		
18-24y	13.2	12.9
25-34y	18.3	17.6
34-44y	17.2	17.0
45-54y	15.0 [a]	18.4
55-64y	16.9	16.1
65 and older	19.4	18.0
Education level		
Bachelor's Degree or higher	35.1	33.4
Income		
Less than $20 K	19.1 [a]	15.8
$20 K–$39 K	24.6 [a]	18.9
$40 K–$59 K	18.9 [a]	15.8
$60 K–$79 K	14.2 [a]	12.4
$80 K–$99 K	7.7 [a]	9.3
> $100 K	15.6 [a]	27.7
Race and ethnicity [b]		
White	73.7	73.8
Hispanic	17.9	16.9
Black or African American	17.5 [a]	12.6
Vegetarian or Vegan	8.0	

[a] Indicates statistical differences for the sample against the population value based on equality of proportion statistics (significance level 0.05).
[b] Following the Census Bureau, Hispanic origin is asked separate from other race questions; as a result, the percentages sum to more than 100%.

unconditional market shares were also used to derive the demand curves of each meat alternatives across treatments. Based on equation (2), following Caputo et al. (2020), the demand curves were derived by substituting the estimated coefficients into probability equations with the prices of all meat products set to $5.00/lb, except for the product of interest whose price levels were set at successively higher or lower price levels. The estimated coefficients, along with each individual's choices can also be used to calculate "individual specific" coefficients (Train, 2009). These "individual specific" coefficients were used to calculate predicted market shares for each respondent and then use ordinary least squares regressions to determine how these market shares vary with socio-economic and demographic characteristics. In addition, to investigate the relationships between preferences for policy preferences and product preferences, the mean individual market shares from the choice model were compared for people who supported and opposed policies.

5. Results and discussion

Table 3 reports the RPL estimates for each of the four treatments: Control, Branding, Sustainability, and Technology (note: summary statistics for choices of each alternative in each treatment are provided in appendix Table A1 and multinomial logit estimates that assume preference homogeneity are in appendix Table A2). A likelihood ratio test of the null hypothesis that coefficients are equal across treatments, conducted by comparing the sum of the estimates from each treatment to the pooled model, yields a chi-square value of 278 with 27 degrees of freedom. The null is rejected at the $p < 0.01$ level, indicating information and/or brands significantly affected the parameter estimates[5]. For each treatment and product type, the price coefficient is negative and statistically significant indicating a decrease in utility with increasing price. The estimated coefficients of the alternative specific constants indicate the utility of each meat type relatively to the opt-out option. The coefficients for Beef, Plant-pea, and Plant-yeast are statistically significant and positive, meaning that holding price constant, people prefer buying one of the meat products than nothing at all.

More specifically, farm-raised beef is the most preferred followed by the plant-based alternatives using pea protein and heme produced by yeast. On the other hand, the coefficient Lab, referring to lab-grown meat, is not statistically significant from zero in all four treatments. This indicates that, on average, the utility for the lab-grown meat does not statistically differ from the no-buy option. However, the estimated standard deviation around the mean preference for lab-grown meat is large, indicating significant preference heterogeneity in the population. For example, in the control treatment, the coefficient Lab has an estimated mean of −0.25 and estimated standard deviation of 3.75, indicating lab-grown meat was preferred to "none" by 47% of consumers and avoided by the other 53%.

Following Scarpa and Del Giudice (2004) and Caputo et al. (2018), the share of the population with positive preferences for each of the products was calculated (Table 4). Providing information has only a relatively small impact on the proportion of consumers with a positive value for lab-grown meat. While providing the brand name increases the share of consumers with positive preferences for lab-grown meat from 47% to 53%, providing sustainability information results in the largest increase to a total of 56% of consumers with positive preferences. For the plant-based alternatives, much larger shares of consumers have positive preferences relative to "none", with over 8 out 10 consumers attaching a positive value to these plant-based alternatives. This share reduces when brands or technology information is presented.

Table 5 reports the mean WTP values for the various meat alternatives across treatments. The farm-raised beef burger has the largest mean WTP (relative to "none") ranging from $10.18 to $11.35/lb, while lab-grown meat has the lowest mean WTP. Comparing treatment 1 with treatments 3 and 4 reveals that providing sustainability information leads to a higher mean WTP for the plant-based alternatives while providing information on the technology reduced their mean WTP values for plant-based meat using pea protein. This result shows that it is beneficial for providers of the new meat alternatives to provide consumers with the information on the environmental benefits of plant-based meat alternatives as it increases the WTP. However, when consumers learn more about the underlying technologies used to produce the patties, it may reduce the WTP. When looking at the effect of brand names (treatment 1 versus 2), it can be noticed that the WTP for the plant-based alternatives fell when the brands were present. While two major brands in the plant-based meat alternative market were included, the brands were likely not known by a large share of consumers at the time of the study (December 2018/January 2019).

Fig. 3A shows the unconditional predicted market shares for the different meat alternatives across treatments when all products are priced at $5/lb. When no information is given, the market share of farm-raised beef is 63%, while the plant-based using pea protein and plant-based using animal-like proteins produced by yeast options have choice shares of 14% and 7% respectively. Lab-grown meat has the smallest share (4%). By providing brand names, the share of consumers choosing farm-raised beef increases to 72%. Proving environmental

[5] Differences across treatments can be due to differences in consumer preferences, differences in the scale parameters, or both. Therefore, we also performed a joint equality test controlling for both preference and relative scale differences. We did so by estimating a joint model that controls for differences in scale and imposes the null hypothesis of parameter equality across information treatments. Results from this model also confirm that the hypothesis of preference equality across treatments is strongly rejected.

Table 3
Random Parameter Logit Model Estimates by Treatment.

		Treatment 1 Control	Treatment 2 Branding	Treatment 3 Sustainability	Treatment 4 Technology	Pooled
Lab[a]	Mean	−0.25 (0.47)[c]	0.25 (0.34)	0.58 (0.53)	0.22 (0.32)	1.10* (0.17)
	St.Dev.	3.75*[d] (0.33)	3.62* (0.50)	3.89* (0.44)	4.63* (0.33)	3.18* (0.18)
Plant-pea[a]	Mean	3.00* (0.30)	1.75* (0.26)	3.11* (0.30)	2.13* (0.22)	2.63* (0.13)
	St.Dev.	3.20* (0.34)	3.34* (0.23)	3.46* (0.42)	3.68* (0.31)	2.39* (0.10)
Plant-yeast [a]	Mean	2.10* (0.28)	2.07* (0.24)	2.61* (0.26)	2.26* (0.25)	2.41* (0.15)
	St.Dev.	2.33* (0.20)	3.19* (0.34)	2.12* (0.16)	3.43* (0.37)	2.27* (0.22)
Beef [a]	Mean	7.33* (0.31)	8.27* (0.41)	7.06* (0.28)	7.68* (0.41)	6.69* (0.18)
	St.Dev.	4.72* (0.28)	4.02* (0.25)	3.60* (0.26)	4.33* (0.22)	4.70* (0.23)
Price[b]	Mean	−0.72* (0.04)	−0.76* (0.04)	−0.68* (0.03)	−0.68* (0.04)	0.66* (0.20)
	St.Dev.	0.72* (0.04)	0.76* (0.04)	0.68* (0.03)	0.68* (0.04)	0.66* (0.20)
# parms		9	9	9	9	9
Log likelihood		−3146	−3084	−3316	−2961	−12646
N choice		4149	4266	4077	3978	16,470
N people		461	474	453	442	1830
AIC		6310.3	6187	6650	5941	25,310
AIC/N		1.521	1.450	1.631	1.494	1.537

Note: A likelihood ratio test of the null hypothesis that coefficients are equal across treatments yields a chi-square value of 6200 with 27 degrees of freedom; the null is rejected at the $p < 0.01$ level.
[a] Parameters are normally distributed.
[b] Parameters are distributed as one-sided triangular.
[c] Numbers in parentheses are standard errors.
[d] One asterisk signifies statistical significance at the 0.05 level or lower.

Table 4
Proportion of positive preferences for each of product based on the RPL model.

	Treatment 1 Control	Treatment 2 Branding	Treatment 3 Sustainability	Treatment 4 Technology
Lab-grown	47.3%	52.8%	55.9%	51.9%
Plant-based using pea protein	82.6%	70.0%	81.6%	71.9%
Plant-based using animal-like proteins produced by yeast	81.6%	74.2%	89.1%	74.5%
Farm-raised beef	94.0%	98.0%	97.5%	96.2%

Table 5
Mean WTP Estimates ($/lb) based on the Random Parameter Logit Models.

	Treatment 1 Control	Treatment 2 Branding	Treatment 3 Sustainability	Treatment 4 Technology
Lab-grown vs. none	-$0.34	$0.33	$0.86	$0.32
Plant-based using pea protein vs. none	$4.16	$2.30	$4.61	$3.14
Plant-based using animal-like proteins produced by yeast vs. none	$2.92	$2.73	$3.87	$3.34
Farm-raised beef vs. none	$10.18	$10.89	$10.45	$11.35

information increases the share of lab-grown meat and plant-based alternative using pea protein to 6% and 16% respectively, while the share of plant-based alternative using animal-like proteins produced by yeast remains unchanged. Technological information results in a 7% share for lab-grown meat and 10% for both plant-based alternatives. This illustrates that providing information has only a small effect on the market shares of the various meat alternatives. Additionally, in the Technology treatment, where people were informed that the plant-based burger patty using animal-like proteins are produced by a GM yeast, had only minor effects on the choice share (control 7%, T4 10%). Interestingly, looking at the market share associated with the "none" option (Fig. 3A), and comparing T1 with T3 and T4, it seems that providing information pulls consumers from "none" into the plant-based products rather than from beef to these products. This may suggest information may attract new consumers into the market of "burger consumption" rather than reducing beef consumption *per se*.

Fig. 3B shows the market shares of the different products, conditional on consumers choosing one of the products. In the control condition, the market share for conventional beef was 72%, plant-based meat 23% and lab-grown meat 5%. These market shares are in line with Slade (2018) who reported a market share of 67% for beef, 21% for plant-based meat and 11% for lab-grown meat. Further, looking at Fig. 3B, it can be noted that conditional on people choosing to buy a product, providing information has little effect on the predicted market shares. Regardless of the type of information about meat alternatives retained by consumers, plant-based and lab-grown meat alternatives appear to present a market share of at least 16% and 4% respectively.

To explore how the market share would change when the product prices vary, demand curves were estimated using the RPL model estimates in Table 3. Fig. 4 illustrates the implied demand curves for each meat (alternative) product across the four treatments, which were constructed over the range of prices used in the experimental design ($3 to $10.50/lb). Fig. 5 reports the implied demand curves for the four alternatives within each treatment group.

Providing consumers with additional information about the technology used to produce and the environmental impact of lab-grown

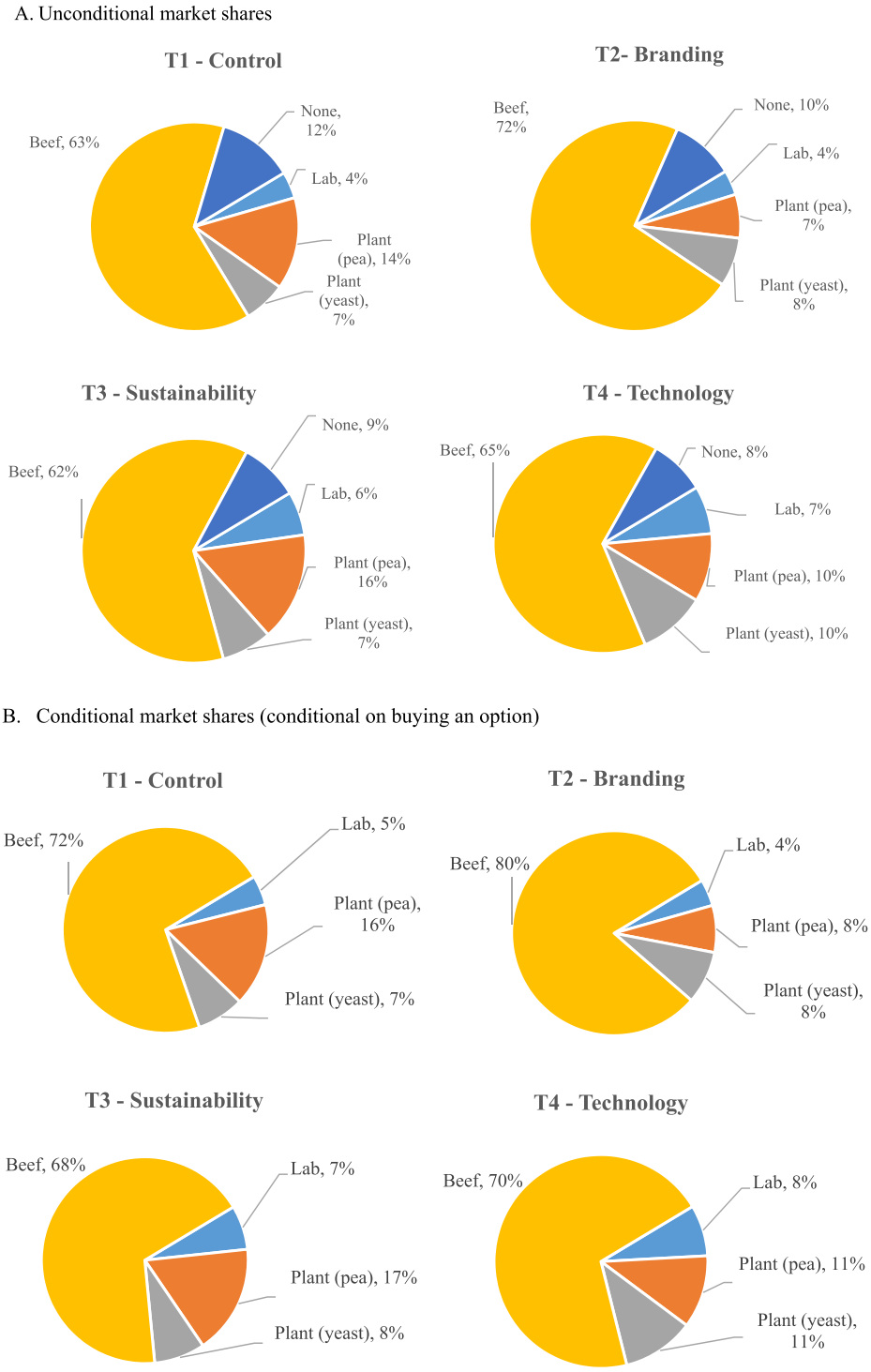


Fig. 3. Predicted Market Shares by Treatment.

meat results in slightly higher market shares, but there are no marked differences between the demand curves in the control and Branding treatment. This evidence is not surprising as the brands of lab-grown meat are relatively new in food markets, while consumers who are more concerned about the sustainability issues may be more willing to purchase lab-grown meat. Conversely, branding seems to drive demand for farm-raised beef as illustrated by the shift in demand of farm-raised beef when brand names are provided to consumers. The farm-raised beef demand curves for the other information treatments (T3 and T4) produce the most conservative market share estimates and they coincide with prices below $4.5/lb. Interesting results emerge for the plant-based meat alternatives. To illustrate, in the case of plant-based meat using animal-like proteins produced by yeast, the demand curve from the technology treatment implied higher market shares than the control, while the demand curves from the other treatments (branding, and sustainability) tend to nearly coincide for all prices with the demand curve in control condition. For the plant-based meat alternative using pea protein, on the other hand, providing consumers with sustainability

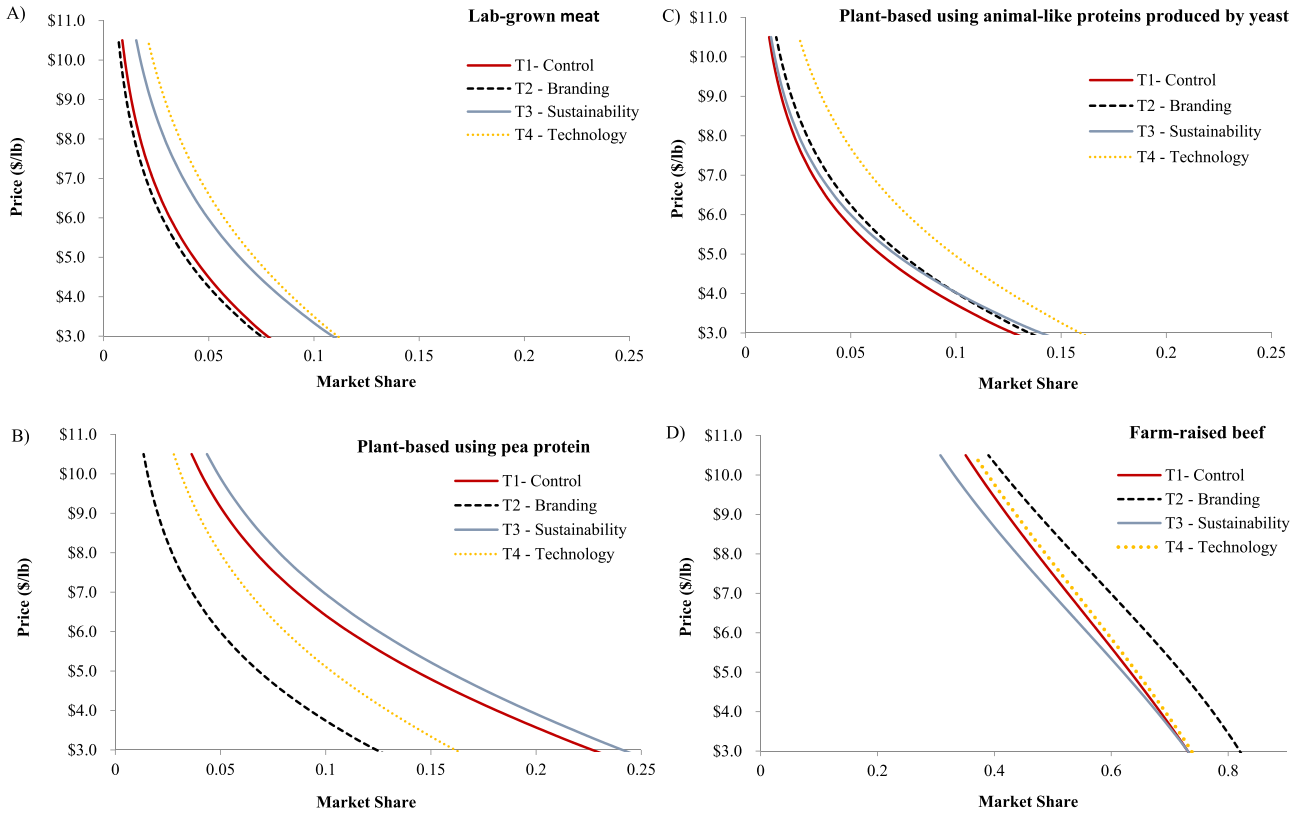


Fig. 4. Implied demand curves for meat and meat-like burger patties: lab-grown (A), Plant-based using pea protein (B), Plant-based using animal-like proteins produced by yeast (C), Farm-raised beef (D), by Treatment.

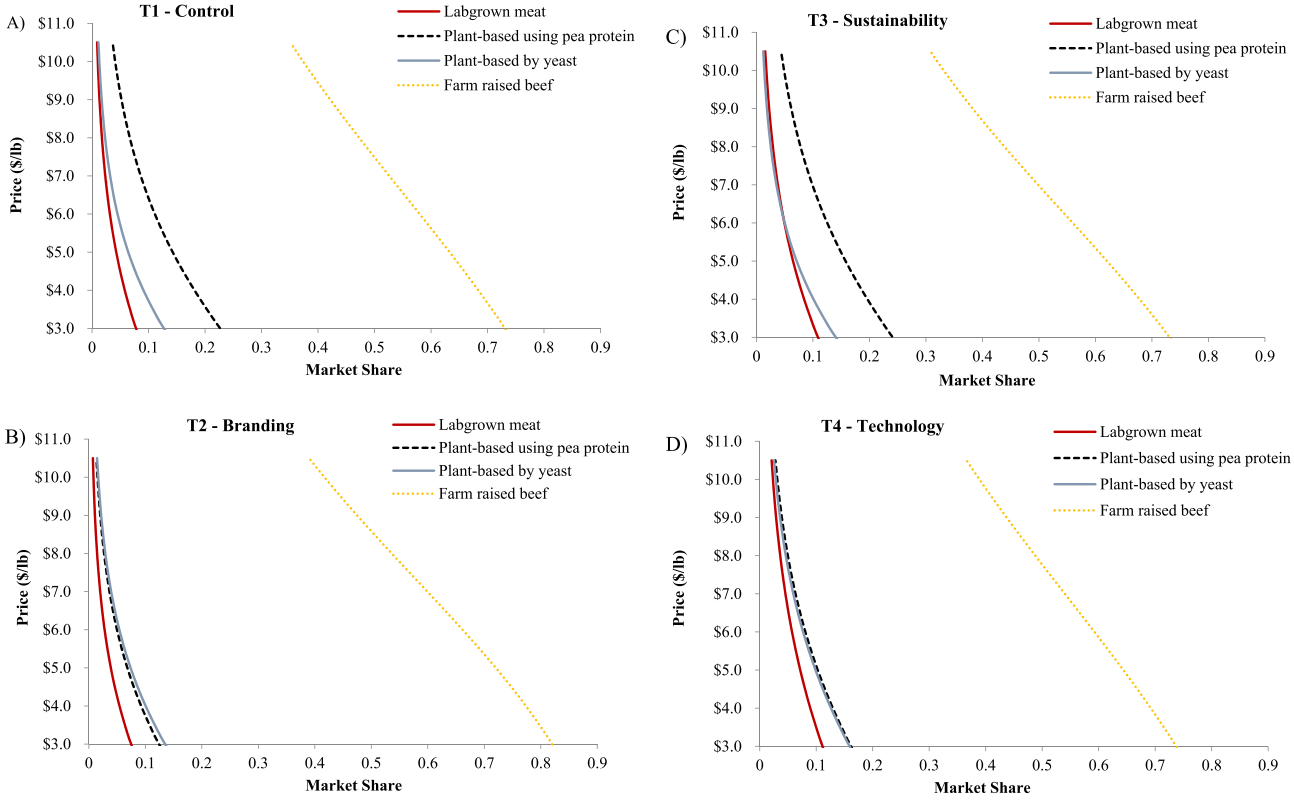


Fig. 5. Implied demand curves for the meat and meat-like burger patties for each of the treatment (control (A), Branding (B), Sustainability (C) and Technology (D)).

Table 6
Relationship between Demographics and Market Shares.

Variable	Lab-grown beef	Plant-based using pea protein	Plant-based using animal-like proteins produced by yeast	Farm-raised beef
Intercept	0.133*[a] (0.032)[b]	0.242* (0.047)	0.268* (0.04)	0.357* (0.072)
Vegetarian	0.043* (0.013)	0.282* (0.019)	0.171* (0.016)	−0.495* (0.029)
Children under 12	0.002 (0.009)	−0.009 (0.014)	0.049* (0.012)	−0.041 (0.021)
College Degree	0.016* (0.008)	0.026* (0.011)	0.003 (0.010)	−0.045* (0.018)
Female	−0.024* (0.008)	0.017 (0.011)	−0.030* (0.010)	0.037* (0.017)
Income: $40 k-$79 k	−0.001 (0.008)	0.012 (0.012)	−0.0004 (0.010)	−0.011 (0.018)
Income: $80 k-$119 k	−0.013 (0.011)	0.020 (0.016)	0.020 (0.014)	−0.027 (0.025)
Income: > $120 k	−0.018 (0.013)	0.031 (0.02)	0.015 (0.017)	−0.028 (0.030)
Age	−0.003* (0.001)	−0.005* (0.002)	−0.005* (0.002)	0.012* (0.003)
Age^2	0.00002 (0.00001)	0.00003 (0.00002)	0.00003 (0.00002)	−0.00008* (0.00003)
Household size	−0.002 (0.003)	−0.005 (0.005)	−0.014* (0.004)	0.021* (0.008)
Northeast region	−0.006 (0.011)	−0.003 (0.016)	0.011 (0.014)	−0.002 (0.024)
Midwest region	−0.002 (0.010)	−0.021 (0.015)	−0.013 (0.013)	0.036 (0.024)
South region	−0.010 (0.009)	−0.005 (0.014)	0.007 (0.012)	0.008 (0.021)
Treatment 2	−0.005 (0.010)	−0.010 (0.014)	−0.014 (0.012)	0.029 (0.022)
Treatment 3	0.011 (0.010)	0.007 (0.014)	−0.004 (0.012)	−0.013 (0.022)
Treatment 4	0.009 (0.010)	0.00001 (0.014)	0.007 (0.012)	−0.016 (0.022)
R^2	0.02	0.15	0.13	0.21

[a] One asterisk represents statistical significance at the 0.01 level or lower.
[b] Numbers in parenthases are standard errors.

information implied slightly higher market shares than in the control treatment, while technological information reduces the market shares and branding results in the most conservative market share for the plant-based alternative with pea protein.

Looking at the demand curves grouped per treatment (Fig. 5), it can be seen that for each treatment, the demand for the three alternatives is relatively close to each other while the demand for farm-raised beef is much larger.

For the Control treatment (T1) as well as the Sustainability (T3) treatment, plant-based using pea protein has a higher market share as compared to the other meat alternatives. Lab-grown meat and plant-based using yeast only differ in these treatments (T1 and T3) in market shares at low prices. In the Branding (T2) and the Technology (T4) treatment, the demand curves for two plant-based meat alternatives coincide while the lab-grown meat has a slightly lower demand.

Table 6 reports the relationship between demographics and "individual specific" market shares, assuming all products are equally priced, and respondents choose one of the four alternatives. Unsurprisingly, vegetarians are significantly more likely to choose one of the plant- or lab-grown alternatives, which is in line with Slade (2018). Compared to meat-eaters, the market share for lab-grown, plant-based using pea, plant-based using animal-like proteins is 4.3, 28.2, and 17.1 percentage points higher, respectively for vegetarians. Results also show consumers with a college degree and men are more likely to choose the non-beef alternatives. The lab-grown and the plant-based meat using yeast, are preferred more by men than by women. Similarly, Slade (2018) reported that men had stronger preferences for lab-grown meat than women. This might be attributed to the technological innovation involved which might be more appealing to men than to women (Slade, 2018). Older consumers were more likely to choose farm-raised beef and less likely to choose the plant-based and lab-grown meats relative to younger consumers. The quadratic term suggests the age effect is most pronounced for the youngest consumers in the sample. Income, region of residence, and treatments had no significant effect on the conditional market shares.

Table 7 shows consumers' policy preferences. The results show opposition to using the word 'beef' on any of the alternative meat products and support for regulating the term to only apply to farm-raised animals. Specifically, more than 70% of the respondents indicate that USDA and FDA should prohibit the word 'beef' on the packaging of meat alternatives. It is worth noting that our results relate to labeling as 'beef' specifically. Our findings are in contrast with a recent consumer study that reported 59.1% of US and 46.3% of UK respondents agreed that food companies should be permitted to use meat-related terms as 'burger', 'steak' and 'sausage' to describe meatless vegetarian products (Ingredient Communications, 2019). While that study used a small sample and was not peer-reviewed, those results suggest consumers may not view all meat-related terms identically. Our results also show that 36% of respondents were supportive of a 10% tax on farm-raised beef to address environmental and animal welfare concerns.

Previous research has shown complex relationships between preferences for policy alternatives and preferences for shopping behavior (e.g., Brooks and Lusk, 2012; Carlsson et al., 2019; Hamilton et al., 2003; Paul et al., 2019). In this case, perhaps unsurprisingly, we find the 36% of respondents who support a tax on beef are less likely to choose beef in the choice experiment (beef market share of 0.56) as compared to the 64% who do not support a tax a beef (beef market share of 0.80), a difference which is statistically different at the 0.01 level according to a *t*-test. Similarly, the 81% of respondents who want to only allow the use of the word 'beef' for cattle-derived products are more likely to choose beef in the choice experiment (beef market share of 0.74) as compared to the 19% who do not support a tax a beef (beef

Table 7A
Policy and Labeling Preferences for Specific Meat Alternatives.

	it should be allowed to be labelled as 'beef'	the USDA and FDA should prohibit the use of the word 'beef' on the labels for these products
Lab-grown meat	29.80%	70.20%
Plant-based meat using pea protein	23.90%	76.10%
Plant-based meat using animal-like proteins produced by yeast	24.20%	75.80%

Table 7B
Policy and Labeling Preferences.

	Support	Oppose
10% tax on beef from cattle in an effort to reduce beef consumption for environmental and animal welfare objectives	36.20%	63.80%
Require that any product labeled as 'beef' come from cattle that have been born, raised, and harvested in the traditional manner, rather than coming from alternative sources such as a synthetic product from plant, insects, or other non-animal components and any product grown in labs from animal cells	81.00%	19.00%

Note: The sample size yields a sampling error of about ± 2.35%.

market share of 0.58), a difference which is statistically different at the 0.01 level according to a *t*-test. In this case, more "pro" farm beef policy attitudes are positively associated with greater likelihoods of choosing farm raised beef when shopping.

6. Conclusion and policy implications

With new plant-based meat alternatives that mimic meat better and the development of lab-grown meat, it is important to better understand consumers' preferences for these meat alternatives. This study provides insights to better understand current consumers preferences and demand for these alternatives vis-a-vis farm-raised meat. Because the new alternatives are being marketed by start-up companies with a strong interest in touting the benefits of their products, the impact of different information and the presence of brands on choice was also tested.

Overall, our study finds that information only has a small impact on consumer choice although the impact varies depending on the types of benefits communicated to the consumers. For instance, providing information on environmental and animal welfare benefits of the meat alternatives has the largest effect on the share of consumers with positive preferences for lab-grown, plant-based using pea protein and using animal-like proteins produced by yeast, respectively. Including brand names tended to increase the share of consumers choosing conventional beef, when conventional beef was branded as Certified Angus Beef. This may be due to Certified Angus Beef brand being more familiar to consumers compared to the other brands, or to the positive quality attributes consumers associated with Certified Angus Beef, which has been found to be a desirable brand in previous studies (Lusk and Schroeder, 2004). While market shares, conditional on choosing a product, were relatively unaffected by information, our study found that information tended to reduce the share of consumers choosing "none." These findings suggest that providing information about environmental and animal welfare benefits might pull more consumers into the market for plant-based and lab-grown meat, rather than damaging demand for conventional meat. When looking at differences in preferences across various demographics, we found that vegetarians, males, younger, and more highly educated individuals tend to have relatively stronger preferences for the plant- and lab-grown alternatives relative to farm-raised beef.

There has been much debate with respect to labeling of plant-based and lab-grown meat. While some stakeholders such as Memphis Meats and North American Meat Institute (2018) refer to 'cell-based meat and poultry," others (e.g., the US Cattleman's Association (2018)) believe food can only be labeled as meat when harvested from animals raised in the traditional matter. The latter group argues consumers might be misled or confused when products that do not come from slaughtered animals are labeled as 'meat' (US Cattlemen's Association (USCA), 2018). Supporting the argument that consumers might be misled by meat labels on plant-based alternatives, The National Cattlemen's Beef Association (NCBA, 2020) reported that only half of the U.S. consumers understands that 'plant-based beef' is an entirely vegetarian product, and 7% believe plant-based beef contains meat. However, this is in contrast with the findings of a House of Lords EU Energy and Environment Sub-Committee UK which reported that "there is no evidence that consumers had felt they were misled by meat-free products and < 4% of people had ever unintentionally bought a vegetarian product instead of a meat free version" (UK Parliament, 2019).

Our study also provides insights into the consumer perspective of the current debate on whether meat alternatives should be labeled as 'beef'. We find that over 70% of respondents prefer that plant- and lab-grown alternatives should be prohibited to use the label 'beef' while 19 to 30% support meat alternatives carrying the word 'beef'. Most consumers (81%) would support a policy that would require that any product labeled as 'beef' comes from cattle that have been born, raised, and harvested in the traditional manner, rather than coming from alternative sources such as from plants, insects, or other non-animal components and any product grown in labs from animal cells. Our results on labeling relates to the term 'beef' specifically and may not generalize to other meat-related terms such as 'burger' or 'sausage.' Moreover, changes in wording or framing of the question (should a label be allowed or banned?) may have substantive effects on policy preferences for the use of meat-related terms. Considering the ongoing debates in both in the US and the EU on the ban of the use of terms associated with meat (e.g., meat, beef, sausage, burger, steak) for plant-based and lab-grown meat alternatives, more empirical research on the consumer perception of the labeling terms used for alternative meat products is recommended.

Overall, this study shows most consumers prefer conventional beef to the alternatives. Holding prices constant and conditional on choosing a food product, 72% chose farm-raised beef, 16% plant-based (pea protein) meat alternative, 7% plant-based (animal-like protein) meat alternative, and 5% lab-grown meat, illustration an estimated market share of the meat alternatives of 28%. Not only is lab-grown beef the furthest from being technological and commercially feasible, it is the least desirable of the products studied. Plant-based meat using pea proteins (i.e., Beyond Meat) was the most popular non-animal alternative followed by plant-based meat using animal like protein from yeast (i.e., Impossible Foods). Due to the novelty of these products, it is possible that these preferences will change, particularly when more consumers are able to taste them. While at present, plant-based meat appears to fit more in the "niche" category, there is future market potential for these products, indicated by the estimated 23% market share for plant-based and 5% for lab-grown meat, resulting in a total of 28% estimated market share for meat alternatives, when equally priced as conventional beef. This is in line with the 21% and 11% market share reported by Slade (2018), for plant-based meat and lab-grown meat, respectively. However, our market share estimates remain much higher than the 10% market share in the global meat industry for plant-based meat alternatives, forecasted for 2029 by Barclays (Barclay, 2019). We are unaware of national-level data on market shares of plant-based alternatives for ground beef categories in retail grocery environments. The future for plant-based meat alternatives remains highly uncertain. On the one hand, some of the current demand may be a result of novelty, which may wear off. While some prominent fast food chains, such as Burger King experienced increase in traffic and sales when the Impossible Burger was first introduced, sales have subsequently fallen (Los Angeles Times, 2020). On the other hand, plant-based alternatives are being target at the much larger market of non-vegetarians and nearly

half of U.S. consumers (49%) report having tried a plant-based meat alternative (International Food Information Council, 2020). In addition, Bryant et al. (2019a) found familiarity with plant-based and lab-grown meat to be a significant predictor of consumer acceptance. With more plant-based alternatives coming to market and consumers becoming more familiar with these products and with the respective brands, it remains interesting to see whether the demand for these products changes as more alternatives become available at the food service and retail level and consumers become more familiar with the alternatives to conventional beef.

7. Limitations and future research

This study focuses on an emerging consumption trends toward alternative beef products. The market of these novel meat alternatives is at the initial phase and new product developments are expected. These new product developments raise questions on how to name the products, how various information messages will impact their marketability and how this differs across geographic areas. This research assesses consumer preferences and demand for alternative meat products focusing on a specific terminology, information settings and a specific study population. Given the novelty of the research area, there is abundant room for future research on factors affecting consumer preferences and how these preferences evolve over time.

Our study focused specifically on the US market because U.S. consumers have one of the highest per-capita beef consumption rates in the world (only lagging Uruguay and Argentina). However, there is likely to be interest in meat alternatives around the world, particularly in some EU locations, where reported rates of vegetarianism and flexitarians are higher. Economist have long noted the positive income-elasticity of meat demand, and meat consumption has risen rapidly in locations such as China and Brazil over the past 40 years as incomes in those countries also increased (Kearney, 2010). Whether and to what extent plant- or lab-based meat alternatives might be attractive in developing countries where protein demand is likely to rise with income growth remains an interesting and open question.

While we included two major brands in the plant-based meat alternative market, the brands were likely not known by a large share of consumers at the time of the study in December 2018 and January 2019. Indeed, our survey result show 44% said they'd never heard of 'lab-grown meat' and 53% said they'd never heard of 'plant-based meat using pea protein'. Because the impact of the brand names is likely different when the brand awareness increases, it might be of interest to see how this brand effect evolves over time. Greater familiarity is likely to be associated with increasing market shares for the plant-based alternatives.

Our results, such as estimated market shares, may differ when other terminology is used to describe the products. Thus, future studies might look into the naming effect of the products. For example, next to lab-grown, several other terms such as cultured, clean, cell-based, artificial, tissue-engineered, in-vitro, synthetic, animal-free and test tube meat are used to describe this product. Bryant and Barnett (2019), who investigated the impact of naming of lab-grown meat on the attitude and intention, reported no significant differences in consumer attitude and intention when using the terms 'cultured' versus 'lab-grown' meat. However, the term 'clean meat' was found to result in a more positive attitude and intention compared to the term 'lab-grown meat'. The wording may thus have an influence on consumer attitudes towards lab-grown meat (Bryant and Barnett, 2019) and consequently towards consumer demand for lab-grown meat. Likewise the term for conventional beef ('farm-raised beef') and for the plant-based alternatives (e.g., 'plant-based using animal-like proteins produced by yeast') may impact the choice behavior, and it would be useful for future studies to explore the impact of the naming of plant-based alternatives. For example, Faber et al. (2020) reported that Belgian and Dutch consumers find terms as 'plant-based diet' more appealing than 'vegetarian diet' or 'vegan diet'. This illustrates that the naming of meat alternatives (e.g., plant-based meat alternative, alternative meat, meatless meat, plant-based meat, vegetarian meat, meat replacer, meat analogue, faux meat etc) may also play a role and its impact on product choice remains to be investigated. Next to the terminology used for the meat alternatives, also other terminology to describe the default option (farm raised meat) could also be tested.

While we investigated the effect of specific sustainability information (environmental and animal welfare), technology information, and use of brand, future studies might investigate other information treatments such as the provision of health information. Word associations collected in our survey (not shown here) suggest the word 'healthy' is highly associated with plant-based alternatives. However, at present, the macro-nutrient content of the plant-based burgers and traditional beef burgers is similar.

Moreover, given the large preference heterogeneity for the meat alternatives, further research could explore the factors that explain differences in market shares across consumers. For example, self-reported attitudinal (e.g., neophobia, lifestyle), food behavioral (e.g., eating habits) and psychological variables as well as knowledge or familiarity might potentially explain some of the variation.

Finally, as discussed in the previous section, more work is needed to understand how restrictions on the use of the words 'meat', 'beef' and meat-related terms (e.g., burger, steak, sausage), perhaps due to labeling policies, might affect consumer choice. More important than these labels or names in signaling to consumers the substitutability of conventional beef and plant-based alternatives might be the placement of products in the retail grocery store. Presumably, placement of plant-based alternatives in or near the meat counter might induce greater substitution. Future research might elicit consumer preferences for product placement in the store and study the impact of product placement on plant-based alternatives purchases.

CRediT authorship contribution statement

Ellen J. Van Loo: Conceptualization, Methodology, Formal analysis, Investigation, Writing - original draft, Writing - review & editing, Visualization. **Vincenzina Caputo:** Methodology, Formal analysis, Writing - original draft, Writing - review & editing. **Jayson L. Lusk:** Conceptualization, Methodology, Formal analysis, Writing - original draft, Writing - review & editing.

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Disclosures

Lusk has given paid speeches and has conducted consulting work for a number of agricultural organizations including the Beef Cattle Research Fund, the North American Meat Institute, the National Pork Board, and Cattlemen's Beef Promotion & Research Board. None of these entities funded this research or had any input on this manuscript.

Appendix

See Tables A1–A2.

Table A1
Count and percent of consumers choosing each alternative by treatment.

Treatment		lab	plant	yeast	beef	none	Total	
							#choices	#people
1	count	221	475	363	2395	695	4149	461
	%	5.33	11.45	8.75	57.72	16.75	100	
2	count	193	410	362	2527	774	4266	474
	%	4.52	9.61	8.49	59.24	18.14	100	
3	count	274	517	406	2319	561	4077	453
	%	6.72	12.68	9.96	56.88	13.76	100	
4	count	251	454	406	2271	596	3978	442
	%	6.31	11.41	10.21	57.09	14.98	100	
Total		939	1856	1537	9512	2626	16,470	1830
		5.7	11.27	9.33	57.75	15.94	100	

Table A2
MNL estimates and resulting WTP.

	Pooled	Treatment 1 Control	Treatment 2 Branding	Treatment 3 Sustainability	Treatment 4 Technology
MNL Estimates					
Lab vs none	0.079*[a] (0.047)	0.010 (0.094)	−0.270*** (0.097)	0.415*** (0.091)	0.162* (0.093)
Plant vs none	0.772*** (0.041)	0.790*** (0.082)	0.495*** (0.083)	1.062*** (0.082)	0.762*** (0.084)
Yeast vs none	0.581*** (0.042)	0.519*** (0.085)	0.369*** (0.085)	0.815*** (0.085)	0.650*** (0.085)
Beef vs none	2.500*** (0.039)	2.506*** (0.079)	2.421*** (0.078)	2.658*** (0.079)	2.447*** (0.079)
Price	−0.178*** (0.005)	−0.186*** (0.009)	−0.180*** (0.010)	−0.181*** (0.009)	−0.163*** (0.009)
WTP Estimates					
Lab vs none	$0.45	$0.05	-$1.50	$2.29	$0.99
Plant vs none	$4.35	$4.25	$2.75	$5.86	$4.67
Yeast vs none	$3.27	$2.79	$2.05	$4.49	$3.98
Beef vs none	$14.08	$13.47	$13.43	$14.65	$15.00
N choice	16,470	4149	4266	4077	3978
N people	1830	461	474	453	442
Loglikelihood	−19660.6	−4911.2	−4904.1	−4955.7	−4846.1

Note: A likelihood ratio test of the null hypothesis that coefficients are equal across treatments yields a chi-square value of 87 with 15 degrees of freedom; the null is rejected at the $p < 0.01$ level.

[a] One, two and three asterisk represent statistical significance at the 0.10, 0.05 and 0.01 level respectively.

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