Artificial Meat or Real Meat?

Santosh Suwal, HaoNan Ou, Zhiqiang Wang, Bethold Owusu

Abstract – Artificial Meat is gaining more and more attention from people. Many companies are now experimenting with artificial meat. Beyond Meat, a producer of plant-based meat substitutes, has products designed to simulate chicken, beef, and pork sausage. The company is collaborating with many fast-food chains, such as KFC, Mc Donald's and Dunkin' Donuts to promote new plant-based meat products. Example like Pizza Hut tested plant-based meat pizza at a location in Phoenix, Arizona, 2019. Burger King, White Castle, Subway, Popeyes also have embraced plant-based meat in recent years. People are highly interested in the unknown. As more and more companies bring their artificial meat products to the American market, people begin to discuss whether we should eat artificial meat or natural meat. Why more and more people choose to eat artificial meat or Vegan meat. That's why we decided to launch this project to understand from the perspective of consumers why they consume artificial meat. The way we design this project is to let us know if people are familiar with or have artificial meat. In addition, we want to know why consumers buy or try artificial meat. Do they make choices out of concerns about health-related issues? Does religion affect their choice of real and artificial meat? Does the place where consumers live affect their decisions? Does the income level of consumers affect their choice of meat consumption? Is there a relationship between people of different ages when they choose to eat real meat or artificial meat? We also want to know if consumers have the opportunity to try artificial meat and if they haven't tried it before, are they willing to do so. our results offer fast-food chain companies an insight to further understand consumer's current preferences about artificial meat.

1. INTRODUCTION

Recently, the word "artificial meat" has come into public view. What is artificial meat? Will it go to the people's table in the future? Artificial meat is just a convenient expression for the public to understand. Strictly speaking, artificial meat refers to Vega meat and Cultured meat. Cultured meat is produced by culturing animal cells in vitro rather than slaughtering animals. Researchers in the United States and the Netherlands have made a breakthrough in Cultured meat. Artificial meat contains higher protein and lower fat. With people's attention to nutrition and health, Artificial meat has a certain market basis and consumer groups. Despite the taste, safety, and cost issues, consumer's interest in consuming artificial meat is spiking. Compare to the real meat, some consumers may not like artificial meats, because its nature is "artificial". If artificial meat is used instead of real meat, many animals will avoid the fate of growing and killing in a bad environment. It can also address the more important challenges facing humanity, such as food shortages caused by population growth and rising food prices.

We created an online questionnaire to help our team collect individual responses to artificial meat. The intents of the survey were to get information on awareness about artificial meat, how popular it is and try to answer if it is a viable option instead of real meat. We have constructed a series of questions that we believe will help us understand why people consume artificial meat. We collected data to see how individuals care about their diet; thus, we focused on important decisions people make when it comes to their diet.

Based on the data we collected, we decided to focus on these topics. Do age and gender affect people's purchase of artificial meat? What's the difference between married and single people in terms of price, freshness and ingredient labels? According to whether they have heard

about artificial meat, if there is a choice, how likely are people willing to try artificial meat for the first time or again? How does location affect people's hearing and try artificial meat?

2. RELATED WORK

2.1 How Vegan is your state?

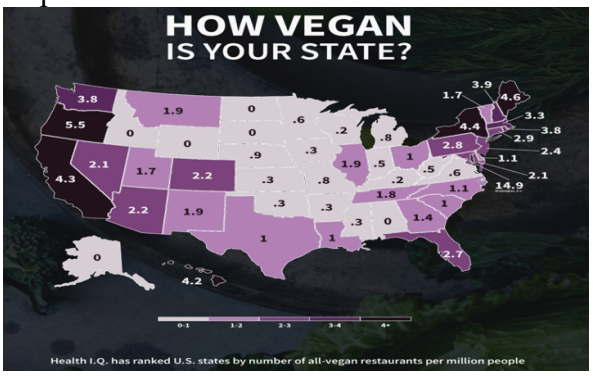
According to "How Vegan is your state?", the research conducted by the Health IQ team 4 years ago. The team found that vegetarianism was becoming mainstream. In recent years, many changes have taken place in the diet structure based on plant substitution, and great progress has been made. Although only 0.5% of the U.S. population said they followed a vegetarian diet in 2009, the number has more than quintupled in the next three years. This trend is consistent with the growth of vegan related Google keyword searches.

In the Health IQ team's research, Oregon ranked first for its friendliness to vegetarians in 2015. With a population of 4 million, it has 22 vegetarian restaurants across the state, equivalent to 5.5 restaurants per million people. This makes Oregon the tallest state for all Vegan Restaurants. In addition, California ranked second because it has 39 million people and 168 vegetarian restaurants, so there are 4.4 restaurants per million people. In addition, New York ranked third in vegan friendliness. New York has 86 vegetarian restaurants with a population of 20 million and 4.3 restaurants per million. However, 55 vegetarian restaurants have been provided in New York City itself, which shows that vegetarians are more concentrated in the city.

The research also mentions that, in response to the needs and opportunities, the national catering industry has taken advantage of this strong interest in vegetarianism. The number of all-vegetarian restaurants has greatly increased and will continue to grow. According to the Vegetarian Resource Group (VRG), nearly 24 years ago, there were only 55 all-vegetarian restaurants in the United States, but by 2015, the number had increased to 660.

The health IQ team visualized the map to rank the States' vegan levels. The basic idea is that they divide the number of vegetarian restaurants in each state by the population of each state to get the number of all-vegetarian restaurants per million people. They then load it on the map by state. Finally, use the color bar to rank the number of vegetarian restaurants in each state. On the basis of the map, we can easily see which state has the highest vegetarians ranking. In addition, the health IQ team create the trend line visualization based on the number of vegetarian restaurants that increased each year. As shown in the figure, the number of vegetarian restaurants increased significantly from 2005 to 2015.

For our project, if we can collect information about the responder's local artificial meat or vegan restaurant. We can also create such maps to better understand whether the geographical environment will affect people's consumption of artificial meat. Since our survey is conducted online, it is a challenge to obtain information about the local vegan meat restaurants of the respondent.

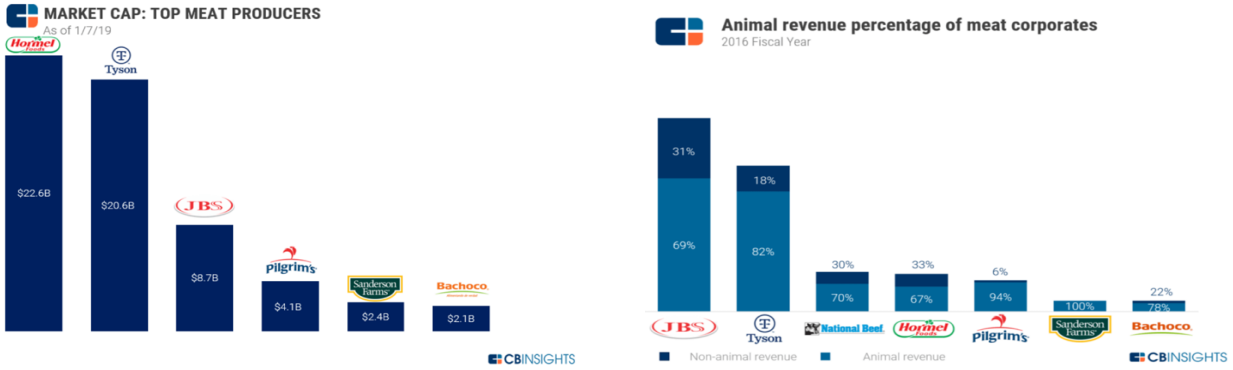


2.2 Our Meatless Future: How The $1.8 T Global Meat Market Gets Disrupted

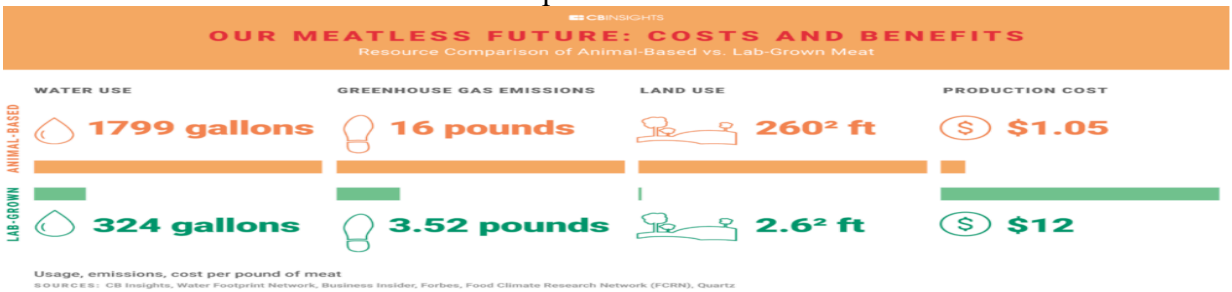
CB insight's research revolves around a theme: "will the meat, seafood substitutes and insect protein industry characterized by laboratory-grown meat become the future of food?" The answer is not now. According to the consensus of industry analysts of CB insights, the global meat market value is $1.8T. It is estimated that 30% of the calories consumed by humans come from meat products, including beef, chicken, and pork. In 2018, USDA data showed that domestic meat production reached a record high of more than 100 billion pounds. That means a staggering number of animals to raise. In the United States alone, there are about 30 million beef cattle, and in Iowa, there are about 20 million pigs.

As of the beginning of 2019, the market value of the six largest meat companies totaled $60 billion, of which the largest Hommel company was valued at $23 billion. But in 2019, Beyond Meat, the manufacturer of the plant-based beyond burger, went on the market at a price close to $1.5 billion. After that, Burger King released ta new menu, “Impossible Whopper”. The new sandwich replaces beef with plant-based meat produced by Impossible Foods. The Impossible Food company has raised more than 700 million in public offerings, and the valuation in the previous round of financing was $2 billion. When artificial meat becomes a hot topic, a new future is coming.

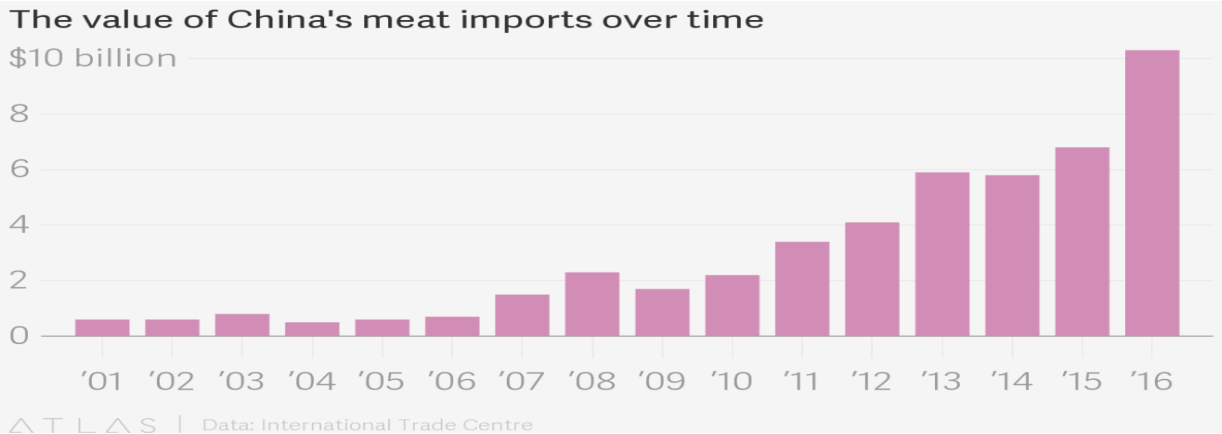
Visualization of top meat producers shows the market value on January 7, 2019, to give a better understanding of the performance of the meat industry in the US market. The Animal revenue percentage of meat corporates uses stacked bars to show the percentage of earnings. We can see companies like Tyson, Pilgrim’s and Sanderson Farms, more than 80% of their revenue comes from animal meat.



Startups destroy the value chain of meat production by developing artificial meat. Currently, about half of the states in the United States are in the process of enacting legislation aimed at preventing plant-based meat products from being labeled as "meat" or "beef". Several large meat-producing states have passed successful laws. In the visualization our meatless future: costs and benefits, comparing water use, greenhouse gas emissions, land use, and production costs. As we can see, artificial meat reduces water use, greenhouse gas emissions, and land use. The only drawback is that it costs 12 times more to produce than real meat.



Not only in the United States, but also in September 2017, China announced a $300 million deal to import laboratory-produced meat from three Israeli companies - Supermeat, Future Meat Technologies and Meat the Future. The aim is to reduce the country's meat consumption by 50%. In the visualization of the value of China's meat imports, we can see now that the cost has reached 10 billion and will rise with time.



In the research of CB insight, it deeply discusses the cost of artificial meat, how the meat industry is challenged and how artificial meat affects the whole world. At the same time, the stock value of artificial meat company and meat company is also discussed. Our project can learn from this study that we can compare the artificial meat industry with the meat industry and collect more information about whether people know these companies. Or, people just consume new things without any producer information.

3. DESIGN OF USER STUDY

3.1 Technology

Our project used Quartrics to conduct surveys, and then we distributed questionnaires to colleagues, friends and family members. We use the Jupyter notebook to conduct exploratory data analysis through python. This step helped us better understand the data and filter out the data with missing value more than 70%. We chose columns that are important to our topic and visualized them using Vega-Lite, folium map with leaflet JS. In addition, we use D3js to create parallel coordinates, circle packing, and hierarchical treemap.

Qualtrics is a simple to use a web-based survey tool to conduct survey research, evaluations, and other data collection activities.

Parallel coordinates are a common way of visualizing high-dimensional geometry and analyzing multivariate data. To show a set of points in an n-dimensional space, a backdrop is drawn consisting of n parallel lines, typically vertical and equally spaced.

A tree structure or tree diagram is a way of representing the hierarchical nature of a structure in a graphical form. Hierarchical treemap shows data in more illustrative form in a small area.

Circle packing is similar with treemap in many ways, but circle packing requires more area to illustrate similar amount of information as treemap. In addition, circle packing requires interaction to retrieve same amount of information as treemap. Circle Packing is in more ways engaging with zoomable circle packed in circles with children circle nested inside parent circles.

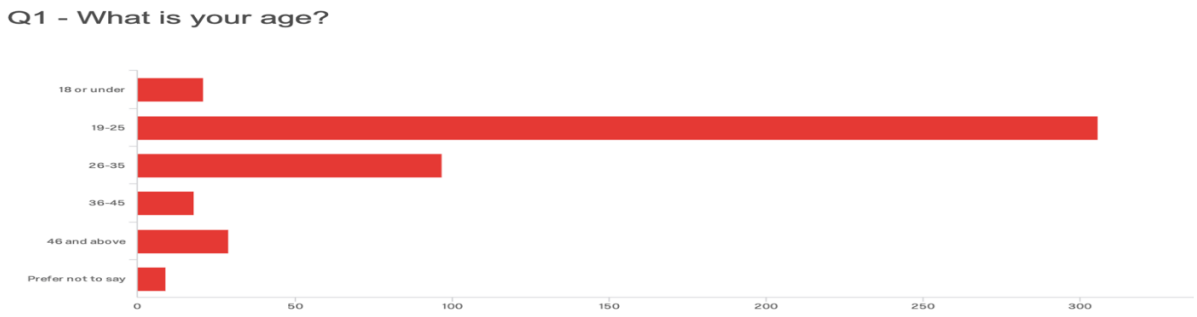
Moreover, d3 JS allows coloring different level of nested circles so that as observer can observe shuttle differences in nested levels.

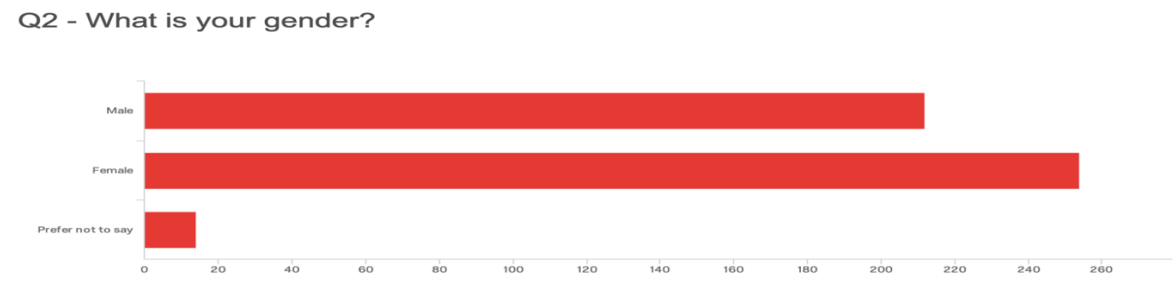
Folium is a python library that helps to create a global map and provides features such as popups, which are clickable and illustrate additional useful information about each data point based on the latitude and longitude. The library can also be used to calculate density by continent down to locality. Folium map uses Leaflet JS under the hood when the output is HTML.

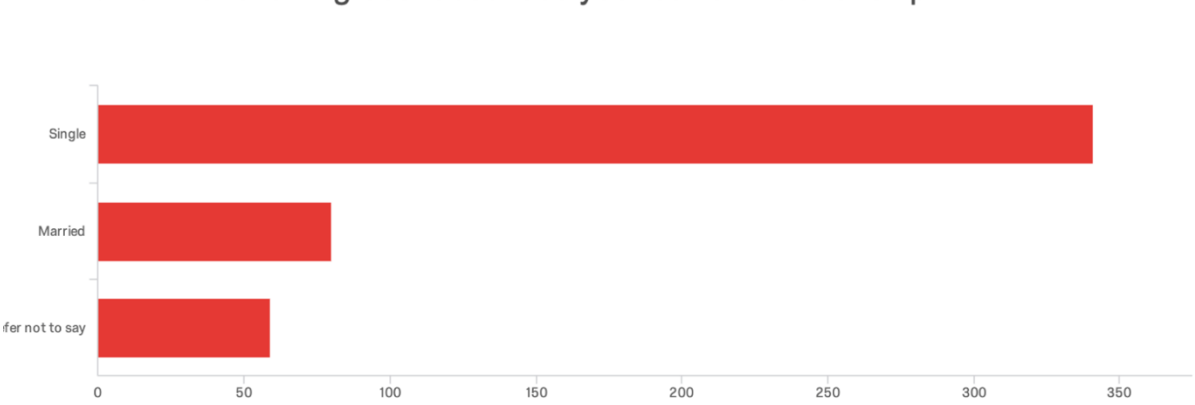
3.2 Data

We have built a list of questions that we think will help us understand the consumption of artificial meat from the perspective of consumers. Our survey contains the following questions:
Q1 - What is your age?
Q2 – What is your gender?
Q3 – what are you live?
Q4 – What is your highest level of education?
Q5 – Which of the following best describes your current relationship?
Q6 – Do you check the nutrition label when you purchase a food product?
Q7 – What information do you look for when you check the nutrition label?
Q8 – When you are shopping for meat products, what factors are important to you? [Rank in order of importance with 1 being the least important and 5 being the most important]
Q9 – Have you heard of artificial/vegan meat before?
Q10 – If you have heard of artificial meat before, from what source(s) did you hear it
Q11 – How often do you hear about artificial meat?
Q12 – Have you tried artificial/vegan meat before?
Q13 – How often do you consume artificial/vegan meat?
Q14 – How often do you consume real meat? (For example: pork/ beef)
Q15 – How likely do you think the taste of artificial meat will be similar compared to the taste of real meat?
Q16 – If you are given a choice, are you willing to try artificial meat?

Our data includes 410 survey responses, and we also collected their locations based on longitude and latitude. We divide them into six age groups, under the age of 18, 19-25, 26-35, 36-45, over 46, and prefer not to say. Since our survey is conducted online, the age distribution of respondents is more likely to be young. In addition, we divide people into three different gender groups, male and female, and prefer not to say. As we can see, we have more female respondents than males. Also, there are four times more single people than married people. It also shows that the rate of late marriage is getting higher and higher.







3.3 Tasks and Set-Up

We decide topics based on the data and then identify the specific columns to use. Our task is based on four themes. Does age and gender influence people's idea of consuming artificial meat? How individuals care about their diet. We focus on the important decisions people make about their diet. For example, what's the difference between married and single people in terms of price, freshness and ingredient labels? We also want to find out how people are familiar with artificial meat. According to whether they have heard about artificial meat, how likely is it to be willing to try or consume artificial meat? How does the geographical area affect people's familiarity and tasting of artificial meat?

For the first topic, will age and gender affect people's perception of consuming artificial meat? We use features as Q1, Q2, and Q13. We try to find a relationship based on visualization, which is based on the frequency of consumption of artificial meat in different age groups and gender groups.

For the second topic, what's the difference between married and single people in terms of price, freshness and ingredient labels. Our task is to analyze the differences in food decisions between couples and single people. We want to know which groups are more concerned about diet and the price they are willing to pay to stay healthy. In addition, we want to investigate how familiar these people are with artificial meat. Which group knows more about artificial meat or is more likely to consume it. We use Q1, Q2, Q3, Q4, Q5, Q8, Q9 and Q12 as our features, just as the graph shown below. The Marriage column consists of singles and couples (married); thus, individuals that responded to this survey indicated whether they were single or married. For the Price, Food freshness and Ingredients column, individuals had to select from a scale of 1-3. 1 means it is very important, 2 means important and 3 means somewhat important. For the ‘Heard of artificial vegan meat’ and ‘Tried artificial vegan meat’, individuals had to select either yes or no. 0 means yes and 1 means no.

	Age	Gender	Area	Education	Marriage	Price	Food_fresshness	Ingredients	heard of artificial_vegan meat	tried artificial/vegan meat
402	26-35	Female	North America/Central America	High school	Single	2.0	1.0	3.0	1	0
403	36-45	Female	North America/Central America	Middle school	Married	1.0	3.0	3.0	0	0
405	18 or under	Female	Europe	Bachelor's degree	Single	1.0	3.0	3.0	1	1
406	18 or under	Male	North America/Central America	High school	Single	2.0	1.0	3.0	0	1
409	19-25	Female	North America/Central America	Bachelor's degree	Single	2.0	3.0	1.0	1	1

For the third topic, we want to find out how people are familiar with artificial meat. According to whether they have heard about artificial meat, how likely is it to be willing to try or consume artificial meat? We decided to create three visualizations, parallel coordinates, circular filling and hierarchical tree diagrams to explore relationships based on features Q9, Q10, Q12, and Q16.

For the fourth topic, how does the geographical area affect people's familiarity and tasting of artificial meat? We use latitude, longitude, Q3, Q9, and Q12 as features. Latitude and longitude are based on IP addresses of survey participants. Q3 contains the continent where each participant lives. Q9 and Q12 represent whether each participant has heard of artificial meat before and has tried artificial meat before, respectively.

	LocationLatitude	LocationLongitude	Q3	Q9	Q12
1	40.725998	-73.848000	North America/Central America	Yes	Yes
2	40.617905	-73.985603	North America/Central America	Yes	No
3	40.620804	-74.042603	North America/Central America	Yes	Yes
4	40.617905	-73.985603	North America/Central America	Yes	Yes
5	3.079895	101.533386	Asia	Yes	No

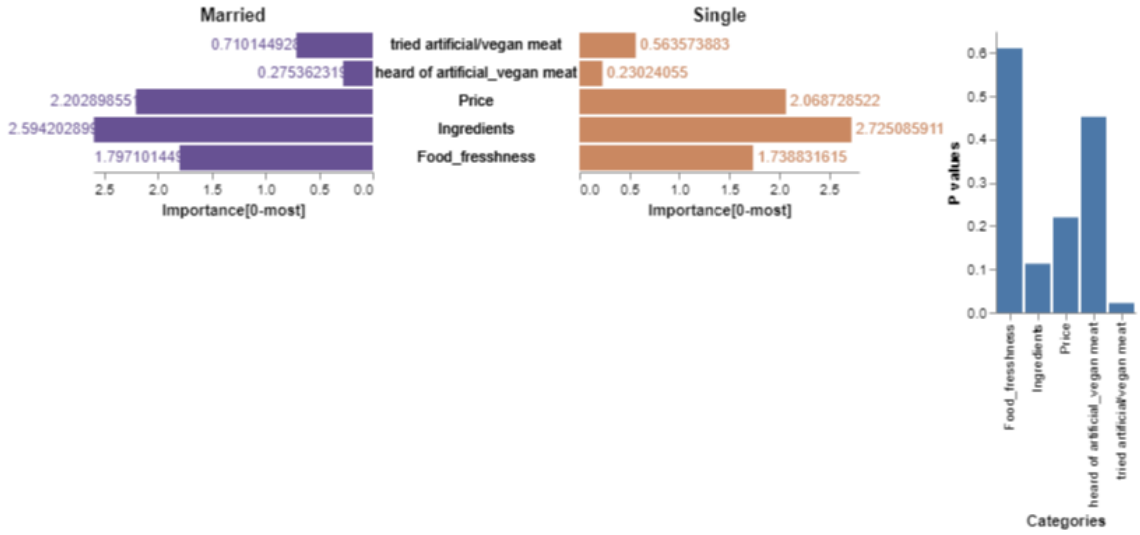
4. STATISTICAL ANALYSIS

4.1 Focus Topics 2

What's the difference between married and single people in terms of price, freshness and ingredient labels? According to the research questions, we make a statistical analysis of the price, the freshness of food and the ingredient label. How concerned are individuals with the price when choosing food? Which group (single or married) spends more on healthy food? How fresh do people want their food to be? Which group would prefer fresh food? Do individuals pay attention to ingredient labeling before making food decisions? Which group pays more attention to ingredient labeling? Is there a statistical difference between married and single?

4.2 Calculation method

Given that our data is categorical, we converted some of the survey responses into numerical so we can obtain some statistics such as mean, standard deviation and p-values of the varying attributes between single and married groups. Based on the Focus Topic 2 research questions, we calculated the mean values of attributes such as "*tried artificial/vegan meat*", "*heard artificial/vegan meat"*, "*price*", "*ingredients*", and "*food freshness"* between the two groups (single and married). After extracting the means, we showed the values on a Pyramidal bar chart.



The above image shows an unordered pyramidal bar chart of the relevant features between Single and Married (Couples). The closer the bar is to 0, the more important it is for that group for the given feature.

1. Feature 1 **('Tried artificial vegan meat'):** From the chart above Singles have 0.564 while married ones have 0.710; this implies that from the individuals who responded to our survey, more Singles have tried artificial meat compared to Married ones because the value for Single is closer to 0.
2. Feature 2 **('Heard of artificial vegan meat')**: From the chart above Singles have 0.230 while married ones have 0.2750; Although the values are very close to each other, we still imply that from the individuals who responded to our survey, more Singles have heard about artificial meat compared to Married ones.
3. Feature 3 **('Price'):** The chart indicates Singles have 2.069 while Married ones have 2.203. This means that from the result of the survey, Singles are more concerned about price when it comes to making food choices compared to Married ones. Thus, Married ones could potentially spend more for healthy food.
4. Feature 4 **('Ingredients'):** The chart indicates Singles have 2.725 while Married ones have 2.594. This means that Married ones tend to check label on food more often compared to Singles. This makes sense because married ones consist of 2 individuals in love who wants to ensure the food available in the house is desired and healthy for each other.
5. Feature 5 **('Food Freshness):** The chart indicates Singles have 1.739 while Married ones have 1.797. These values are very close to each other implying that both groups really want their food to be fresh. Nevertheless, since the value for singles is closer to 0, Singles from the survey wants their food fresher.

4.3 P Value

P values were calculated using MEDCALC. MEDCALC is an online P value calculator which simply takes the means, standard deviation and sample sizes from two groups and calculates the accompanying p values. After converting some of the survey responses from categorical into numerical and obtaining the mean values along with standard deviation from attributes such as "*tried artificial/vegan meat*", "*heard artificial/vegan meat"*, "*price*", "*ingredients*", and "*food freshness"*, we used MEDCALC to obtain the accompanying p values.

5. RESULTS

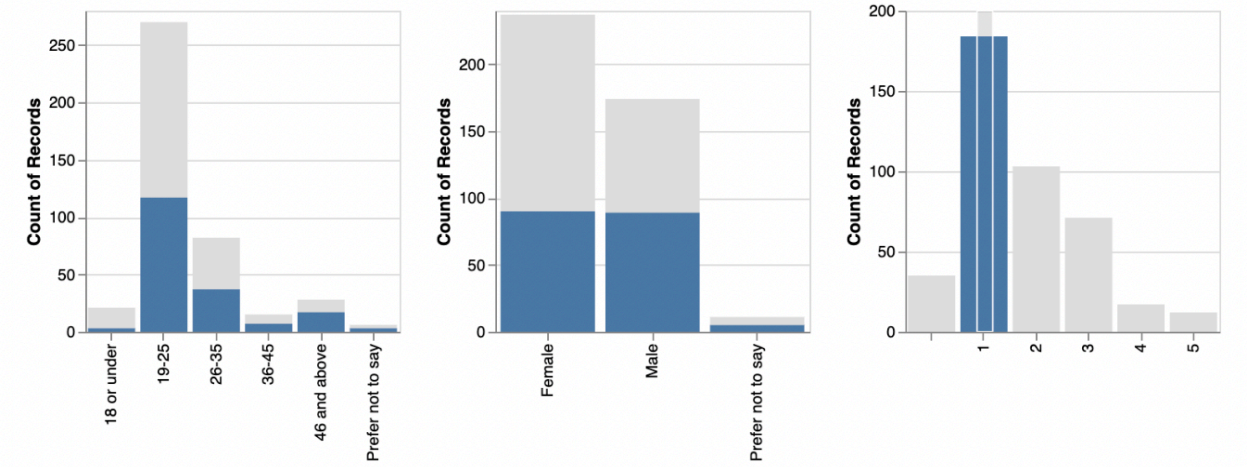
5.1 Price, Freshness and Ingredient Labeling

What's the difference between married and single people in terms of price, freshness and ingredient labeling? Based on our statistical analysis, by generating p-values from the data, we found no statistical differences in features such as heard of artificial/vegan meat. The price, ingredients, and freshness of food are the same between married and single couples because their p-value is greater than 0.05. The only statistical difference between the two groups was the feature of tried artificial/vegan meat, p-value = 0.04.

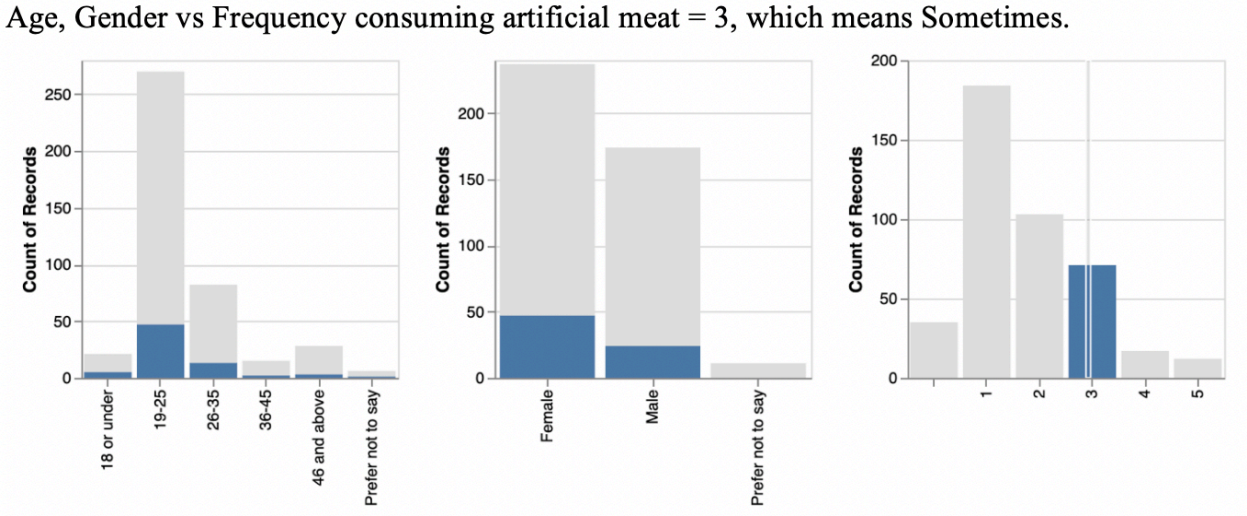
5.2 Age, Gender and Frequency

Will age and gender affect people's perception of consuming artificial meat? We use Vega-Lite to create bar charts to compare the frequency of consumption of artificial meat in different age groups and gender groups. For people who very often consume artificial meat, the age range is between 19 and 35, and females are more likely to consume artificial meat than males. For those who never consume artificial meat, the ratio of males to females is almost 1:1. They are almost 50% of each age group, but for people 46 and older, the proportion of people who have never eaten artificial meat is higher. For people who sometimes eat artificial meat, they account for a high proportion in the 19-25 age group, and the second age group is 26-35 years old.

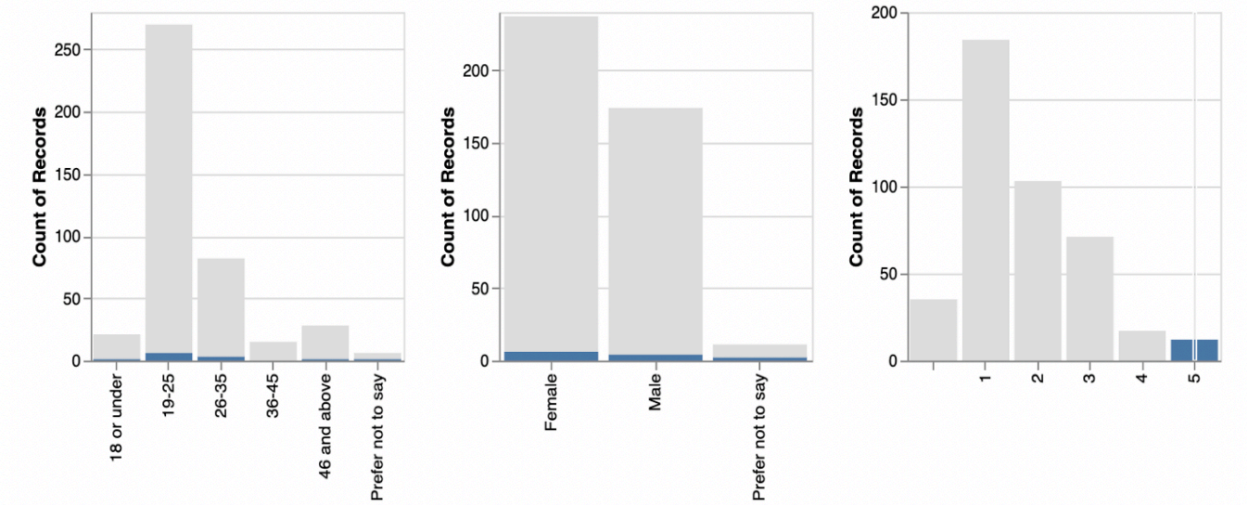
Age, Gender vs Frequency consuming artificial meat = 1, which means never.



Age, Gender vs Frequency consuming artificial meat = 3, which means Sometimes.

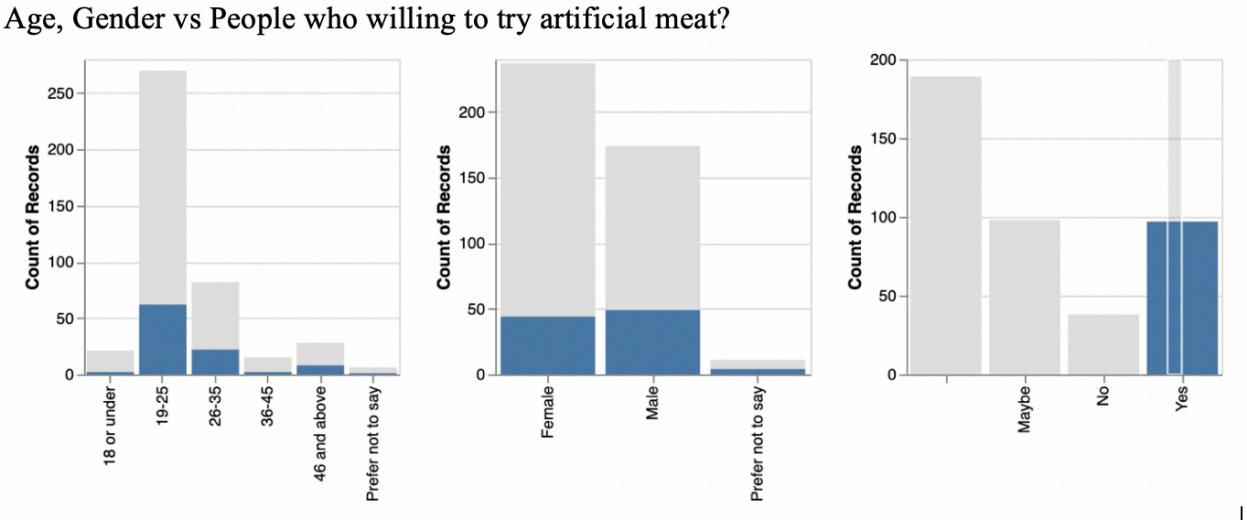


Age, Gender vs Frequency consuming artificial meat = 5, which means Very Often.



As shown in the above figure, users may only find subtle differences among different age groups and gender groups. We also made a bar chart showing who would like to try artificial meat if there was a chance. We can see that compared with other age groups, the proportion of people aged 19-25 is higher.

Age, Gender vs People who willing to try artificial meat?



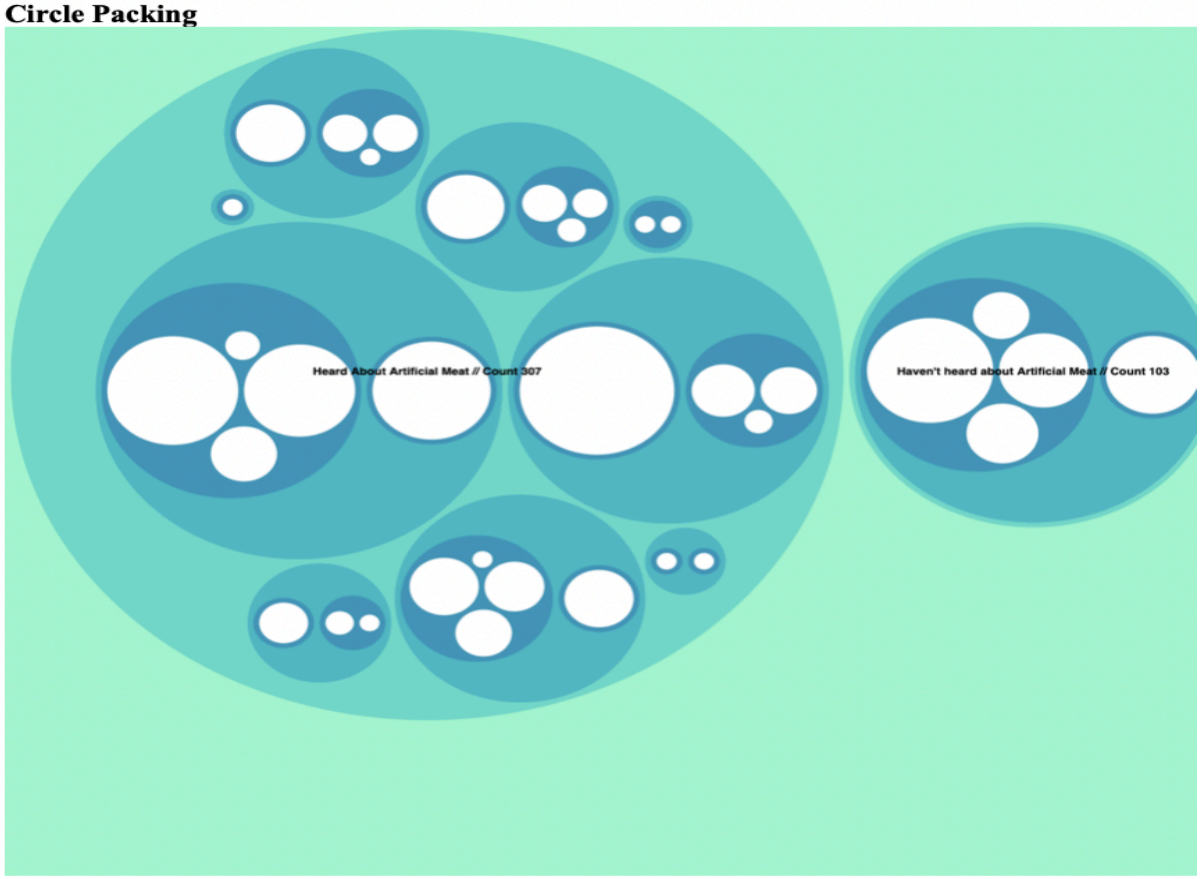
Based on our findings, age is a determinant factor in the decision to consume artificial meat. The age between 19 to 25 are more willing to try artificial meat. Between the ages of 19 to 25 and 26 to 35, the frequency of very often consumption of artificial meat ranked first and second. It can be said that young consumers are more willing to consume artificial meat because they are more likely to access new information through the Internet. These two age groups have the influence to convince their parents or friends in deciding to purchase and try artificial meat. When we look into the correlation between gender and the frequency to consume artificial meat, our data shows that females are more likely to try artificial meat. However, as we delved into our data, we realized that if we had more male participants, the proportion of men who very often consumed artificial meat might increase. For those willing to try artificial meat, the proportion of men who want to try artificial meat is higher than that of women. Therefore, we can say that gender is not a determinant factor to determine the choice of artificial meat consumption.

5.3 Treemap, Circle Packing and parallel coordinates

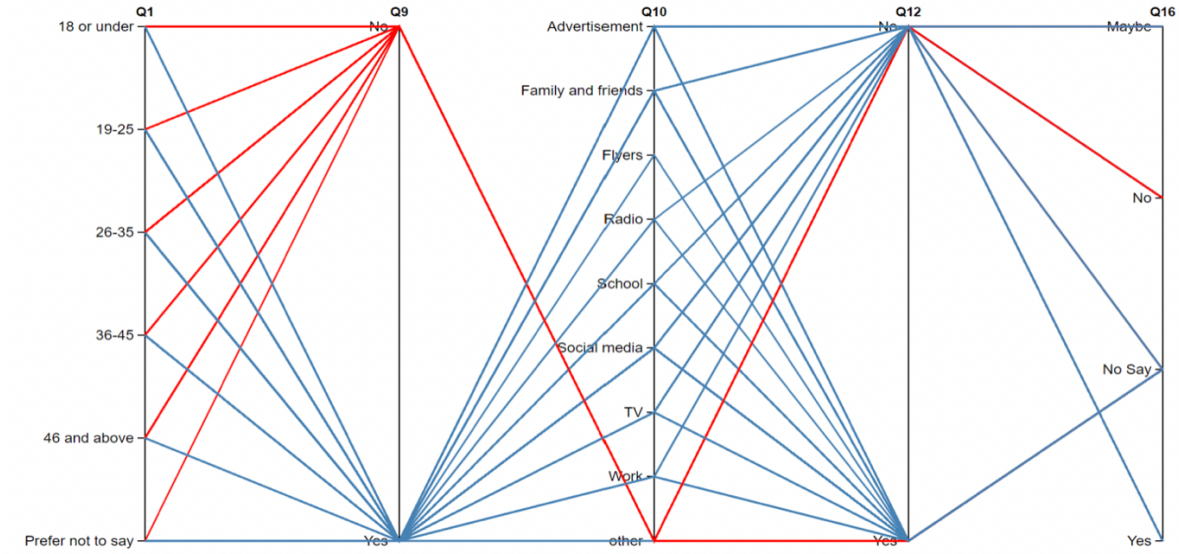
For the research question, we want to find out how people are familiar with artificial meat. According to whether they have heard about artificial meat, how likely is it to be willing to try or consume artificial meat? We crate the treemap shows the heirarchial structure created out of the questions and their respective answer. The visualization clearly shows that more surveyors had heard about the artificial meat. And about half of the people who hadn't heard about artificial meat and hadn't tried artificial meat are willing to try.

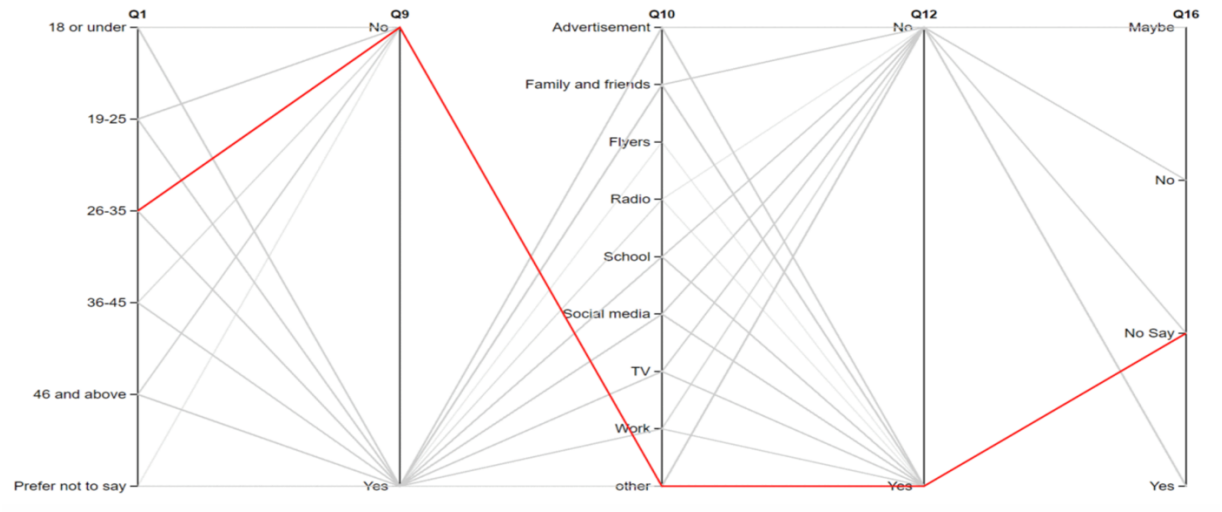
The Circle Packing Visualization is created with interactivity in mind. This visualization helps in exploring how each answer affects the other questions and answer as we go down from Q9 to Q16. It also shows there are different relationships to be explored between the answers. for example, most people heard about artificial meat from social media, more than 50% of surveyors who heard about artificial meat from family and friends tried it while it was only 29% for social media.

Circle Packing



Parallel Coordinates



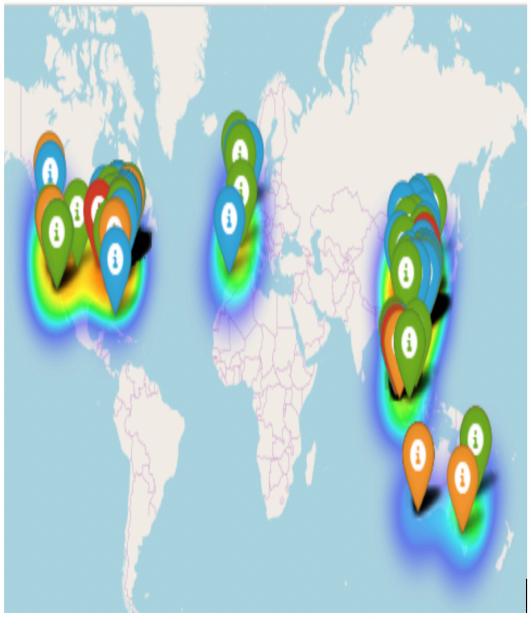


The parallel coordinates visualization is an exploratory visualization just to see how the answers were related to each or among others. The line coloring is done based on answer to Q9. As the visualization shows, all the surveyors who answered No to Q9 either are not willing to try the artificial meat or have no say in it with small percent in may be.

5.4 Geographical

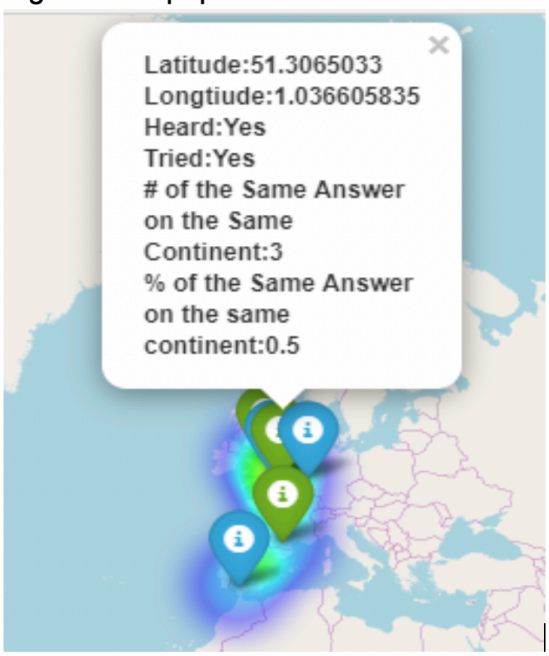
For the research question, how does the geographical area affect people's familiarity and tasting of artificial meat? The idea is to filter data from project.csv and export a global map to location_Map.html. The main library is the python folium library, which creates a global map that has clickable popups. Each popup displays features as mentioned above in Table I and some statistical analysis as can be seen in Figure 2. Finally, the locaton_Map.html is embedded and can be clicked in Vega-Lite.

Figure I. Global Map



Different colors of popups represent different types of answers for Q3 and Q9.

Figure 2. Popup



Here is how each color works:

	Q3(have heard of artificial meat before?)	Q9(have tried artificial meat before?)
Green	Yes	Yes
Blue	Yes	No
Red	No	Yes
Orange	No	No

Each popup contains an IP address, answers for Q3 and Q9, the number of the same answer on the same continent(for figure 2, there are 3 participants with the same answer in Europe), and the percentage of the same answer on the same continent(for figure 2, 50% of participants in Europe are with the same answer which represents as green).

Based on the results from Figure 1, there are mostly green and blue popups. This means that most people have at least heard of artificial meat before. Another interesting result is that most popups belong to North America/Central America. Hence, the result may be a little underrepresented since above 50% of participants are from NA/CA. Also, from Figure 1, there isn't any popup in South America. A possible explanation is that participants fill out the survey inadvertently.

8. CONCLUSION

Based on this survey, most people have heard of artificial meat before. As technology continues to evolve, the chance of people heard of artificial meat is quite high. Most people have at least heard of artificial meat than tried it because people need to know food before there is a chance to try it.

The visualizations were very helpful in exploring the hierarchical relationship of the answers. We were able to discover family and friends was one of the strongest factors that determined if the surveyor wanted to try artificial meat. Social Media was a reached bigger demographic while fewer people who haven't previously heard about artificial meat more less likely to try artificial meat.

According to our data, we can say that young consumers are more willing to consume artificial meat. Hence, as the market for artificial meat expands, there is a high possibility that artificial meat will become the meat of the future as consumers continue to express an interest in health and in artificial/vegan meat products.

REFERENCES:

The Health IQ Team, How VEGAN IS YOUR STATE?, 2015,
https://www.healthiq.com/blog/vegan-restaurants-by-state/

CB INSIGHTS, *Our Meatless Future: How The $1.8T Global Meat Market Get Disrupted, Novemeber 13, 2019,*
https://www.cbinsights.com/research/future-of-meat-industrial-farming/