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Consumer Preferences for Lab Grown Meat: The Effect of Information on Consumer Choice

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Abstract

Global population growth and increased meat demand present challenges for the agricultural industry to produce meat sustainably. *In-vitro* meat (IVM) is an alternative that could reduce negative impacts associated with livestock production. The goal of this study was to examine consumers' preferences for IVM. A choice experiment was created with twelve choice tasks that varied across five attributes: production method (IVM or conventional), carbon trust label, organic label, animal welfare label, and price. 1,120 US consumers were randomly assigned to one of four information treatments, differing by information presented regarding IVM: 1) neutral (baseline), 2) positive, 3) negative, and 4) combined. To test our hypotheses, differences in mean willingness to pay between treatments were estimated using a combinatorial approach. Results show that consumers prefer traditionally produced ground beef over IVM. In order to select IVM, subjects required large discounts ranging from $1.17 to $1.84 per lb. Negative information framing appears to be a more powerful tool, resulting in the largest required discount. However, positive information significantly reduced the discount required. Food retailers should expect to offer steep discounts to attract customers; however, presenting positive information about the benefits of IVM can reduce the discount substantially.

Keywords: in-vitro meat, willingness to pay, information framing effects

Introduction

The consumption of meat has increased over time due to a number of important factors, including increased urbanization, growing incomes, and continued population growth. The demographic transition to urbanized systems has resulted in smaller populations living in rural areas. Fifty five percent of the global population resided in urban areas in 2019, and over the next decade this percentage is projected to grow to about 60% (OECD-FAO, 2019). Growing incomes have also led to an increase in the consumption of meats (Delgado, 2003). Although meat consumption varies widely between developed countries and less developed countries, in general, as countries see increases in income, meat consumption also rises. In the US and other developed countries, meat accounts for approximately 15% of daily energy intake and 40% of daily protein intake (Daniel, 2011). In the US, per capita meat consumption is 115 kg (over 250 lbs) of meat consumed annually (Ritchie, 2019). Increased meat consumption is affected by economic development and urbanization and leads to changes in the demands on the agricultural sector, including production and distribution ("Global and regional food", 2008). Continuing population growth also places greater pressure on the agricultural sector as demand for meat increases. By 2050, the global population is predicted to be about 9.15 billion (Thornton, 2010). According to the Food and Agricultural Organization, 70% more food than currently produced will be needed in order to provide for this rate of population growth (Chriki, 2020). The agricultural industry must consider how to sustainability feed this population, while minimizing the negative impacts associated with intensive farming, including impacts on the environment, food safety, and animal welfare.

Alternatives to traditional meat production are being developed in part to help reduce the consumption of meat, including plant-based diets and meat substitutions. *In-vitro* meat (IVM) presents a potential alternative that could reduce the dependence on intensive farming methods, thereby reducing the negative impacts of the agricultural sector. IVM is a process intended to recreate the intricate livestock muscle structure with significantly fewer cell requirements than livestock slaughter. A live animal biopsy provides a muscle sample which is then cut to free stem cells that can divide and multiply to eventually form an animal-like product (Chriki, 2020). IVM provides a potential production process for meat with fewer environmental impacts, lower food safety risks, and fewer animal requirements. However, consumer acceptance of IVM products is crucial to the scale of impact that such technology could have in the marketplace.

The process involved in IVM can reduce negative impacts to the environment, appease animal cruelty advocates, and increase overall health. The creation and production of IVM occurs in a controlled environment and with fewer animals necessary for production, so there is less risk for disease and outbreaks of animals that may produce contaminated meat (Chriki, 2020). It is important to consider the views taken by groups who do not eat meat for ethical reasons and negative implications involved in the process and idea of animal slaughter. Segments of the population that refrain from eating meat for ethical or religious reasons may view the process of IVM as acceptable, and therefore it is important to consider their opinions on this process (Mouat, 2018).

Meat consumption has continued to increase steadily. Meat is a source of nutrition as it provides essential amino acids and is a high-quality protein source. Protein content is dependent on the source, but the average protein content in animal sources is 22%. Meat sources provide the body essential amino acids which are the building blocks of protein, and such amino acids must be supplemented through the food an individual consumes (Pereria, 2013). Outside of nutritional benefits, individuals consume meat as part of custom because “it is normal, it is natural, and it is necessary" (Joy, 2010). Religious beliefs may also reinforce meat eating (Clough, 2005). Consumers also find eating meat to be pleasurable (Clough, 2005).

As the consumption of meat and demand on the agricultural system increases, environmental impacts will also increase. In the US, the agriculture industry accounts for 10% of total greenhouse gas emissions (EPA, 2019). Meat production also affects water scarcity. The lifecycle for meat production includes the crops grown for feed and continues through the consumer purchase and disposal. For a 150-gram beef burger, the water requirement is 2,400 liters (Hoekstra, 2012). Water intake of livestock varies based on differing factors of the animal and environment (age, weight, species, season). The land needed to raise livestock, including grazing and feed production, is tremendous. The agricultural sector occupies 26% of "ice-free terrestrial surface of the planet", and the expansion of livestock production can lead to increases in negative practices such as deforestation (Steinfeld, 2006).

Animal welfare has also grown in importance to consumers over time (Kilders and Caputo, 2021). Some methods used in intensive farming have been subject to criticism by individuals advocating for animal welfare. In a report released by the US Department of Agriculture in March of 2020, 9.41 billion pounds of commercial red meat was produced from January to February of 2020 (an increase of 6% from 2019) and just over 2.5 million animals were slaughtered ("Livestock Slaughter", 2020). The use of IVM could lead to large reductions in the number of cattle required for slaughter to produce meat.

Shifting from intensive livestock production to a lab grown meat industry would have wide-ranging economic effects. The livestock industries are important contributors to employment and to the gross domestic product (GDP) of agriculture. Slightly more than 1 billion people are employed within the industry, and the livestock industry accounts for 40% of agricultural GDP (Steinfeld, 2006). With a shift towards IVM, employment opportunities may shift or be lost and the contribution to the GDP may be impacted.

In addition to the negative environmental impacts associated with the livestock industry and concerns relating to animal rights, there are a range of health-related concerns that have led to meat substitutes (Joshi, 2015). Vegetable-based diets are lower in cholesterol and saturated fat and higher in antioxidants, folate, and fiber than meat-based diets (Lea, 2003). Vegetarian diets are also associated with lower risk for diseases including type 2 diabetes, while diets high in processed meat are associated with an increase of diseases including coronary heart disease, diabetes, and cancer (McEvoy, 2011). Health has been researched to be one of the most important attributes consumers take into consideration when making decisions on meat consumption (Verbeke, 2000). The desirable health benefits of meatless diets may lead individuals to lower meat intake or stop intake altogether. Besides health concerns, religious beliefs, including Hinduism and Buddhism, dictate a vegetarian pattern of eating or consumption of meat prepared a certain way.

As an alternative to the traditional livestock industry, IVM is a system that creates an animal product from the muscle tissue of an animal by rapidly duplicating the cell makeup of the tissue until a meat product is formed. With this method, there are several benefits including decreased livestock slaughter needed to produce the same amount of meat product, less possibility for the spread of diseases through livestock contact, and significant benefits for environmental consequences produced by agricultural sector. IVM would provide a strict and regulated system to control foodborne diseases and exposure to hazards such as pesticides in traditional livestock production facilities (Bhat, 2015). The number of animal slaughters would decrease significantly. IVM avoids animal slaughter entirely since cells are removed through a biopsy of a living animal, but should be noted that animal welfare concerns still exist due to animal biopsy that is required (Bhat, 2015; Schaefer, 2014). This concern must be considered when looking at consumer opinions regarding IVM. IVM also has the potential to reduce the carbon footprint of the meat industry by as much as 90% (Bhat, 2015; Tuomisto, 2012). With the emergence of IVM, much is still unknown about the acceptance by consumers.

The goal of this study was to examine consumers' preferences and willingness to pay (WTP) for IVM as an alternative protein source. The goal was accomplished by carrying out two objectives. The first objective investigated the effects of information on consumer choice by comparing consumers' valuations of IVM when information about IVM is phrased positively and when it is phrased negatively. The second objective was to explore how consumers' valuations may vary across demographics of the population (age, political orientation, animal welfare attitudes, and likelihood to buy cultured meat). Accomplishing these two objectives provides outputs useful for guiding labeling policies and information campaigns around IVM.

Literature Review

Consumer acceptance of IVM has been studied in the general population. Acceptance of IVM or other substitutes as an alternative protein source was low. Consumers were not aware that the meat industry has a significant impact on environmental issues, and the willingness to change current meat-eating patterns was also low (Hartmann, 2017). Although consumer's might be willing to try IVM, only a small number of that population reported they would eat IVM over traditional meat products (Bryant, 2018). If acceptance of consumers to try IVM is not substantial, this could represent a barrier to marketing IVM to a broader population. The willingness of consumers to buy IVM is dependent upon the success of IVM in replicating the characteristics including texture and taste of typical meat products. One study found that 44% of the population sampled reported a willingness to buy cultured meat if it was similar to traditional meat products (Mancini, 2019).

The information presented to consumers can also influence acceptance of IVM (Asioli et al., 2021). The terminology used when labeling IVM affects marketing campaign strategy and labeling policy and could be a major factor in its acceptance (Watson, 2020). Asioli et al. (2021) found that subjects in their choice experiment strongly preferred chicken meat produced through conventional production methods over IVM. However, they also found that the terms used to describe IVM were important. The term ‘cultured’ was found to be less disliked than ‘lab-grown’ and ‘artificial’. Their results demonstrated the importance of how IVM is communicated to the public.

Materials and Methods

Qualtrics software was used to construct and deliver the choice experiment and survey to participants. Participants provided informed consent prior to moving forward with the survey. The survey was administered online since this was the most effective way with current resources to reach a larger population from a wider demographic group across the US. A monetary incentive was provided to individuals to encourage participation.

Choice Experiment Design

The product chosen to be evaluated was ground beef hamburger patties. Red meat is consumed in larger amounts in comparison to poultry and pork (Daniel, 2011). Specifically, ground beef is the most consumed beef product in the US, with 40 to 45% of beef consumed being ground beef (Greene, 2012). The choice experiment used five attributes in all treatments to describe the different types of raw hamburger products: “production method”, “carbon trust label”, “organic”, “animal welfare”, and “price” (Table 1). The attribute “production method” was used to determine consumers’ willingness-to-pay for different raw beef products. Two levels were specified for production method: “Conventional” or “Cultured/lab grown”. The information was associated with lab grown meat and was presented in a neutral, positive, negative, or positive and negative perspective. Information sets were constructed using current information regarding lab grown meat including the benefits or drawbacks compared to current livestock practices. The neutral information included the general idea of lab grown meat and how it is created. Second, we used the “carbon trust label” attribute to represent environmental impact of the raw ground beef. Environmental impacts are a large concern surrounding conventional meat products, and the “carbon trust” was specifically used to indicate a commitment to reducing CO_2 emissions. Products were reported either with the “carbon trust label" or with "no label reported". Third, an "organic" attribute was included that indicates the use of antibiotics or growth hormones used in producing raw beef products. The two levels were therefore "organic label" or "no label reported". Fourth, we included information regarding animal welfare surrounding the product. Animal welfare is a problem presented in conventional meat products through upbringing or slaughtering methods. The "animal welfare" label means animals used for production were raised using high-welfare farming practices. Thus, the levels were "animal welfare label" or "no label is reported". Finally, four price levels were created that are representative of current market prices for four-pound packages of ground chuck hamburger patties in the US ($3.5/lb, $6.3/lb, $9.1/lb, and $12.0/lb).

A sequential Bayesian approach to construct the experimental design was used (Blimer et al., 2008; Scarpa et al., 2007; Scarpa and Rose, 2008). Using the software Ngene and uninformative priors, we constructed an efficient design for use in a pilot survey (Blimer et al., 2008). Parameter priors from the pilot study (n= 203) then updated a Bayesian efficient design (Scarpa and Rose, 2008). Each choice task was composed of three product alternatives (options A, B, or C) and a "no buy" option (option D). The choice tasks within the block and products within each choice task (options A, B, or C) were randomly ordered. A sample choice set is provided in Appendix 2.

The choice experiment was provided to the respondents following the explanation and description of attributes as well as the information treatment. Respondents were asked to read a cheap talk script to reduce the hypothetical bias affecting the WTP in stated preference studies (Cummings, and Taylor, 1999). After the twelve choice tasks, respondents were asked to fill out a questionnaire to collect consumers' demographic characteristics and further data.

Data Collection

Qualtrics was used to collect data from 1,120 US consumers in 2021. Consumers were randomly recruited by the market research company Dynata (https://www.dynata.com/). Participants were paid a small financial incentive for participating in the survey. Only consumers 18 years or older were included in the survey. Respondents who took less than 6 minutes or more than 45 minutes to complete the survey or did not pass the attention check were not included in the analysis. We verified following randomization to treatments that we achieved balance for observable characteristics across treatments. The results shown in Table 2 test the equality of means across treatment for most sociodemographic characteristics and fail to reject at the 5% significance level. After the choice task, described in the following section, we provided a self-administered, online questionnaire to obtain information on additional factors so that we could test for possible correlations between these factors and individuals' WTP for lab grown meat. The questionnaire collected information regarding participant's marital status, education, employment status, age, political orientation, likelihood of buying cultured meat and animal welfare attitudes.

Random assignment was prioritized throughout the study when providing prior information and values for individuals willingness to pay. Within the group given basic information with positive and negative effects of lab grown meat, the participants were randomly assigned to either positive or negative effects of lab-grown meat given first, followed by the counter. Research shows that depending on the individual, receiving either solely positive, solely negative, or both positions will have an effect on the choices the individual makes (Ein-Gar, 2012). To ensure the loss of subjects is minimal, the survey will use Likert-scale questions and will take no longer than 10 minutes to complete.

Specific variables collected in the questionnaire section of the survey were considered that have had previous significance in acceptance of novel food technologies. These variables were age, political orientation, likelihood of buying cultured meat, and animal welfare attitudes. The variable for likelihood of buying cultured meat was tested following the CE. The variable for animal welfare attitudes was created using an animal attitude scale consisting of six Likert scale statements assessing attitudes toward the use of animals. Each item was scored on a seven-point scale, with the anchors of strongly agree and strongly disagree at each end of the scale and neutral in the center. The six items measured attitudes toward the treatment and use of animals, including their use as food, in research, how animals should be slaughtered, and how the government should be involved in regulating animal welfare. High scores on these attitude measures represented increased concern for the welfare of other species. Similar scales of various lengths have been used in research (e.g. Herzog, 2015). An electronic copy of the survey can be obtained by contacting the authors.

Experimental Treatments

To test our research hypotheses, each respondent was assigned to a treatment differing only by the information phrasing in regard to IVM. All subjects in each treatment were presented with the neutral information from Treatment 1 or the experimental control. A description of each treatment follows, and the information sets used in the survey are listed in Appendix 1.

<u>Treatment 1: Neutral Information</u>

Treatment 1 included 284 subjects who were presented with only the neutral information, which was presented to all subjects in the experiment, and read as follows: *Meat consumption has been crucial for the human diet for thousands of years. The human population by 2050 is expected to be about 9.15 billion, and according to the Food and Agricultural Organization, 70% more food* *than what is currently produced will be needed to sustain this population. Lab grown meat, also known as in vitro meat, is an alternative system to current livestock practices that creates an animal product from a sample of tissue from an animal and rapidly duplicates the cell tissue to form a meat product. The cells are kept within an environment with a growth solution to replicate the conditions of the inside of an animal in order to make a product similar to taste, texture, and appearance of meat from different animals.*

Treatment 2: Positive Information

Treatment 2 included 277 subjects who were first presented with the neutral information on IVM and then were presented with the following, positive information: *In vitro meat presents many advantages to current livestock practices. Raising livestock has negative effects on the environment. Greenhouse gas emissions from agriculture productions, including methane and nitrogen, largely come from the livestock industry. Meat production requires a substantial amount of water depending on animal type and age. A typical quarter-pounder burger requires about 634 gallons (2,400 liters) for its production. Water pollution is an issue from animal waste that can affect produce as well. Land use and degradation is also a consequence of livestock practices. In vitro meat would significantly reduce the issues caused by the livestock industry currently by reducing number of animals slaughtered for same amount of meat (no animal slaughter is needed for this process), reducing the carbon footprint of the livestock industry, decreasing water use and contamination, land use, and consequently greenhouse gas emissions from the livestock industry.*

Treatment 3: Negative Information

275 subjects were assigned to Treatment 2. These subjects were presented with the neutral information as well as negative information about IVM which reads as follows: *In vitro meat*

(IVM) as an emerging market still has many unknowns in its viability and does present some issues and concerns for producers and consumers. An initial problem with IVM is the type of cell that will be used. Muscle stem cells are a possible option, but it is difficult to control these cells in a large number needed for replication to create a meat product. It is also still unknown if holding and duplicating cells would become genetically instable, so cancerous cell development could possibly arise. Texture of IVM can also be an issue for consumers. It would be difficult to produce an identical meat product to that of a product from living livestock. Hence, IVM might not be identical in taste, appearance, texture, and composition to livestock products.

<u>Treatment 4: Combined Information</u>

Treatment 4 included 284 subjects who were presented with the neutral, positive, and negative information about IVM.

Research Hypotheses

Based on the treatments described previously, we tested a series of hypotheses to determine impact of positive and negative information on consumers' mWTP values for buying lab grown hamburger products. First, we tested Treatment 1 (neutral) vs. Treatment 2 (positive) to investigate whether positive information significantly increased consumers' willingness to pay for lab grown meat. Therefore, we tested the following:

$$H_{01}: \left(WTP^{Neutral} - WTP^{Positive}\right) = 0$$

$$H_{11}: \left(WTP^{Neutral} - WTP^{Positive}\right) \neq 0$$

Second, we tested Treatment 1 (neutral) vs. Treatment 3 (negative) to investigate whether negative information significantly reduced consumers' WTP for IVM. Thus, we tested the following:

$$H_{02}: \left(WTP^{Neutral} - WTP^{Negative}\right) = 0$$

$$H_{12}: \left(WTP^{Neutral} - WTP^{Negative}\right) \neq 0$$

Third, we tested Treatment 1 (neutral) vs. Treatment 4 (combined) to investigate whether combined positive and negative information resulted in significantly different WTP for IVM. Therefore, we tested:

$$H_{03}: \left(WTP^{Neutral} - WTP^{Combined}\right) = 0$$

$$H_{13}: \left(WTP^{Neutral} - WTP^{Combined}\right) \neq 0$$

Fourth, we tested Treatment 2 (positive) vs. Treatment 3 (negative) to examine the magnitude of the effects of positive and negative information on WTP for IVM. Thus, we tested the following:

$$H_{04}: \left(WTP^{Positive} - WTP^{Negative}\right) = 0$$

$$H_{14}: \left(WTP^{Positive} - WTP^{Negative}\right) \neq 0$$

Fifth, we tested Treatment 2 (positive) vs. Treatment 4 (combined) to investigate whether there were any significant differences in WTP for IVM between the positive and combined treatments. Thus, the following was tested:

$$H_{05}: \left(WTP^{Positive} - WTP^{Combined}\right) = 0$$

$$H_{15}: \left(WTP^{Positive} - WTP^{Combined}\right) \neq 0$$

Sixth, and finally, we tested Treatment 3 (negative) vs. Treatment 4 (combined) to investigate whether there were any significant differences in WTP for IVM between the negative and combined treatments. Thus, the following was tested:

$$H_{06}: \left(WTP^{Negative} - WTP^{Combined}\right) = 0$$

$$H_{16}: \left(WTP^{Negative} - WTP^{Combined}\right) \neq 0$$

We also tested the effects of age, political orientation, and attitudinal factors of the likelihood to buy cultured meat and animal welfare attitudes, on individuals' mWTP formation for IVM. Each of these factors is discussed further here.

1. Effect of age: previous literature found that older adults are less willing to accept new food technologies (Sourcier, 2019). Thus, we expect that older participants will have higher mWTP values than younger participants.
2. Effect of political orientation: prior research has shown that liberal/left consumers were more accepting of IVM and saw it as more ethical and natural than those who identified as conservative (Wilks, 2017). Thus, we hypothesize that participants who identify as liberal will have higher mWTP values for IVM.
3. Effect of likelihood to buy cultured meat: consumers that indicate an increased likelihood to buy cultured meat will have a higher mWTP variable for lab grown meat.
4. Effect of animal welfare attitudes: as a reduction in animal slaughter is a prominent benefit of lab grown meat and an increase in WTP for specific products is associated with an increase in animal welfare (Kilders, 2021), we hypothesize that consumers who have a higher score for animal welfare attitudes will have a higher mWTP value.

Econometric Analysis

In order to test our research hypotheses, a discrete choice framework was used to estimate the effect of the information treatments on consumers WTP values. The mixed logit model was selected in order to account for preference heterogeneity, and the model was specified in WTP space in order to directly estimate mWTP at the individual level (Train, 2009). WTP space models offer more realistic WTP distributions as well as greater stability in WTP estimates. The WTP space models are consistent with random utility theory (McFadden, 1974) and Lancaster consumer theory (Lancaster, 1966). The utility (*U*) function is specified as:

$$U_{ijt} = \alpha_i(ASC - PRICE_{ijt} + \theta_{i1}PRODUCT_{ijt} + \theta_{i2}CARBON_{ijt} + \theta_{i3}ORGANIC_{ijt} + \theta_{i4}WELFARE_{ijt}) + \epsilon_{ijt} \quad (1)$$

where i refers to the individual, j refers to three options available in each choice set, t refers to the number of choice situations, and α_i is the price scale parameter assumed to be random and to follow a log-normal distribution. The *ASC* is a dummy coded alternative constant indicating the selection of the "no-buy" option available in a choice set. The price ($PRICE_{ijt}$) attribute is represented by four experimentally defined price levels (i.e., \$3.50/lb, \$6.30/lb, \$9.10/lb and \$12.00/lb). $PRODUCT_{ijt}$ is a dummy variable representing the production method, taking the value of 0 if the production method is 'conventional' and the value of 1 if the production method is 'cultured'. $CARBON_{ijt}$ is a dummy variable representing the Carbon Trust label, taking the value of 0 if no label is present and the value of 1 when the Carbon Trust label is present. $ORGANIC_{ijt}$ is a dummy variable taking the value of 0 if no Organic label is reported and 1 if the Organic label is present. $WELFARE_{ijt}$ is a dummy variable representing the Animal Welfare label, taking the value of 0 if no label is present and 1 if the label is included. θ_{i1}, θ_{i2}, θ_{i3}, and θ_{i4} are coefficients that represent the estimated individual level mWTP values for production method, Carbon Trust label, Organic label, and Animal Welfare label, respectively. Finally, $\in_{ijt}$ is an unobserved random term assumed to be normally distributed following an extreme value type I (Gumbel) distribution, independent and identically distributed (iid) over alternatives. The parameters for the non-price attributes were modelled as random parameters with a normal distribution and the no-buy parameter was modelled as a fixed parameter.

To test our six research hypotheses, the differences in the mWTP between the treatments were estimated using the combinatorial approach by Poe, et al. (2005). The test used generated a distribution of 1,000 WTP using the Krinsky and Robb (1986) bootstrapping method. The resulting mWTP for each treatment and their significance or lack thereof, indicated whether each respective null hypothesis is accepted or rejected, for each attribute. To test the effects of age, political orientation, and attitudinal factors of the likelihood to buy cultured meat and animal welfare attitudes, on individuals' mWTP formation for IVM, we conducted subsample analyses. The models were estimated using the gmnl package in R (Sarrias and Daziano, 2017).

Results

The results of the mixed logit model specified in WTP space in Equation (1) for the four treatments are reported in Table 3. We measured the mWTP values for consumers in each treatment based on the attributes in the choice experiment: production method, carbon trust, organic, animal welfare, and price. In all four treatments, subjects indicated, on average, a preference for ground beef that was produced using conventional methods over cultured meat, as indicated by the negative mWTP values (Table 3). Production method had the largest response from subjects in magnitude, when compared to the coefficients of the other attributes (the price coefficient is provided as a preference space coefficient and is not comparable). Subjects in Treatment 3 (negative information) had the largest mWTP value of -$7.34 for cultured meat; this negative mWTP value can also be interpreted as requiring the largest discount to purchase the product. Subjects exposed to neutral information and combined information (Treatments 1 and 4) had similar WTP values of -$5.55 and -$5.72, respectively. Subjects exposed to positive information (Treatment 2) required the lowest discount -$4.68. Subjects in all four treatments also expressed positive, significant preferences for the organic label, with mWTP ranging from $1.50 to $2.79, and the animal welfare label, with mWTP ranging from $3.28 to $4.11. The carbon trust label was not found to be significant in any treatment. The negative and significant price coefficient, provided in Table 3 as a preference space estimate, indicated that in all four treatments, subjects preferred lower prices.

Hypotheses Tests

Next, we examined the hypotheses tests related to the effect of information on the WTP for cultured meat. Table 4 summarizes the results of the hypotheses tests. First, we tested Treatment 1 (neutral) vs. Treatment 2 (positive) to investigate whether positive information significantly affected consumers' WTP for lab grown meat. The results of this test were mixed, with significantly higher positive mWTP values observed for the carbon, organic, and animal welfare labels but an insignificant effect on production method. Table 3 shows that the mWTP for the production attribute is larger in magnitude in Treatment 1 than in Treatment 2, -$5.55 and -$4.68, respectively; however, the effect of positive information regarding the benefits of cultured meat production was not a strong enough to induce significantly lower premiums required by consumers.

Second, we tested Treatment 1 (neutral) vs. Treatment 3 (negative) to investigate whether negative information significantly reduced consumers' WTP for IVM. The results of this hypothesis test demonstrate that when subjects were presented with negative information regarding IVM, they required a significantly higher premium, $1.84, than those presented with neutral information. Only differences between the production method attribute were found to be significant when comparing Treatments 1 and 3.

Third, we tested Treatment 1 (neutral) vs. Treatment 4 (combined) to investigate whether combined positive and negative information resulted in significantly different WTP for IVM. The results for this hypothesis 3 were similar to those for hypothesis 1, with positive and significant differences found for all attributes except production method. The subjects exposed to neutral information had significantly higher mWTP values for all attributes except the production attribute, which was not found to be significantly different between Treatments 1 and 4.

Fourth, we tested Treatment 2 (positive) vs. Treatment 3 (negative) to examine the different effects of positive and negative information on preferences for cultured meat. The results of this hypothesis test indicate that positive and negative information induced significant differences for all attributes. Negative information led to lower WTP values for the carbon, organic, and animal welfare attributes, relative to positive information. Notably, the difference in WTP for the production attribute was the most substantial in magnitude than in another other hypothesis test, with subjects in the negative information treatment requiring an additional discount of $2.67 when compared to subjects exposed to positive information on IVM. This result clearly demonstrates the power of how information regarding the IVM technology is framed to consumers can have a substantial impact on preference formation.

Fifth, we tested Treatment 2 (positive) vs. Treatment 4 (combined) to investigate whether there were any significant differences in WTP for IVM between the positive information and combined information treatments. Results were mixed, though a weakly significant difference was found for the production method attribute, indicating that the combined information treatment led to larger discounts required by subjects, compared to subjects in the positive information treatment.

Finally, we tested Treatment 3 (negative) vs. Treatment 4 (combined) to investigate whether there were any significant differences in WTP for IVM between the negative and combined treatments. Significant differences were observed for all attributes. Those exposed only to negative information required a larger discount to purchase cultured meat products than those exposed to combined information, but placed a lower value on all other attributes.

Subsample Analysis

Next, we to test for heterogeneity in the treatment effects, we conducted a sub-sample analysis using the factors of age, political orientation, attitudinal factors of the likelihood to buy cultured meat, and animal welfare attitudes. These results are summarized in Table 5. Age had little effect on the WTP for cultured meat, with a weak significance found only in Treatment 4, where increasing one year in age resulted in a decrease of $0.10 mWTP, on average. Age was not found to be significant in any other treatment. Political orientation was found to be positive and significant in treatments 1 and 3, although the significance was weak. In treatments 1 and 3, the discount required by subjects decreased by $3.22 and $4.07, respectively, as political orientation moved from republican to democrat, indicating democrats may be generally more accepting of IVM technology. Subjects indicating a willingness to purchase cultured meat were found to have significantly higher mWTP values in all treatments. Subjects indicating strong preferences for animal welfare were found to have significantly higher mWTP values in Treatment 2 and but in Treatment 3, these subjects had significantly lower mWTP values.

Discussion

Our goal was to evaluate the effects of different types of information regarding the benefits and consequences of cultured meat technology has on consumer preferences for IVM. We also examined how such information may influence preferences for three other labels: organic, carbon trust, and animal welfare. Finally, our subsample analysis allowed us to investigate any correlations between select consumer characteristics and WTP for IVM.

Our results are interesting and have broad ranging implications. First, the mWTP in all treatments for IVM was negative, indicating that consumers are not as accepting of IVM as they are of traditional production methods. Another way to interpret these findings is that retailers of IVM products should expect to offer substantial discounts in order to attract consumers. Second, we observed important differences in mWTP values between treatments demonstrating that the framing of information about cultured meat can have a significant impact on consumer preferences for IVM. Subjects in Treatment 2 (positive information) required the lowest discount to choose IVM while subjects in Treatment 3 (negative information) required the highest discount. Hypothesis 4, which examined the differences between negative and positive information framing, further supports this conclusion with the largest significant difference in mWTP for IVM. What may be troubling from a marketing perspective, are the results of Hypothesis 1 which found there to be no significant difference in the discount required when comparing neutral information to positive information. Food retailers may find it challenging to attract consumers to cultured meat products via positive advertising campaigns.

Third, our subsample analysis offered only limited insights into the significance of age, political orientation, and animal welfare preferences on the discounts required for consumers to purchase cultured meat. One explanation why our results did not support previous findings in the literature is that perhaps the negative reaction to IVM technology is so strong in magnitude across the majority of subjects, that it becomes difficult to detect less important factors. The only variable in the subsample analysis with explanatory power across all four treatments was a high likelihood of buying cultured meat in the future. Regardless of the information framing employed, those who were more willing to buy cultured meat placed a higher value on the product. Surprisingly, the animal welfare attribute was small in magnitude and only significant in two treatments. Since IVM technology could vastly reduce the number of animals slaughtered for meat, we expected a stronger and significant animal welfare attribute in our experiment. Again, perhaps the reaction to IVM is so strong that it overwhelms otherwise important attributes of the product. An alternate explanation could be that participants view the production of cultured meat as being harmful to the animal.

Conclusion

Our results show that consumers generally prefer ground beef meat produced through the conventional production method and tend to reject IVM. Consumers in our study also express significant, positive preferences for the organic and animal welfare labels. The information treatments were also found to significantly influence the magnitude of the estimated willingness to pay values. Our findings provide insights into consumer preferences for and attitudes towards lab grown meat, which can be useful in communicating with the public about these new products. Our results provide important insights into the role that information plays in the formation of preference for cultured meat products. Negative information framing appears to be a more powerful tool than positive information to influence consumer preferences for IVM. However, our results demonstrate the positive information about the benefits of IVM can have a significant effect on the discounts required to attract consumers to cultured meat products. The results clearly demonstrate that consumers will expect a heavy discount in order to consume IVM which places pressure on producers of cultured meat to be able to take an idea from a laboratory setting and scale it to a level where economics of scale can drive the cost of production low enough to accommodate consumer price expectations.

Further research is needed to fully explore the potential market for IVM. The traditional livestock industry is expected to push hard for labeling requirements on IVM. How such labels are framed could have substantial impacts on the market for cultured meat. Given the amount of research documenting consumer interest in animal welfare, an experiment designed to examine how to better synthesize the themes of animal welfare and IVM would be interesting. The ability to combine attributes that increase WTP with those that reduce WTP in order to “balance” out the pricing of IVM could be critical to reducing the discounts indicated in our results. Finally, the ability to introduce real cultured meat products to consumers in a real choice experiment, where consumers can gain experience with IVM would lead to more reliable results that can more easily be translated to market settings.

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Tables

Table 1: Attributes, levels, and definitions

ATTRIBUTES	LEVELS	DEFINITION
Production method	"Conventional" "Cultured/Lab Grown"	"Conventional" products are produced by raising beef cattle in beef cattle farms, at different ages the cattle are transported to slaughterhouses where they are slaughtered and quartered "Cultured/Lab Grown" products are produced by taking a small number of cells from a live calf or steer by means of an unpainful biopsy, cells will proliferate in nutrient-rich medium until cultured beef is formed
Carbon Trust Label	Carbon Trust Label No label is reported	"Carbon Trust" indicated the product was produced with a commitment to reduce carbon emissions
Organic	Organic Label No label is reported	"Organic" means no antibiotics or growth hormones were ever used in producing the product, produced without pesticides, synthetic ingredients, bioengineering, or ionizing radiation
Animal Welfare	Animal Welfare Label No label is reported	"Animal Welfare" means animals used for production are raised outdoors on a pasture or range for their entire lives using sustainability and high-welfare farming practices
Price	$14.0 ($3.5 per pound) $25.2 ($6.3 per pound) $36.4 ($9.1 per pound) $48.0 ($12 per pound)	Prices for four-pound packages of ground chuck hamburger patties with price per pound specified

Table 2: Sociodemographic characteristics

Variable	Treatment 1: Neutral Information	Treatment 2: Positive Information	Treatment 3: Negative Information	Treatment 4: Combined Information
	(N= 284)	*(N= 277)*	*(N= 275)*	*(N= 284)*
Gender				
Male	52.65%	54.51%	49.82%	54.58%
Female	47.54%	45.49%	50.18%	45.42%
Chi-squared= 0.1094				
Age				
18-35	30.28%	34.30%	27.27%	35.21%
36-53	43.66%	33.57%	39.27%	33.10%
54-71	19.72%	24.19%	24.73%	26.06%
71>	6.34%	7.94%	8.73%	5.63%
Chi-squared= 0.1094				
Area of Growing Up				
Urban	66.55%	67.15%	61.82%	67.61%
Rural	33.45%	32.85%	38.18%	32.39%
Chi-squared= 0.2432				
Area of Residence				
Urban	70.42%	69.31%	65.09%	72.89%
Rural	29.58%	30.69%	34.91%	27.11%
Chi-squared= 0.2432				
Employment				
Student	5.63%	6.86%	4.36%	5.99%
Independent Worker	10.21%	11.55%	9.82%	12.32%
Private-sector worker	35.56%	30.69%	34.55%	27.11%
Public-sector worker	9.86%	10.83%	12.00%	14.08%
Retired	18.66%	22.74%	21.82%	20.42%
Unemployed	10.56%	11.91%	11.27%	11.97%
Not in paid employment	5.28%	1.81%	2.55%	2.82%
Other	4.23%	3.61%	3.64%	5.28%
Chi-squared= 0.6532				

Table 2: Sociodemographic characteristics continued

Variable	Treatment 1: Neutral Information	Treatment 2: Positive Information	Treatment 3: Negative Information	Treatment 4: Combined Information
	(N= 284)	***(N= 277)***	***(N= 275)***	***(N= 284)***
Income				
Less than $15,000	11.27%	12.27%	10.55%	11.27%
$15,000-29,00	11.97%	13.00%	9.09%	15.14%
$30,000-44,000	8.80%	10.11%	13.45%	9.51%
$45,000-59,000	11.27%	13.00%	18.55%	10.92%
$60,000-74,000	8.80%	11.19%	5.45%	7.04%
$75,000-89,000	9.15%	10.11%	7.64%	9.15%
$90,000-119,000	11.27%	9.03%	9.45%	11.62%
$120,000-149,000	11.97%	13.72%	14.18%	11.27%
$150,000 or more	15.49%	7.58%	11.64%	14.08%
Chi-squared= 0.0882				
Political Orientation				
Republican	27.11%	31.05%	29.82%	26.06%
Democrat	46.13%	38.99%	37.09%	45.07%
Independent	23.59%	28.16%	28.73%	27.11%
Other	3.17%	1.81%	4.36%	1.76%
Chi-squared= 0.2197				
Education				
Less than high school	2.11%	1.81%	1.45%	1.41%
High school/GED	16.20%	19.49%	15.27%	20.42%
Some college	17.61%	15.16%	18.55%	17.25%
2-year College Degree	8.45%	8.30%	12.73%	9.86%
4-year college degree	28.17%	27.44%	27.27%	25.00%
Master's Degree	22.89%	22.38%	17.09%	20.42%
Doctoral Degree	1.41%	4.00%	4.36%	3.17%
Professional Degree	3.17%	1.44%	3.27%	2.46%
Chi-squared= 0.6379				

Table 2: Sociodemographic characteristics continued

Variable	Treatment 1: Neutral Information	Treatment 2: Positive Information	Treatment 3: Negative Information	Treatment 4: Combined Information
	(N= 284)	*(N= 277)*	*(N= 275)*	*(N= 284)*
Race				
White	72.54%	75.09%	76.00%	77.46%
Black or African American	10.21%	6.50%	8.00%	7.75%
American Indian or Alaska Native	1.06%	0.00%	1.09%	1.06%
Asian	8.45%	7.94%	5.82	5.63%
Native Hawaiian or Pacific Islander	0.70%	0.00%	0.36%	0.00%
Hispanic or Latino	2.46%	3.61%	4.36%	2.46%
Other	4.58%	6.86%	4.36%	5.63%
Chi-squared= 0.6417				

Table 3: mWTP Results from WTP Space Models for Four Treatments

Attribute	Treatment 1: Neutral Information	Treatment 2: Positive Information	Treatment 3: Negative Information	Treatment 4: Combined Information
	mWTP (p-value)	mWTP (p-value)	mWTP (p-value)	mWTP (p-value)
Production Method	-5.55 *** (0.00)	-4.68 *** (0.00)	-7.34 *** (0.00)	-5.72 *** (0.00)
Carbon Trust	0.65 (0.24)	-0.27 (0.79)	0.66 (0.22)	-0.22 (0.00)
Organic	2.79 *** (0.00)	1.97 *** (0.00)	2.73 *** (0.00)	1.50 *** (0.00)
Animal welfare	4.11 *** (0.00)	3.28 *** (0.00)	4.00 *** (0.00)	3.39 *** (0.00)
Price (in Preference Space)	-21.26 *** (0.00)	-19.14 *** (0.00)	-21.25 *** (0.00)	-22.05 *** (0.00)
AIC	4890.73	4651.325	4637.827	4872.592
BIC	5119.866	4879.463	4865.675	5101.728
n	284	277	275	284

∗∗∗, ∗∗ and ∗ denote statistical significance at the 1, 5 and 10 per cent levels, respectively.

Table 4: Hypotheses Tests Comparing mWTP Between Treatments

Hypotheses Tests	Production Method	Carbon Trust	Organic	Animal welfare
	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)
$H_{01}:(WTP^{Neutral} - WTP^{Positive}) = 0$	-0.83 (0.097)	0.93 *** (0.00)	0.82 *** (0.00)	0.84 *** (0.00)
$H_{02}:(WTP^{Neutral} - WTP^{Negative}) = 0$	1.84 *** (0.00)	0.002 (0.495)	0.04 (0.43)	0.0978 (0.35)
$H_{03}:(WTP^{Neutral} - WTP^{Combined}) = 0$	0.202 (0.381)	0.89 *** (0.00)	1.28 *** (0.00)	0.704 *** (0.00)
$H_{04}:(WTP^{Positive} - WTP^{Negative}) = 0$	2.67 *** (0.00)	-0.93 *** (0.00)	-0.78 *** (0.00)	-0.737 *** (0.00)
$H_{05}:(WTP^{Positive} - WTP^{Combined}) = 0$	1.04 * (0.04)	-0.04 (0.399)	0.47 *** (0.00)	-0.13 (0.275)
$H_{06}:(WTP^{Negative} - WTP^{Combined}) = 0$	-1.64 ** (0.01)	0.88 *** (0.00)	1.25 *** (0.00)	0.606 *** (0.00)

∗∗∗, ∗∗ and ∗ denote statistical significance at the 1, 5 and 10 per cent levels, respectively.

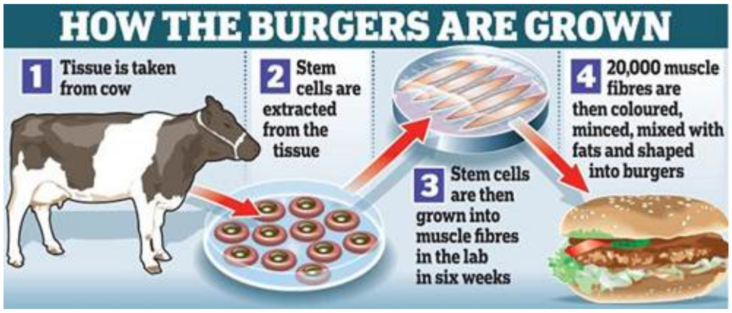
Table 5: Results of Sub-Sample Analysis of mWTP for Lab Grown Meat

Variable	Treatment 1: Neutral Information	Treatment 2: Positive Information	Treatment 3: Negative Information	Treatment 4: Combined Information
Age	-0.05 (0.31)	-0.05 (0.14)	-0.08 (0.13)	-0.10 * (0.03)
Political Orientation	3.22 * (0.03)	-0.31 (0.79)	4.07 * (0.01)	1.67 (0.22)
Buying Cultured Meat	2.64 *** (0.00)	2.21 *** (0.00)	2.14 *** (0.00)	1.99 *** (0.00)
Animal Welfare	-0.02 (0.89)	0.35 *** (0.00)	-0.31 * (0.04)	0.24 (0.06)
Constant	-9.32 * (0.02)	-15.79 *** (0.00)	-0.39 (0.93)	-12.15 ** (0.00)

***, ** and * denote statistical significance at the 1, 5 and 10 per cent levels, respectively.

Appendices

Appendix 1: Information Treatments



Note: same image shown in each treatment

<u>“Neutral” Information</u>

Meat consumption has been crucial for the human diet for thousands of years. The human population by 2050 is expected to be about 9.15 billion, and according to the Food and Agricultural Organization, 70% more food than what is currently produced will be needed to sustain this population. Lab grown meat, also known as *in vitro meat*, is an alternative system to current livestock practices that creates an animal product from a sample of tissue from an animal and rapidly duplicates the cell tissue to form a meat product. The cells are kept within an environment with a growth solution to replicate the conditions of the inside of an animal in order to make a product similar to taste, texture, and appearance of meat from different animals.

<u>“Neutral” Information and Positive Effects of Lab Grown Meat</u>

Meat consumption has been crucial for the human diet for thousands of years. The human population by 2050 is expected to be about 9.15 billion, and according to the Food and Agricultural Organization, 70% more food than what is currently produced will be needed to sustain this population. Lab grown meat, also known as *in vitro meat*, is an alternative system to current livestock practices that creates an animal product from a sample of tissue from an animal and rapidly duplicates the cell tissue to form a meat product. The cells are kept within an environment with a growth solution to replicate the conditions of the inside of an animal in order to make a product similar to taste, texture, and appearance of meat from different animals.

In vitro meat presents many advantages to current livestock practices. Raising livestock has negative effects on the environment. Greenhouse gas emissions from agriculture productions, including methane and nitrogen, largely come from the livestock industry. Meat production requires a substantial amount of water depending on animal type and age. A typical quarter-pounder burger requires about 634 gallons (2,400 liters) for its production. Water pollution is an issue from animal waste that can affect produce as well. Land use and degradation is also a consequence of livestock practices. *In vitro meat* would significantly reduce the issues caused by the livestock industry currently by reducing number of animals slaughtered for same amount of meat (no animal slaughter is needed for this process), reducing the carbon footprint of the livestock industry, decreasing water use and contamination, land use, and consequently greenhouse gas emissions from the livestock industry.

<u>"Neutral" Information and Negative Effects of Lab Grown Meat</u>

Meat consumption has been crucial for the human diet for thousands of years. The human population by 2050 is expected to be about 9.15 billion, and according to the Food and Agricultural Organization, 70% more food than what is currently produced will be needed to sustain this population. Lab grown meat, also known as *in vitro meat*, is an alternative system to current livestock practices that creates an animal product from a sample of tissue from an animal and rapidly duplicates the cell tissue to form a meat product. The cells are kept within an environment with a growth solution to replicate the conditions of the inside of an animal in order to make a product similar to taste, texture, and appearance of meat from different animals.

In vitro meat (IVM) as an emerging market still has many unknowns in its viability and does present some issues and concerns for producers and consumers. An initial problem with IVM is the type of cell that will be used. Muscle stem cells are a possible option, but it is difficult to control these cells in a large number needed for replication to create a meat product. It is also still unknown if holding and duplicating cells would become genetically instable, so cancerous cell development could possibly arise. Texture of IVM can also be an issue for consumers. It would be difficult to produce an identical meat product to that of a product from living livestock. Hence, IVM might not be identical in taste, appearance, texture, and composition to livestock products.

<u>"Neutral" Information with Positive and Negative Effects of Lab Grown Meat</u>

Meat consumption has been crucial for the human diet for thousands of years. The human population by 2050 is expected to be about 9.15 billion, and according to the Food and Agricultural Organization, 70% more food than what is currently produced will be needed to sustain this population. Lab grown meat, also known as *in vitro meat*, is an alternative system to current livestock practices that creates an animal product from a sample of tissue from an animal and rapidly duplicates the cell tissue to form a meat product. The cells are kept within an environment with a growth solution to replicate the conditions of the inside of an animal in order to make a product similar to taste, texture, and appearance of meat from different animals.

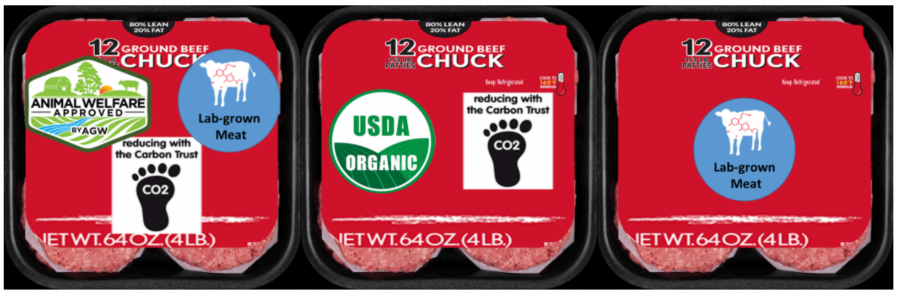
In vitro meat presents many advantages to current livestock practices. Increased meat consumption has negative effects on the environment. Greenhouse gas emissions including methane and nitrogen are largely produced by the livestock industry. Meat production requires a substantial amount of water depending on animal type and age. A typical quarter-pounder burger requires 2,400 liters for its production. Water pollution is an issue from animal waste that can affect produce as well. Land use and degradation is also a consequence of livestock practices. In vitro meat would significantly reduce the issues caused by the livestock industry currently by reducing number of animals slaughtered for same amount of meat, reducing the carbon footprint of the livestock industry, decreasing water use and contamination, land use, and consequently greenhouse gas emissions from the livestock industry.

However, in vitro meat (IVM) as an emerging market still has many unknowns in its viability and does present some issues and concerns for producers and consumers. An initial problem with IVM is the type of cell that will be used. Muscle stem cells are a possible option, but it is difficult to control these cells in a large number needed for replication to create a meat product. It is also still unknown if holding and duplicating cells would become genetically instable, so cancerous cell development could possibly arise. Texture of IVM can also be an issue for consumers. It would be difficult to produce an identical meat product to that of a product from living livestock. Hence, IVM might not be identical in taste, appearance, texture, and composition to livestock products.

Appendix 2: Sample Choice Set

Assume that you are shopping for 4 lbs of beef patties.

The three options are of the same size, quality, taste, and other characteristics. **They differ only in price and the method in which the beef patties were produced as indicated by the presence or absence of certification labels.**



Not buy any of them

$36.4 ($9.1/lb)	$36.4 ($9.1/lb)	$25.2($6.3/lb)	Not buy any of them
○	○	○	○

Appendix 3: Cheap Talk Script

The following script was presented to all subjects in the study:

Studies show that people tend to act differently when they face hypothetical decisions. In other words, they say one thing and do something different. For example, some people would say they would choose an item in a hypothetical situation, but when faced with non-hypothetical or real choices (e.g., in supermarket), they will not actually choose the item that they said they would choose. We want you to behave in the same way that you would if you really had to choose between products in a retail store.

Now please imagine you are shopping beef patties at retail store where you usually buy your groceries.

The button to continue with the survey will appear in 15 seconds. Please use the time to read the information carefully before proceeding.