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Do plant-based and blend meat alternatives taste like meat? A combined sensory and choice experiment study

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Abstract

We conducted a combined sensory and discrete choice experiment study with a 100% beef burger, a plant-based burger using pea protein, a plant-based burger using animal-like protein, and a blended burger with 70% beef and 30% mushroom involving US consumers. Respondents were either assigned to a blind or an informed tasting condition with information about the ingredients before tasting the burgers. Results reveal that (i) beef burgers are preferred over alternatives, (ii) consumers favor blended burgers over alternatives in the blind condition but demand decreases in the informed condition; (iii) consumers prefer the plant-based burger with animal-like protein over the one with pea protein.

KEYWORDS

choice experiments, consumer preferences and demand, hybrid meat, meat alternatives, plant-based burgers, sensory experiment

JEL CLASSIFICATION

Q13, Q11, C91

High meat consumption worldwide, especially in North America and Europe, is becoming a threat to the preservation of the environment and human health. The food sector causes up to 30% of global greenhouse gas (GHG) emissions (Willett et al., 2019) and the livestock sector in particular is responsible for the food industry's largest GHG impact (Gerber et al., 2013). Climate change and biodiversity loss are also closely connected to the current animal industry (Dupont & Fiebelkorn, 2020). The projections for population increase, which will likely result in a growing demand for meat, constitute a looming challenge for the sustainability of the food system (Aschemann-Witzel et al., 2019). Next to the environmental challenges related to meat production, adverse effects on human health (Forouzanfar et al., 2015), such as increased risks of cardiovascular disease (CVD) (Bechthold et al., 2019) and a high prevalence of cancers (Bouvard et al., 2015) have been linked to the consumption of red and processed meat (National Cancer Institute, 2020).

As a result of these health and environmental concerns, many scientific bodies such as the EAT–Lancet report (Willett et al., 2019), and several national and international health authorities and organizations have emphasized the need to reduce animal-based products in favor of a more plant-based diet (U.S. Department of Health and Human Services and U.S. Department of Agriculture, 2015; World Health Organization, 2017). For example, the "Dietary Guidelines for Americans 2015–2020" stress the importance of a diet with lower meat consumption to limit the intake of sodium and calories from saturated fats, thus reducing the risk of CVD. The new guidelines for Americans 2020–2025 (Dietary Guidelines Advisory Committee, 2020) are currently being developed; and the 2020 advisory committee report includes suggestions to reduce red and processed meat intake due to negative health outcomes.

Radical transformations are also prevailing in the food system. For instance, the use of technologies to manufacture meat from plant-based products or engineer meat in labs are revolutionizing food markets, as evidenced by the many different meat-like substitutes increasingly available to consumers worldwide. Examples of meat-like substitutes include 100% plant-based (e.g., soy burgers) and hybrid vegetable–meat products (Grasso & Jaworska, 2020), as well as more innovative alternatives, such as insect products (Caparros Megido et al., 2016) and cultured meats produced using in vitro cultures of cells or tissues (Verbeke et al., 2015). Yet, although the market potential for plant-based alternatives seems promising (Aschemann-Witzel et al., 2020), uncertainty with regard to consumer preferences and demand for meat alternatives emphasizes a key question: are consumers ready to replace traditional meat products with meat analogs? To replace meat with plant-based meat substitutes, consumer preferences need to be met, especially from a sensory perspective (e.g., taste, texture, and appearance), as low sensory expectations are among the main factors recognized as a barrier to the success of plant-based meat alternatives (van der Weele et al., 2019).

This study combined a sensory experiment and a discrete choice experiment (DCE) on burger patty selection to (1) determine consumer preferences and demand for meat-based, plant-based, and hybrid burgers currently available in the US market and (2) explore whether and how preferences and demand for plant-based and hybrid burgers are influenced by taste. Respondents were randomly assigned to either the blind tasting condition, in which respondents tasted the products without any product information and then completed the choice experiment, or the informed tasting condition, where respondents were given information about each product before the choice experiment exercise. Respondents were asked to choose between a beef burger (beef burger patties, made using 100% beef), two plant-based burgers (one made with pea protein and one with animal-like protein), and a blended burger (made from 70% beef and 30% mushrooms). Our results indicate that (1) consumers prefer beef burgers over the plant-based product alternatives in both conditions, (2) consumers favor blended mushroom burgers more than the plant-based burgers but demand for them decreases when

consumers know that they are a blended option; (3) consumers like the plant-based burger with animal-like protein more than the plant-based burger with pea protein.

Our findings make important contributions to literature on consumer preferences and demand for alternative meat products. For example, while emerging research has focused on consumer preferences and demand for meat versus plant-based alternatives and lab-grown products (Martin et al., 2021; Van Loo et al., 2020), a systematic understanding of how sensory aspects influence consumer valuation of these products is still lacking. Understanding whether consumer preferences and demand for plant-based products depend on sensory aspects such as taste is crucially important for various reasons. First, if consumers are willing to try a new meat alternative, a positive sensory experience, which meets expectations, will be key for repeated purchases. Second, while the market for meat substitutes was relatively small and developed mainly for vegetarians in the past,[1] interest in the production of more meat-like substitutes has grown significantly in the last few years to address a larger group of potential consumers, which include meat-eaters (Hartmann & Siegrist, 2017; Van Loo et al., 2020). The new meat analogs are better at mimicking meat than previous plant-based alternatives and have more similar sensory characteristics to meat (e.g., taste, texture). Therefore, our results provide insights for market opportunities for both processors and retailers. For instance, marketers as well as large-volume distributers (e.g., food service outlets and cafeterias) could better promote their meat-like alternatives by providing free in-store tasting opportunities to raise consumer awareness of these products.

Our results also provide relevant information for policymakers. Understanding how and why respondents might choose to switch to meat alternatives or firmly remain meat consumers is vital in developing strategies and policies that support a reduction in meat consumption. For example, from a policy perspective, it is valuable to predict how popular the new generation of plant-based meat alternatives may become. This gives an indication as to whether the product will remain a niche product or has the potential to become a dominant force in the meat market. In this case, product labeling (can products be labeled with "meat," "sausage" and other livestock-related words) and product positioning in the store (meat aisle versus separate vegetarian section), may need to be studied more closely.

The remaining study is organized as follows: we first provide some additional background on research concerning meat substitutes before outlining our empirical analysis. This is followed by a description of our sample characteristics and presentation of our results. We conclude the paper with a discussion of our findings as well as potential future impacts and research directions.

BACKGROUND

Meat plays an important role in the diet and cultural identity of most European and North American consumers (Lentz et al., 2018; Oleschuk et al., 2019). It is associated with many traditional meals, making it one of the most popular foods in many Western countries (Apostolidis & McLeay, 2016). Flavor and texture are the most liked features of meat for most consumers (Elzerman et al., 2011). Combined, these factors constitute substantial obstacles for the expansion of plant-based meat,[2] and indeed, research has shown that, overall, consumers have low sensory expectations and sensory acceptance of meat alternatives (van der Weele et al., 2019).

Despite these dietary and cultural attachments to traditional meat products, interest in replacing traditional animal-based proteins (e.g., beef, poultry and pork) with plant protein-based products (i.e., plant-based meat, mycoprotein, algae, cultured meat, and insects) has been

growing within the food industry (Hashempour-Baltork et al., 2020), the scientific community and among consumers (Aschemann-Witzel et al., 2019; Dupont & Fiebelkorn, 2020; Payne et al., 2019). While early meat alternatives targeted vegetarian and vegan consumers (Slade, 2018), recent product innovations aim to meet the expectations of omnivores (He et al., 2020). To this end, different types of meat alternative protein sources are being developed, such as pulses (i.e., lentils and beans), algae (Onwezen et al., 2021), and other plant-based products including peas, soy, wheat (Martin et al., 2021; van der Weele et al., 2019).

More recent product innovations include meat alternatives that simulate meat-like properties. Novel plant-based burgers have been launched which claim to better mimic the sensory properties of meat patties (e.g., Impossible Burger[3] and Beyond Meat Burger[4]). Hybrid meat products, which are partially composed of meat protein and some plant-based ingredients, have also been introduced as meat alternatives that do not necessarily compromise the sensory aspects of 100% meat products, while simultaneously reducing meat consumption (Spencer & Guinard, 2018) For instance, hybrid beef patties can be produced by partially replacing ground beef with a plant-based ingredient such as soy protein (Fiorentini et al., 2020) and mushrooms (Sogari et al., 2021), which have little to no taste themselves and resemble meat in their texture.

The worldwide demand for these emerging plant-based products is growing fast, pushed by increasing concerns related to animal welfare, health, and the environment. In the United States, grocery stores have seen an increase in plant-based meat sales,[5] especially when such products were placed in the meat department (The Good Food Institute, 2020). These market trends show that plant-based meat products have the potential to move from a niche market, with a market share of 3% in the US meat market (Meat Demand Monitor, 2021), to the mainstream meat market in the future. For example, recent evidence based on scanner data indicate that the new generation of plant-based meat alternatives are complements for red meat (beef and pork) and substitutes for white meat (poultry and fish) (Zhao et al., 2022).

A few studies have looked at how consumers view sensory aspects of meat alternative burgers. Caparros Megido et al. (2016), who examined consumers' overall sensory liking of four types of meat-alternative patties, found that participants preferred a traditional beef burger over a mealworm/beef burger followed by a mixed mealworm/lentil burger and, finally, a lentil burger. This indicates how the presence of animal protein, even if it is not from a traditional source (e.g., insects), can result in a better product evaluation (e.g., mixed mealworm/lentil burger) compared to a fully vegetarian option. In the same vein, Schouteten et al. (2016) evaluated three different burgers (i.e., insect-based, plant-based, and meat-based) in a sensory experiment under blind, expected, and informed conditions. The insect-based burger was liked more (overall acceptance) under the informed condition than in the blind one, suggesting that consumers, especially young adults, could be willing to compromise on taste if they are informed about the ingredients and associated benefits (e.g., insects as more sustainable food sources than meat). Taken together, results from these studies suggest that the taste, flavor, and other meat attribute information are essential in meat look-alike products as they can constitute major obstacles to the expansion of such products on a large scale.

To explore how the presence of these new plant-based protein alternatives impact US beef demand, Taylor et al. (2022) recently surveyed 3000 US residents. Their results show that US consumers would choose a regular beef patty about three times more often than a plant-based protein patty (i.e., Beyond Burger), if the price was the same. Moreover, they found that regular meat consumers (i.e., omnivorous diet) tend to choose plant-based alternatives less often when a beef item is available than consumers who do not eat meat regularly (i.e., flexitarian). A recent study by Van Loo et al. (2020) used an online choice experiment survey to evaluate

consumer preferences and demand for plant-based burgers, including burgers using animal-like protein derived from yeast and plant-based meat using pea proteins. Results from this study indicated that farm-raised beef was the most preferred, followed by plant-based meat using pea proteins, and finally, plant-based meat using animal-like protein from yeast (Van Loo et al., 2020). In the studies by both Tonsor et al. (2021) and Van Loo et al. (2020) participants did not taste the products and made their choices based on various listed prices associated with each meat alternative.

Including actual tastings of various meat alternatives could influence general product evaluation and provide more realistic information about consumer preferences for plant-based meat products. As highlighted by Aschemann-Witzel et al. (2020), the taste of the plant-based products is highly important for consumers to consider switching from actual meat; and, currently, many consumers have negative perceptions of the sensory qualities of meat replacements (Clark & Bogdan, 2019). Martin et al. (2021) investigated consumers' preferences for a meat-based product (pork sausage) and a vegetable protein-based counterpart (plant-based sausage) using a sensory experiment. The authors explored consumers' purchase intentions and willingness-to-pay (WTP) for the products using blind and informed sensory experiments, with the latter involving a tasting with packaging information and informative messages including the health and environmental benefits of rebalancing diets in favor of plant protein. Their results showed that consumers' intention to purchase pork sausage was higher in the blind experiment, but the WTP for the plant-based product was significantly higher after consumers were provided with additional informative messages. Combined, these studies show that for meat analogs to be successful, they should offer the consumer a meat-like experience and therefore need to look and taste like meat. Given the importance of these sensory characteristics, asking consumers to actually taste the product might have a significant impact on their overall acceptance, because low expectations could be disconfirmed (Aschemann-Witzel et al., 2019; Sogari et al., 2019). Based on these premises, in our study, we combined a sensory test and choice experiment for two primary processed plant-based burgers (plant-based patty using pea protein and using animal-like proteins produced by yeast) whose appearance resembles a traditional beef burger, one blended burger (beef and mushroom patty), and a conventional 100% beef patty. To our knowledge, this is one of the first studies investigating consumer preferences for different plant-based meat alternatives relative to a conventional beef burger, including a sensory test with a blind and informed condition.

EXPERIMENTAL PROCEDURES

Recruitment

The data collection took place in September 2019 at the Sensory Evaluation Center at Cornell University. We recruited 172 untrained consumers, 86 for the blind tasting condition and 86 for the informed tasting condition. Respondents were recruited through invitations distributed via e-mails, flyers, and social networks. To be eligible for participation, respondents had to fulfill four recruitment criteria: (1) be older than 18 years, (2) not be allergic/intolerant to any ingredients potentially present in the foods investigated (i.e., wheat/gluten, tree nuts, soy, and coconut), (3) be a primary food shopper in their household, (4) and have purchased beef burgers in the past 6 months.

Between-subjects design

Upon arrival at the study site, participants were provided with an identification number and randomly assigned to either a blind tasting or an informed tasting condition (Figure 1). They were then invited to a room with six computers in separate booths. Next, they were asked to sign a consent form[6] and were informed about receiving a participation fee of $5 at the end of the experiment. Respondents were then asked to enter their identification number in the computer to start the experiment.

Both the blind and informed tasting conditions included a DCE exercise, in which respondents were able to choose between four burger patty alternatives and a no-buy option. The patty alternatives presented to the respondents were ground beef patties, plant-based patties using pea protein, plant-based patties using animal-like protein,[7] and blended patties made from 70% beef and 30% mushroom. As in Van Loo et al. (2020), six price levels ranging from $3/lb. to $10.5/lb. (in $1.5 increments) were used to price each product in the different choice tasks to

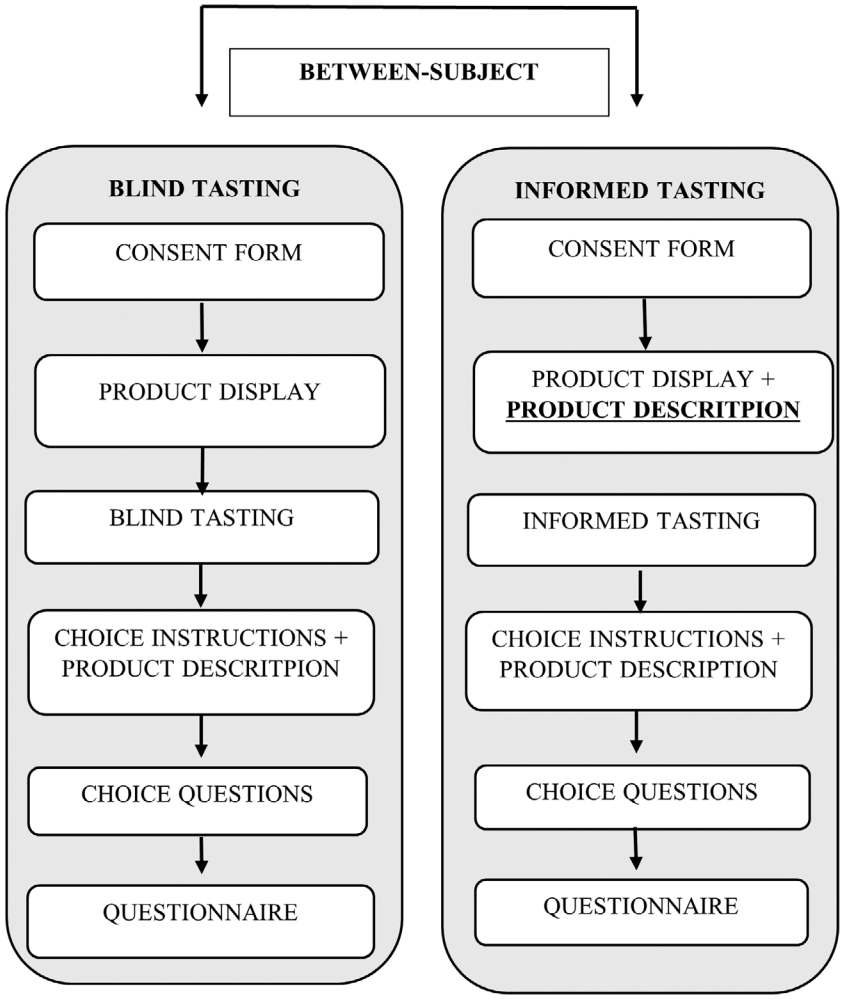

FIGURE 1 Overview of the combined sensory and choice experiment with two conditions: A blind (left) and informed (right) tasting condition

reflect the range of actual prices for different burger alternatives in grocery stores. Likewise, the choice questions were framed and designed following Van Loo et al. (2020). The price levels were allocated across the four product alternatives using a fractional factorial orthogonal design, which resulted in 36 choice questions. To reduce the number of choice questions per respondent, we generated four blocks, each composed of nine choice questions. Participants were randomly assigned to one of the four blocks. The order of the choice questions within each block was randomized. An example choice question is shown in Figure SA2.

However, the experimental steps followed to implement the between-subject experiment differ across the two conditions. To illustrate, in the blind tasting condition, participants were first asked to read the consent form, examine the four burgers and then taste them. No further information on the products was provided. After completing the tasting session, they were asked to read the choice experiment instructions along with a product description displayed within the choice questions prior to completing the DCE exercise. Following Bazzani et al. (2017), we adopted a blind test approach so that the sensory characteristics of the burgers would not affect consumer preferences for the experimentally designed products. In the informed tasting condition, on the other hand, participants were asked to examine the four burgers, each reporting the product name and description, prior to the tasting session. After completing the tasting, respondents were asked to read the choice experiment instructions, including a product description linking the experimentally designed burger alternatives and the burgers they tasted before answering the DCE questions. To avoid brand effects, no brand names associated with the four products were provided to participants during the informed experiment. Table SA1 outlines the product name reported in the choice questions and the product description provided to the respondents during the experiments. We used similar wording as in Van Loo et al. (2020).

Burger preparation and sensory tasting

The selected burgers were commercially available and purchased from the local supermarket and the University Dining center. The 100% beef burger patties and the plant-based burger using protein were purchased directly from the Cornell Dining representatives, whereas the plant-based burger made using animal-like protein and the blended burger were purchased from local grocery stores in Ithaca and in Cortland, NY, USA. The following branded products were purchased for the plant-based alternatives: Impossible Burger, Beyond Meat Burger, and Blend Burger, while the 100% beef burger patties were provided directly from the college's dining service.

Our application focuses on only four product samples to avoid fatigue and satiation during the evaluation, which may otherwise lead to potential study bias (Deliza, 2018). All four burgers were bought in a frozen condition to ensure a similar sensory quality during the experiments. Burgers were prepared according to the instructions provided on the package, that is, cooked using a pan, in a professional kitchen next to the sensory room. Burgers were cooked and cut into portions prior to the testing and were kept warm in slow cookers.

During the sensory and choice experiment, the burgers were served for evaluation within 30 min of cooking. Product samples were presented in the same quantity (1/2 patty) and served in transparent containers using a randomized complete block design (Williams, 1949). The order in which the product samples were presented to the respondents during the sensory experiment was randomized in both the blind and informed tasting conditions. Furthermore, product samples were served monadically (i.e., one at a time) to the participants in individual

computer-equipped sensory booths under red lights with adequate ventilation, and temperature regulation (Lawless & Heymann, 2010). Filtered water and crackers were available to participants who were instructed to cleanse their palate before tasting each sample (Lawless & Heymann, 2010). The respondents were placed in individual booths and were instructed on how the test would be performed. Data were collected using computers with the RedJade Sensory Software Suite (RedJade Sensory Solutions LLC), while the choice questions and exit questionnaire were designed in Qualtrics.

EMPIRICAL ANALYSIS

Data collected from both the blind and informed sensory and choice experiments were modeled using a mixed logit model (MXL) for panel data (Train, 2009). The MXL model is built upon the random utility theory according to which the individual n assigns utilities to each of the J presented alternatives and then selects the alternative j that yields the highest perceived utility in any given choice situation t (McFadden, 1974). As explained above, each choice question was represented by four burger alternatives offered at different prices and a "none" option. Hence, the utility that participant n derives from selecting a burger alternative j can be expressed as follows:

$$U_{njt} = \beta_j + \alpha * \text{PRICE}_{jt} + \varepsilon_{njt},$$

where β_j is an alternative-specific constant indicating the utility for each alternative j (i.e., 100% beef burger, plant-based burger made using pea protein, plant-based burger made using animal-like protein, and blended burger made using 70% beef and 30% mushroom) relative to the "none" option (the utility of the "none" option is normalized to zero for identification purposes); α represents the marginal utility of the price; PRICE_{jt} is the price of alternative j in choice situation t; and ε_{njt} is the independently and identically distributed extreme value stochastic error term.

The MXL accounts for respondent heterogeneity when making choices by assuming that preference parameters have a continuous distribution over the population (Train, 2009). In this study, random taste variation was accounted for by assuming that preferences for the burger alternatives follow a normal distribution, while the price coefficient was assumed to be fixed. Following Scarpa et al. (2005), we also added an error component to account for correlation across utilities, as it captures the additional variance shared by the hypothetical purchase. We estimated two MXL models with error component (MXL-EC), one for each condition. Both models were estimated using simulated maximum likelihood estimation (Train, 2009) with 1000 Halton draws. The coefficients estimated from the MXL-EC models were used to calculate total and marginal WTP for the four selected burger alternatives.[8] Both total and marginal WTP were constructed using unconditional (population moments) parameter estimates from the MXL-EC model as well as conditional (individual-specific) parameters estimates using the Bayesian procedures illustrated in Train (2009). The unconditional WTP estimates were used to explore differences in consumer valuation for the selected burger alternatives across the blind and informed tasting conditions. To this end, we employed the parametric bootstrapping method proposed by Krinsky and Robb (1986) followed by the nonparametric test introduced by Poe et al. (2005).[9] Food choice studies utilizing these procedures to explore differences across experimental treatments include Caputo et al. (2018) and Lusk and Schroeder (2004), among

others. The conditional WTP estimates, on the other hand, were used to explore individual-specific behavioral outputs across experiments, including distributional features of WTP estimates conditioned to represent each respondent's choice. We used the estimated conditional WTPs (means and standard deviations) and adopted the centipede approach illustrated in Hensher et al. (2005) to plot the distributions of total WTPs across individuals within each tasting condition.

Finally, to further explore differences in choice behavior across the blind and informed tasting conditions, we also derived the demand curves associated with each burger type for both sensory conditions (blind and informed tasting). Following Van Loo et al. (2020) and other food demand analysis studies (e.g., Caputo et al., 2020a, 2020b; Lusk & Tonsor, 2016), we used the parameter estimates from the MXL-EC model and calculated the unconditional market shares for each burger alternative based on eq. (2).[10]

RESULTS

Table SA2 reports the sample characteristics of the overall sample and by treatment. No significant difference in terms of demographics was found across the two conditions (blind and informed tasting condition), while Table SA3 compares the familiarity of the participants with the four types of burgers used in the study. The results show that, as expected, beef burgers had the highest degree of familiarity (87%), followed by plant-based burgers made using animal-like protein (13%), and pea protein (10%). The lowest familiarity was associated with the blended burgers, probably due to the scarce availability of this product in the market. The familiarity was not impacted by providing information prior to the tasting in the informed condition.

Table 1 reports the coefficient estimates (means and standard deviations) from the MXL-EC model for each sensory experiment. For each experiment, the price coefficient is negative, indicating a lower likelihood of purchase when respondents faced higher prices. The alternative-specific constants, which represent the different burger alternatives used in the choice experiments, are positive and statistically significant. This indicates that, with prices held constant, consumers preferred one of the four burger alternatives relative to the "none" option. Results also reveal statistically significant standard deviations for all burger alternatives in both conditions, signaling a significant amount of random taste variation among consumers. Interestingly, in both conditions, the standard deviations associated with the plant-based burgers made using pea protein (3.21 and 4.33 in the blind and informed sensory experiment, respectively) and plant-based burgers made using animal-like protein (3.04 and 2.61 in the blind and informed sensory experiment, respectively) are greater in magnitude compared to the 100% beef burger (1.63 and 2.26 in the blind and informed condition, respectively) and the blended burger alternatives (0.81 and 1.90 in the blind and informed condition, respectively). This indicates that consumer heterogeneity is a strong preference pattern for emerging meat alternatives.

Table 2 reports the total and marginal unconditional WTP estimates for the burger alternatives selected for this study. Results indicate that the total WTP to obtain a 100% beef burger relative to the none-option is the largest among the burger alternatives, with mean WTP values of $9.23 and $8.46 in the blind and informed tasting conditions, respectively. These total values are similar to those reported by Van Loo et al. (2020) who found that US consumers are willing to pay between $10.18 and $11.35 for farm-raised beef. Respondents had the second largest mean WTP (relative to "none") for the blended burger in the blind experiment, $8.88. Interestingly, this value drops to $6.94 in the informed sensory experiment. Among the plant-based

TABLE 1 Estimates from the MXL-EC model, blind and informed tasting conditions

		Blind tasting	Informed tasting
Alternative-specific constants			
100% Beef burger	Mean	6.95* (0.51)	7.08* (0.58)
	St. Dev	1.63* (0.26)	2.26* (0.36)
Plant-based using pea protein	Mean	3.73* (0.69)	3.96* (0.76)
	St. Dev	3.21* (0.60)	4.33* (0.72)
Plant-based using animal-like proteins	Mean	5.10* (0.61)	6.43* (0.60)
	St. Dev	3.04* (0.47)	2.62* (0.38)
Blended burger (70% mushroom and 30% meat)	Mean	6.68* (0.51)	5.81* (0.58)
	St. Dev	0.81* (0.49)	1.90* (0.34)
Price	Mean	−0.75* (0.05)	−0.84* (0.05)
ERC	St. Dev	1.57* (0.46)	2.04* (0.37)
Model statistics			
Choices		774	774
Log-likelihood		−700.946	−701.950
Parameters		10	10
AIC/N		1.837	1.840

Note: Numbers in parentheses are standard errors.
*Statistically significant at the 0.01 level.

alternatives, consumers have a higher total WTP for plant-based burgers made using animal-like proteins ($6.82 and $7.73 in the blind and informed conditions, respectively), while the lowest total WTP is associated with plant-based burgers made using pea protein across both sensory conditions; consumers are willing to pay $4.97 and $4.75 relative to "none" in the blind and informed conditions, respectively. This implies that people who want to switch to more plant-based meat alternatives prefer the blended burger, as compared to plant-based burgers made using animal-like proteins or made using pea protein.

Figure 2 plots the distributions for the total conditional (individual-specific) WTP for each burger alternative across the blind and informed tasting conditions, respectively. Upper and lower confidence intervals for 95% probability intervals are also depicted. This process allows us to observe the individual-specific WTP for all product alternatives across the blind and informed tasting conditions. Most strikingly it can be seen that across the two conditions the variation is lowest for the meat and blended option, indicating that the more familiar taste of actual meat leads to less uncertainty among consumers. Moreover, we can also see that in the informed tasting conditions the variation increases for the blended burger patties. This increase in variation is akin to what was recently observed by Kilders and Caputo (2021), who found an increase in variation related to the individual-specific WTP for milk from gene-edited cows, when information was given to the respondents. In terms of the plant-based alternatives, we notice substantially larger variation across both sensory conditions and respondents. This indicates that there seems to be a divergence between consumers who favor the taste of those meat alternatives and those who do not. Variation across sensory conditions for those options is comparable, indicating that consumers might not be too receptive to product information.

TABLE 2 Total and marginal unconditional willingness-to-pay measures, blind and informed tasting conditions

Treatments	Blind tasting	Informed tasting	*p* Values[a]
Total willingness-to-pay			
100% Beef burger vs. None	$9.23[b] (0.59)[c] [8.082, 10.316][d]	$8.46 (0.55) [7.384, 9.541]	0.1689
Plant-based burger using pea protein vs. none	$4.97 (0.88) [3.253, 6.686]	$4.75 (0.86) [3.070, 6.423]	0.4275
Plant-based burger using animal-like proteins vs. none	$6.82 (0.76) [5.327, 8.312]	$7.73 (0.60) [6.556, 8.898]	0.8277
Blended burger vs. none	$8.88 (0.60) [7.8710, 10.049]	$6.94 (0.56) [5.856, 8.040]	0.0085
Marginal willingness-to-pay			
100% Beef vs. plant-based burger using pea protein	$4.26 (0.78) [2.738, 5.579]	$3.72 (0.82) [2.113, 5.320]	0.3106
100% Beef vs. plant-based burger using animal-like proteins	$2.41 (0.62) [1.194, 3.635]	$0.74 (0.52) [−0.279, 1.750]	0.0181
100% Beef vs. blended burger	$0.35 (0.36) [−0.346, 1.054]	$1.52 (0.50) [0.533, 2.506]	0.0288
Plant-based using pea protein vs. plant-based burger using animal-like proteins	$−1.85 (0.86) [−3.543, 1.054]	$-2.98 (0.81) [−4.563, 2.506]	0.1688
Plant-based using pea protein vs. blended burger	$−3.91 (0.74) [−5.3361, −2.459]	$-2.20 (0.82) [−3.811, −0.583]	0.0604
Blended burger vs. plant-based burger using animal-like proteins	$−2.06 (0.58) [−3.202, −0.919]	$0.78 (0.53) [−0.251, 1.818]	0.0001

[a]*p* Values were obtained utilizing the Poe et al. (2005) nonparametric test.
[b]Reported statistics are point estimates of WTP.
[c]Numbers in parentheses are standard errors calculated using the Krinsky–Robb bootstrapping method.
[d]Numbers in brackets are confidence intervals calculated using the standard errors derived from the Krinsky–Robb bootstrapping method.

Finally, to further explore differences in consumer valuation for the various burger alternatives, we derived the demand curves associated with each burger type. Figure 3 displays the implied demand curves for 100% beef burgers and the selected plant-based meat alternatives for both the blind and the informed tasting conditions.

Looking first at the 100% beef burger, irrespective of the sensory condition, the market share is consistently the highest for all price levels. Interestingly, it is also observed that for higher price levels, the market share for the 100% beef burgers is higher in the informed tasting condition than the blind tasting condition, while at lower price levels it is higher in the blind tasting condition than in the informed tasting condition. This could

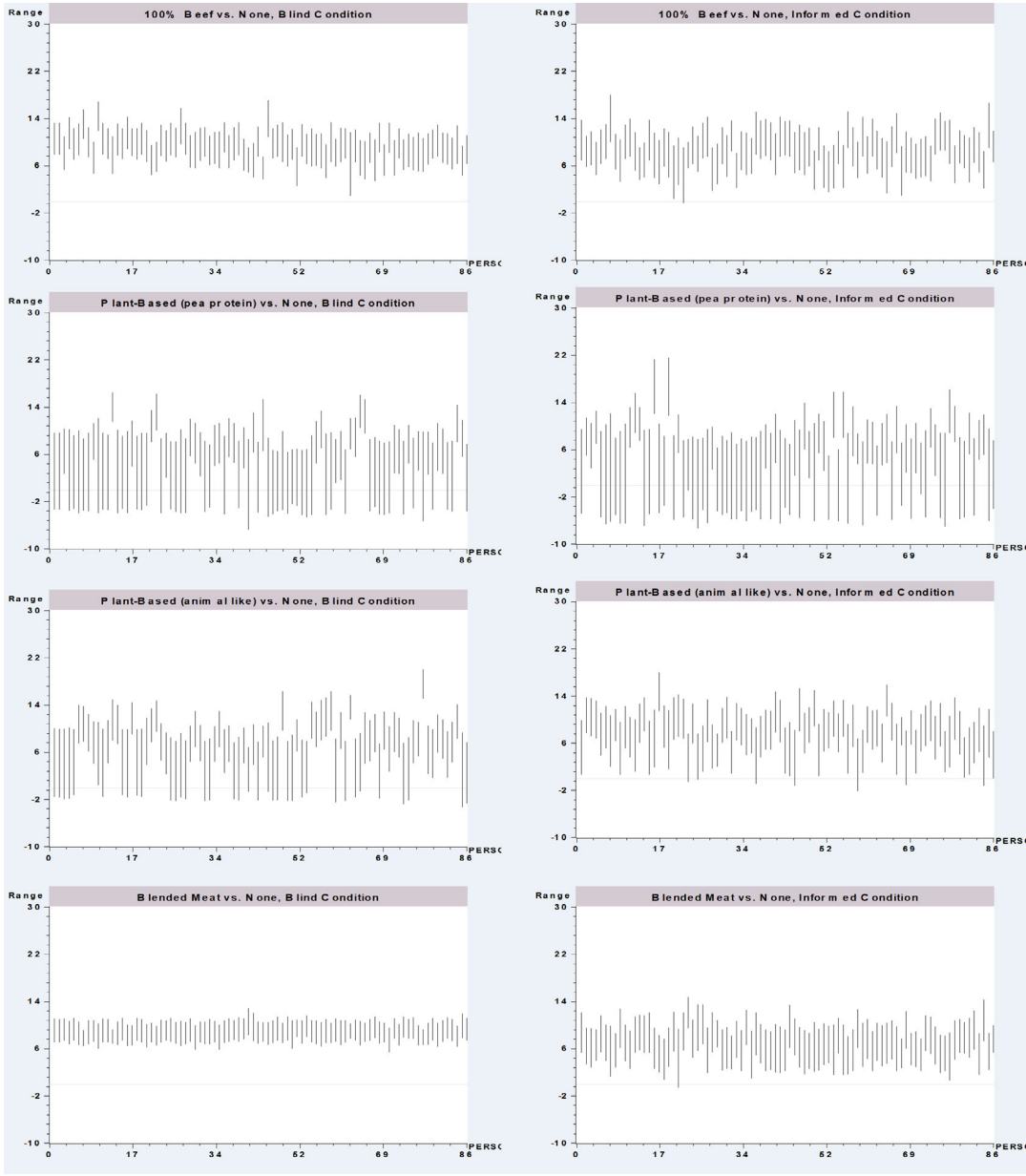

FIGURE 2 Conditional distributions of total WTPs (product alternatives versus none) and confidence intervals, blind and informed tasting conditions [Color figure can be viewed at wileyonlinelibrary.com]

indicate that respondents who are aware that they are "compromising" in their beef burger consumption are only willing to do so if they are facing lower prices. In addition to the noticeable differences between the preferences for the 100% beef burger across sensory conditions, it is also easily observable that the market shares for the two plant-based burgers (plant-based burger using animal-like protein and pea protein) are comparable across the blind and informed tasting conditions; the market shares for the blended burger vary

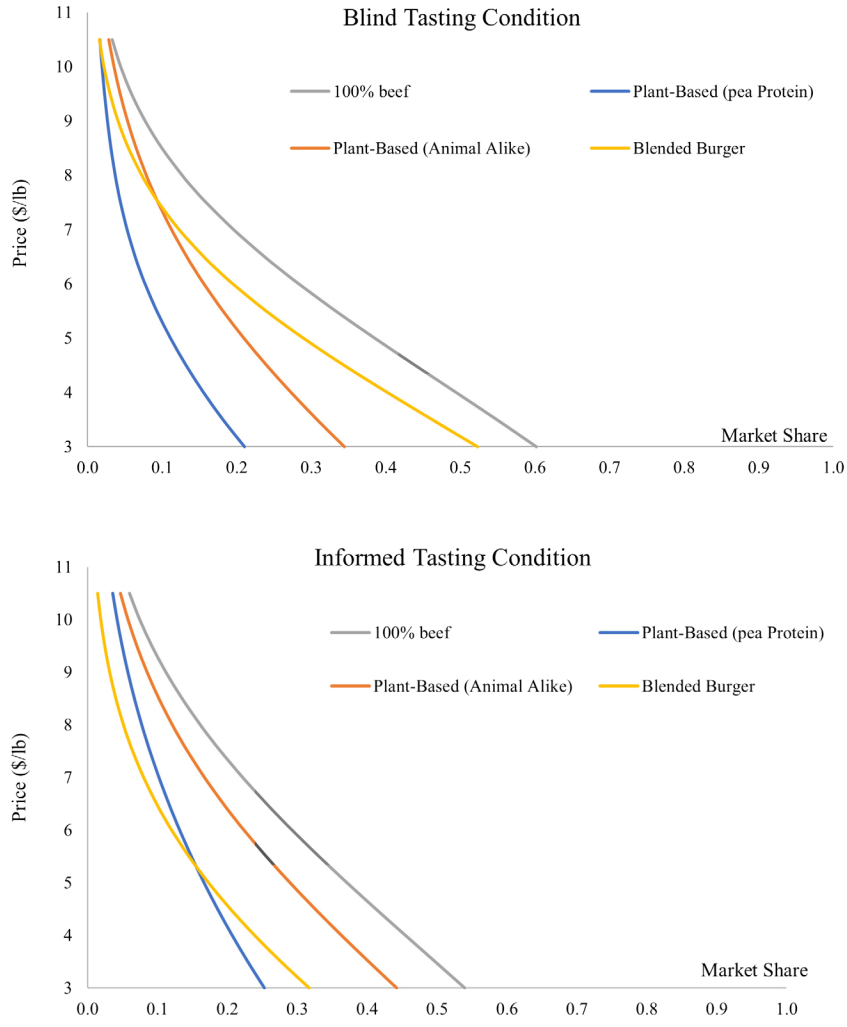

FIGURE 3 Implied demand curves for each selected plant-based meat alternative by condition [Color figure can be viewed at wileyonlinelibrary.com]

substantially between the two sensory conditions. To illustrate, in the blind tasting condition, the blended burger has the second highest market share up to a price of around $7.50/lb, above which the market share for the plant-based burger using animal-like protein exceeds that for the blended burger. In the informed tasting condition, on the other hand, the blended burger has the lowest market share for price levels above $5.50/lb. This indicates that among the meat-alternative burgers the informed tasting condition mainly had a negative impact on blended burgers, meaning that respondents might not be willing to reduce their consumption of pure beef by a substantial amount, but are willing to favor meat-free options over blended options. This also aligns with the findings of Schouteten et al. (2016) who found that informed consumers are more willing to compromise on taste than noninformed ones.

DISCUSSION AND CONCLUSION

In recent years, the development of plant-based and hybrid alternatives similar in use and esthetic characteristics to meat have received considerable attention by academics, food marketers, and policymakers (Apostolidis & McLeay, 2016; Slade, 2018). In the United States, the market share and overall interest is increasing both in the retail and foodservice sector (e.g., fast food chains) (Van Loo et al., 2020). However, despite this emerging trend, there is little knowledge regarding consumers' choices in relation to these products, including how taste appreciation and information about the production methods affects consumer preferences and WTP.

This study provided insights into consumers' preferences and WTP for plant-based and hybrid burger patties currently available on the US market (plant-based burgers using pea or animal-like protein and blended burgers consisting of 70% beef and 30% mushroom) relative to a 100% beef burger. To do so, we implemented a combined sensory and DCE, where respondents either only received instructions for the experiment (blind tasting condition) or both instructions and precise information on the available options (informed tasting condition) prior to the product tasting.

In line with Tonsor et al. (2021) and Van Loo et al. (2020) our results show that irrespective of the sensory conditions, the 100% real beef patty is still the most preferred option among those available. Possible explanations for this finding could be a low familiarity with the plant-based concept or an atypical perception of the sensory characteristics compared to conventional meat (van der Weele et al., 2019). If we compare the preferences for the other three burger alternatives, we find that in the blind tasting condition the blended burger is preferred (except at very high prices) while in the informed tasting condition the plant-based burger using animal-like protein is preferred. Interestingly, when looking at the WTP and demand for the three alternative burger options, we found that the demand for the blended burger was the second highest in the blind tasting scenario, but the second lowest in the informed tasting condition.

This demonstrates how the blind tasting makes the blended burger with 70% beef more acceptable than the meat-free alternatives (i.e., the plant-based burgers using pea or animal-like protein) when participants are not aware of the type of burger. However, when consumers know more about the ingredients of the blended burger the demand decreases. This contrasts with earlier findings by Profeta et al. (2021) who found that meat hybrid variants were less preferred than 100% meat products, but favored more than the vegetarian-based alternative. Evidence from our study shows that even small amounts of information can drastically alter respondents' perceptions and preferences. It also shows the interesting dichotomy between taste and information, as respondents seem to generally favor the taste of the blended option but upon learning that they are already "compromising" on their meat consumption they prefer to then completely switch to the plant-based option.

Considering the ongoing debate on whether plant-based meat alternatives can be labeled as "meat," "sausage," "beef," or other related words (Britschgi, 2021), our findings represent an interesting insight. When people are informed that the burger is blended, our results show that they evaluate the blended burger as the least favorable burger. They show that the market positioning of blended burgers, which have struggled to gain significant market traction (Foodnavigator, 2021), might benefit from omitting the blended component, while plant-based options benefit from a clear distinction from meat. This could particularly hold true since the results by Tonsor et al. (2021) show that the market share for beef is relatively stable and unaffected by the presence of meat alternatives, meaning that the available options are competing

for the share of consumers open to consuming the blended and plant-based options. We also find that between the two 100% plant-based alternatives, the burger made using animal-like protein, is consistently preferred to the burger made from pea protein. This is consistent with a study by Lemken et al. (2019) which suggests that highly processed products made using legumes would have low acceptance if marketed as an alternative to meat. Moreover, this discrepancy in demand has been noted since the execution of our experiment, as Beyond Meat, which used pea-like protein, has adjusted the composition of its burger to even more closely resemble a typical meat flavor (Foodnavigator-usa, 2021). This corresponds to suggestions by Fiorentini et al. (2020), to emphasize messages such as "tastes like meat" to create positive expectations in consumers.

Overall, our results suggest that the success of plant-based alternatives is heavily dependent on both the information to which respondents are exposed, including the product names, as well as the taste. Nevertheless, this study is subject to some limitations. First, we used a relatively small sample for a DCE,[11] which is explained by the difficulties in collecting a large sample for sensory lab experiments. Future studies could expand upon our sample size to confirm the robustness of our findings. Second, we focused on burger patties, which constitute only one of the available meat categories in which plant and blended options are available. Studies by Lusk et al. (2015) and Caputo et al. (2020a, 2020b) show that in evaluations of consumer preferences, the product and processing stage matter. Thus, future research could look into demand and preferences for sausages, ground meat, and so forth. In addition, future research could also investigate the role of different labeling (e.g., healthy, sustainable information) and different food items (e.g., egg, fish) on consumer preferences for alternative animal protein.

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ENDNOTES

[1] Initial meat substitutes were targeted at vegetarians who wanted to reduce their meat consumption (Hashempour-Baltork et al., 2020) for health reasons (Apostolidis & McLeay, 2016; Birch et al., 2019) and/or ethical beliefs related to the environment and/or animal welfare concerns (Apostolidis & McLeay, 2016; Circus & Robison, 2019).

[2] Currently, there is no universal definition of meat substitutes, but researchers and the food industry identify such products as meat alternative products, often plant-based, that look similar to meat and mimic the taste of meat (Apostolidis & McLeay, 2016; Hoek et al., 2011).

[3] To date, the company Impossible Foods, one of the first to introduce a plant-based burger mimicking meat, sells its Impossible burger in approximately 17,000 grocery stores in the United States, with a sixfold growth in production since 2019 (Business Wire, 2021).

[4] Beyond Meat, another US food pioneer in the sector of plant-based items, is distributing its plant-based Beyond Burger across Europe, and is planning to distribute its product to the Middle East and Africa (Food Ingredients, 2021).

[5] To date, the company Impossible Foods, one of the first to introduce a plant-based burger mimicking meat, sells its Impossible burger in approximately 17,000 grocery stores in the United States, with a sixfold growth in production since 2019 (Business Wire, 2021).

[6] Upon review of the human subject protocol, this study was deemed exempt by (*omitted for review purposes*) Institutional Review Board.

[7] The term "animal-like protein" refers to the heme protein. Heme is an iron-containing molecule that occurs naturally in plants and animals and is responsible for the characteristic taste and aroma of meat. Heme found in animal muscle is carried by a protein called myoglobin. Some plants also have heme; and in plants it is carried by the protein leghemoglobin, which is closely related to myoglobin (Impossible Foods, 2018). Using this heme protein in the burger patty, allows it to better mimic the taste of an animal meat burger.

[8] The total WTP for each burger alternative was calculated as the negative ratio of the corresponding alternative-specific constant to the price coefficient; hence, it expresses the total WTP for each of the burger alternative j versus the "none" option. The marginal WTP for pairs of burgers was computed by subtracting the total WTP for burger j from the total WTP for burger k; hence, it represents the WTP to exchange burger j for another burger alternative k.

[9] The Krinsky and Robb (1986) approach was employed to generate 1000 observations drawn from multivariate normal distributions using the vector of the coefficient estimates and the variance–covariance matrix from the MXL model. The 1000 bootstrapped values of marginal WTPs obtained from the bootstrapping procedures were then used to perform the Poe test, which compares all possible combinations of the 1000 bootstrapped values across the two tasting conditions for each burger alternative. As a result, 1,000,000 (1000×1000) differences were calculated for each null-hypothesis test of interest.

[10] We did so by substituting the estimated coefficients into probability equations with the price of all products set at \$5.00/lb, except for the product of interest whose price levels were varied over the range of prices used in the experimental design (\$3.00–\$10.50). We then plotted the computed market share values against the corresponding prices.

[11] As argued by Caputo and Scarpa (2022), current sampling theory has not yet adequately addressed sample size requirements for DCEs in terms of the reliability of estimates produced. Following Caputo and Scarpa (2022), for each sensory condition we evaluated our design ex post and computed the S statistic, which is a statistical measure that provides the theoretical minimum sample size necessary to obtain asymptotically significant parameter estimates. The S estimates indicate that that less than 10 respondents would have been needed to identify the effects associated with the price and alternative-specific constants used in the blind and informed conditions. Our sample size is quite a bit larger than the one suggested by the S estimates, indicating that our results are powerful enough to derive conclusions.

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SUPPORTING INFORMATION

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