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LAB-GROWN CHICKEN VS FARM-RAISED CHICKEN

Part 1: Research Proposal

I. Executive Summary / Abstract

In recent years there has been a remarkable surge in interest for meat alternatives. Consumers have become more conscious of their environmental footprint and the moral impact of their decisions which has opened the door for new methods of production and innovative alternatives to explode in popularity and therefore profitability. In 2021, the global alternative meat market was valued at 5.4 billion dollars and is projected to grow to 12.3 billion dollars by 2029.[1] One such method gaining traction, but still in its infancy as it pertains to consumer awareness, is lab-grown chicken. Since consumers still place high importance on maintaining the taste and sensory attributes of traditional meat, this study seeks to quantify consumer taste preferences of lab-grown chicken and traditional chicken. In this experiment, the control group will consume two samples of farm-raised chicken meat, and the treatment group will consume one sample of farm-raised chicken meat and one sample of lab-grown chicken meat. Untrained participants (n = 210) will be selected based on a quota sampling criteria to partake in this study from a population of self-selected participants and be assigned to each group based on a stratified sampling criteria. The main objective will be to determine if there is a significant preference between the taste of lab-grown chicken meat and farm-raised chicken meat.

II. Statement of the Problem

Consumers of meat have become increasingly conscious of both the environmental and moral implications of their dietary choices causing a shift in the food industry toward meat alternatives and alternative means of production. From an environmental perspective, the existing meat production process contributes heavily to climate change and deforestation. Nearly 80% of greenhouse gasses, comprising 12% of global anthropogenic GHG emissions, are caused by the meat production process, and this has been proven to cause habitat destruction for other animals[2]. From a moral perspective, there is concern whether it is morally right to slaughter living animals for human consumption. Although meat alternatives have saturated the market, cruelty-free methods of meat production are still in exploration but hold a lot of appeal to consumers as they allow them to honor their values while continuing to enjoy the taste of meat. One new approach to tackle the growing demand for sustainable meat alternatives is to grow the meat in a laboratory. However, consumer acceptance, specifically on the taste and texture of lab-grown meat, could be a significant barrier to this alternative taking off in popularity. Thus, to increase confidence for investment in companies exploring expansion into lab grown meat production, we propose conducting a study to analyze consumers' preferences and perceptions on the taste of lab-grown chicken compared to farm-raised chicken in order to determine whether there is a discernible difference in taste.

III. Literature Review

In light of the aforementioned shift in the food industry, it is not surprising that consumer preference for meat alternatives has become a prominent area of investigation for researchers. A lot of effort has been put behind examining what influences consumer choices between traditionally farmed meat and alternative options, such as plant-based or lab-grown meat. What the studies have found is that health and environmental concerns were the major drivers of consumer interest in seeking alternatives.[3] Lab-grown meat produces less greenhouse gas emissions while consuming fewer natural resources, solving for the proven desire consumers have to do better for the environment.[4] Taste and sensory attributes have also been shown to be crucial factors in consumer acceptance. Research has shown that when given the choice between farm-raised meat, plant-based meat, and lab-grown meat, 72% of consumers chose farm-raised meat. When brand names were introduced, the percentage of consumers who chose farm-raised meat rose to 80%. In simulated purchasing scenarios, farm-raised meat was still the favored choice among consumers despite heavy price reductions to plant-based and lab-grown meat.[5] This indicates that consumers have a strong conscious preference for "real" meat and are willing to pay a premium for it. However, studies also show that consumers hold mostly negative opinions about lab-grown meat.[6] Although 75% of consumers said they would not be willing to eat lab-grown meat, willingness to eat lab-grown meat was proven to increase as familiarity with lab-grown meat increases.[7] This means that while consumer attitudes towards lab-grown meat are currently poor, these attitudes can be changed and therefore once attitudes change, purchasing decisions may too. This is exactly what happened with plant-based meat. At inception, this alternative was met with heavy skepticism as the taste and texture did not satisfy consumers. However, advancements in technology and investment from companies like Beyond Meat and Impossible Foods played a significant role in popularizing plant-based meat by creating innovative products that closely mirrored the taste and texture of traditional meat.[8] Additionally, research confirmed consumer willingness to try plant-based meat significantly increased after experiencing positive sensory attributes during taste tests.[9] The existing literature has examined consumer attitudes towards lab-grown meat and hypothetical meat purchasing decisions, but this study seeks to understand consumers' taste preferences between lab-grown chicken meat and conventional chicken meat. If consumers try lab-grown chicken and they like it, the popularity of lab-grown chicken will likely increase, giving confidence to companies that investment in expanding operations of this alternate production method will pay off.

IV. Research Questions, Hypotheses, and Effects

As a growing number of consumers seek sustainable food options, lab-grown meat holds immense potential to change the meat industry to be more sustainable and morally-sensitive. However, consumers' preferences play a critical role in determining the success of lab-grown meat in the existing market. To determine if consumers have a differing taste perception of lab grown meat, this study aims to address whether participants can distinguish between the taste of farm-raised chicken meat and the taste of lab grown chicken meat.

The main research question is: "Is the difference in taste ratings significantly different between the control group, which consumed two samples of farm-raised chicken meat, and the treatment group, which consumed one sample each of lab-grown and farm-raised chicken meat?" The null hypothesis would be: "The difference in taste ratings between the control group and the treatment group is equal" The alternative hypothesis would be: "The difference in taste ratings between the control group and the treatment group is not equal". The minimum meaningful difference will be 0.25 based on a 1 to 5 rating scale with a standard deviation of 0.5 giving us a minimum effect size of 0.5.

The secondary research question is: "Is the difference in price valuation significantly different between the control group, which consumed two samples of farm-raised chicken meat, and the treatment group, which consumed one sample each of lab-grown and farm-raised chicken meat?" The null hypothesis would be: "The

difference in price valuation between the control group and the treatment group is equal." The alternative hypothesis would be: "The difference in price valuation between the control group and the treatment group is not equal". The minimum meaningful difference will be $2.00 with a standard deviation of $2.00 giving us a minimum effect size of 1.

The results will help us understand consumers' preferences and perceptions on lab-grown meat, and the results will assist us in making our decisions regarding investment in production and optimal pricing of lab-grown chicken meat.

V. Importance of the Study and Social Impact

Authors (Names and Percentages): Paul Cho, 50% / Jade Adams, 50%

Growing consumer awareness of both the environmental and moral implications of their dietary choices has generated significant demand for alternative meat products in the food industry. In this context, lab-grown chicken has the opportunity to penetrate and succeed in the market as long as taste and texture maintain parity to regular chicken. There is a clear indication that alternative meat products can play a significant role in mitigating climate change by reducing anthropogenic GHG emissions while protecting wildlife habitat[2]. If consumers are as satisfied with the taste of this alternatively produced chicken as they are with regular chicken, we have the opportunity to reduce traditional farming of chicken and the negative environmental consequences it has. This knowledge on taste parity will be relevant for food manufacturers, policymakers, and companies aiming to invest in and promote this more morally sound production method. Heavy investment will be needed to expand production in the lab so confidence in the success of the lab-grown chicken in the market is paramount.

VII. Research Plan - Population of Interest

For this research plan, the population of interest will be potential consumers of chicken meat products residing in the United States. The study aims to gather insights from individuals who are likely to make informed decisions about consuming lab-grown meat. Therefore, participants must be adults aged 18 years and above to ensure participants can provide informed consent and make meaningful taste and price preference evaluations. In addition, participants must be residents of the United States since the study is conducted within the jurisdiction of the FDA, which recently approved lab-grown chicken meat.

To maintain the focus on potential consumers of chicken meat products, individuals who have an aversion to consuming chicken or dietary restrictions will be excluded from the study. Participants who have a strong aversion to consuming chicken, whether due to personal preference, religious beliefs, or dietary restrictions, will be excluded to ensure they do not introduce bias in taste preference evaluations. Individuals who avoid consuming for health-related dietary reasons will be excluded to ensure the consistency of taste evaluations based on standard seasoning.

By adhering to these inclusion and exclusion criteria, the study will gather data from a relevant and appropriate population, providing valuable insights into the taste and price preferences of potential consumers of lab-grown meat.

VIII. Research Plan - Sample Selection

Given that we need to conduct this study physically, we will have to limit the sample geographically to reduce costs and participation bias associated with travel. We have selected Charleston, South Carolina as the geographic location for this study because as of 2022, Charleston's demographics closely resemble those of the entire U.S.[10] Although we would like to avoid excluding a large proportion of the population from the study, sampling from the entire U.S. population is not practical given the physical aspects of our study. Focusing on Charleston as the source of our sampling helps us progress in sample selection while maintaining reasonably representative demographic diversity. In addition, Charleston's population is smaller compared to its major metropolitan counterparts (i.e. New York City, Los Angeles), which will help mitigate the costs associated with our recruitment process.

Participants will be recruited through social media, television, and mail advertising in which participants can express interest in participating for a monetary incentive if they are selected. Multiple channels of advertising are utilized to prevent participation bias from those that are more inclined to utilize a particular channel. However, this sampling method is still based on participants' election to participate, so it will inevitably result in participation bias. Participants may be more likely to be people that are motivated by the monetary incentive, perhaps from lower income households. Participants may also be more likely to be more progressive-minded people that are willing to try lab-grown chicken or may also have stronger opinions pertaining to lab-grown meat.

Although it is not possible to completely eliminate participation bias, we can attempt to minimize it with several measures. First, participants will also be asked to provide basic demographic information such as race, gender, income, and age. Given that information, we can utilize quota sampling to ensure that participants are selected to participate in a way such that the sample is demographically representative of the U.S. population and does not disproportionately represent demographic groups that are more likely to participate in experiments. Furthermore, the experiment will be conducted on both weekends and weekdays and at different times in order to prevent participation bias due to scheduling availability. Given that we are reaching out to households, we determined that any person within the same household is eligible to participate as long as they meet the criteria. This is meant to encourage participation and to help ensure that we have a sufficient population of willing participants from which to properly quota sample. Although eligible participants from the same household may share similar preferences, we can assume that they are still independent, individual decision-makers when it comes to taste, and as such, they are allowed to participate as long as it meets our quota sampling requirements.

Participants will be randomly assigned to the control and treatment groups from within each demographic group via stratified sampling. Although we can potentially eliminate selection bias through simple random sampling at this point, there is potential for disproportionate representation due to chance given to the small sample size. As such, stratified sampling by demographic group is intended to ensure both the control and treatment groups are still demographically representative of the overall population.

IX. Research Plan - Operational Procedures

As referenced previously, recruitment will be conducted through social media, television, and mail advertising. Each channel will provide the same information to prospective participants: the topic of the study, which is lab-grown chicken meat, information on the cash incentive, and the times and locations the study will take place. The monetary incentive will be $100 cash offered for completing the entire experiment. Although $100 may seem excessive for a simple experiment, the amount reflects compensating participants for transportation time and related costs in addition to an incentive. Social media and television users will be prompted to visit a website link to express interest. The website will require the prospective participant to provide consent to

consume natural and lab-grown meat, their availability to perform the taste test, and answer demographic questions pertaining to age range, income range, and ethnicity identification. Prospective participants that view the mail advertisement will have the option to utilize the same website link or mail back the advertisement with the required information. Social media advertisements will ideally be shown to all users over the age of 18. However, if users under the age of 18 try to participate, they will be excluded based on the aforementioned age criteria. Television advertisements will be displayed on a variety of channels to prevent selection bias. Mail advertisements will be sent to all households within Charleston. Prospective participants must provide all required information to be eligible for participation. To encourage participation and to prevent participation bias based on location or scheduling, we will offer study locations on both weekday and weekend days in North, South, West, East, and Central Charleston. Participants will be invited for participation based on location and time availability, in addition to our demographic quota sampling criteria. Participants will also be randomly assigned to either the control group or treatment group at this time in accordance to our stratified sampling criteria. Participants not initially selected may be considered at a later time if initially selected participants fail to show up.

Once participants arrive at the testing location, they will be taken to a simple room with a table, chair, and a screen. Participants will be first provided with their first sample of chicken meat and asked to consume it. After participants have finished consumption and answered all necessary research questions, they will be presented with water as a palate cleanser before repeating the same process with their second sample of chicken meat. The first research question simply asks participants to rate the consumed meat sample from a scale of 1 to 5. Immediately following the participant's answer to the first research question, we will proceed with the second research question, in which the participant will be shown a photo of a dish with the sampled meatballs as the primary ingredient. Participants will be asked how much they would be willing to pay at a restaurant for the dish if the dish consisted of the meatballs they just consumed. Participants are required to provide a numerical figure for the second research question. Research questions will be displayed on the screen and participants will respond verbally. Experiment assistants will record responses digitally on a computer with pre-set inputs. This is to prevent biases from any potential interactions between assistants and participants.

We will need to prepare edible chicken samples for the purposes of this study. To ensure consistency, only one person will prepare the food samples and all samples will be made with a set procedure. Samples will only require heating under boiled water with a set temperature and a fixed amount of time at testing sites. Given that lab-grown meat is typically different in texture from natural meat, samples will be grounded up to prevent such bias. We will prepare two 100-gram samples of chicken meatballs for each participant. Each meatball will be seasoned with exactly 1 gram of salt to provide a more pleasant taste while maintaining consistency within the experiment. This will be done before the chicken meat is formed into meatballs to ensure the salt is evenly distributed. The control group will receive two samples of natural chicken, while the experiment group will receive one natural sample and one lab-grown sample.

Survey Questions:

1. [Sample 1]
    a. What would you rate this sample on a scale of 1 (most dissatisfied) to 5 (most satisfied)?
    b. How much are you willing to pay for this plate of meatballs at a restaurant (not including tip or drinks)?
2. [Sample 2]
    a. What would you rate this sample on a scale of 1 (most dissatisfied) to 5 (most satisfied)?
    b. How much are you willing to pay for this plate of meatballs at a restaurant (not including tip or drinks)?

X. Research Plan - Brief Schedule

We estimate this research will take place over the course of three months. The study will be broken down into four major phases: the planning phase, the data collection phase, the analysis phase, and the summation phase. The planning phase will take three weeks and include productionalizing the research design, ensuring the ethical considerations, getting the relevant approvals, procuring the sample meatballs, ensuring repeatability of sample quality, and designing and launching the recruitment advertising. During this time, the researchers will determine the television channels on which to advertise the study, capture and align the photos that showcase the sampled meatballs, procure the testing location center rentals, and train the test administrators. Next, the data collection phase will take four weeks. This phase includes airing of television advertisements and participant recruitment followed by participant screening and selection to ensure criteria defined above are upheld in the final selected sample. Next during this phase, researchers will conduct the taste tests which will include randomly assigning participants between the control and treatment group, ensuring flawless logistics of the participants, sample meatball delivery, and administration of the taste test. Results will be collected during this phase before we move to Data Analysis. This next phase of Data Analysis will take three weeks. Researchers during this phase will clean and organize the data that was collected to ensure any erroneous responses are removed. Statistical analysis will then be conducted and interpretation of the results will be done to determine the conclusions from this sample group on the taste rating of consumers. Lastly, one week will be spent on the summation phase. This phase will involve peer reviews, post-mortem documentation of the procedures, notes for future reference, and draft iterations of the research publication. Key results will be summarized and shared with the relevant stakeholders in the industry for use in their investment decisions for lab-grown meat production. This schedule is an estimate of the research plan, but the actual timeline could vary based on unforeseen obstacles and delays.

XI. Research Plan - Data Collection

Data collection will be facilitated digitally, and only the minimum amount of data points required to complete the study will be collected. The minimum amount of data points include survey question responses and participant demographic information (i.e. participant age, participant income). Participant contact information must also be collected for legal and accounting purposes. Upon arrival to the study, participants will be asked to provide identification, which can be a state-issued ID such as a driver's license or a government-issued ID such as a passport. Based on the participant's ID, study facilitators will update the necessary participant's records accordingly. Copies or scans of the participant's ID are not necessary and will not be taken. The study's data collection page will be on a computer cleared for research purposes by the study architects in coordination with the research company's information technology team. Study facilitators will interface with the data collection screen. Study participants will not interface with the data collection computer in an effort to prevent nonsensical responses and strengthen data integrity. If participants are unsure about what is expected, study facilitators will assist. The computer will be cleared of non-essential applications that may hinder or delay study performance. Study facilitators will be instructed not to alter computer settings without prior written approval from the study designers. As part of high-integrity standards and practices, researchers are to be certified in data security and privacy measures within the research space when onboarded to the organization. Additionally, researchers must

take and pass an annual data security and data privacy training course to stay up to date on the latest privacy and security measures. Researchers must be recertified every year due to the ever-changing nature of data security and privacy best practices and legal requirements. The research company's data security team will handle these measures and vet the annual and certification trainings in accordance with their subject area expertise.

XII. Research Plan - Data Security

To ensure the security of the data collected for this study, all records will be stored in a password protected cloud location. In addition, a password change policy will be in place for this cloud location, which will require the password to be changed every six months or whenever an individual who knows the password leaves the team or the organization. This approach will ensure that only authorized users can access and manage the data. The participant responses will serve as the base data set, capturing line-level observations for this study. The participant responses table will be created to store all participants securely by having a field for a unique six digit numerical participant ID that will be set to join to the participant reference table, which has the same participant ID field. By linking the participant ID across tables, it ensures the security and confidentiality of the data collected while easing the process of analyzing and interpreting the data. The participant reference table will contain encrypted personal information of the participants and it will be permissioned based on the data security principle of leave privilege. Only individuals who absolutely need the de-anonymized participant-level data will be granted permission to view it. This approach will reduce the risk of unauthorized access to sensitive data while ensuring the data privacy.

XIII. Research Plan - Outcomes (Dependent Variables)

The dependent variables of our study will be taste rating, which is an ordered numerical categorical variable, and price preference, which is a continuous variable. The taste rating will be measured to evaluate the participants' ratings of the meat samples. Participants will be asked to rate the taste of the two samples, and their ratings for each sample will be recorded. To record this variable participants will be presented with two meat samples, lab-grown and farm-raised, and will indicate their preference based on a taste rating scale of 1 to 5, where a difference of 0 indicates no taste preference between samples and a difference of 4 indicates the greatest taste preference between the samples. For the price preference variable, the price the participant is willing to pay will be recorded which will allow us to understand the price point consumers are willing to purchase lab-grown chicken meat at. Participants will be asked what they would pay for a lab-grown chicken meat dish at a restaurant (i.e. $5, $10), and their willingness to pay will be used to calculate the consumer price differential between lab-grown meat and farm-raised meat.

XIV. Research Plan - Treatments (Independent Variables)

The independent variables of this study are the treatment of whether the participant consumes Lab-Grown Meat or Farm-Raised Meat Samples. The main treatment involves randomly providing participants with two meat samples: either two traditional farm-raised chicken samples or one from lab-grown chicken and the other from farm-raised chicken. Participants will taste and compare these samples to determine if they detect any taste difference between the two. To administer this test participants will be randomly assigned to either the treatment group (lab-grown meat sample) or the control group (natural meat sample). The hypothesis is that there will be no significant taste difference between the two groups which will deem investment in lab-grown meat production practical.

XV. Research Plan - Other Variables

Outside of the outcomes and treatments, we will also collect data on demographics and familiarity with lab-grown meat. Demographic data collection will be limited to race, age, gender, and income. This data should already be available as part of the participant recruitment process. In order to better define the target market interested in lab-grown meat for future advertising purposes, these data points will be collected to assess differences in taste perception or if certain profiles are more sensitive to price. Familiarity with lab-grown meat is another important outside variable to collect as prior research outlined in the literature review has shown that we see a correlation in acceptance of lab-grown meat and familiarity. Collecting this variable can ensure we gauge how prior exposure might influence their taste perception and price preference. To measure this participants will answer questions related to their previous experience with lab-grown meat or similar meat alternatives after completing the first two research questions. These questions will be assessed on a numerical Likert scale.

XVI. Statistical Analysis Plan

For our intended analysis we plan to ensure accurate and complete data prior to interpreting conclusions through thorough data cleaning and preparation. Missing data will be handled appropriately and outliers will be identified and evaluated for removal. With the cleaned data, we will utilize a two-sample t-test to determine significance in the difference in taste ratings between the control group and the treatment group for the main research question. Given that the difference could either be greater or less than, we will utilize a two-sided alternative. We will apply the same statistical test to the secondary research question. In addition to the formal research questions, we will also consider other variables collected during the experimental process as part of our analysis. These variables include categorical demographic information, and numerical data on familiarity with lab-grown meat. For analysis with these other variables, we will also aggregate all rating and price point data from both control and treatment groups and specify the type of meat (farm-raised or lab-grown) as an additional other variable. With these variables, we can create a multiple regression model that assesses the effects of these other variables on either the rating or the price valuation of the chicken sample. Reporting will be done in clear tables and graphs and the limitations of the study clearly outlined with any dissemination of results. Following this statistical analysis plan will ensure we provide meaningful insights into consumer perception of lab-grown chicken and uphold moral principles for participants voluntarily participating in our study.

XVII. Sample Size and Statistical Power

We will be referencing the main research question in setting parameters for sample size and statistical power. First, the significance level (often referred to as alpha) will be standardized to 5% ($\alpha = 0.05$). The significance level is a measure of the probability that the sample's test is a result of chance. A significance level of 5% is considered the standard for most research studies. Moreover, given that the results of this study is meant to inform consumer preferences, a lower significance level is not necessary as 5% is a tolerable level of potential error when it comes to determining consumer preferences. However, this would not be the case for studies with higher stakes such as those for clinical trials.

Next, the level of statistical power will be set to 95%. The power metric measures how well the data will detect the studied effect, which in this study is the difference between the average rating of lab-grown meat and the average rating of natural chicken meat. A power of 95% will require a slightly larger sample size compared to a power of 80%, which is the standard minimum for statistical tests. However, given that taste preferences are subtle, a larger power would ensure a higher degree of confidence that the true effect is captured in the testing.

The effect size was calculated to be 0.5, based on a difference in means of 0.25 and a standard deviation of 0.5. The minimum meaningful difference in ratings will be benchmarked at 0.25, judged on the basis of a Likert scale of 1 to 5. This means that we expect a minimal difference of 0.25 between the average rating of lab-grown meat and the average rating of natural meat to be meaningful. This 0.25 figure is rationalized considering that if 25% of the group had a rating with at least a 1 magnitude of difference (out of 5) in the same direction, while the remaining 75% of the group retained their original ratings, then deviation in average rating would be at least 0.25. This implies that if at least 25% of the group can detect a noticeable difference then we would consider that to be meaningful. In the context of a restaurant, the majority of parties at a restaurant consist of two or more people.[11] Hence if at least 25% of participants can detect a difference in taste, we can expect at least half the parties at a restaurant to include an individual that can detect a difference in taste. As such, we determined the threshold for meaningfulness to be if the majority of parties at a restaurant included an individual that can detect a difference in taste. As for the standard deviation, that is set at 0.5 considering that we are evaluating a difference in ratings of two meat samples within each group. We do not expect a significant difference in ratings of the meat samples within each group given the similar cooking techniques utilized, hence we set the standard deviation at 0.5, which would entail a 2 standard deviation range of -1 to 1 difference in rating between the two samples with a group.

Finally, being that the alternative hypothesis states that we expect the average ratings to not be equal, rather than greater than or less than the other, a two sided test is appropriate.

With these aforementioned parameters determined, the minimum sample size can then be calculated. Using the "pwr" library in R, the minimum number of participants in each group is 105. This sample size for each group is both reasonable and achievable within the context of this research design.

XVIII. Possible Recommendations

For the main research question, we reviewed taste rating comparison. If the null hypothesis was not rejected, this indicates that there is no significant and meaningful difference in rating between lab-grown chicken meat and farm-raised chicken meat, suggesting that consumers are equally satisfied with the two types of meat. In this case, the recommendation would be to continue investing in the expansion of lab-grown meat production,

as consumer preferences for taste would not be a significant barrier to market adoption. Efforts could be directed towards promoting the environmental and morally-sensitive benefits of lab-grown meat as a sustainable and humane alternative to traditional meat. If the null hypothesis was rejected and there is a significant and meaningful difference in taste perception in one meat type versus the other, we would have to consider which type is rated more highly. If the lab-grown meat is rated higher, we can proceed with the same recommendation as the null hypothesis not rejected scenario. If the lab-grown meat is rated lower, we would recommend additional effort to be made to improve the taste of the lab-grown chicken.

For the second research question we analyzed price preference. If the null hypothesis is not rejected, this indicates that there is no significant and meaningful difference in willingness to pay between lab-grown chicken meat and farm-raised chicken meat, suggesting that consumers are willing to pay equal prices for both types of meat. In this case, the recommendation would be to focus on pricing strategies that align lab-grown meat with the price range of natural meat. Companies can promote lab-grown meat on the basis of its differentiating features, such as a sustainable and morally-sensitive product without substantially deviating from the pricing of conventional meat. If the null hypothesis is rejected, this indicates that there is a significant and meaningful difference in willingness to pay between lab-grown chicken meat and farm-raised chicken meat, suggesting that consumers have distinct price preferences for each type of meat. In this situation, the recommendation would be to conduct a price optimization analysis to determine the ideal pricing for lab-grown meat that maximizes consumer acceptance and market penetration. It might be necessary to explore pricing strategies that make lab-grown meat more competitive with natural meat while emphasizing its unique attributes, such as sustainability and animal welfare benefits.

Regardless of the research findings, it is crucial to focus on consumer education and awareness campaigns about lab-grown meat's benefits and positive impact on the environment and animal welfare. Building consumer trust and acceptance for this novel food technology will be essential for successful market adoption. Additionally, ongoing research and development efforts should be prioritized to continuously improve the taste, texture, and overall consumer experience of lab-grown meat products. Collaborative efforts between industry players, regulatory bodies, and consumer advocacy groups will also play a vital role in promoting the growth and acceptance of lab-grown meat as a sustainable and morally-sensitive alternative in the food industry.

XIX. Limitations and Uncertainties

While this experiment will uncover useful consumer behaviors and attitudes, there are some limitations that we must consider. First, the participation in this experiment is voluntary, as such there is inherent participation bias. However, this bias was mitigated as much as possible given the aforementioned controls via quota sampling and stratified sampling. Next, the preparation of both samples of meat are likely to eliminate the component of texture, which was indicated in previous research as an important factor on meat consumer perceptions. Also, the preparation of lab-grown meat in meatball form is not necessarily representative of how lab-grown meat will be served and prepared so further research could be done using different presentations of the chicken meat. Another uncertainty in this study is the concept of ratings. Consumers may taste the difference between lab-grown meat and farm-raised meat but rate the two equally. So if the average ratings for lab-grown meat and farm-raised meat in this study are statistically equal, then this means that there is a level of uncertainty with what lab-grown meat manufacturers can accurately market as a result of this study. For example, lab-grown meat manufacturers may not be able to accurately say that consumers “can’t taste the difference”. Rather the phrasing may have to slightly change to something like, “consumer satisfaction levels for lab-grown meat are no different than farm-raised meat”. Another factor to consider is that as indicated in the literature review, consumers are willing to pay a higher price for sustainably and morally sourced products. An increased price point

can offset the dilutive gross margin companies exploring lab-grown chicken will face. However, in this study we assessed the consumer's price valuation of the chicken meat based purely on taste rather than knowledge of its sourcing, hence testing price valuation based on sourcing knowledge can be a variable to consider for future research. Furthermore, while this study is built on the notion that lab-grown meat is more morally-sensitive than farm-raised meat, this study does not explore the true morally-sensitive impacts of lab-grown meat such as carbon emissions, ethical sourcing, sustainability, and manufacturing waste.

Part 2: Simulation of Effects

XX. Simulated Studies

				Percentage of ...			
Research Question	**Scenario**	**Mean Effect in Simulated Data**	**95% Confidence Interval of Mean Effect**	**False Positives**	**True Negatives**	**False Negatives**	**True Positives**
Question 1	No Effect	-0.0016	(-0.2770, 0.2743)	5.60%	94.40%		
	Effect: Rating Decrease of 0.5	-0.5016	(-0.7770, -0.2257)			6.30%	93.70%
Question 2	No Effect	-0.0063	(-1.1079, 1.0973)	5.60%	94.40%		
	Effect: Willingness to Pay Decrease of $2.00	-2.0051	(-3.0173, -0.9177)			4.10%	95.90%

Source for above screenshot

For each research question, two scenarios were simulated, creating four separate simulation scenarios. Each scenario simulated 1,000 experiments. In each scenario, we simulated two values for each group. In the control group, both values represent a farm-raised chicken sample. In the treatment group, the first value represents the lab-grown chicken sample and the second value represents the farm-raised chicken sample. The second value is subtracted from the first value in all cases to calculate the mean effect.

The first research question sought to measure the difference between ratings of lab-grown meat and farm-raised meat. The first scenario covers the first research question where no effect is observed. Under this scenario, there is no significant and meaningful difference between the average rating of lab-grown meat and the average rating of farm-raised meat. To properly simulate this lack of effect, we will use the same mean and standard deviation inputs for both the control and treatment groups. For simplicity, we assumed a neutral rating of 3 for the mean. Assuming that most people will not have a strong opinion on the taste of chicken meat, we selected a standard deviation of 0.5, which would entail a -1 to 1 two standard deviation range. This would imply that 95% of participants rated the samples between 2 and 4, which is reasonable given our assumptions. This no effect scenario would be beneficial for lab-grown meat manufacturers as it would support the assertion that consumers enjoy lab-grown meat just as much as farm-raised meat. The simulated data shows the average rating difference is close to zero (-0.0016), with a confidence interval close to a range of 0.5: (-0.277, 0.2743). Our 95% power parameter helped yield strong results: 5.6% false positives and 94.4% true negatives.

Next, the second scenario also covered the first research question except this time there was an expected decrease of 0.5 in the average rating of lab-grown meat compared to farm-raised meat. As such, we adjusted the mean rating for the treatment group to be 0.5 lower than 3 to 2.5. Standard deviations are kept constant for both groups for simplicity, and the control group retained its mean of 3 as in scenario 1. The average observed difference in the simulations was -0.5016, which is close to the -0.5 expectation. The confidence interval still shows a range of 0.5, except now the confidence interval shifted to an entirely negative range: (-0.777, -0.2257). The strong statistical parameters again yielded reliable results: 6.3% false negatives and 93.7% true positives. This scenario would be unfavorable to lab-grown meat manufacturers as it shows that consumers rate lab-grown meat worse than farm-raised meat in a blind taste test.

The third scenario covered the second research question, which seeks to measure the average difference in willingness to pay between lab-grown meat and farm-raised meat. There is no meaningful effect in this scenario, meaning consumers are willing to pay the same price for lab-grown meat as they are for farm-raised meat. As such similarly as in scenario 1, we will utilize the same mean and standard deviation for both the control and treatment groups for the simulation. The mean will be set at $8, while the standard deviation is set at $2 to reflect a potentially wide range of preferences and spending tolerances. This would imply that 95% of participants would present a price valuation of between $4 and $12, which we consider a reasonable price range for a plain dish of meatballs. Consequently, the observed effect is -0.0063, which is practically zero. The confidence interval covered a range of approximately 2: (-1.1079, 1.0973). This scenario produced a 5.6% false positive rate and a 94.4% true negative rate. The results of this simulation would benefit lab-grown meat manufacturers as it shows that consumers are willing to pay just as much for lab-grown meat as they are for farm-raised meat.

The fourth and final scenario covered the second research question under the condition that there was a $2.00 decrease in the willingness to pay for lab-grown meat compared to the willingness to pay for farm-raised meat. Given that, we adjusted the mean price valuation of the treatment group lower by $2 from $8 to $6. The standard deviation remained at $2 for the control group, but was decreased to $1.5 for the treatment group to account for the decreased mean value. Furthermore, given the defined effect of a $2 decrease in price valuation, the implied assumption is that participants are more likely to value the lab-grown meat at a lower price point and may also be in greater consensus with each other, resulting in the reduced standard deviation. Accordingly, the mean effect in the simulated data was -2.0051, and the confidence interval was (-3.0173, -0.9177). The strong underlying parameters again produced reliable results: a 4.1% false negative rate and a 95.9% true positive rate. This scenario would be unfavorable to lab-grown meat manufacturers as it shows that consumers are willing to pay less for lab-grown meat compared to farm-raised meat.

XXI. References

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