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# Consumers within the Spicy Pepper Supply Chain

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**Abstract:** "Spicy pepper" is a term used to describe a variety of "pungent" peppers, sometimes referred to as hot, chili, or chile. The USDA reports that the per capita availability of chile peppers has increased more than 100% since the early 1980s. While the availability of spicy peppers has increased, easily accessible data regarding which varieties are consumed, how they are used by households, and who is most likely to consume them is not available. This paper provides insights into U.S. spicy pepper production and consumption as provided by a review of existing trade data and a survey of U.S. consumers.

## 1. Introduction

The number of people originally from other countries living in the United States, i.e., the "foreign-born" population as defined by the U.S. Census, was nearly 45 million in 2019 [1]. The percentage of the foreign-born population increased from a low of 5% in 1970 to nearly 14% in 2019. Today immigration accounts for 38% of the U.S. population growth rate [2]. Immigrants to the U.S. come from many different countries for numerous reasons including work, family, school, and safety. In 2019, more than 1 million people coming from more than 200 countries received lawful permanent resident status [3] (Figure 1). These individuals live throughout the U.S. [4]. Immigration to the U.S. has resulted in an increasingly diversified population.
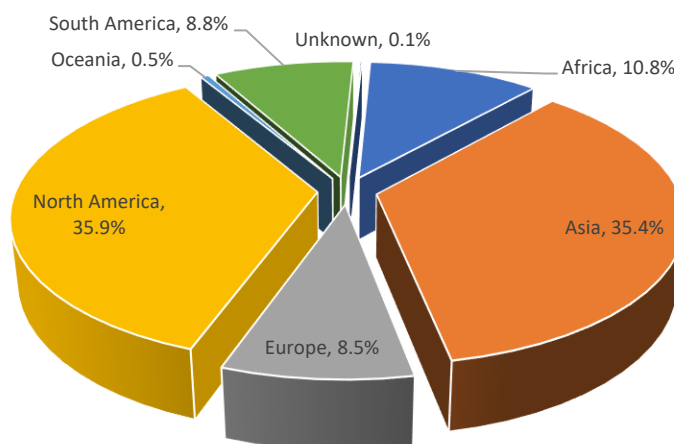


**Figure 1.** Region of birth for people receiving lawful permanent resident status in 2019. Source: USDHS, 2019 [3].

Immigrants often bring their cultures with them. Culture can be defined as "the distinctive ideas, customs, social behaviors, products, or way of life of a particular nation, society, people, or period" [5]. Cultural habits or customs are often developed during childhood and internalized such that they are difficult to change [6]. Cultures are often associated with a population's food tastes and preferences and culinary practices. Other factors often linked to food preferences include religion, occupation (income), geographical factors (distance to food stores), age, ethnicity, and health [7].

Peppers, specifically spicy peppers, is a vegetable group common in many cultures. The term "Spicy pepper" is used to describe a variety of "pungent" peppers, sometimes referred to as hot, chili, or chile. The pungency of spicy peppers is most often measured using the Scoville scale created by Wilbur Scoville in 1912. The scale is a measure of how many times a pepper sample is diluted with water until taste-test participants could no longer feel heat. Today the heat of chile pepper cultivars ranges from zero Scoville Heat Units (SHU) to more than 2 million SHU [8].

Pepper production and consumption data reported by the USDA is commonly reported for two groups; (1) "peppers" or "Bell peppers" and (2) "chile peppers." The chile peppers are represented by a combined group of spicy pepper varieties and/or cultivars. Chile peppers are, or can be grown, in most U.S. states, although the majority of commercial chile pepper production, 100% in 2020, is centered in New Mexico and California. The production from these two states are generally long green chiles referred to as New-Mexico type chile or Anaheim chile.

Per capita consumption of fresh chile peppers has increased from just over three pounds per person in 1980 to more than seven pounds per person in 2020 (Figure 2). While per-capita consumption has increased significantly over the last 40 years (135%), the majority of the increased demand has been satisfied by imports. Figure 3 shows that over the same 1980–2020 period, domestic chile pepper production declined more than 50% (nearly 75% from its peak in 1992) while imports increased by more than 950% [9].
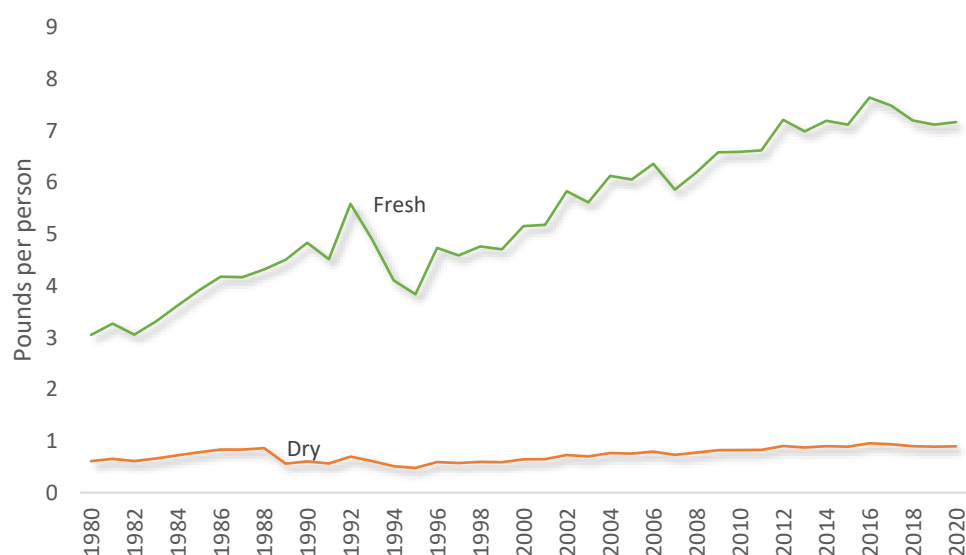


**Figure 2.** Per capita chile pepper consumption, 1980–2020. Source: USDA-ERS [9].
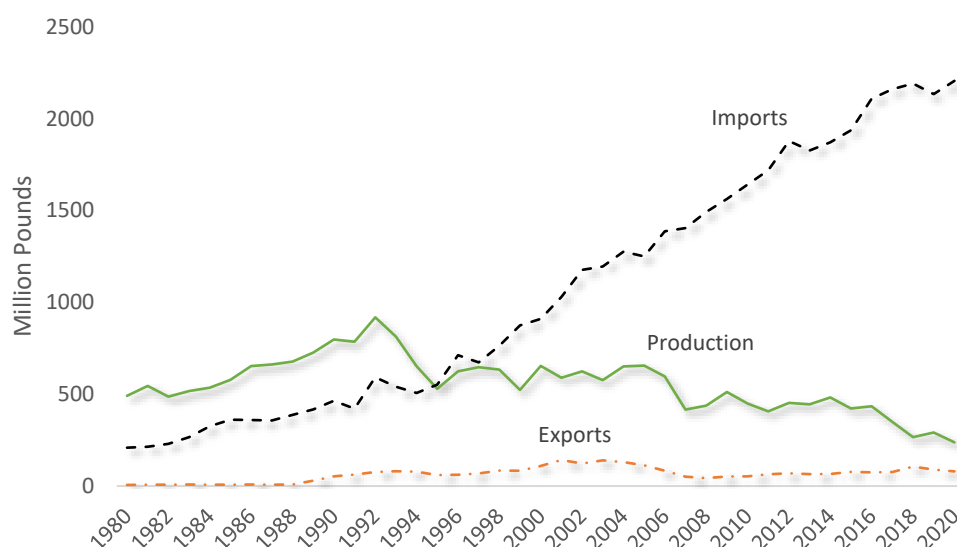
**Figure 3.** Chile pepper production, exports, and imports, 1980–2020. Source USDA-ERS [9].

The long-term decline in chile pepper production is the result of many factors including domestic labor availability, cost differentials between chile pepper producing countries, and profits for U.S. producers of chile and alternative crops. One way to encourage domestic production is to identify ways the crop could be more profitable, including identifying consumer willingness (and ability) to pay premiums for U.S.-grown chile peppers. Additionally, little is known about chile pepper consumption as data that identifies which varieties are consumed, how they are used by households, and who is most likely to consume them is not widely available. This paper provides insights into U.S. spicy pepper consumption gained via results from a nationwide panel survey.

## 2. Materials and Methods

### 2.1. Data

To better understand the current consumption of spicy peppers, specifically New Mexico-style chile peppers, in the U.S., a nationwide panel survey was conducted in July 2021. The survey instrument, created in the online survey program Qualtrics, was administered to panelists managed by the sample exchange platform company Cint. A total of 859 participants completed the survey after reading the human subjects' consent information. Survey demographics and their U.S. Census counterparts are shown in Table 1.

**Table 1.** Survey and U.S. population demographics.

| Demographic | Survey | Census [1] |
|:---:|:---:|:---:|
| Census Region (n = 850) | | |
| Northeast | 22.5% | 17.1% |
| Midwest | 21.9% | 20.8% |
| South | 40.4% | 38.3% |
| West | 15.3% | 23.9% |
| Education (n = 856) | | |
| High school degree or less | 27.5% | 39.1% |
| Some college, no bachelors | 31.2% | 30.3% |
| Bachelor's degree | 27.0% | 19.3% |
| Graduate or professional degree | 14.4% | 11.3% |
| Sex (n = 858) | | |
| Female | 50.6% | 50.7% |

| | | |
|---|---|---|
| Male | 49.1% | 49.2% |
| Prefer not to answer | 0.3% | 0.1% |
| Race (n = 858) | | |
| American Indian or Alaska Native | 3.1% | 0.9% |
| Asian | 6.6% | 5.8% |
| Black or African American | 10.3% | 13.2% |
| Native Hawaiian or Pacific Islander | 0.7% | 0.2% |
| White or Caucasian | 76.1% | 74.2% |
| Other | 3.1% | 5.7% |
| Hispanic (n = 858) | 11.9% | 18.4% |
| Household income (n = 858) | | |
| Less than USD 24,000 | 20.3% | 18.1% |
| USD 25,000–49,000 | 27.9% | 20.3% |
| USD 50,000–99,000 | 35.4% | 30.2% |
| USD 100,000–149,999 | 10.7% | 15.7% |
| USD 150,000 or more | 5.7% | 15.7% |
| Age (n = 858) | | |
| Under 25 years of age | 11.0% | 11.9% |
| 25–34 years of age | 17.6% | 17.9% |
| 35–44 years of age | 15.9% | 16.4% |
| 45–54 years of age | 18.3% | 16.0% |
| 55–64 years of age | 14.1% | 16.6% |
| 65–74 years of age | 18.5% | 12.4% |
| 75 years of age or older | 4.7% | 8.8% |

[1] U.S. Census Bureau American Community Survey. 2019 ACE 1-Year Estimates.

A careful examination of the data in Table 1 shows some discrepancies between survey participant percentages and U.S. population percentages in several demographic categories. For example, the survey under-sampled individuals in the West Census Region, individuals with a high school degree or less, and Hispanics. Additionally, the invitation to participate in the survey was sent to multiple panelists, with the first 859 panelists completing the survey included in the analysis, i.e., the selection of participants was not completely random. Due to these factors, readers are cautioned not to make inferences about the general population. Readers should consider the results as informative but not necessarily representing the U.S. population.

Survey participants were asked to provide additional information, in addition to the general demographic information summarized in Table 1. Specifically, participants were asked a series of questions about their diet, health, and shopping habits, as they related to vegetable purchases.

Participants were instructed "According to recommendations of the UDSA MyPlate Program, the average person should consume 3 cups of vegetables each day. Do you, on a typical day consume less than the suggested amount of vegetables, consume the suggested amount of vegetables, or consumer more than the suggested amount of vegetables?" Slightly more than one-half (53%) of the participants indicated they consumed less than the recommended amount, one-third (34%) indicated they consumed the suggested amount, with the remaining 13% indicating they consumed more than the recommended amount.

Four out of five participants (82.5%) indicated they were the primary shopper in their household. Nine out of 10 participants indicated they "liked" vegetables in general. Participants tended to consume fresh vegetables (54.7%) more than in frozen (23.7%), canned (18.7%), and dried (3.8%) forms. Participants were also asked where they tended to purchase fresh vegetables. A majority (68%) of the participants indicated they purchased fresh vegetables from traditional supermarkets. In total, 13% indicated they purchased fresh

vegetables from specialized food stores, 10% indicated they purchased vegetables from convenience stores, and 5% direct from farmers (farmers' markets or roadside stands).

Participants were instructed, "According to the U.S. Department of Health and Human Services, a healthy eating pattern includes a variety of vegetables from all of the subgroups, fruits (especially whole fruits), grains (at least half which are whole-grain), fat-free or low-fat dairy, a variety of protein foods (that can include animal-based proteins, legumes, nuts, seeds, and soy products), and oils." Participants were then asked how consistent their diet was with the described healthy eating pattern. Slightly over half (54%) indicated their eating patterns were consistent with the guidelines and about one in five (19%) indicated their diet was inconsistent with the guidelines.

Similar to the question related to healthy diets, participants were instructed "The U.S. Department of Health and Human Services recommends that adults should do at least 150 min (2.5 h) per week of moderate-intensity aerobic physical activity. Alternatively, they recommend that an adult can do 75 min (1.25 h) per week of vigorous-intensity aerobic activity" and then asked if their exercise habits were consistent with the statement. Just under half (47%) indicated that they exercised less than the recommended amount.

### 2.2. Methods

Participant's responses related to their spicy pepper consumption were explored descriptively using graphs and simple statistics such as chi-square goodness of fit tests. The importance of factors that influenced the likelihood that a survey participant indicated they frequently purchased (and assumed consumed) spicy peppers was examined using a binary logit regression model, a regression model that assumes errors follow a logistic distribution.

Logistic regression models are used to predict the likelihood or probability of a categorical dependent variable, e.g., a dependent variable that can take on one of two values (binary logit model). In this case, the regression model is used to predict the likelihood or probability that an individual purchases spicy peppers frequently, where frequent is defined as making a purchase at least once per month (the dependent variable) using various independent or explanatory variables associated with the participant, e.g., age, sex, and race or ethnicity. The probability is given as:

$$P_i = 1/(1 + \exp(z_i^{\wedge\prime} \beta)) \tag{1}$$

where

$$z_i^{\wedge\prime} \beta = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \cdots + \beta_n X_{ni} \tag{2}$$

where the Xs represents explanatory variables associated with an individual participant and the βs represent parameters that describe the influence of the explanatory variables on the probability that an individual purchases spicy peppers frequently. The specific variables used in the model are presented in Table 2. A maximum likelihood procedure is used to estimate the parameters.

**Table 2.** Explanatory variables for the binary logit model.

| Variable Name | % | Explanation |
|---|---|---|
| Frequent Consumer | 67.3 | Dependent variable that equals one if the participant indicated that they purchase spicy peppers in any form at least once per month. |
| Vegetable Eater | 47.0 | Equals one if a participant indicated that they consume the USDA My Plate Program recommended amount or more of vegetables. |
| Healthy Diet | 18.6 | Equals one if a participant indicated that their diet is consistent or very consistent with U.S. Dept. of Health and Human guidance. |
| Foodie | 40.5 | Equals one if a participant indicated that they considered themselves "foodie." |

| Food Explorer | 33.0 | Equals one if a participant indicated that they "try to use unique, gourmet, new, or exotic ingredients in my cooking." |
| Age_2 | 48.3 | Equals one if a participant indicated that their age was between 35 and 64 years. |
| Age_3 | 23.2 | Equals one if a participant indicated that their age was 65 years or greater. |
| Income_1 | 20.3 | Equals one if a participant indicated that their household income was less than USD 25,000. |
| Income_2 | 27.8 | Equals one if a participant indicated that their household income was between USD 25,000 and 49,999. |
| Income_3 | 35.4 | Equals one if a participant indicated that their household income was between USD 50,000 and 99,999. |
| Income_4 | 10.7 | Equals one if a participant indicated that their household income was between USD 100,000 and 149,999. |
| Bachelor Plus | 41.2 | Equals one if a participant indicated that they held a bachelor's or higher degree. |
| Minority | 24.0 | Equals one if a participant indicated that they were not Caucasian. |
| Hispanic | 12.0 | Equals one if a participant indicated that they were Hispanic. |
| Southwest Ties | 21.5 | Equals one if a participant indicated that they had lived in the southwest, i.e., Arizona, New Mexico, or Texas. |
| Census Northeast | 22.2 | Equals one if participant indicated that they lived in the Northeast Census Region. |
| Census West | 15.1 | Equals one if participant indicated that they lived in the West Census Region. |
| Census South | 39.9 | Equals to one if participant indicated that they lived in the South Census Region. |

The logistic model described above was used to estimate the effects that various survey participant attributes have on their purchase of spicy peppers. The dependent variable was created using participant responses to questions about the frequency of spicy pepper purchases. Specifically, if a participant indicated they purchased spicy peppers in any form (fresh, dried, canned, or frozen) they were classified as "frequent" spicy pepper consumers, and the dependent variable was set equal to one. Otherwise they were classified as non-frequent spicy pepper consumers and the dependent variable was set equal to zero. Approximately two-thirds of participants (67.3%) indicated that they purchased spicy peppers at least once per month.

Independent variables, all binary dummy variables, used to explain spicy pepper consumption included self-reported characteristics including participant vegetable consumption, the importance of price, diet, foodie, willingness to explore new foods, age, income, monthly budget for food purchases, education, race, Hispanic ethnicity, having lived in the southwest, and current residence, i.e., the Census region where they live. Table 2 presents a summary of the variables and how they were developed for use in the model. The percentage column indicated the number of participants who fit into the category, e.g., 40.5% of participants indicated that they consider themselves a "foodie."

## 3. Results and Discussion

### 3.1. Descriptive Analysis

Survey participants were provided a list (with pictures) of common spicy pepper varieties/cultivars in three different categories, fresh, dried, and other processed (canned or frozen). Table 3 shows the varieties/cultivars presented to the survey participants and the percent of participants indicating that they had purchased the pepper in the last three months. More than 95% (95.6%) of survey participants indicated that they had consumed some form of spicy pepper in the last three months. The proportion of participants who

consumed spicy peppers in the last three months was compared to the demographic categories in Table 2. Using a chi-square goodness of fit test, the null hypothesis that proportions of spicy pepper consumption were independent between each of the demographic categories in Table 2 could not be rejected.

**Table 3.** Spicy pepper consumption in the last three months.

| Category/Variety | Number | Percent |
|---|---|---|
| Fresh | | |
| Jalapeno | 541 | 63.0% |
| New Mexico-type long green chile pepper | 225 | 26.2% |
| Habanero | 206 | 24.0% |
| Poblano | 188 | 21.9% |
| Serrano | 167 | 19.4% |
| Other | 148 | 17.2% |
| Dried | | |
| Paprika powder | 472 | 54.9% |
| Cayenne Powder | 406 | 47.3% |
| Chile flakes | 357 | 41.6% |
| Dried red chile pepper | 341 | 39.7% |
| Dried New Mexico-type long red chile pepper | 118 | 13.7% |
| Dried serrano pepper | 105 | 12.2% |
| Ancho | 58 | 6.8% |
| Other | 89 | 10.4% |
| Other Processed | | |
| Canned chopped green chile | 283 | 32.9% |
| Frozen chopped green chile | 205 | 23.9% |
| Chipotle peppers in adobo sauce | 166 | 19.3% |
| Frozen red chile puree | 151 | 17.6% |
| Other | 144 | 16.8% |

Survey participants who indicated they did not eat spicy peppers in any form were asked to identify why they did not. Seven possible reasons were provided to participants in addition to an opportunity to provide additional reasons. Participants were allowed to identify more than one reason if desired. The 38 participants who indicated that they did not consume spicy peppers in the last three months provided 122 reasons. The most common reasons provided (from the seven provided) by participants for not consuming spicy peppers were that they were "too spicy or hot" and they did not like the taste (Figure 4). Several of the "Other" additional reasons offered by participants were associated with digestive issues caused by spicy peppers.

**Figure 4.** Factors that influenced participants to choose not to consume spicy peppers.

Survey participants were asked about the importance of nine characteristics of spicy peppers in their decision to purchase (price, production region, packaging, and production system, e.g., organic/traditional) and consume (taste, freshness, color, size, and health characteristics) the products. The percentage of participants indicating that an individual characteristic was important or very important to their decision to purchase or consume peppers ranged from 84% to 42% (Figure 5). As might be expected, taste and freshness were rated high in terms of importance in the participant's decision-making process. Almost two-thirds of participants (61.2%) rated understanding the health characteristics of spicy peppers third as either important or very important to the decision to consume spicy peppers. Price, a clear economic variable, was rated fourth.
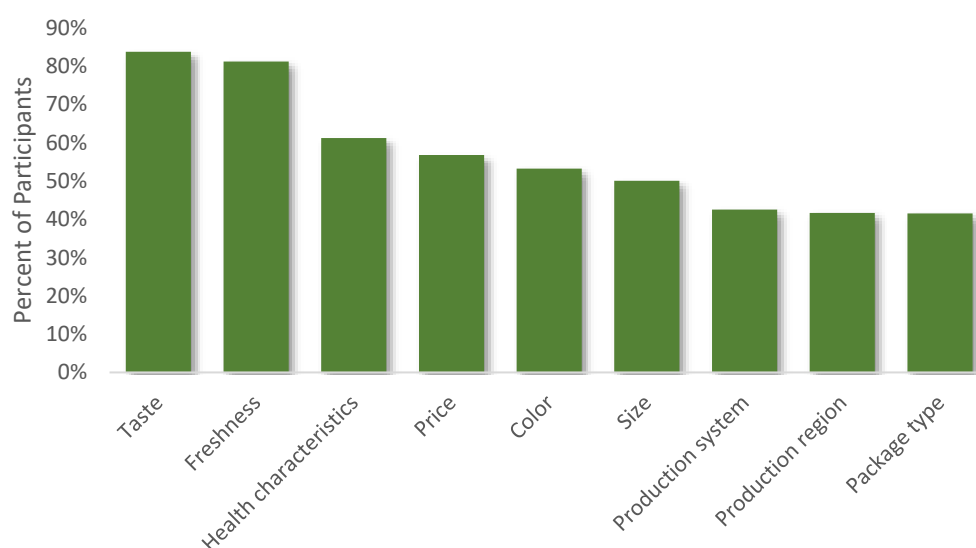


**Figure 5.** The importance of spicy pepper characteristics.

Associated with the health characteristics of spicy peppers, survey participants were provided six potential health-related claims that may be made about spicy peppers. The claims included [10–12]:

- Metabolize glucose. Research suggests that chile peppers assist in weight loss.
- Improve insulin sensitivity. Research suggests that chile peppers improve blood sugar and insulin reaction.

- Anti-inflammatory. Chile peppers increase blood flow to tissues and reduce vascular plaque buildup.
- Boost your body. Chile peppers are full of vitamins A, B, and E.
- Help fight infections. Chile peppers are powerful at slowing the growth of common food-borne illnesses.
- High in antioxidants. Chile peppers help remove free radicals from the body.

Participants were asked to rate the importance of the claims on considerations to consume spicy peppers. Three out of four participants rated the "fighting infections" (74.4%), "boosting your body" (74.1%), and "high in antioxidants" (73.7%) as important or very important (Figure 6).
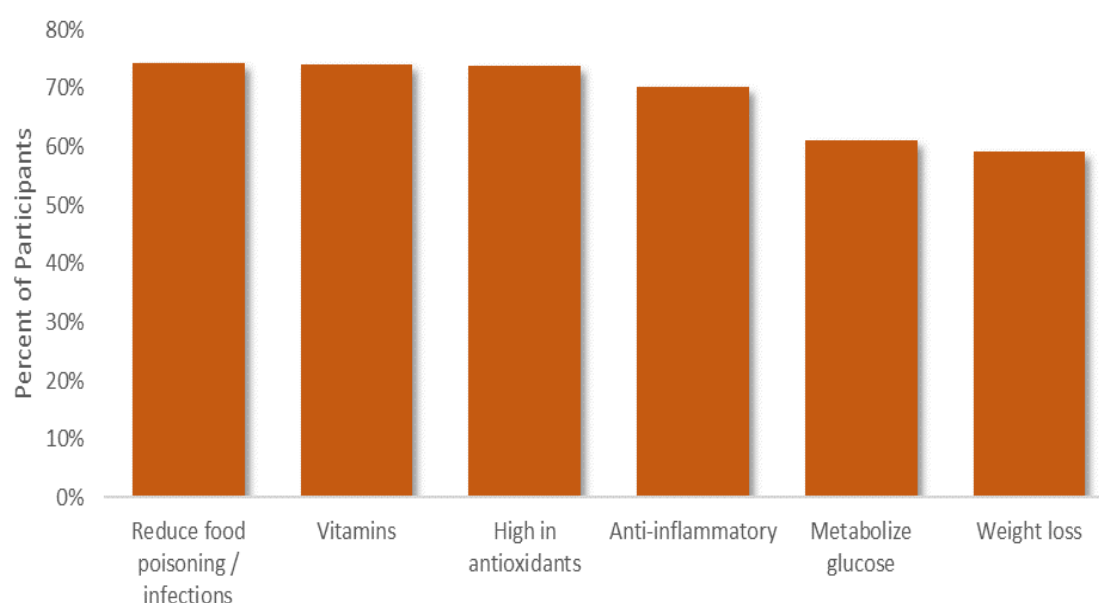


**Figure 6.** The importance of spicy pepper characteristics.

*3.2. Binary Logit*

The binary logit regression results are shown in Table 4. The likelihood ratio test is a test to determine if the parameters associated with the explanatory variables are statistically significantly different from zero, i.e., $\beta_1 = \beta_2 = \cdots = \beta_n$. The likelihood test statistic (177.97) and accompanying p-value (<0.0001) indicate that the model fits statistically significantly better than a model that includes only an intercept term, i.e., at least one of the parameter estimates associated with the independent variables is statistically different from zero. Other measures of model fit, R-square (R-Square = 0.2098, Max-rescaled R-Square = 0.2905) and the percent concordant/discordant pairs (78.4 concordant, 21.6 discordant) both suggest the model does a relatively good job predicting the participants' frequency of purchasing spicy peppers.

**Table 4.** Logit regression parameter estimates, standard errors, statistics, and p-values.

| Parameter [1] | Estimate | Wald Chi-Square | *p*-Value |
|---|---|---|---|
| Intercept | −1.3779 | 9.7134 | 0.0018 |
| Vegetable Eater | 0.4734 | 6.9186 | 0.0085 |
| Healthy Diet | −0.0824 | 0.1517 | 0.6969 |
| Foodie | 0.6046 | 9.4808 | 0.0021 |
| Food Explorer | 1.0561 | 20.7263 | <0.0001 |
| Age_1 (18–34 years) | 1.4092 | 30.6506 | <0.0001 |
| Age_2 (35–64 years) | 0.9337 | 21.1462 | <0.0001 |

| | | | |
|---|---|---|---|
| Income_1 (Less than USD 25,000) | 0.1205 | 0.0913 | 0.7625 |
| Income_2 (USD 25,000–49,999) | 0.1690 | 0.1959 | 0.6581 |
| Income_3 (USD 50,000–99,999) | 0.5495 | 2.1745 | 0.1403 |
| Income_4 (USD 100,000–149,999) | 0.4835 | 1.2748 | 0.2589 |
| Bachelor Plus | 0.2478 | 1.6786 | 0.1951 |
| Minority | −0.1714 | 0.3368 | 0.5617 |
| Hispanic | 0.7138 | 9.2664 | 0.0023 |
| Southwest Ties | 0.4173 | 3.5588 | 0.0592 |
| Census Northeast | 0.0382 | 0.0241 | 0.8767 |
| Census West | 0.1234 | 0.1959 | 0.6581 |
| Census South | 0.0371 | 0.029 | 0.8648 |

[1] Variables left out to avoid singularity issues included Age_3 (65 years or older), Income_5 (USD 150,000 or more), and Census Midwest.

Results shown in Table 4 show seven of the 17 variables, including the intercept, in the model were significant at the 10% level (six at the 5% level). The probability that participants indicated they were a frequent consumer of spicy peppers increased if they:

- indicated their vegetable consumption was consistent with USDA's My Plate Program recommendations,
- considered themselves a "foodie" in that they agreed or strongly agreed with the statement "I would consider myself a person who devotes attention and energy to knowing food ingredients and preparation techniques and finds enjoyment in top-notch ingredients and preparation,"
- were a "food explorer" in that they agreed or strongly agreed with the statement "I try to use unique, gourmet, new, or exotic ingredients in my cooking,"
- identified their race as non-white or non-Caucasian (identified as American Indian or Alaska Native, Asian, Black or African American, or Native Hawaiian or Pacific Islander),
- if they were younger than 65 years, i.e., between 18 and 34 years or between 35 and 64 years old, or
- had ties to the Southwest indicating that they live or had previously lived in Arizona, New Mexico, or Texas.

Other factors included in the model, e.g., diet quality/health, income, education, Hispanic, or current geographic residence as defined by Census Regions had no statistically significant impact on the frequency of spicy pepper consumption.

## 4. Conclusions

As the U.S. becomes more culturally diversified via various influences including immigration and tourism, so too do the food preferences of its population. Spicy or pungent peppers sometimes referred to as hot, chili, or chile, are benefiting from changing food preferences. Per capita fresh chile pepper consumption has more than doubled over the last 40 years and per capita consumption of dry chile peppers has increased by more than 46%. While spicy pepper consumption has increased significantly, the increase has largely been met via imports as domestic production of spicy peppers (as a USDA category "chile peppers") has declined over the last 25 years. By better understanding spicy pepper consumers and their consumption patterns, it may be possible for U.S. farmers and food manufacturers to identify ways to meet increasing demand.

A nationwide panel survey was implemented in the summer of 2021 to gather information to better understand consumer preferences for spicy peppers. While the survey is not necessarily representative of the U.S. population and results should not be inferred to the population, the results do shed light on spicy pepper consumption.

The probability that participants purchased spicy peppers at least once per month increased with vegetable consumption in general, if a participant identified as a "foodie"

or as someone who likes to explore new foods, minorities, had ties to the southwest or who were younger. The findings, if consistent with the larger population, are positive for the industry as younger consumers currently consume spicy peppers more frequently and are likely to continue that trend as they age and the population continues to become more diverse from a racial or ethnicity standpoint.

Domestic farmers seeking market opportunities within the spicy pepper market might benefit by better understanding their final consumer, i.e., the population that consumes spicy peppers. The preliminary results from the survey described in this paper suggest opportunities to target younger, ethnically diverse, and foodie consumers. Further research could explore in greater depth the impact ethnicity has on spicy pepper consumption in the United States, i.e., explore in more detail the ties between different ethnic populations and spicy pepper consumption.

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