

Has the Rise of Veganism and Other Plant-Based Diets Impacted America's Food Industry?

Abstract

“The charts of veganism’s popularity over the last several years have climbed like staircases steadily from left to right, year after year, whether looking at veganism as a diet and lifestyle, as a keyword, or as a growing market trend” reports Sentient Health [1]. It is clear that healthier eating habits and a greener lifestyle are seemingly becoming more popular in the United States. Despite this, processed foods and obesity levels are still on the rise [13]. We explore this juxtaposition, and challenge whether plant-based diets are truly making an impact in the US. In particular, we investigate how meat production, obesity levels and relevant stock prices have been affected since the vegan wave, and whether the rise of plant-based diets have truly made an impact, or whether it is all just a cultural fad.

We find that after numerous tests, as well as through insightful visualisations, the impact of veganism has been insignificant across all aforementioned topics. Meat production, even after accounting for various economic and population factors, trends the same as it did before plant-based diets became popular. Stock values of companies directly impacted by meat demand have not held any major decreases since veganism began trending and daily fruit and vegetable consumption even seems to be trending downwards since the rise of non-meat diets.

Introduction

Veganism and the new ‘green wave’ of eating has made an impact on a cultural level in the US, from Erewhon smoothies increasing in popularity and becoming a trend on social media platforms such as TikTok [2], to Michelin star restaurants going vegan [3], but has this made any impact on the meat and processed food markets? This reports focuses on the

economic and cultural behaviour of the US that may have been affected by this new trend and whether it has affected the markets.

Due to a lack of vegan population data on the internet, we first attempt to pinpoint a time which we can consider as being a suitable barrier between a pre- and post-vegan America. We then analyse how (a) meat production, (b) relevant stock prices and (c) nutritional data behaves in these two eras. If plant-based eating were truly as significant in the food industry as it is on social media, then one would expect to see visible changes in each of these three categories, and so we explore this by trying to identify significant qualitative and quantitative trends between a pre- and post-vegan America.

Nontechnical Summary

Main Questions

Our investigation attempts to follow the two central questions:

- *Has the rise in plant-based diets made any significant impact on the US food industry on either a production or consumer level?*
- *Who does the average vegan tend to be, and how does this affect the impact that they can have?*

Key Findings

First, we identify that the vegan culture really began to grow in size in 2017. There were significant shifts in the idea of meat-free diets in this year [4, 5] as well as its relevancy as a Google search term also taking off in this year [11].

However, despite this, we find that veganism has failed to make any significant impact on both a production and consumer level. We find that, even after filtering out economic and population factors, meat production trends see no major changes pre- and post-2017 (fig. 1).

We also find that major players in the meat industry, such as Hormel Foods and Pilgrims Pride have seen no significant impact on their stock value between the

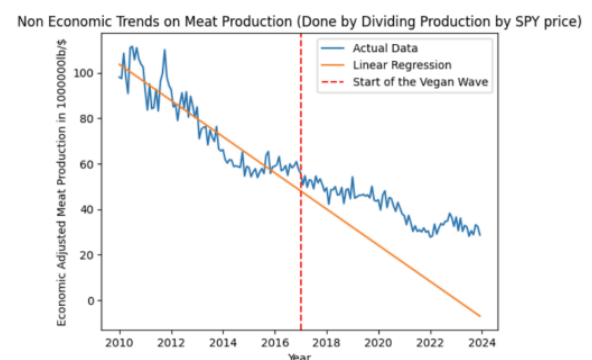


FIG. 1: When considering non-economic factors, meat production still seems to be trending at around/above the benchmark.

two time periods, indicating that meat consumption trends are also unaffected on the consumer side.

Finally, we find that since 2017, if there has been any change in the US populations consumption of fruit and vegetable, then it has actually been a decrease, further arguing against plant-based diets having any significant impact. We attempt to further explore this data, to identify any trends between different strata in the US, and find that wealthier, more educated individuals tend to consume their greens more. We also find that older people tend to eat more of their five a day (fig. 2), contradicting the data that vegan people tend to be younger [12], and so decide to omit any further experimentation of the second question, due to this inadequate data.

Technical Summary

Data Exploration

With the abundance of data available to us, our main goals were the following:

- Find datasets that had these qualities:
 1. Datasets that had isolated exposure to either vegan or non-vegan factors (i.e. we deemed agricultural data unsuitable, as this encompasses both growing crops and raising livestock).
 2. Datasets with a significant amount of datapoints.
- Identify any trends/patterns in these relevant datasets.

The Obesity Data provided contained a multitude of questions related to diet, obesity and physical activity directed to a variety of different strata. Questions regarding daily fruit and vegetable consumption were of most interest to us; however, the data available for these were bi-annual, and only go back to 2003 for high-schoolers and 2017 for adults, seemingly violating (2). Despite this, the wide range of stratified data in areas such as age, income and education gave us a good opportunity to gain insights into trends of what the average plant-based eater could look like, and so we later continue to explore this data further.

The Stocks Data contained information on the stock prices of a range of commodities, equities and ETFs. Of all the provided securities, we believed that the

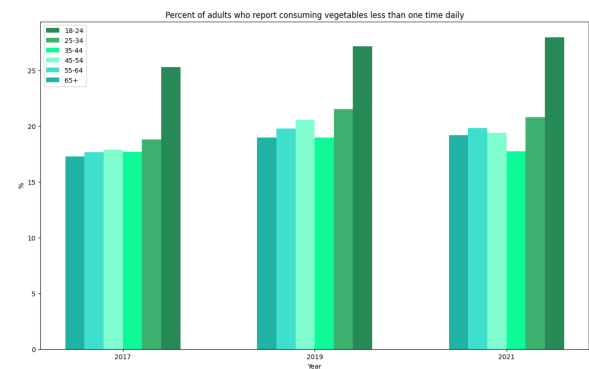


FIG. 2: 18-24 year olds are consistently and by far the age group who seem to be consuming the least amount of vegetables, which is also the age group of 36% of US vegans [12]. 25-34 represent 44% [12], but come in at second in the above graph.

only ones that could satisfy (1) above were corn commodities and Hormel Foods (HRL) and Pilgrims Pride (PPC) stocks based on their stock descriptions:

- HRL: “focusing on the packaging and selling of ham, Spam, sausage and other pork, chicken, beef and lamb products”
- PPC: “produces, processes, markets and distributes fresh, frozen and value-added chicken and pork products to retailers, distributors and food service operators”

However, after reading further literature, it was clear that corn (like many commodities) was very sensitive to a wide range of geopolitical factors including climatic conditions, weather and government policies [6] and so are sensitive to more than just demand, hence violating (1). This leaves HRL and PPC stock information, which has monthly stock data since before 2000, and so we also investigate these further.

The Meat Data provided contained a dataset on meat production data dating back to well before the 2000s, and so was an obvious decision to include in our analysis; however, it required thorough quality control. A common theme within the dataset, occurring a total of eight times, was a couple of NA rows in the production column, followed by a huge spike in the third. We conjectured that this represented quarterly data rather than monthly data, and so we calculate the mean monthly production for that quarter, and then replace the three erroneous cells by this value. Huge time periods of NA production values was also common; however, all datasets were complete from 2001 onwards, providing more than enough insight, and so we only focused on values from this point onwards.

Has Veganism Affected Meat Production

The provided meat production data is broken down into different animals and then even further as to whether the meat produced was commercial or federally produced. The latter division provided no insights, as the data for each animal was very similar whether it was commercial or federally inspected, so we disregarded this factor. Furthermore, we aggregated all data rather than focusing on individual animal trends, in order to identify trends on the entire meat production output in the US.

In order to visualise any differences in trends pre- and post-veganism (which we considered to be 2017 as mentioned before), we used a linear regression based on pre-veganism production data, and compare how the curve compares to post-veganism production data.

The simplicity of a linear regression is certainly a limitation, as it cannot capture complex trends; however, opting for more complex time-series predictive models (e.g. LSTMs), would be far less insightful. Even if our model was accurate within 10% for each time step, these small errors quickly compound, since our post-veganism data contained over seventy time steps, giving a far less reliable picture.

Using the linear regression, qualitatively, we see that meat production seems to trend above the benchmark in the post-vegan era (fig. 3). In order to confirm this quantitatively, we performed a t-test, with our null-hypothesis being that the monthly change in meat production has not changed. This resulted in a p-value of 0.014, confirming our assumption was correct.

Per Capita Analysis

However, it is very easy to argue that our analysis does not isolate the affects of veganism, with the US population steadily increasing and being a clear reason as to why meat production would also increase. We used an external dataset of US population on a monthly basis from the Federal Reserve bank of St. Louis [7] to find the population during the time of interest. The dataset was tidy, with no NA values and did not need any cleaning. After dividing the monthly production by the monthly population and multiplying by a million to get the production in pounds per person, we apply the same regression and tests as before and the conclusions are similar (fig. 4). Under the same null hypothesis, the p-value this time is 0.011, even smaller than before and so we can reach the same conclusion that the meat trajectory data has not had a significant change since the vegan wave, even when factoring in the increasing population of the US.

Economy Adjusted Analysis

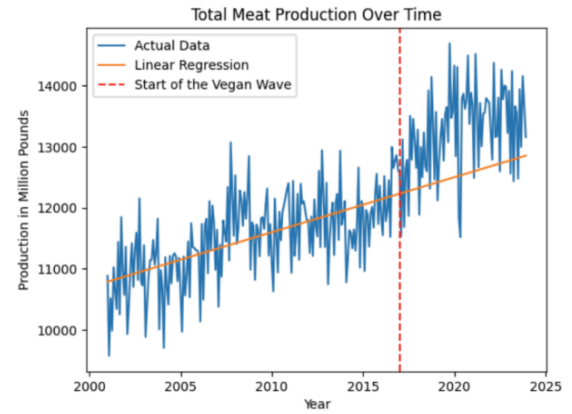


FIG. 3: Meat production data with linear regression using pre-2017 production data. After 2017, the data generally exceeds projections.

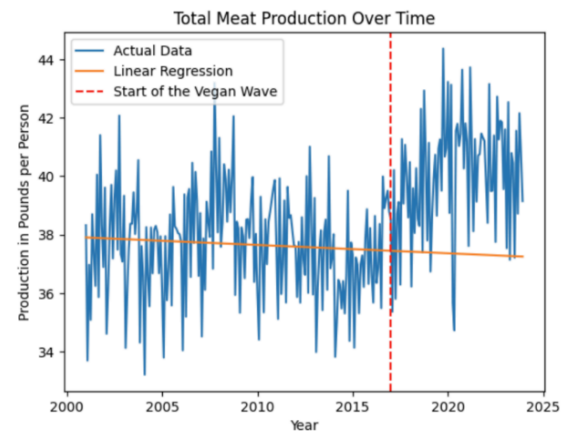


FIG. 4: Meat production per capita data with linear regression using pre-2017 production data. Post-2017 is even further above projection.

However, as can be observed by a large dip in 2020 and general downwards trends in 2008-10, it could be hypothesised that economic factors such as the initial hit of COVID and the 2008 financial crash, cause trends in meat production. Based on these observations, we hypothesise that major trends in meat production are affected by the state of the US economy. If we can confirm this, then we can normalise by the current economic state, and then observe non-economic trends, in which the affect of veganism should be observable, if it has had an affect.

In order to quantify the US economy, we chose to use the S&P 500, which is known to be an accurate indicator of the US economy [8]. Therefore, to test our hypothesis that the US economy affects meat production, we compare SPY stock, which tracks the S&P 500 and is given to us in the Stocks Data, against meat production to test whether there is a correlation. SPY stock close price wasn't given on a daily level; therefore, in order to create a monthly dataset of SPY close price to compare against monthly meat production, we used the earliest SPY datapoint available for each month (which was never later than the 4th), and assumed that this was the same as its close price on the first day of the month.

As can be seen in the scattergram, the correlation between SPY stock and meat production was significant (fig. 5) and was confirmed by a 0.778 correlation coefficient, which is (very) significant for over 250 datapoints.

Therefore we proceed by assuming that economic growth implies causation of meat production growth. This assumption is backed up by our data and from our reading [10]. After dividing meat production by SPY price and running the same regression as earlier, we observe meat production rates being under the expected projections based on the linear regression (fig. 6). However, the p-value for this t-test is 0.129, giving very little evidence to suggest that this is significant. Furthermore, after noticing the unusual peak around 2008, a period with significant exogenous influences on the economy, we try to perform the regression with data after this peak and it can be observed that again meat production is still above the expected projection (fig. 7). The general downwards trend since the recession is not accelerated post-veganism, hence, overall based on these results, there is little to no evidence to conclude

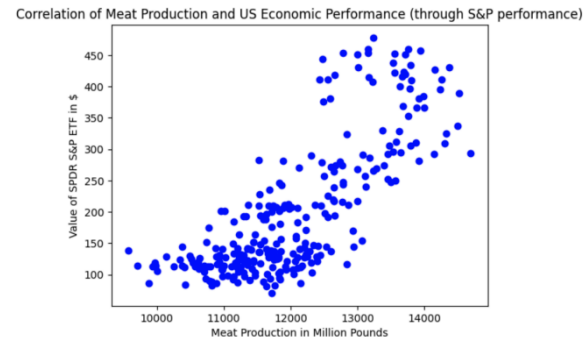


FIG. 5: Scattergram of the meat produced at a particular month against the value of SPY in the opening of that same month. 0.778 correlation coefficient.

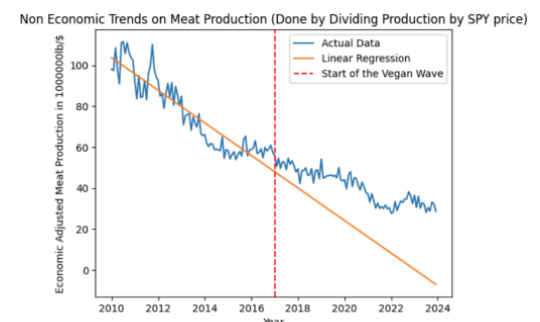
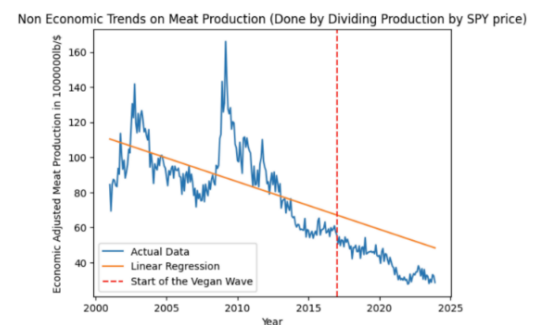


FIG. 6, 7: Meat production normalised by dividing by the value of SPY with linear regression using pre-2017 data. The decrease since 2017 is only part of a larger trend, and cannot be confidently attributed to the rise of plant-based diets.

that veganism has made any impact on meat production.

Has Veganism Had an Impact on the Consumer Level

HRL and PPC Stock Analysis

As mentioned earlier, we decided to investigate the affects of veganism on HRL and PPC stock, due to their isolated involvement with meat products and the importance of public consumption on their stock value. The Stocks Data given was tidy, with no preprocessing required. High and low prices were of no interest to us, as daily volatility was irrelevant to our question, and we arbitrarily decided to use close prices rather than opening prices.

In order to consider other economic factors that come to play when it comes to HRL/PPC stock values, we compare them against all other stocks given in the Stocks Data. To do this, we first create two vectors, with the same number of rows as there are number of stocks. Each row in the first vector contains its mean-squared error (MSE) with respect to its pre-veganism linear regression before 2017 and the corresponding row in the second vector contains its MSE with respect to the same regression after 2017. Although there is enough data to assume a normal distribution by the Central Limit Theorem, we are assuming the independence of each of the stocks, by using a 2-sample t-test on these vectors, a limitation since all stocks are in similar industries. We observe a p-value of 0.066 (fig. 8) giving weak evidence that the MSE of the stocks have changed since veganism has become mainstream.

Upon performing the same test on only HRL and PPC, we obtain a p-value of 0.659 (fig. 9), which gives no evidence to suggest that the MSE of these two stocks have changed since veganism. This result shows that despite their possibly being a shift in overall stock prices since veganism, the two stocks that are most isolated to the meat industry have not been impacted by veganism at all. Furthermore, since the p-values are so different for each hypothesis, we can safely attribute the small p-value to external influences outside the scope of our research topic.

Fruit and Vegetable Consumption Analysis

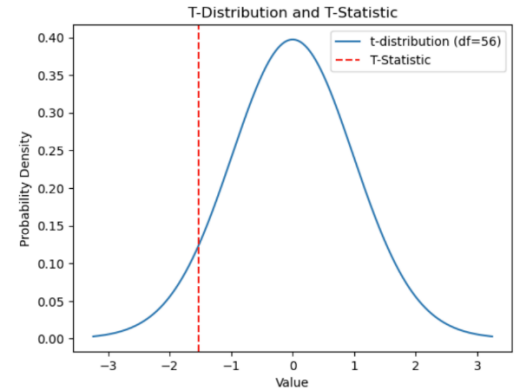


FIG. 8: Hypothesis test on all stock data, as to whether MSE from the stocks' linear regression has changed significantly since 2017. 0.066 p-value.

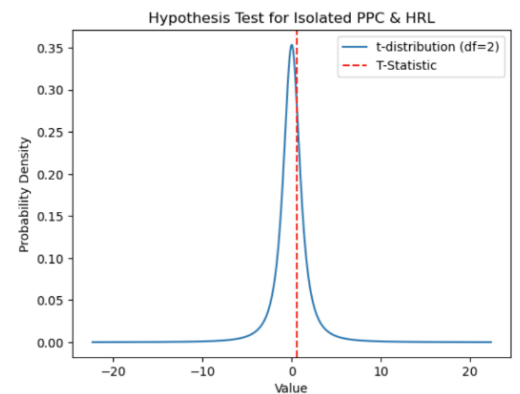


FIG. 9: Hypothesis test on HRL and PPC stock data, as to whether MSE from these stocks' linear regression has changed significantly since 2017. 0.695 p-value.

Our final analysis involved the exploration of the relevant questions in the Obesity Data. The data is given for each state, and so we aggregate this to US-wide figures by taking the weighted average of percentages based on the sample size in each state, to get a total US percentage.

The questions of our concern involve the percentage of adults and high-schoolers that don't eat any fruit or vegetables each day. Adult data only starts in 2017, so we have no pre-veganism data and so we ignore it for now and focus more on the trend in high-schoolers fruit and vegetable eating habits. It can be observed that the percent of high schoolers not eating their fruit or vegetables actually tends to trend upwards (fig. 10, 11), with a t-test confirming that this trend is actually significant, with a p-value of 0.015 for vegetables and 0.007 for fruit. Due to the small amount of data and the small subsection of the US population that is represented in this test, this result should be taken with a grain of salt; however, this certainly does not support the idea that veganism has had a significant impact on eating habits, particularly with the majority of vegans tending to be younger [12].

Conclusion

Limitations and Future Directions

Most limitations to our individual tests have been discussed at each step of the process, but one of the principal limitations of our research was not being able to work with vegan population data and having to assume a hard 'veganism boundary' rather than being able to model it through its gradual increase in popularity. As veganism continues to grow, and data on the vegan population begins to become collected in the future, research with this data could lead to more interesting results.

Further research into why plant-based diets have had no impact on the food industry would also be interesting, since around 10% of Americans claimed to not eat meat in 2022 [5] and so lack of people certainly cannot be the reason. It would be interesting as to whether this is because those who do eat meat are consuming it more, or because this 10% of the population is somehow less influential. We attempt

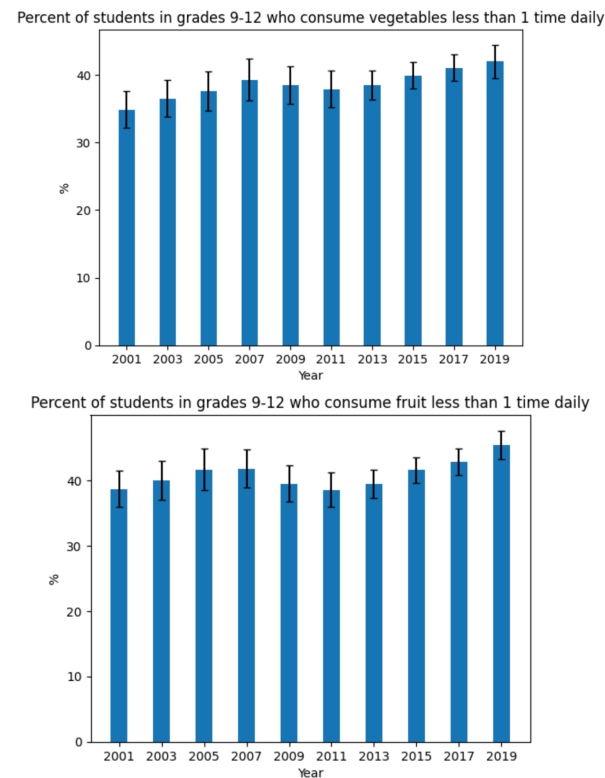


FIG. 10, 11: Visualising the steadiness/slight increase in the number of students who consume less than 1 vegetable/fruit per day since 2017.

this in the appendix; however, due to the little data available and the lack of relevancy of said data, we come to no avail.

Result

We conclude by claiming that, based on our analysis, there has been no significant changes to none of (a) meat production, (b) relevant stock prices and (c) nutritional data due to veganism and other plant-based diets. The vegan trend has had no meaningful impact on either a consumer or production level, and the US food industry continues to trend as it did before.

Appendix

What does the Average Vegan Look Like

In order to explain for the lack of impact that vegans have had on both a production and consumer level, we tried to investigate what the average vegan looks like in order to conjecture an explanation based on the demographic.

We explore the same questions as above in the Obesity Data dataset, this time exploring how income, age and education impacts the amount of fruit and vegetable consumed.

However, the gaping limitation of this is that assuming that the number of vegans will trend similarly to the number of people who eat 1 or more fruit/vegetable a day is a very large assumption with a lot of flaws. This is reflected in our results, as we find that those who eat more fruit or vegetable tend to be wealthier, more educated and, most importantly, older (fig. 12, 13, 14). This last factor contradicts the idea that vegans do tend to be younger [12], and so based on this contradiction, we decided not to explore this avenue further.

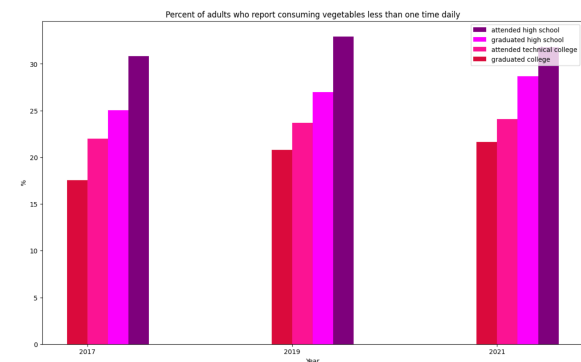
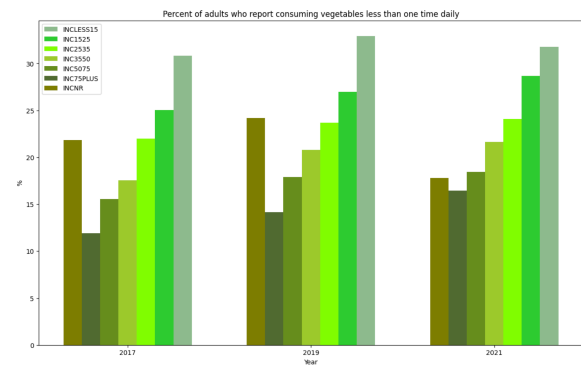


FIG. 12, 13: People that eat more fruit and vegetables tend to be wealthier and last longer in the education system.

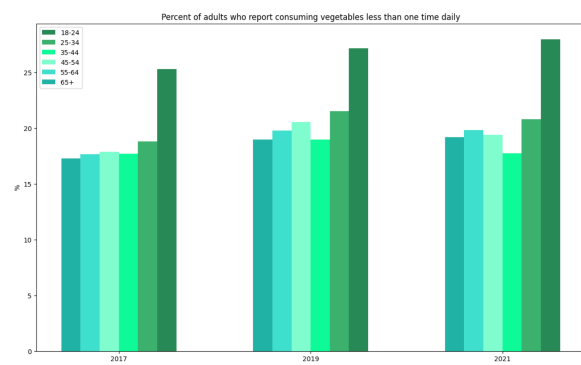


FIG. 14: 18-24 year olds are consistently and by far the age group who seem to be consuming the least amount of vegetables, which is also the age group of 36% of US vegans [12]. 25-34 represent 44% [12], but come in at second in the above graph. Hence, this data is clearly not a good indicator of trends in veganism.

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