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#PorkandPigs: an online media listening analysis of public perception of the U.S. swine industry

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Abstract

With the majority of the U.S. swine industry being generally bounded by social licensing, there is a growing need to understand social perspectives to better adapt to consumer demands. Online and social media data are rich datasets that researchers are leveraging to tackle economic and societal challenges. The information that can be gleaned from online media regarding public perceptions makes it an important tool for producers to understand driving topics of interest to the public. This study utilized a prominent online and social media listening and data analytics platform to identify and quantify online and social media mentions related to the U.S. swine industry from January 1, 2020, to December 31, 2023. A general search for online media referencing pork and pigs was designed resulting in a total of 41,093,309 mentions. The search was further queried to specific topics of food and cooking (20,580,068 mentions), price (2,866,548 mentions), welfare (1,615,208 mentions), sustainability (771,819 mentions), and top authors/organizations within the U.S. swine industry (1,430 mentions). The study spanned the geographic locations of the overall US (including U.S. Minor Outlying Islands), the top 5 most populous states, and the top 5 pork-producing states as of 2024. Of all mentions, X/Twitter was the largest domain for nearly all mentions related to pork and pigs. Major organizations designed to spread information between the general public and pork producers had a minor impact on the overall conversation and no online media presence in the top 5 most populous states. Net sentiment was overall positive across all 4 yr and all geographies except for major events such as the COVID-19 pandemic, the H1N1 Swine Flu, the passing of California Proposition 12, environmental events, and inflation-associated pork prices. Overall, most media presence had positive net sentiments and with most interest surrounding ways to cook pork and how to keep bacon cheap. Understanding public perceptions of the U.S. swine industry provides the opportunity to make informed decisions on marketing strategies and production practices.

Lay Summary

Online and social media is an extensive network of public information that researchers can use to understand important topics of interest to the general public. This data is largely untapped by agricultural industries, such as the U.S. swine industry, to assist in decision-making to best meet consumer needs and demands. This study used an online and social media listening and data analytics platform to evaluate and measure online and social media conversation related to the U.S. swine industry across the entire US, the top 5 most populous states, and the top 5 pork-producing states from January 1, 2020, to December 31, 2023. A total of 41,093,309 mentions in the US were found for the primary search. Of that overall search, 50.08% of those mentions referenced food and/or cooking, 6.98% referenced price, 3.93% referenced welfare, 1.88% referenced sustainability, and less than 0.01% referenced major authors within the swine industry. X/Twitter was the largest domain for nearly all mentions related to pork and pigs except for sustainability-related mentions where news sources were more common. This research provides a glimpse into public perceptions of the U.S. swine industry and offers opportunities to understand and respond to consumer preferences more effectively.

Introduction

The U.S. swine industry is largely self-regulated compared to other countries (von Keyserlingk et al., 2024). Self-regulation is greatly associated with, or derived from, social license meaning that industry practices conform to societal pressure and values (Gunningham et al., 2004; Rollin, 2011). With the constant flux of societal values, self-regulated industries must adapt to those values to retain public trust. There is a growing interest in exploring public perceptions of animal production practices to facilitate informed decisions in the industry.

A survey conducted primarily with millennial U.S. participants reported that animal care, profitability, farm size, compliance with environmental rules and regulations, workers' rights and welfare, and pigs' quality of life were important characteristics of an ideal pork/pig farm (Sato et al., 2017). Consumer-led changes paired with industry-led changes, such as legislative changes, may help avoid impending disruptions to those working in the industry (Ceccato et al., 2022).

Meat has been a main component in the diets of U.S. residents for decades (Daniel et al., 2011). Pork, specifically, has been a major commodity as the US produces 11% of the world's pork (USDA Foreign Agricultural Service, 2022). Pork consumption has fluctuated in the US with consumption averaging about 22 kg per capita annually in 2010 and increasing to a peak of 23.6 kg per capita in 2019 (Widmar,

2024). However, there has been a slow, yet steady, decline in consumption since 2019 that has markedly contributed to the challenges the U.S. swine industry has faced in the last several years.

A major challenge for the U.S. swine industry is the decreasing pork consumption by younger consumers. Millennials and American youth are recognized as individuals born between 1982 and 2000 and represent over one-fourth of the nation's population (U.S. Census Bureau, 2015). The millennial generation is the most diverse generation in U.S. history with 44.2% being part of a minority race or ethnic group. While the majority of U.S. residents report regularly consuming animal products, there is increasing evidence of meat-avoidance behavior in younger, higher-educated, and higher-income consumers in the US (Tonsor and Lusk, 2022). Millennial consumers have been found to spend less of their total weekly income on pork and food away from home than ever before (Conley and Lusk, 2018). The current trend of younger consumers eating less pork results in the forecast of annual pork consumption declining by 1 kg from 2024 to 2034 (Shike, 2024).

Understanding the demographics and preferences of potential consumers is vital in the marketing strategies of the U.S. pork industry. Social media is where Millennials and Gen Z primarily obtain their news, product/service information, content discovery, and more compared to older generations, making it a key location for analysis to better understand conversations in these generations (Nissen, 2023). Thus, there is increasing interest in exploring the context of online and social media in the agricultural economy to assist in data-driven decision-making.

The number of social media users globally increased from 1 billion in 2010, to 2.62 billion in 2018 (Clement, 2018), to 5.07 billion by 2024 (Petrosyan, 2024). Additionally, government and nonprofit organizations, public officials, and other organizations use social media, most notably X/Twitter, to communicate with the general public, convey important messages, and rapidly spread information (Kuttschreuter et al., 2014; Mickoleit, 2014). The large number of users representing broad swaths of the public on online and social media makes it a great platform to spread and obtain information rapidly. However, big data presents challenges as to how best to employ analyses (Taylor et al., 2014). Although advancements in science, data analytics, and the rise of large-scale intensive farming indicate a shift toward data-driven decision-making, agriculture still has a long way to go to explore incorporating public perceptions and big data analytics into the optimization of production practices and on-farm decisions.

The swine industry is heavily reliant on volatile feed (input) prices, changing domestic and international consumer demand, and, ultimately, pork (output) prices to determine profitability. This study identified key drivers of public sentiment related to pork and pigs in the US. This paper uses online and social media data to examine public perceptions of the U.S. swine industry across an array of topics including welfare, sustainability, price, food and cooking, and highly relevant organizations within the swine industry. Additionally, the top 5 pork-producing states and top 5 most populous states were analyzed to better understand perceptions nearer/further from production regions. It was hypothesized that the majority of mentions related to pork and pigs would reference food and cooking. The net sentiment was hypothesized to be higher in the top 5 pork-producing states compared to the top 5 populous states. It was hypothesized that events impacting hog farmers such as plant closures during the COVID-19 pandemic and implementation of Proposition 12 in California would show a greater response in the top 5 pork-producing states compared to the top 5 populous states.

Materials and Methods

The supply and demand of U.S. pork markets within the US was determined by overall market trends of pork products summarized using monthly data from 2020 to 2023 provided by the USDA. The U.S. public's perceptions of the U.S. Pork Industry from January 2020 to December 2023 were quantified and summarized using online "listening" to allow for searching and amassing of data from online and social media sources.

U.S. Pork Production and Consumption Data

Total sales of pork from farm to wholesale, wholesale to retail, and retail sales in cents per kg of retail equivalent were obtained from the USDA Economic Research Service (ERS) (USDA-ERS, 2024a). The quarterly disappearance of pork data was used as a proxy for consumption obtained from the USDA-ERS (USDA-ERS, 2024b). Monthly cost for carcass weights data was collected from the USDA National Agricultural Statistics Service (NASS) (USDA-NASS, 2024). Prices for various cuts of pork were obtained from the U.S. Bureau of Labor Statistics via the Center for Food Demand Analysis & Sustainability at Purdue University (CFDAS, 2024).

Data Collection

Online media can include comments, posts, reviews, responses, blogs, etc. (Widmar et al., 2020b). Researchers parameterize searches centered around a desired topic using inclusionary search terms, excluded terms, specific domains, and authors to analyze public conversations and sentiments (Mahoney et al., 2020; Widmar et al., 2020a). Online listening is an emerging research tool that allows for the comparison of online public perception to the public interest by comparing online media presence to stocks, event attendance, retail markets, and more (Mahoney et al., 2020; Widmar et al., 2020b; Ellman et al., 2023). The Quid (previously Netbase) platform is an online media listening platform equipped with search and analysis capabilities for online media including X/Twitter, Facebook, Instagram, news, blogs, forums, consumer reviews, and other media sources (Netbase, 2018a). Additionally, Quid's Natural Language Processing (NLP) system (Netbase, 2018b) is an accurate and relevant online media analytic tool for open searches. Quid has proven to be one of the top social listening platforms used for general research purposes in addition to product development (Carr et al., 2015).

To quantify and study the volume and net sentiment of online and social media related to the U.S. Pork industry, the Quid platform was used to search and analyze online and social media from January 1, 2020, to December 31, 2023. Social and online media are fluid due to posts being removed or reinstated, so it is imperative to report the dates on which data was formally collected and finalized. Data were downloaded and summarized between February 20th and February 22nd, 2024. While searches across countries and in multiple languages are technologically possible, the local

language, slang, shorthand, and cultural context of social media posts prove challenging and must be acknowledged by researchers. The geography for all searches employed in this analysis was limited to the United States (including U.S. Minor Outlying Islands) and posts in English were studied exclusively.

To identify and quantify social and online media posts, a query was parameterized using terms related to pigs and pork products to filter online media for activity of interest. "Post" refers to the number of documents that contain mentions of the selected topics, while "mentions" are individual sentences within a post that contain primary search terms. The number of posts will never be greater than the number of mentions, because each post will contain at least one mention. Researchers combined common terms and hashtags to reference inputs to common pig production terms, such as pig farm and pigs, and references to pork products, based on a previously published paper (Widmar et al., 2022), such as bacon and pork loin, to develop a list of 54 primary search terms as follows: pig, #pig, #pigs, hog, #hog, #hogs, pork, #pork, swine, #swine, tenderloin, pork tenderloin, pork loin, pork chop, bacon, sausage, pepperoni, spareribs, ham, #RealPigFarmer, sow, #sow, boar, #boar, piglet, #piglet, #piglets, piglets, #sows, farrow, farrowing, hog farm, pig farm, swine farm, #hogfarm, #hogfarming, #PorkMonth, pig farmer, hog farmer, swine farmer, gilt, gilts, pork production, commercial swine farm, commercial hog farm, commercial pig farm, farrow-to-finish, farrow-to-wean, wean-to-finish, farrow-to-nursery, modern pig farmer, #SwineProduction. In addition to inclusionary search terms, exclusionary search terms were identified to tailor searches to the specific subject matter intended. For example, phrases such as "sowing doubt", "Peppa Pig", and "you uncultured swine", among others, were excluded due to irrelevance to the subject matter. Phrases related to political jargon such as "adding pork to the bill," "pork-filled bill," and police officers referred to as "pigs," were excluded as best as possible in the search parameters. All exclusionary terms, authors, and domains are provided in the supplementary material (Appendix A).

Posts and mentions related to pork and pigs returned by the original query were further filtered into 5 subsets of conversations by topic including welfare, sustainability, food and cooking, price, and prominent authors in the pork industry. To identify references to welfare, 66 terms were chosen as subsearch parameter keywords. These words and hashtags included represented a variety of topics related to welfare including biosecurity, California Proposition 12, enrichment, and more. To identify references to sustainability, 66 terms were selected as a subsearch parameter including terms such as greenhouse gas emissions, carbon footprint, antibiotic-free, and more. To identify references to food and cooking with pork, 61 terms were selected as a subsearch parameter including terms such as BBQ, bacon, grilling, and more. To identify references to the price of pork, 17 terms were identified including pork price, cost, retail, and more. Lastly, authors and terms prevalent in the pork industry were identified to analyze their impact on public conversation and perception. A total of 9 major authors (National Pork Board, Pork Checkoff, National Pork Producers Council, Iowa Pork Producers Council, Indiana Pork Producers Council, Illinois Pork Producers Council, Minnesota Pork Producers Council, North Carolina Pork Producers Council, United States Department of Agriculture) and associated campaigns

totaling 63 search terms were included as subsearch parameter keywords. All subsearch parameters and terms can be found in Appendices B to F.

To allow for comparison across areas of different impact potentials, specific geographic regions were identified. Filters included the top 5 pork-producing states as of 2022 (USDA National Agricultural Statistic Services, 2024), including Iowa, Minnesota, North Carolina, Illinois, and Indiana (11.7% of the U.S. population), and the top 5 most-populated states including California, New York, Texas, Florida, and Pennsylvania (37.2% of the U.S. population; U.S. Census Bureau, 2023). It was hypothesized that conversations in pork-producing states may differ from those in highly populated states. These 2 groups of states were analyzed as a collective of 5 states and then by individual states to compare conversations and sentiments based on geographic location.

Due to the nature of social media, areas with a greater population result in a greater number of mentions than areas with a smaller population. Additionally, Quid's updated geolocation classification as of January 2023 allowed location identification of posts that did not directly provide geolocation metadata. Prior to 2023, the location was only assigned if geolocation metadata was provided in the original post. Following the update in January 2023, Quid was able to estimate the location for posts that use specific terms, phrases, and location-specific terminology leading to an overall increase in the number of posts collected. The number of mentions was averaged by year and the deviation from the mean by month for each year was calculated to account for variation in population and change in data collection in 2023. The total number of mentions per year is provided in the tables. Raw data for the weekly and annual number of mentions and net sentiment is available upon request.

Sentiments associated with search results were analyzed; Quid's patented Natural Language Processing engine identifies positive, negative, and neutral sentiments toward a particular topic and assigns it a rating (Netbase, 2018b). Researchers reviewed a subset of online media returned, a process referred to as "tuning," and checked for consistency in sentiment, both positive and negative, to determine contextual correctness. The net sentiment is the total percentage of positive posts minus negative posts bound between +100% and –100%. A neutral category is constructed but has no impact on the net sentiment calculation.

Results and Discussion

Individual states within each group did not differ significantly from each other or the compiled results for the top 5 most populous states and top 5 pork-producing states, therefore, individual data for those states is available upon request. Results are reported for the whole US, top 5 most populous states, and top 5 pork-producing states, collectively, for all topics. When analyzing the data within the top 5 most populous states and top 5 pork-producing states, X/Twitter accounted for ≥99% of the number of mentions in the captured data with other social media platforms having minor mentions. The top 5 most populous states account for approximately 37% of the total U.S. population and the top 5 pork-producing states account for ~11% of the total U.S. population. The percentage of mentions for the overall US coming from X/Twitter and for each geographic location was proportional to the population in the top 5 most populous

Table 1. Overall mentions, sources, and domains for all topics related to pork and pigs with the geography limited to the entire US including U.S. Minor Outlying Islands during the period of January 1, 2020 – 0000 hours, to December 31, 2023 – 2359 hours

Topic	Mentions, n	Percent of general conversation[1], %	Top sources	Percent of mentions[2], %	Top domains	Percent of mentions[3], %
General	41,093,309	—	X/Twitter	77.3	twitter.com	93.4
			Forums	9.3	boards.4channel.org	2.1
			News	7.5	opentable.com	1.3
			Blogs	5.4	boards.4chan.org	1.3
			Consumer reviews	0.4	smokingmeatforums.com	0.2
Food/cooking	20,580,068	50.08	X/Twitter	73.6	twitter.com	92.4
			Forums	9.4	opentable.com	2.3
			News	4.5	boards.4channel.org	1.8
			Blogs	7.1	boards.4chan.org	1.6
			Consumer reviews	0.6	booking.com	1.5
Price	2,866,548	6.98	Twitter	47.5	twitter.com	85.5
			News	26.0	boards.4channel.org	3.3
			Forums	13.5	zolmax.com	1.9
			Blogs	12.3	boards.4chan.org	1.9
			Consumer reviews	0.4	reportsnreports.com	1.4
Welfare	1,615,208	3.93	X/Twitter	59.9	twitter.com	90.2
			News	23.3	zolmax.com	2.6
			Blogs	9.1	boards.4channel.org	1.9
			Forums	7.2	boards.4chan.org	1.4
			Consumer reviews	0.1	swineweb.com	0.7
Sustainability	771,819	1.88	News	40.1	twitter.com	80.0
			X/Twitter	30.7	boards.4chan.org	2.6
			Blogs	20.1	swineweb.com	2.4
			Forums	8.5	medium.com	1.8
			Consumer reviews	0.2	boards.4channel.org	1.7
Author	1,430	0.003	X/Twitter	100	twitter.com	100.0

[1]Calculated as the number of mentions for each topic divided by the total number of mentions. Total will not always add to 100% based on search parameters.
[2]Calculated as the number of mentions from each source divided by the total number of mentions. Total will not always add to 100%.
[3]Calculated as the number of mentions from each domain divided by the total number of mentions. Total will not always add to 100%.

states. However, the top 5 pork-producing states appeared to have a lower contribution to the overall percent of mentions in the overall US than would be proportional to their population indicating a lower online and social media presence in this subset of states (Tables 1, 2, and 3).

General #PorkandPigs

A total of 41,093,309 mentions in the US during the period of January 1, 2020 – 0000 hours, to December 31, 2023 – 2359 hours, were found for the primary search conducted related to pork and pigs (Table 1). During that period, 50.08% of those mentions referenced food and/or cooking, 6.98% referenced price, 3.93% referenced welfare, 1.88% referenced sustainability, and less than 0.01% referenced major authors within the swine industry. There were 9,231,283 mentions for the primary search for the geographical location of the top 5 most populous states. Of those mentions, 47.63% referenced food and/or cooking, 4.25% referenced price, 3.15% referenced welfare, 0.76% referenced sustainability, and there were no mentions referencing the selected authors for this study. There were 2,367,817 mentions for the primary search for the geographical location of the top 5 pork-producing states. Of those mentions, 50.12% referenced food and/or cooking,

4.89% referenced price, 3.10% referenced welfare, 1.00% referenced sustainability, and 0.04% referenced the selected authors for this study.

X/Twitter had the most mentions found for all topics except for sustainability where news sources returned the highest volume of results. It is important to note that X/Twitter is known to be used in the US more in big cities, urban suburbs, and exurbs, which tend to be wealthy and well-educated, while it is used less by people in farmlands, native American lands, and working-class individuals (Chinni, 2023). Discussion about the swine industry in online and social media across the US was mostly focused on topics related to food and cooking of pork. These findings are consistent with the top likes and top things mentioned in general conversation where terms such as "breakfast," "dinner," "egg," "cheese," and "pizza" are frequently stated (Table 2). Top likes and things for the top 5 most populous states most frequently referenced food-related topics (Table 3). The top 5 pork-producing states also mentioned food-related topics, but there were more mentions related to the meat supply industry such as "no pork" (Table 3).

In 2020, the top 5 words or phrases referred to the H1N1 Swine Flu Pandemic as many people began comparing the

Table 2. Overall mentions, sources, attributes, and phrases by year with the geography limited to the entire US including U.S. Minor Outlying Islands during the period of January 1, 2020 – 0000 hours, to December 31, 2023 – 2359 hours

Year	Mentions, n	Top 5 sources	Percent of mentions[1], %	Top 5 likes[2]	Top 5 dislikes[3]	Top 5 things[4]
2020	11,294,581	X/Twitter	81.5	Win	Infect	Swine flu
		Forums	9.4	Great	Kill 575,000 people	H1N1
		Blogs	4.8	Breakfast	Swine flu	H1N1 swine flu
		News	4.0	Dinner	Kill	Egg
		Instagram	<1.0	Make	Infect 61 million American	Cheese
2021	8,122,771	X/Twitter	68.8	Breakfast	Kill	Egg
		Forums	13.4	Great	Make	Cheese
		Blogs	9.4	Dinner	Die	Pizza
		News	7.2	Easy	Swine flu	Chicken
		Instagram	<1.0	Win	Problem	Pulled pork
2022	7,727,789	X/Twitter	66.9	Great	Get people kill	Cheese
		Forums	13.4	Breakfast	Die	Egg
		News	11.9	Dinner	Lose	Chicken
		Blogs	7.4	Win	Dry	Pork belly
		Consumer reviews	<1.0	Easy	Issue	Pizza
2023[5]	13,948,147	X/Twitter	84.5	Breakfast	Kill	Egg
		News	7.9	Great	Not get job do	Cheese
		Forums	4.4	Dinner	Die	Pizza
		Blogs	2.3	Win	Lose	Chicken
		Consumer reviews	<1.0	Make	Swine flu	Pork belly

[1]Calculated as the number of mentions from each source divided by the total number of mentions. Total will not always add to 100% based on sources outside of the top 5 sources.
[2]Refers to the top attributes associated with a positive net sentiment.
[3]Refers to the top attributes associated with a negative net sentiment.
[4]Refers to the overall top words or phrases.
[5]As of January 2023, Quid updated geolocation classification allowing location identification of posts that did not directly provide geolocation metadata. Previously, the location was only assigned if the original post provided geolocation metadata. With the update in January 2023, Quid was able to ingest post text and estimate the location for posts that use specific terms, phrases, and location-specific terminology causing an overall increase in the number of posts collected.

Swine Flu to the COVID-19 Pandemic (Tables 2 and 3). Meat supply as a whole in the US saw a spike in attention in the early days of the pandemic as a result of several plant shutdowns (Bunge, 2020) and supply chain issues (Balagtas and Cooper, 2021; Hobbs, 2021). This was reflected in this study with a drastic increase in the number of mentions relative to the mean number of mentions each year in March 2020 for the entire US (Figure 1), the top 5 most populous states (Figure 2), and the top 5 pork-producing states (Figure 2). Comparing the increase in mentions between the top 5 most populous states and top 5 pork-producing states, the mean number of mentions increased at the same frequency of about 60% in March 2020, but quickly declined back to the 2020 annual mean by May 2020 in the top 5 most populous states but remained elevated until June 2020 for the top 5 pork-producing states. The net sentiment during this increase in mentions significantly dropped for the entire US, and both subsets of states (Figure 2). In January 2021, there was an increase in mentions for all demographics (Figures 1 and 2) in part due to the passing of the COVID-19 Relief Package that removed restrictive language that blocked eligibility for pork producers and added funding to compensate pig farmers forced to euthanize animals due to COVID-related supply chain disruptions (NPPC, 2021). While the number of mentions increased at this time, there was no major shift in overall net sentiment in any of the geographic locations evaluated in this study.

Total mentions referencing the U.S. swine industry were highest in 2020 and declined in 2021 and 2022. The increased mentions in 2023 are likely due, in at least part, to the change in data collection by Quid. Net sentiment for the general conversation regarding pork and pigs was positive for all collection points except for March 2020 when net sentiment drastically decreased to about −50% for the entire US, the top 5 most populous states, and the top 5 pork-producing states due to the outbreak of the COVID-19 pandemic and comparison to the H1N1 Swine Flu epidemic.

Food/Cooking

It has been found that Millennials are spending less of their total weekly food income on pork and are spending less of their budget on food away from home than ever before (Conley and Lusk, 2018). Millennials are defined as being born between 1982 and 2000 and have surpassed Baby Boomers as the largest living generation (U.S. Census Bureau, 2015). Product recall awareness is lower in millennials, but their change in consumption is more reactive when a recall occurs compared to other generations (Peake et al., 2014). Millennials and Gen Z are much more likely to rely on social media for news, product/service information, and content discovery compared to older generations (Nissen, 2023).

The topic of food and cooking in this study accounted for about 50% of the total conversation related to pork and pigs

Table 3. Overall mentions, sources, attributes, and phrases by year with the geography limited to the top 5 most populous states and top 5 pork-producing states during the period of January 1, 2020 – 0000 hours, to December 31, 2023 – 2359 hours

		Top 5 most populous states				Top 5 pork-producing states		
Year	Mentions, n	Top 5 likes[2]	Top 5 dislikes[3]	Top 5 things[4]	Mentions, n	Top 5 likes	Top 5 dislikes	Top 5 things
2020	3,472,230	Win	Infect	Swine flu	866,360	Dinner	Infect 1.4 Billion people	Swine flu
		Prize winning yam	Kill 575,000 people	H1N1		Win	Swine flu	H1N1 swine flu
		Breakfast	Kill	H1N1 swine flu		Breakfast	Kill	Swine Flu Pandemic
		Dinner	Swine flu	H1N1 Swine Flu Pandemic		Prize winning yam	Infect 61 million American	No pork
		Make	Infect 61 million American	Egg		Great	Handle	Cheese
2021	2,064,840	Breakfast	Kill	Egg	551,635	Breakfast	Kill	Cheese
		Make everything better	Swine flu	Cheese		Come out perfect	Swine flu	Egg
		Dinner	Make	Pizza		Dinner	Die	Pizza
		Make	Die	Swine flu		Make everything better	Make	Chicken
		Italian sausage	Problem	Bacon egg		Lunch	53 people	Swine flu
2022	1,902,575	Breakfast	Get people kill	Egg	504,424	Breakfast	Get people kill	Cheese
		Dinner	Die	Cheese		Dinner	Die	Egg
		Great	Swine flu	Pizza		Amazing	Lose	No pork
		Happy little water sausage	#nasty pig	Chicken		Top	Poultry waste problem	Chicken
		Win	Suffer	No pork		Win	Suffer	Pulled
2023[5]	1,791,638	Breakfast	Kill	Egg	445,398	Breakfast	Make	Egg
		Great	Make	Cheese		Dinner	Kill	Cheese
		Dinner	Lose	Pizza		Win	Lose	Pizza
		Good pig	Swine flu	Chicken		Great	#nasty pig	Chicken
		Delicious	Hell no pig	No bacon		Good pig	Swine flu	Pulled pork

[1]Calculated as the number of mentions each year divided by the total number of mentions of the general conversation from the top 5 most populous states and the top 5 pork-producing states.
[2]Refers to the top attributes associated with a positive net sentiment.
[3]Refers to the top attributes associated with a negative net sentiment.
[4]Refers to the overall top words or phrases.
[5]As of January 2023, Quid updated geolocation classification allowing location identification of posts that did not directly provide geolocation metadata. Previously, the location was only assigned if the original post provided geolocation metadata. With the update in January 2023, Quid was able to ingest post text and estimate the location for posts that use specific terms, phrases, and location-specific terminology causing an overall increase in the number of posts collected.

for all geographic locations (Table 1). For all geographies, For the 3 geographic locations selected in this study, the percentage of general conversation related to food and cooking was lowest in 2020 (Tables 4 and 5) likely due to the increased conversation dedicated to the COVID-19 pandemic.

"Breakfast" and "dinner" were among the leading attributes with positive net sentiment for the general US, top 5 most populous states, and top 5 pork-producing states across all 4 yr (Tables 4 and 5). This indicates that these are the 2 meals often related to pork products. For leading attributes with negative net sentiment, "overrated" and "burnt" were consistently among the top 5 for all geographic location categories with "dry" being a top dislike for the overall US. This is unsurprising as pork today has about 16% less fat and 27% less saturated fat compared with pork in 1991 making it easier for consumers to overcook (Newman and Garden-Robinson, 2010). In the top 5 populous states, pork was mainly

mentioned as an addition to dishes like "eggs," "cheese," and "pizza" (Table 5). In contrast, the top 5 pork-producing states referenced more main pork products like "chop" and "pulled pork" in addition to these terms (Table 5) suggesting pork is often consumed as a main dish.

The overall net sentiment was positive for all 4 yr for the conversation regarding food and cooking for the entire US (Figure 3), the top 5 most populous states, and the top 5 pork-producing states (Figure 4). There was an increase in the number of mentions from the mean in April 2020 for all 3 geolocation groups. Interestingly, there was a consistent mention of the packaging of bacon not being resealable as an issue for consumers for the entire US, the top 5 most populous states, and the top 5 pork-producing states. This corroborates findings from a survey conducted by SurveyMonkey in 2021, which found that the ability to reseal meat products is very important to their purchasing decisions (Forcinio, 2021).
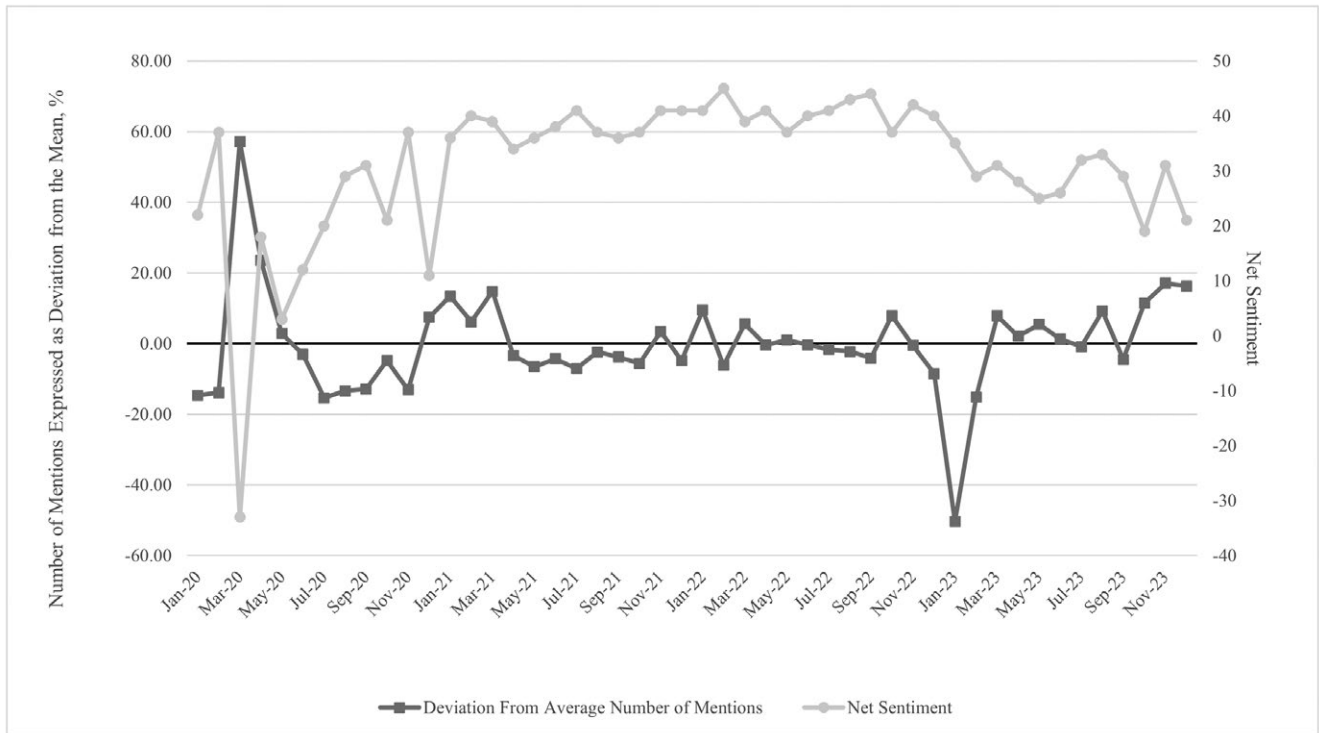
Figure 1. Overall deviation from the mean for number of mentions and overall net sentiment by month for general with the geography limited to the entire US including U.S. Minor Outlying Islands during the period of January 1, 2020 – 0000 hours, to December 31, 2023 – 2359 hours.
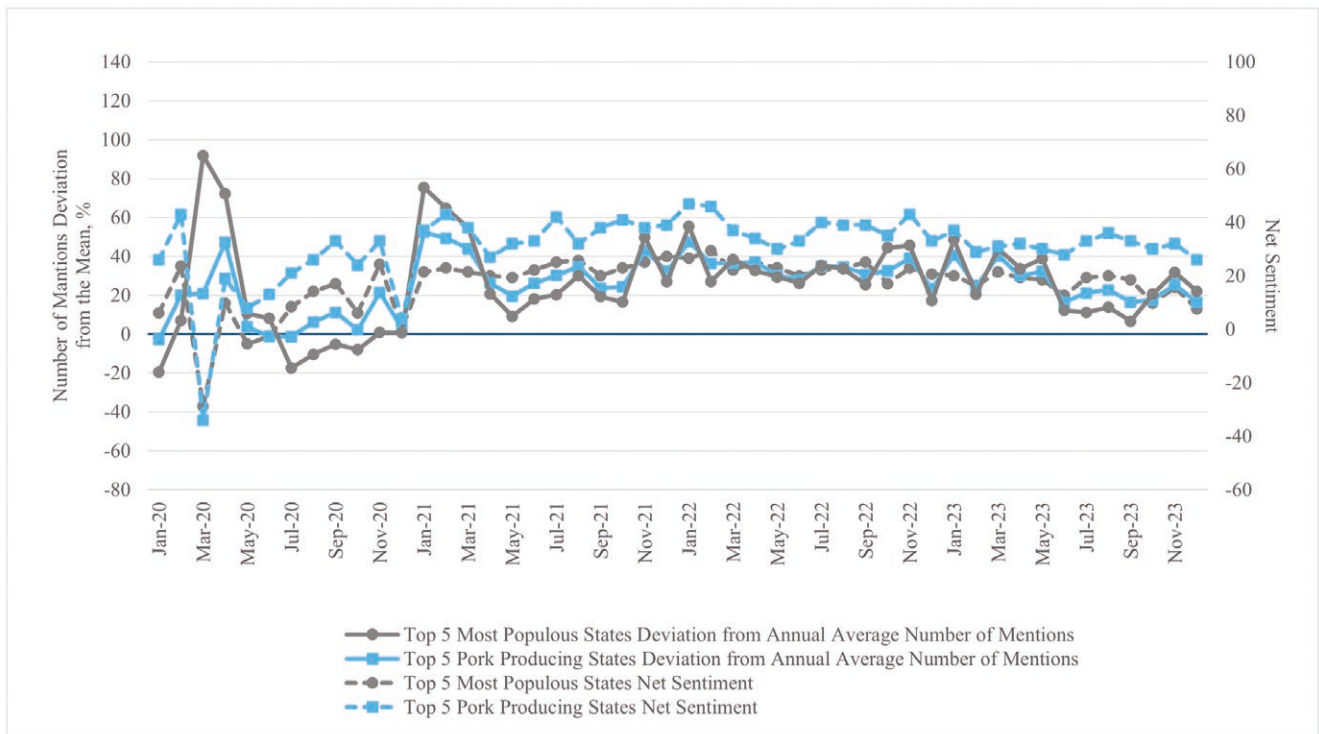
Figure 2. Overall deviation from the mean for number of mentions and overall net sentiment by month for general with the geography limited to the top 5 most populous states and top 5 pork-producing states during the period of January 1, 2020 – 0000 hours, to December 31, 2023 – 2359 hours.

Research conducted on resealable packaging in ground beef showed that consumers associate resealable packaging with sustainability (auri, 2021). Resealable packaging is considered to be convenient by consumers and guide purchasing decisions by individuals (Barbut and Leishman, 2022). The impact of resealable packaging on purchase decisions paired with the

Table 4. Mentions, sources, attributes, and phrases by year for food and cooking topic with the geography limited to the entire US including U.S. Minor Outlying Islands during the period of January 1, 2020 – 0000 hours, to December 31, 2023 – 2359 hours

Year	Mentions, n	Percent of general conversation[1], %	Top 5 sources	Percent of mentions[2], %	Top 5 likes[3]	Top 5 dislikes[4]	Top 5 things[5]
2020	4,945,586	43.79	X/Twitter	77.28	Breakfast	Vicious	Egg
			Forums	10.74	Win	Make	Cheese
			Blogs	6.84	Dinner	Burnt	Pizza
			News	4.74	Great	Kill	Pulled pork
			Instagram	< 1	Prize winning yam	Cold	Pepperoni pizza
2021	4,340,469	53.44	X/Twitter	66.37	Breakfast	Make	Egg
			Forums	12.40	Great	Burnt	Cheese
			Blogs	12.28	Dinner	Recall	Pizza
			News	7.68	Easy	Overrated	Pulled pork
			Instagram	1.15	Easy to make	Dry	Chicken
2022	4,115,282	53.25	X/Twitter	64.17	Breakfast	Dry	Cheese
			News	13.37	Dinner	Overcook	Egg
			Forums	12.82	Happy little water sausage	Burnt	Pork belly
			Blogs	9.17	Easy	Make	Pizza
			Consumer reviews	< 1	Great	Die	Chicken
2023[6]	7,178,731	51.47	X/Twitter	80.74	Breakfast	Burnt	Egg
			News	10.29	Dinner	Make	Cheese
			Forums	4.55	Great	Lose	Pizza
			Blogs	3.00	Easy	Dry	Pork belly
			Consumer reviews	1.40	Sweet Italian sausage	Overcooked	Chicken

[1]Calculated as the number of mentions each year divided by the total number of mentions of the general conversation from the entire US.
[2]Calculated as the number of mentions from each source divided by the total number of mentions. Total will not always add to 100% based on sources outside of the top 5 sources.
[3]Refers to the top attributes associated with a positive net sentiment.
[4]Refers to the top attributes associated with a negative net sentiment.
[5]Refers to the overall top words or phrases.
[6]As of January 2023, Quid updated geolocation classification allowing location identification of posts that did not directly provide geolocation metadata. Previously, the location was only assigned if the original post provided geolocation metadata. With the update in January 2023, Quid was able to ingest post text and estimate the location for posts that use specific terms, phrases, and location-specific terminology causing an overall increase in the number of posts collected.

continuous appearance of mentions regarding resealable bacon packaging suggests that producers and meat packagers should explore the impact of resealable packaging on bacon sales.

There are consistent increases in the number of mentions from the mean in November of each year for the entire US (Figure 3), the top 5 most populous states, and the top 5 pork-producing states (Figure 4). This may be attributed to the increase in ham sales during the holiday months, specifically Thanksgiving (National Pork Board, 2016). There is an increase in posts related to Thanksgiving recipes in November each year. The drastic decrease in the deviation from the mean number of mentions in January 2023 is attributed to the change in geolocation by Quid at this time (Figure 3). This shift is not visible in the top 5 most populous states and top 5 pork-producing states due to the small number of overall mentions compared to the overall US.

The large share of mentions related to food and cooking shows that consumers mostly care about the pork consumption when discussing the U.S. swine industry. Current efforts are being made by the national organizations National Pork Board and Pork Checkoff which are designed to bridge the consumer–producer relationship to educate consumers on nutritional factors of pork, share authentic and cultural pork recipes, and address existing unfavorable perceptions of the swine industry through their interactive website pork.org (National Pork Board, 2023).

Price

Price was the second most discussed topic across the entire US (6.98%), the top 5 most populous states (4.25%), and the top 5 pork-producing states (4.89%). The top likes associated with the price of pork across the overall US are consistent that pork is "cheap" and "fresh" (Table 6). However, the likes of pork being cheap were contradicted by the top 5 dislikes including the terms "expensive" and "cost" of pork. This was similar to the top likes and dislikes in the top 5 most populous states and top 5 pork-producing states (Table 7). Interestingly, a top dislike in 2021 in the top 5 most populous states included "California law taking effect" referring to Proposition 12 (Table 7). This is the first instance that California Proposition 12 was referenced in the top 5 likes, dislikes, or things in this study. The top 5 pork-producing

Table 5. Mentions, sources, attributes, and phrases by year for food and cooking topic with the geography limited to the top 5 most populous states and top 5 pork-producing states during the period of January 1, 2020 – 0000 hours, to December 31, 2023 – 2359 hours

	Top 5 most populous states				Top 5 pork-producing states			
Year	Mentions, n	Top 5 likes[2]	Top 5 dislikes[3]	Top 5 things[4]	Mentions, n	Top 5 likes	Top 5 dislikes	Top 5 things
2020	1,442,330	Win	Vicious as fu**	Egg	393,080	Dinner	Make	Cheese
		Prize winning yam	Make	cheese		For the win	Overrated	Egg
		Breakfast	Burnt	pizza		Breakfast	Make me bad	Pizza
		Dinner	Kill 150,000 people	Pepperoni pizza		Prize winning yam	10lb sausage	Pepperoni pizza
		Make	Cold	Ham sand-wich		Delicious recipe	@faradhusky cooking bacon	Pulled pork
2021	1,064,175	Breakfast	Overrated	Eggs	295,660	Breakfast	Burnt	Cheese
		Dinner	Make	Egg		Dinner	Make	Egg
		Italian sausage	Burnt	Cheese		Lunch	No bacon	Pizza
		Make	Increase	Pizza		Make everything better	Bad	Chicken
		Great	Recall	Bacon egg		Good sausage	Bad sausage	Pulled pork
2022	977,639	Breakfast	Die	Egg	265,545	Breakfast	Die	Cheese
		Dinner	Kill	Cheese		Dinner	Pork tenderloin sandwich	CHOP
		Happy little water sausage	Make	Pizza		Top	Too small	Egg
		Top	Burnt	Chicken		Happy little water sausage	Overrated	Pizza
		Make	Pork tenderloin sandwich	Pulled pork		Amazing	Burnt	Pulled
2023[5]	912,574	Breakfast	Lose	Egg	232,521	Breakfast	@tcm frying bacon	Egg
		Dinner	Make	Cheese		Dinner	Overrated	Cheese
		Great	Dead at 22	Pizza		Bacon egg	Burnt	Pizza
		Delicious	Burn	No bacon		Great	Die	Pulled
		Bacon egg	Bad	Pulled pork		Cheese	Recall	Pulled pork

[1]Calculated as the number of mentions each year divided by the total number of mentions of the general conversation from the top 5 most populous states and the top 5 pork-producing states.
[2]Refers to the top attributes associated with a positive net sentiment.
[3]Refers to the top attributes associated with a negative net sentiment.
[4]Refers to the overall top words or phrases.
[5]As of January 2023, Quid updated geolocation classification allowing location identification of posts that did not directly provide geolocation metadata. Previously, the location was only assigned if the original post provided geolocation metadata. With the update in January 2023, Quid was able to ingest post text and estimate the location for posts that use specific terms, phrases, and location-specific terminology causing an overall increase in the number of posts collected.

states included top mentions in the likes, dislikes, and things that were more focused on trends specifically related to the swine industry including inflation, seasonal decline of prices, and supply chain issues (Table 7) The percent of the conversation referencing price was highest in 2022 for all geographic categories which correlate with the highest cost of pork for all cuts of meat (Figure 5) and the highest retail cost (USDA-ERS, 2024a) over the period examined in this study.

There was an overall increase in the number of mentions from the mean for the overall US, the top 5 most populous states, and the top 5 pork-producing states due to the outbreak of the COVID-19 pandemic in 2020 (Figures 6 and 7). At the start of the COVID-19 pandemic, all meat supply received an increase in public attention as a result of several plant shutdowns (Bunge, 2020) and supply chain disruptions (Balagtas and Cooper, 2021; Hobbs, 2021). While conversations in the top 5 pork-producing states were more

focused on the shutdown of farms and plants, the conversation in the top 5 most populous states was centered around panic-buying pork and tips to make pork purchases last longer. There was a drop in net sentiment correlated with the increase in the number of mentions related to price in March 2020 related to the shutdown of several meat packing plants and hog farms (Figure 7). The top 5 most populous states had a greater decline in net sentiment than the top 5 pork-producing states. Overall, net sentiment remained positive regarding price from late 2020 to the end of the collection period.

There was a gradual increase in the cost of pork from April 2021 ($13.75/kg) until its peak in October 2021 ($16.18/kg; Figure 5). The increase in the cost of bacon is directly attributable to the increase in inflation rates in the U.S. economy (U.S. Inflation Calculator, 2024). Additionally, there was a decrease in net sentiment in the top 5 pork-producing states regarding
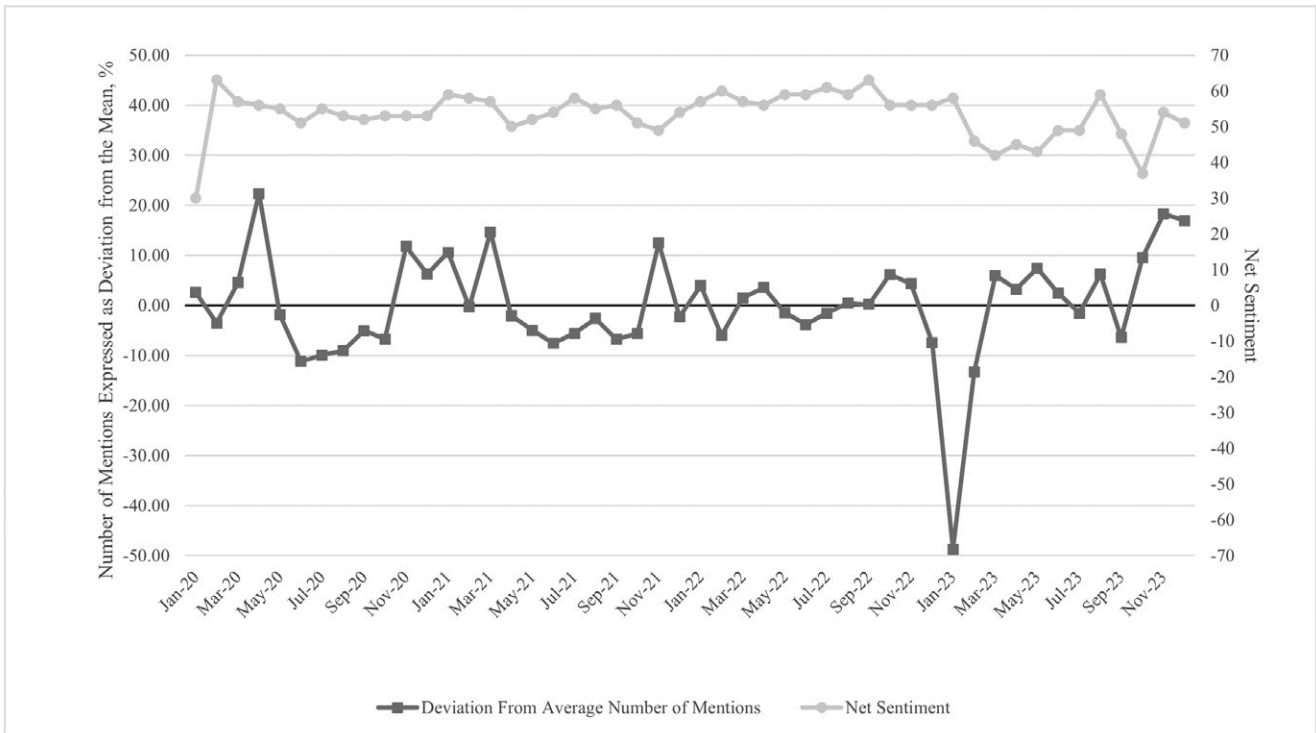
Figure 3. Overall deviation from the mean for number of mentions and overall net sentiment by month for posts related to food/cooking with the geography limited to the entire US including U.S. Minor Outlying Islands during the period of January 1, 2020 – 0000 hours, to December 31, 2023 – 2359 hours.
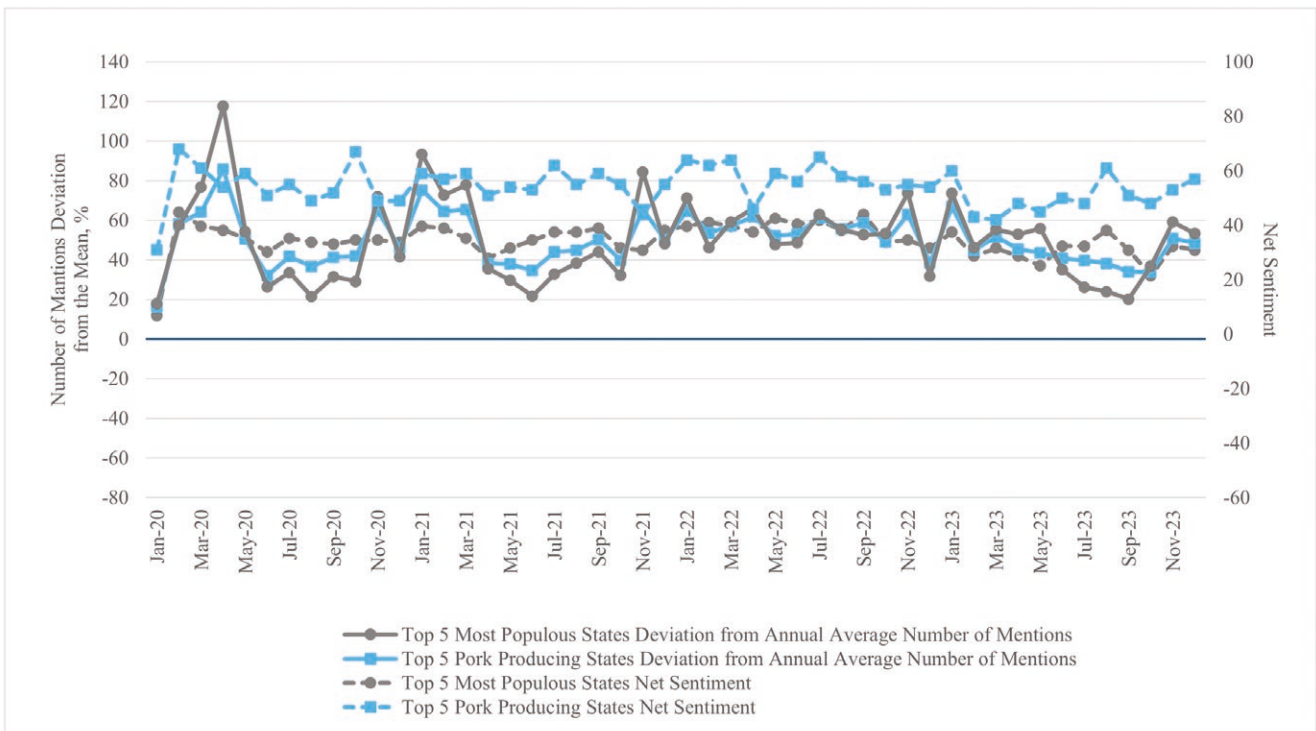

Figure 4. Overall deviation from the mean for number of mentions and overall net sentiment by month for posts related to food/cooking with the geography limited to the top 5 most populous states and top 5 pork-producing states during the period of January 1, 2020 – 0000 hours, to December 31, 2023 – 2359 hours.

Table 6. Mentions, sources, attributes, and phrases by year for price topic with the geography limited to the entire US including U.S. Minor Outlying Islands during the period of January 1, 2020 – 0000 hours, to December 31, 2023 – 2359 hours

Year	Total number of mentions	Percent of general conversation[1]	Top 5 sources	Percent of mentions[2]	Top 5 likes[3]	Top 5 dislikes[4]	Top 5 things[5]
2020	698,252	6.18	X/Twitter	52.63	Worth	Kill	Swine flu
			News	18.49	Cheap	Kill 12,469 people	Beef
			Forums	16.42	Fresh	Expensive	Price
			Blogs	12.20	Fresh pork	Price	No Pork
			Instagram	<1	Price	Tax payer dollar	No beef
2021	646,707	7.96	X/Twitter	38.81	Fresh	Expensive	Price
			News	26.56	Fresh pork	Price	Beef
			Blogs	16.98	Cheap	close higher	Pork price
			Forums	16.72	Amazing	Cost	Chicken
			Instagram	<1	Make	Rise	Cheese
2022	669,398	8.66	X/Twitter	37.58	Fresh	Price	Price
			News	33.75	Cheap	Expensive	Chicken
			Forums	15.18	Fresh pork	Rise	Pork belly
			Blogs	13.14	Help	Too damn high	Beef
			Consumer reviews	1	Sell	Cost	Pork price
2023[6]	852,191	6.11	X/Twitter	57.54	Cheap	Swine flu vaccine	Swine Flu
			News	25.60	Cheaper meat	remove from market	Price
			Blogs	8.28	Fresh	Cost	Swine flu vaccine
			Forums	7.32	Dinner	Expensive	Pork belly
			Consumer reviews	1.23	Make	Carry disease	Chicken

[1]Calculated as the number of mentions each year divided by the total number of mentions of the general conversation from the entire US.
[2]Calculated as the number of mentions from each source divided by the total number of mentions. Total will not always add to 100% based on sources outside of the top 5 sources.
[3]Refers to the top attributes associated with a positive net sentiment.
[4]Refers to the top attributes associated with a negative net sentiment.
[5]Refers to the overall top words or phrases.
[6]As of January 2023, Quid updated geolocation classification allowing location identification of posts that did not directly provide geolocation metadata. Previously, the location was only assigned if the original post provided geolocation metadata. With the update in January 2023, Quid was able to ingest post text and estimate the location for posts that use specific terms, phrases, and location-specific terminology causing an overall increase in the number of posts collected.

the price of pork in September 2021. While the price of bacon increased by over 2 dollars per kilogram during this period, the other cuts of pork increased by less than $1.00/kg (Figure 5) resulting in an overall decline in the farmers' share of profit (USDA-ERS, 2024a) and a decline in the disappearance of pork in quarters 2 and 3 of 2021(USDA-Agricultural Marketing Service, 2023). There was a delayed response in the decrease in net sentiment regarding pork prices in the top 5 most populous states until October 2021 when there was an increase in the number of mentions regarding the increase in the cost of bacon due to inflation (Figure 7). Interestingly, the impact of inflation on pork prices resulted in a greater and earlier decline in net sentiment in the top 5 pork-producing states compared to the top 5 most populous states.

It is important to consider political affiliation in the realm of online and social media conversation and sentiment as X/Twitter, the largest site for conversation in this study, has a higher user percentage in urban areas compared to rural areas (Pick et al., 2019). A recent report from the Center for Food Demand Analysis and Sustainability (CFDAS) at Purdue University shows a strong correlation between political affiliation and consumer food demand and food sustainability behaviors (Balagtas et al., 2023). When comparing consumer

behaviors, those identified as liberal reported purchasing items promoted as more ethical or sustainable (i.e. local foods, grass-fed, cage-free, organic) more than moderate or conservative individuals. This study by Balagtas et al. (2023) also examined the impact of animal welfare regulation on consumers' decisions to purchase pork products. Of the different attributes most important when deciding to buy pork products, consumers ranked price as the most important attribute and animal welfare as the least important regardless of income class or political affiliation. However, liberals were more likely to decrease spending on pork consumption if animal welfare issues were called into question and were more willing to increase spending on pork under the implementation of Proposition 12 (Balagtas et al., 2023).

Animal Welfare

The percentage of mentions related to the topic of animal welfare in the search results obtained was 3.93% for the overall US, 3.15% for the top 5 most populous states, and 3.10% for the top 5 pork-producing states. The share of search results related to welfare was lowest in 2020 when conversation around COVID-19 increased. Throughout all 4 yr for the

Table 7. Mentions, sources, attributes, and phrases by year for price topic with the geography limited to the top 5 most populous states and top 5 pork-producing states during the period of January 1, 2020 – 0000 hours, to December 31, 2023 – 2359 hours

Year	Top 5 most populous states				Top 5 pork-producing states			
	Mentions, n	Top 5 likes[2]	Top 5 dislikes[3]	Top 5 things[4]	Mentions, n	Top 5 likes	Top 5 dislikes	Top 5 things
2020	135,470	Cheap	Kill 12,469 people	Swine flu	38,360	Make	Kill 12,469 people	Flu
		Best sausage	Destroy dollar	Beef		Low	Tax payer dollar	Swine flu
		#free ham	Swine flu	No Pork		Higher	Get $600	Beef
		Quit well	Expensive	No beef		Worth it	Expensive	No pork
		Worth it	Excessively	No fish		Help	Bad flu	No fish
2021	91,181	Favorite vegan bacon	Expensive	Price	27,642	Dinner	Price	Price
		Hot sausage	Price	Cheese		Delicious	Expensive	Beef
		Dinner	Cost	Pork price		Cheap	Rise	Pork price
		Ham hock	Harder to find	Pork belly		Ham hock	Jump	Delicious
		Insulin price	California law taking effect	Delicious bacon		Tasty meal	Pull	Summer sausage
2022	91,041	Cheap	Price	Price	27,591	Cheap	Expensive	Swisher sweets
		Awesome specialty sausage	Expensive	Swisher sweets		Tamworth pork	Price fixing	Hennessey
		Dinner	Not reduce inflation	Hennessey		Best summer sausage	Increase inflation	Pork price
		Cheaper price	Cost	Egg		West barbecue Bowl	Swine flu	No pork
		Best smoked bacon	Go up	Cheese		Enable huge bill	Continue seasonal decline	Hog price
2023[5]	74,340	Cheaper	Swine flu vaccine	Swine flu	22,297	Cheap	Swine flu vaccine	Bacon nationwide
		Dinner	Carry parasite	Swine flu vaccine		Delicious Iowa pork	Expensive	Swine flu vaccine
		Delicious	Carry disease	Feral hog		Dinner	Carry parasite	Swine flu
		Unc's House sausage	Cost farmer $ billions	Bacon nationwide		Moratorium	Remove from market	Beef
		91 + rescue pig	Remove from market	Price		Cheap eating	Carry disease	Pork producer

[1]Calculated as the number of mentions each year divided by the total number of mentions of the general conversation from the top 5 most populous states and the top 5 pork-producing states.
[2]Refers to the top attributes associated with a positive net sentiment.
[3]Refers to the top attributes associated with a negative net sentiment.
[4]Refers to the overall top words or phrases.
[5]As of January 2023, Quid updated geolocation classification allowing location identification of posts that did not directly provide geolocation metadata. Previously, the location was only assigned if the original post provided geolocation metadata. With the update in January 2023, Quid was able to ingest post text and estimate the location for posts that use specific terms, phrases, and location-specific terminology causing an overall increase in the number of posts collected.

overall US, the top likes included terms surrounding helping and saving animals while the dislikes included terms about death and suffering (Table 8). The top things for the overall US consistently included "African Swine Fever," and terms that anthropomorphize pigs such as "little" and "mother." These characteristics of terms are even more apparent in the top 5 most populous states with words such as "happy," "intelligent," and "gratitude" repeated in the top 5 likes, and names assigned to pigs in the top 5 things (Table 9). The top dislikes for the top 5 most populous states also include phrases such as "unimaginable," "immeasurable," and "torture" when referring to the slaughter of pigs. Comparably, the top 5 pork-producing states included more on industry-focused terms such as "organic," "healthy," and "wholesome" in the top likes, and terms such as "confining," "slaughter," and "recall" in the top dislikes (Table 9). The top things mentioned are

also more production-focused in the top 5 pork-producing states with terms referring to pork producers, African Swine Fever, and pig pens observed more as a higher percentage of overall mentions.

There was an increase in the number of mentions in March and April 2020 for the overall US (Figure 8), the top 5 most populous states, and the top 5 pork-producing states (Figure 9). This increase was associated with the outbreak of COVID-19 among workers in packing plants and production systems greatly affecting the movement of swine to slaughter (Dyal, 2020). The shutdown of slaughter and meat processing plants led to the necessity of "Welfare Slaughter," a term describing the killing of healthy, noninfected animals in response to animal disease outbreaks (AASV Board of Directors, 2020). The number of mentions increased in the top 5 pork-producing states and overall US in March and April, but the
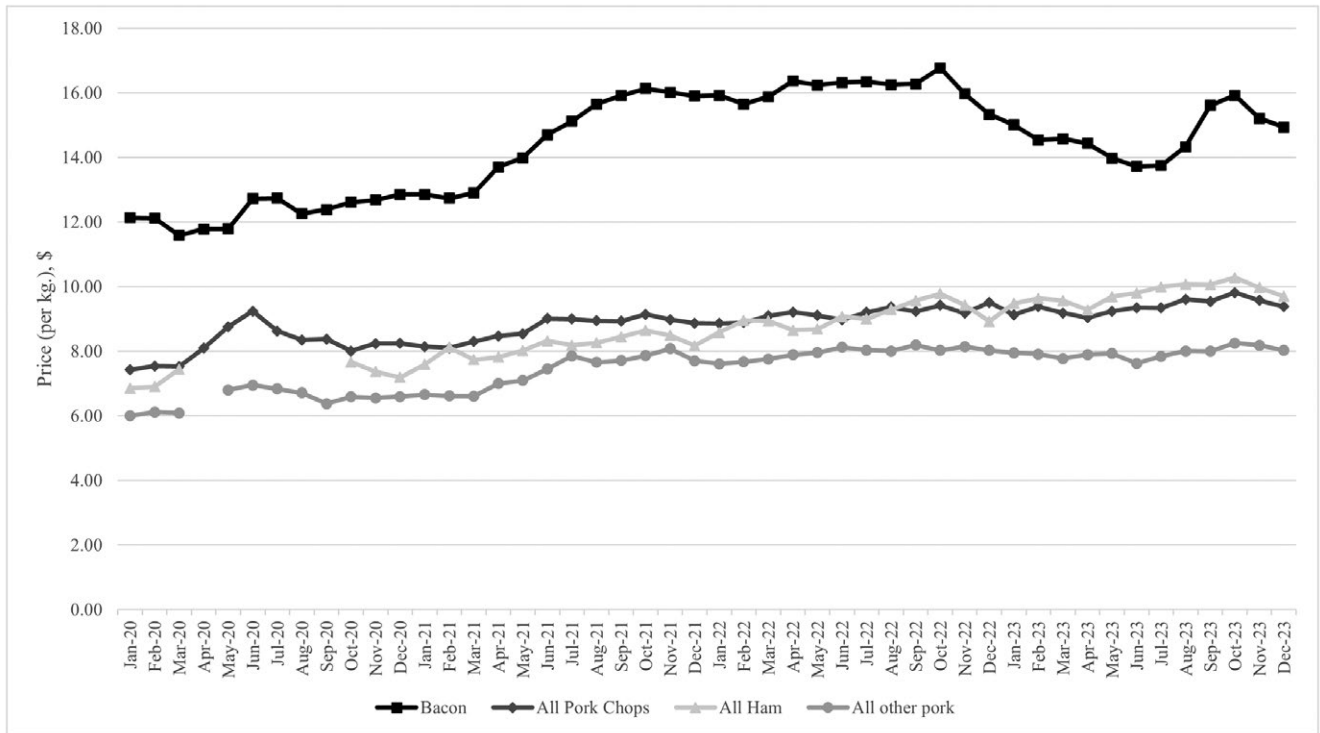
Figure 5. The average monthly price per kilogram ($/kg) of various cuts of pork in the US from January 2020 to December 2023 adapted from USDA report (USDA-ERS, 2024a). Missing data occurred in 2020 due to recording issues caused by the COVID-19 Pandemic.
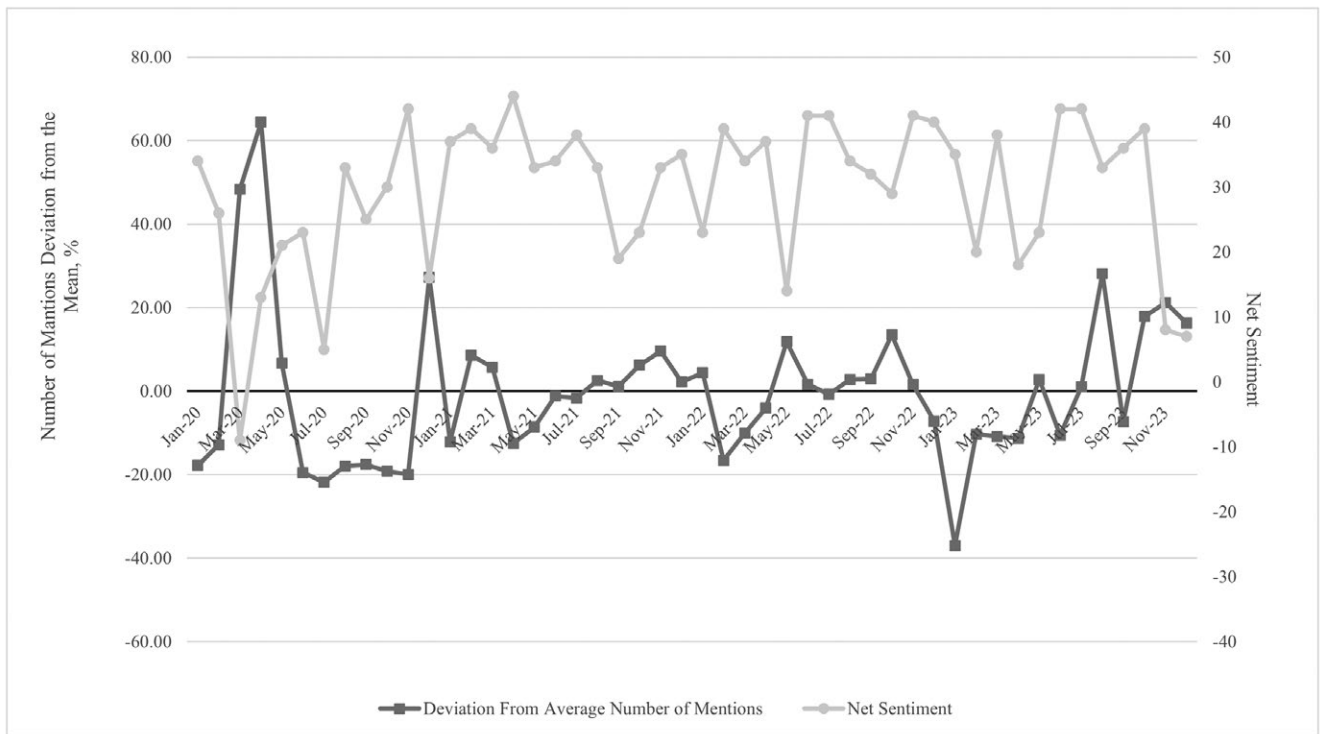

Figure 6. Overall deviation from the mean for number of mentions and overall net sentiment by month for posts related to price with the geography limited to the entire US including U.S. Minor Outlying Islands during the period of January 1, 2020 – 0000 hours, to December 31, 2023 – 2359 hours.

number of mentions declined in April in the top 5 most populous states. Research has shown that rural areas depend more on community-based news media as information sources compared to urban areas, resulting in extended conversations regarding community-based news (Beaudoin and Thorson, 2004). It is hypothesized that the number of mentions related
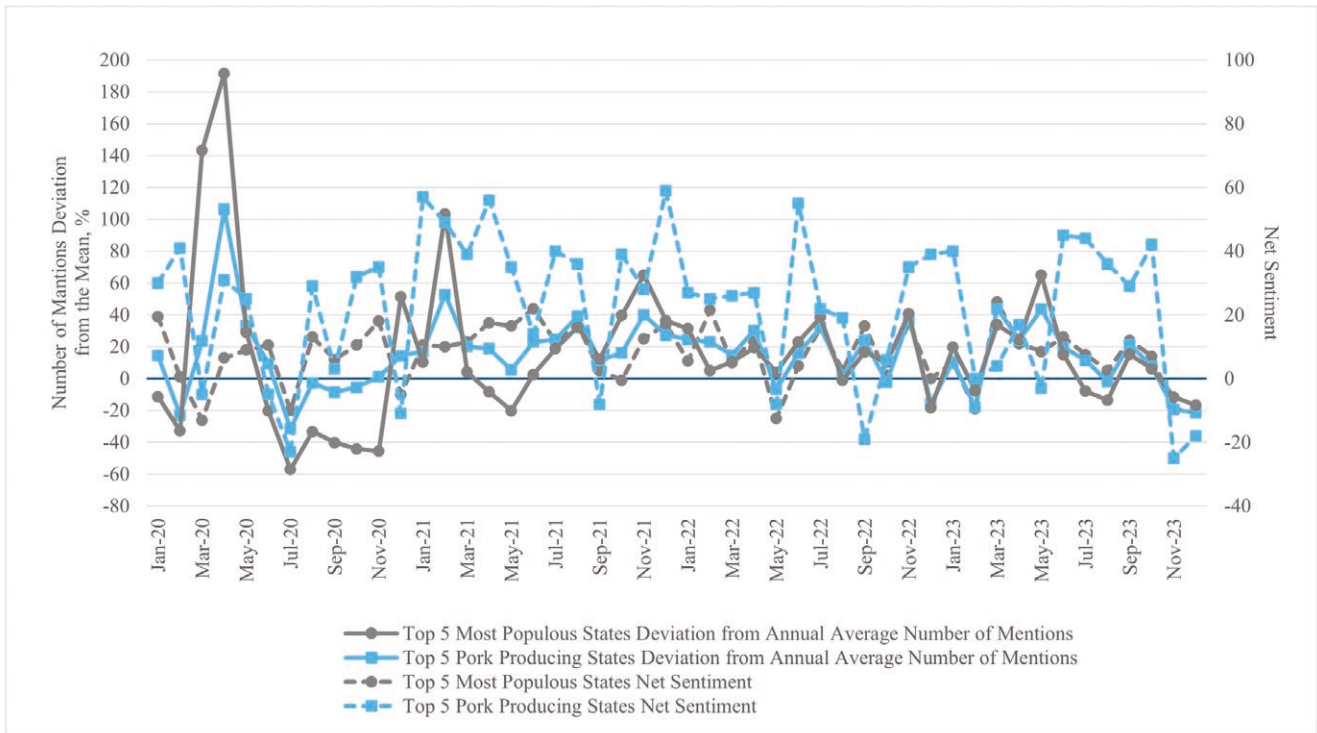
Figure 7. Overall deviation from the mean for number of mentions and overall net sentiment by month for posts related to price with the geography limited to the top 5 most populous states and top 5 pork-producing states during the period of January 1, 2020 – 0000 hours, to December 31, 2023 – 2359 hours.

to animal welfare did not stay elevated in the top 5 most populous states due to how quickly news stories move on social media in more populated areas. There was a notable increase in the number of mentions referencing welfare occurred in October 2022 when an artificial intelligence video of a pig standing on a rolling ball became very popular. Net sentiment dropped in regard to this post because people were upset with the video being fake or people believing the pig was real and forced to perform.

A survey conducted in 2014 found that respondents from the Midwest region of the US were less concerned about domestic livestock animal welfare and were more frequently reported not having a source of information regarding animal welfare than those from other regions of the US (McKendree et al., 2014). Additionally, respondents with higher levels of concern about animal welfare were more frequently self-reported members of the Democratic Party and sources were less likely to be from industry groups related to experts on the subject (government, veterinarians, academics). The societal pressure that often governs farming practices emphasizes the concern that those involved in animal production are less concerned about welfare and allow other sources to shape the conversation around livestock operations (Te Velde et al., 2002). This is an ongoing issue as the increasing number of residents in urban areas are unfamiliar with farming practices, but their lack of knowledge paired with increased critical media attention on intensive production has led to excessive and unreasonable criticism toward pig farmers (Maes et al., 2020). This has led to a proven increase in institutional, societal, and internalized forms of stigmatization against the swine industry that eventually blocks the forward innovation of improving animal welfare in the industry (Fynbo and Jensen, 2018).

California, the most populous state in the US, passed a law (Proposition 12) aimed at improving animal welfare across several livestock sectors. Pork producers fought the decision in court, but inevitably, Proposition 12 was passed in May 2023 and put into effect in June 2023 (Block and Amundson, 2023). Standard farming practice requires sows to be moved into breeding stalls after nursing a litter when the sow's physical condition is at a low point allowing the sow time to recover physically before being mixed in a pen with other sows (Marchant-Forde, 2009). Proposition 12 prohibits the use of breeding stalls immediately after weaning leading to increased fighting among sows to establish hierarchy at the most vulnerable time in that animal's life (Venesky, 2024). Increased lameness, reproductive failure, feed access competition, and reduced feed intake have all been observed with the removal of breeding stalls postweaning (Spoolder et al., 2009). There was an over 2% increase in the overall percentage of mentions related to welfare in 2023, and specific posts in May 2023 were increased by 59% specifically referencing the ruling of Proposition 12 (Figure 9). Interestingly, the conversation surrounding welfare only slightly increased in the top 5 most populous states compared to the overall US and top 5 pork-producing states (Figure 9). In this current study, it was observed that the number of mentions significantly increased from the mean in May 2023 for the top 5 pork-producing states only and net sentiment dropped (Figure 9).

Sustainability

The overall percentage of mentions contributing to the topic of sustainability was 1.88% for the entire US, 0.76% for the top 5 populous states, and 1.00% for the top 5 pork-producing

Table 8. Mentions, sources, attributes, and phrases by year for welfare topic with the geography limited to the entire US including U.S. Minor Outlying Islands during the period of January 1, 2020 – 0000 hours, to December 31, 2023 – 2359 hours

Year	Total number of mentions	Percent of general conversation[1]	Top 5 sources	Percent of mentions[2]	Top 5 likes[3]	Top 5 dislikes[4]	Top 5 things[5]
2020	408,972	3.62	X/Twitter	66.56	Fun shooting piglet	Kill	Swine fever
			News	15.11	Highly intelligent	Die	African swine fever
			Forums	9.21	Fun	Die to slaughter	Swine flu
			Blogs	8.82	Fresh	Infect	H1N1 Swine Flu epidemic
			Instagram	<1	Deserve love	Outbreak	Pig pen
2021	355,929	4.38	X/Twitter	47.49	Help	Recall	African swine fever
			News	27.15	Rescue	Kill	Pork product
			Blogs	14.38	Space	Die	Price
			Forums	9.49	Make	Spread	Swine flu
			Instagram	1.43	Fresh pork	Pepperoni product	Space
2022	344,286	4.46	X/Twitter	47.64	Sale to feed piglet	Die	African swine fever
			News	33.19	Help	Suffer	Pig pen
			Blogs	11.09	Fresh pork	Not care about anything	Little piglet
			Forums	7.77	Rescue	Kill	Pig milk
			Instagram	<1	Provide	Kill pig	Chicken
2023[6]	506,021	6.55	X/Twitter	71.62	Rescue	Injured to slaughter	Little piglet
			News	20.33	Help	Suffer	African swine fever
			Blogs	4.20	Important	Kill	Pig pen
			Forums	3.59	91 + rescue pig	Die	Mother pig
			Consumer Reviews	<1	Sale to feed piglet	Subject to egregious abuse	Rescue

[1]Calculated as the number of mentions each year divided by the total number of mentions of the general conversation from the entire US.
[2]Calculated as the number of mentions from each source divided by the total number of mentions. Total will not always add to 100% based on sources outside of the top 5 sources.
[3]Refers to the top attributes associated with a positive net sentiment.
[4]Refers to the top attributes associated with a negative net sentiment.
[5]Refers to the overall top words or phrases.
[6]As of January 2023, Quid updated geolocation classification allowing location identification of posts that did not directly provide geolocation metadata. Previously, the location was only assigned if the original post provided geolocation metadata. With the update in January 2023, Quid was able to ingest post text and estimate the location for posts that use specific terms, phrases, and location-specific terminology causing an overall increase in the number of posts collected.

states. The main source for mentions for the topic of sustainability was news sources for the entire US for 2021 to 2023 with X/Twitter being the main source in 2020 (Table 10).

Throughout all 4 yr for the entire US, the term "organic" is in the top 5 likes while the terms "kill" and "waste" appear in the top 5 dislikes (Table 10). The term "organic" was also in the top 5 likes for all 4 yr for the top 5 most populous states with the dislikes including more industry-focused dislikes than the overall US with terms such as "shocking footage," "destroy environment," and "create more emission annually" (Table 11). The top 5 pork-producing states include the term "organic" in the top 5 likes, but the overall likes are much more focused on sustainability, quality, and the environment compared to the top 5 most populous states and overall US (Table 11). The top 5 dislikes for this geographic location focused heavily on environmental issues produced by the swine industry including "pollution," "public health," "waste problem," and "violate state regulation". The overall US appears to be most concerned with hog waste and organic farming in reference to sustainability. The top 5 things in the top 5 most populous states contained a mix of food-related terms and industry-related terms. The top 5 things for the top 5 pork-producing states have very few food-associated terms and almost all terms are related to the swine industry and farming.

In recent years, consumers' attitudes towards pork are more positive when terms like "organic" and "all-natural" are on the labels regardless of their understanding of the terms (Abrams et al., 2009). In that study, participants assumed that "organic" meant that the pork was healthier, and the animals were raised without antibiotics or pesticides. There has also been an overall decline in the consumption of red and processed meat in high-income countries in part due to consumers' concern for the environmental impacts of livestock (Clonan et al., 2016). Consumers have increasingly demanded sustainably produced pork by driving efforts to

Table 9. Mentions, sources, attributes, and phrases by year for welfare topic with the geography limited to the top 5 most populous states and the top 5 pork-producing states during the period of January 1, 2020 – 0000 hours, to December 31, 2023 – 2359 hours

	Top 5 most populous states				Top 5 pork-producing states			
Year	Mentions, n	Top 5 likes[2]	Top 5 dislikes[3]	Top 5 things[4]	Mentions, n	Top 5 likes	Top 5 dislikes	Top 5 things
2020	105,180	Fun shooting piglet	Kill	Swine flu	25,380	Fun shooting piglet	Kill	African swine fever
		Highly intelligent	Die	Swine fever		Avocado for top	Die to slaughter	Swine flu
		Rescue	Die to slaughter	African swine fever		Good work	Die	Little piglet
		Curious pig	Go through immeasurable suffering	H1N1 Swine Flu epidemic		Deserve love	Club to death	H1N1 Swine Flu epidemic
		Space	Club to death	Little piglet		Deserve compassion	Screaming pig	Pig pen
2021	66,131	Rescue	Recall	Piglet nicknamed Smokey	17,470	Special	Desperate to stop people	African swine fever
		Space	Unavailable in state	The piglet		Organic	Squeeze rescue to lie	Pig pen
		Happy	Bay of Piglets attack	Space		11 healthy piglet	Detect	Space
		Win	Emergency slaughter	Porky pig		Assist producer	Spread	Swine flu
		Hold gratitude	Kill	Pig pen		Find guilty	Recall	Hog pen
2022	63,485	Rescue	Endure unimaginable suffering	Piglet nicknamed Smokey	16,981	Contented piglet	Endure unimaginable suffering	African Swine Fever
		Sick piglet	Not care about anything	Pen		Sustainability	Die	Pork producer
		Hold gratitude	Torture	Pig pen		Hold gratitude	Disgusting American piglet	Pork industry
		Happy	Force	Little piglet		Recover	Confining mother pig	Rescued piglet
		Treat humanely	Female pig	Rescued piglet		Happy	Not care about anything	Pig pen
2023[5]	56,280	Rescue	Recall	Little piglet	13,599	Feel better piglet	Recall	Little piglet
		Cute little piglet	Await slaughter	Pig pen		Pig pen	High U.S. pork production	AFRICAN swine fever
		World's intelligent animal	Endure unimaginable suffering	Sausage product		Not enough	Issue	Pork producer
		Help	Kill	Happy piglet		Help mom relax	Curtail China's pork output	US
		91 + rescue pig	Die	Moon Pig		Continue produce wholesome pork	Await slaughter	Cute little piglet

[1]Calculated as the number of mentions each year divided by the total number of mentions of the general conversation from the top 5 most populous states and the top 5 pork-producing states.
[2]Refers to the top attributes associated with a positive net sentiment.
[3]Refers to the top attributes associated with a negative net sentiment.
[4]Refers to the overall top words or phrases.
[5]As of January 2023, Quid updated geolocation classification allowing location identification of posts that did not directly provide geolocation metadata. Previously, the location was only assigned if the original post provided geolocation metadata. With the update in January 2023, Quid was able to ingest post text and estimate the location for posts that use specific terms, phrases, and location-specific terminology causing an overall increase in the number of posts collected.

improve environmental practices, animal welfare standards, and reduction of carbon footprints (See, 2024). This demand has resulted over the last 50 yr in US swine producers on a per unit basis using 75.9% less land, 25.1% less water, and 7.7% reduced potential for global warming (Putman et al., 2018).

When considering the change in the number of mentions from the mean over the 4-yr period, there are 2 specific time points that are worth noting for the overall US (Figure 10). In April 2020, there was an elevated number of mentions assumed to be caused by the closing of Smithfield Foods and Tyson Foods pork processing plants (The Pig Site 2020a, 2020b). This increase in the number of mentions was observed primarily in the top 5 most populous states (Figure 11) and partially in the top 5 pork-producing states (Figure 11) as its occurrence impacted the entire US regardless of geographic location. The overall net sentiment became negative with the increase in mentions related to the plant shutdowns for the overall US, top 5 most populous states and top 5 pork-producing states.
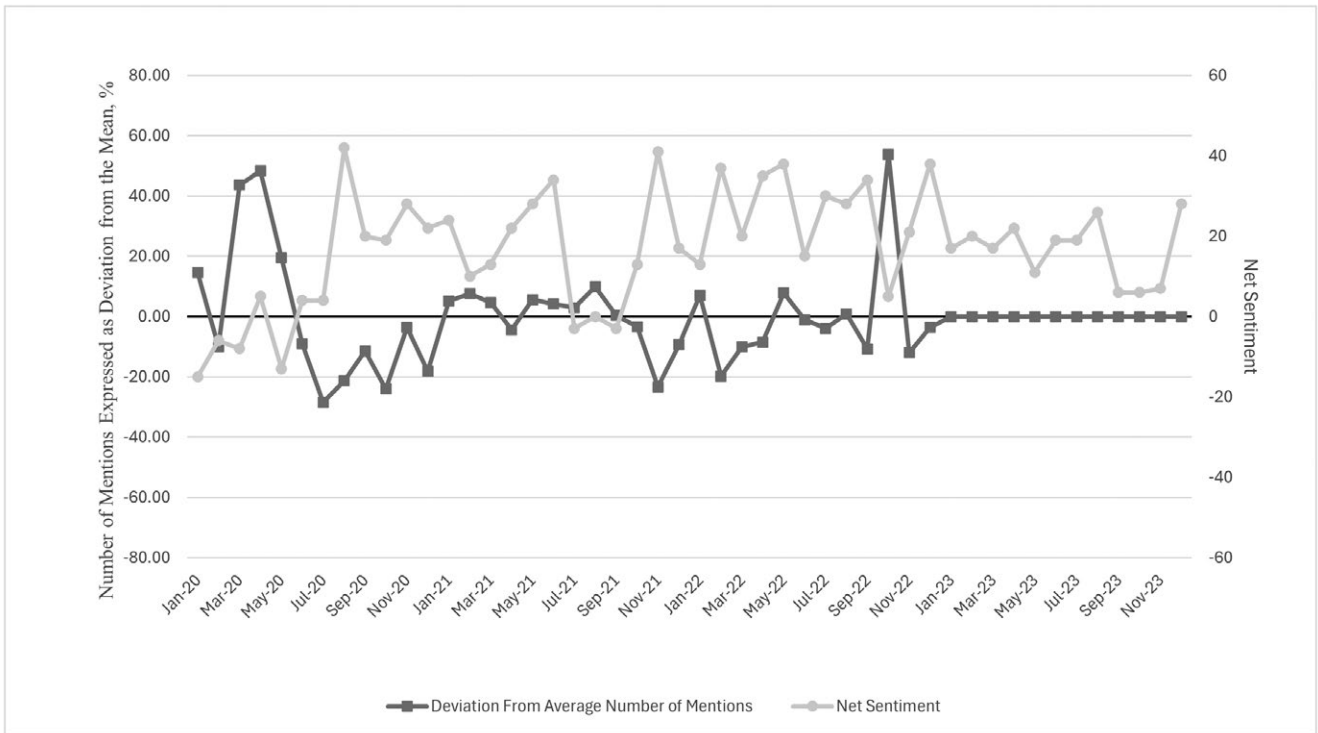
Figure 8. Overall deviation from the mean for number of mentions and overall net sentiment by month for posts related to welfare with the geography limited to the entire U.S. including U.S. Minor Outlying Islands during the period of January 1, 2020 – 0000 hours, to December 31, 2023 – 2359 hours.
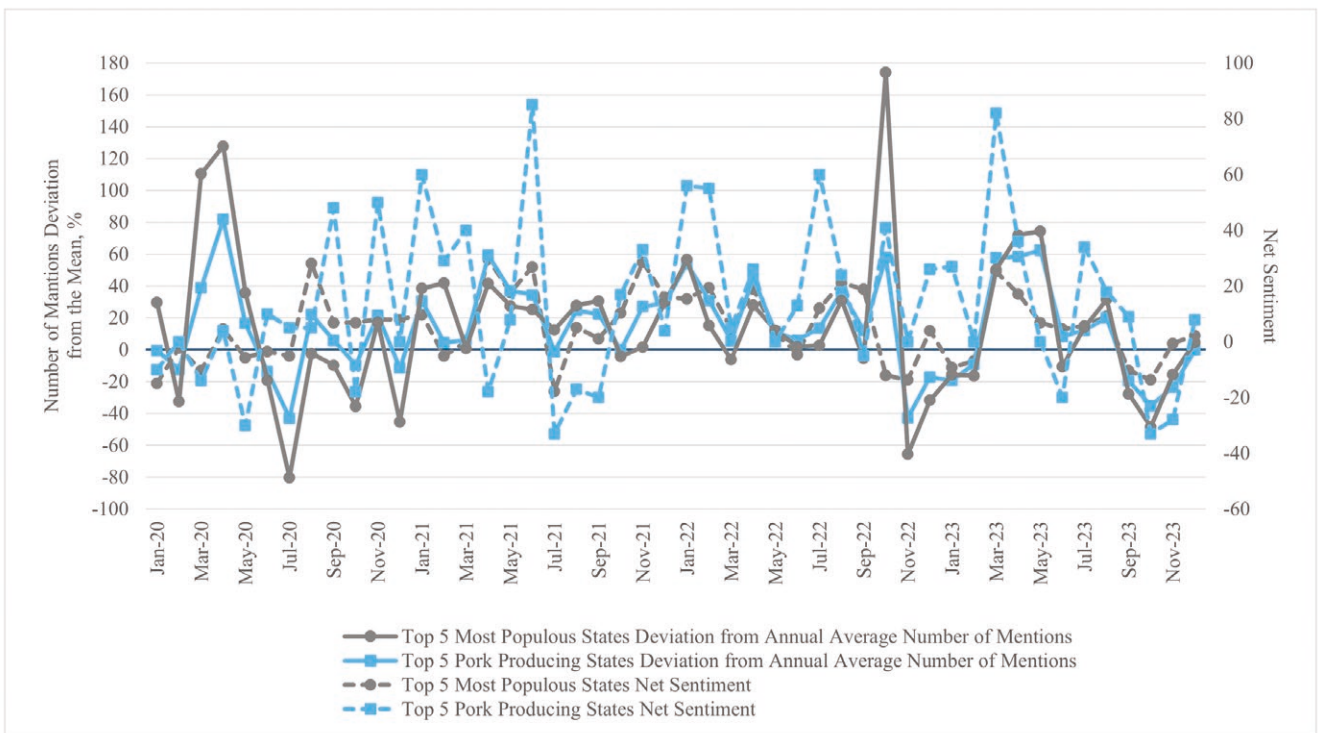

Figure 9. Overall deviation from the mean for number of mentions and overall net sentiment by month for posts related to welfare with the geography limited to the top 5 most populous states and top 5 pork-producing states during the period of January 1, 2020 – 0000 hours, to December 31, 2023 – 2359 hours.

Table 10. Mentions, sources, attributes, and phrases by year for sustainability topic with the geography limited to the entire US including U.S. Minor Outlying Islands during the period of January 1, 2020 – 0000 hours, to December 31, 2023 – 2359 hours

Year	Mentions, *n*	Percent of general conversation[1], %	Top 5 sources	Percent of mentions[2], %	Top 5 likes[3]	Top 5 dislikes[4]	Top 5 things[5]
2020	171,492	1.52	X/Twitter	38.14	Organic	Waste	Swine flu
			News	29.68	Meat	Kill	Chicken
			Blogs	19.65	Make	Swine flu	Beef
			Forums	12.09	More nutrition per serve	Wipe out pig	Pork producer
			Instagram	<1	Work	NC's biggest environmental issue	African swine fever
2021	180,318	2.22	News	34.69	Natural beef bacon	Produce waste	Beef
			Blogs	29.35	Organic	23 million pig	Egg
			X/Twitter	24.36	Easy	Kill	Avocado
			Forums	10.40	Make	Push up pork price	Boiled local egg
			Instagram	1.11	Delicious	Large litter	Natural beef bacon
2022	190,415	2.46	News	48.18	Make	Waste	Chicken
			X/Twitter	21.81	Help	Poultry waste problem	Beef
			Blogs	21.41	Organic	Die	Pig heart
			Forums	8.29	Price beyond meat	Kill	Poultry
			Instagram	<1	Flavor	Swell	Recipe
2023[6]	229,594	1.65	News	45.36	Organic	Die in own waste	Chicken
			X/Twitter	37.64	Delicious	Kill	Cheese
			Blogs	11.95	Delicious meat	Die	Swine flu
			Forums	4.54	Flavor	Kill us	Beef
			Consumer reviews	<1	Cook	Suffer	Bacon grease

[1]Calculated as the number of mentions each year divided by the total number of mentions of the general conversation from the entire US.
[2]Calculated as the number of mentions from each source divided by the total number of mentions. Total will not always add to 100% based on sources outside of the top 5 sources.
[3]Refers to the top attributes associated with a positive net sentiment.
[4]Refers to the top attributes associated with a negative net sentiment.
[5]Refers to the overall top words or phrases.
[6]As of January 2023, Quid updated geolocation classification allowing location identification of posts that did not directly provide geolocation metadata. Previously, the location was only assigned if the original post provided geolocation metadata. With the update in January 2023, Quid was able to ingest post text and estimate the location for posts that use specific terms, phrases, and location-specific terminology causing an overall increase in the number of posts collected.

The second spike in number of mentions in the overall US occurred in August 2023 with the greatest contribution to the increase coming from mentions related to the successful transfer and function of a pig kidney to a human (Thompson, 2023). With this information, the meat from the GalSafe pig, the pig created for kidney transplantation to humans, became a correlated topic of conversation. The meat from GalSafe pigs was approved by the FDA in 2020 for human consumption for individuals with alpha-gal syndrome (AGS), an allergy transmitted by ticks, that triggers the immune system in response to red meat and mammal-derived products (FDA, 2020).

There was a slight increase in number of mentions in February 2021 followed by a sharp decline in net sentiment in the top 5 most populous states (Figure 11). The posts were associated with the release of an article outlining how factory farms contribute to environmental racism. The article in question specifically discusses hog operations in North Carolina and the linear relationship between race/ethnicity of residents within a 3-mile radius of industrial hog operations (Cappiello, 2021). The topic of environmental racism has been especially important in North

Carolina with Smithfield Foods placed under scrutiny via a subsidiary, Murphy-Brown, being sued in 2019 for offensive smells, manure spills, invasive insect populations, and more (Harrison, 2020). This topic, while important, was a small portion of the conversation related to sustainability in the top 5 most populous states and did not appear to be a large area of conversation in the overall US or top 5 pork-producing states.

The last 2 noticeable increases in the number of mentions from the mean occurred in the top 5 pork-producing states in April 2021 and June 2023 (Figure 11). In April 2021, there was a marked increase in mentions referring to a recent update of the ratio of people to pigs in Iowa. An online article was published in April 2021 that stated that pigs outnumbered human residents in Iowa by a ratio of 7 to 1 and produced waste at a volume equivalent to nearly 84 million people (Hope-D'Anieri and Frerick, 2021). This article continued on to discuss the decline in water quality in Iowa, the decline in the health of individuals who lived near hog farms, and the legal challenges facing hog farmers in Iowa. In the realm of sustainability, this article received a large

Table 11. Mentions, sources, attributes, and phrases by year for sustainability topic with the geography limited to the top 5 most populous states and top 5 pork-producing states during the period of January 1, 2020 – 0000 hours, to December 31, 2023 – 2359 hours

Year	Top 5 most populous states				Top 5 pork-producing states			
	Mentions, n	Top 5 likes[2]	Top 5 dislikes[3]	Top 5 things[4]	Mentions, n	Top 5 likes	Top 5 dislikes	Top 5 things
2020	24,480	Organic	Waste	Swine flu	7,390	Organic	Waste	Hog lagoon
		Fight coronavirus	Close due to coronavirus	Pork processing		Environment	Foolish	Pork processing
		Fight swine fever	Money	No pork		Animal rights	Result in pollution	Boneless pork loin
		Meat	Shocking footage	America		Heritage breed pork	Irresponsible	3 million gallon hog feces/ urine spill
		Organic bacon	Do more harm	America's largest pork processing plant		Double bacon turkey	Resource	Resource
2021	16,700	Natural beef bacon	Produce waste	Beef	5,750	Natural beef bacon	Produce waste	Beef
		Climate pork	Make	Organic romaine lettuce		Organic	Harm public health	Industrial hog factories
		Organic sausage	Obese pig	Avocado		Essential quality aspect	Die from	Chinese industrial hog factories
		Delicious	Shut down pork industry	Boiled local egg		Daily pleasure	No clean energy	Organic grape tomato
		Work	Waste time	Natural beef bacon		Man	Threatened	Organic romaine lettuce
2022	16,023	Organic	Massive poop	No pork	5,122	Sustainability	State's larger hog waste	Hog manure
		Cleanest animal	Destroy environment	Massive poop		Sustainable	Poultry waste problem	Pig farming industry
		Proper environment	Bacon grease	Bacon grease		Sugar	Create more emission annually	Hog farming
		Cute	Create more emission annually	Hog farming		Dedicated to that	Massive poop	Massive poop
		Floral print	Destructive people on earth	Beef		Bacon roll	Apply manure	Egg
2023[5]	13,070	Organic	Kill us	Swine flu	5,505	Been 30,000-gallon spill	Violate state regulation	Hog confinement
		Ecosystem	Die in own waste	U.S. pork		Organic	Fine $10,000	Northwest Iowa hog confinement owner
		Make	22 million	Downed pig		Optimal hog environment	Kill us	Hog manure
		High quality bacon	Suffer	Tenderloin center		Antibiotic-free pork	waste	Urine
		Legged Pig	Uninhabitable	Tenderloin neighborhood		Bay leaf	TERF pig slop garbage	Swine flu

[1]Calculated as the number of mentions each year divided by the total number of mentions of the general conversation from the top 5 most populous states and the top 5 pork-producing states.
[2]Refers to the top attributes associated with a positive net sentiment.
[3]Refers to the top attributes associated with a negative net sentiment.
[4]Refers to the overall top words or phrases.
[5]As of January 2023, Quid updated geolocation classification allowing location identification of posts that did not directly provide geolocation metadata. Previously, the location was only assigned if the original post provided geolocation metadata. With the update in January 2023, Quid was able to ingest post text and estimate the location for posts that use specific terms, phrases, and location-specific terminology causing an overall increase in the number of posts collected.
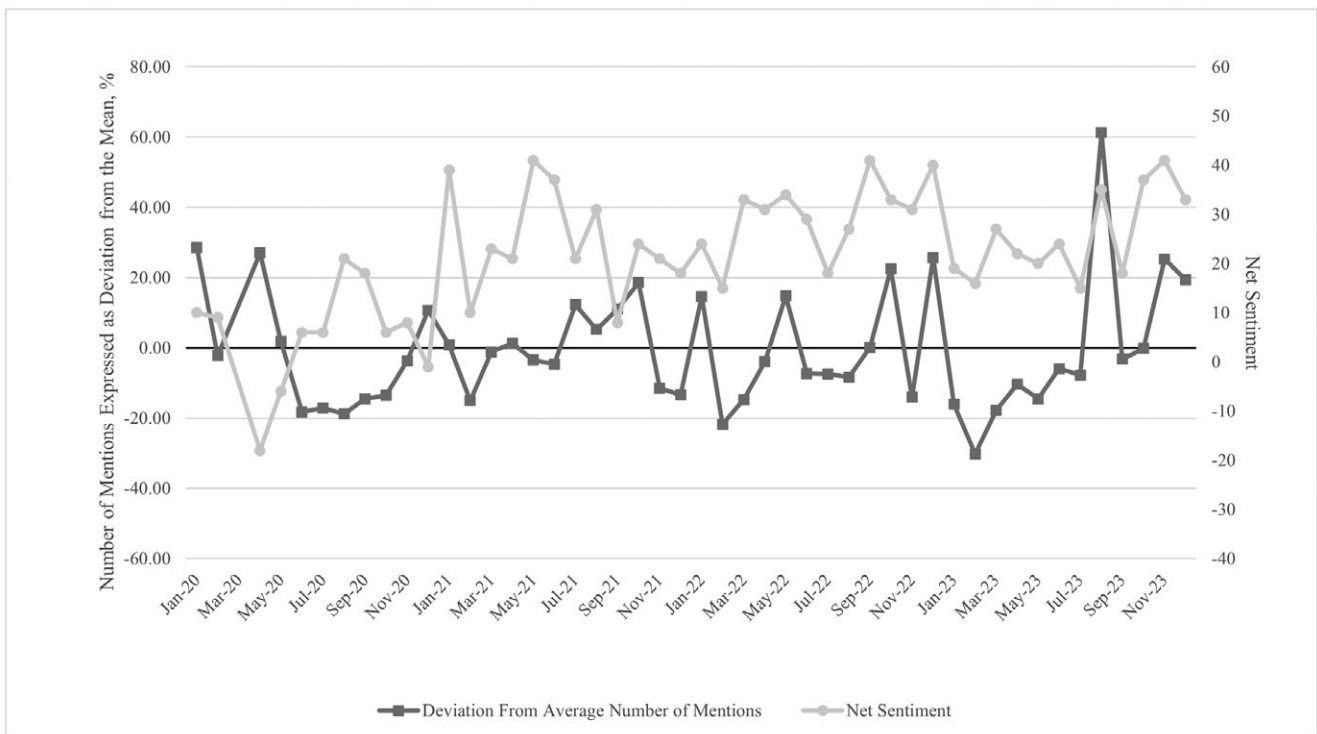
Figure 10. Overall deviation from the mean for number of mentions and overall net sentiment by month for posts related to sustainability with the geography limited to the entire US including U.S. Minor Outlying Islands during the period of January 1, 2020 – 0000 hours, to December 31, 2023 – 2359 hours.

amount of attention from the top 5 pork-producing states as shown by the increase in the number of mentions at this time. In June 2023, there was another increase in the number of mentions from the mean number of mentions in the top 5 pork-producing states that was attributed to the release of the book: "The Swine Republic: Struggles With the Truth About Agriculture and water Quality" by Chris Jones (Jones, 2023). This book emphasizes the issue of contaminated water in Iowa and the increasing contamination of other waterways with nitrogen and phosphorous, such as the Mississippi River, via manure and fertilizer from hog farms. While discussion increased surrounding this book which contains a negative view of the swine industry, net sentiment actually increased in the top 5 pork-producing states. It is interesting to note that the conversation directly related to sustainability in the swine industry causes greater deviation from the mean in number of mentions and sentiment changes in the top 5 pork-producing states compared to the top 5 most populous states.

There was a sharp decline in the net sentiment in the top 5 pork-producing states in April 2022. The posts associated with this decline in net sentiment referred to the recent release of a report that Smithfield Foods, the largest pork producer in the US, caused 748 reported spills in Missouri, resulting in 7.3 million gallons of farm waste (Socially Responsible Agriculture Project, 2022). This represents how a disaster in the swine industry drives sentiment in pork-producing states but failed to change the search results meaningfully in other geographies. More research must be conducted to understand why sustainability-related topics contribute to the variation in net sentiment between these geographic locations.

Lastly, the top 5 most populous states and top 5 pork-producing states (Figure 11) both had a large increase in the

number of mentions from the mean in January 2023. When evaluating the posts related to this increase, there was a circulating video on X/Twitter about ways to reduce bacon waste by storing bacon slices on parchment paper individually in the freezer. This demonstrates the public's desire to reduce food waste as well as the continued demand for resealable bacon packaging.

Authors

In addition to the perspectives of the general public, it is important to consider the values within the industry including producers, workers, nutritionists, and other positions in the chain such as veterinarians and academics/scientists (Jagosh et al., 2012). The organizations selected for this study aimed to bridge the gap between consumers and producers, yet they were mentioned in only 0.003% of US search results (Table 1). The top 5 populous states had no mentions, and only 0.04% (860 mentions) were found in the top 5 pork-producing states between 2020-2023. This minimal social media presence may hinder their influence on public discussions about pork, which is concerning given that populous states like California shape swine industry policies, as seen with Proposition 12. Future campaigns should target audiences more effectively and consider the use of X/Twitter due to its high level of interaction with the public as demonstrated in these findings. Net sentiment was overall positive for the entire US and the top 5 pork-producing states except for 4 mo from January 2021 to April 2021 for the entire US. This drop in sentiment can be attributed to the release of the US beef and pork exports data released by the USDA in January 2021 which showed red meat exports were low due to transportation and labor shortages in China and Mexico (USMEF, 2021). Due to the low number
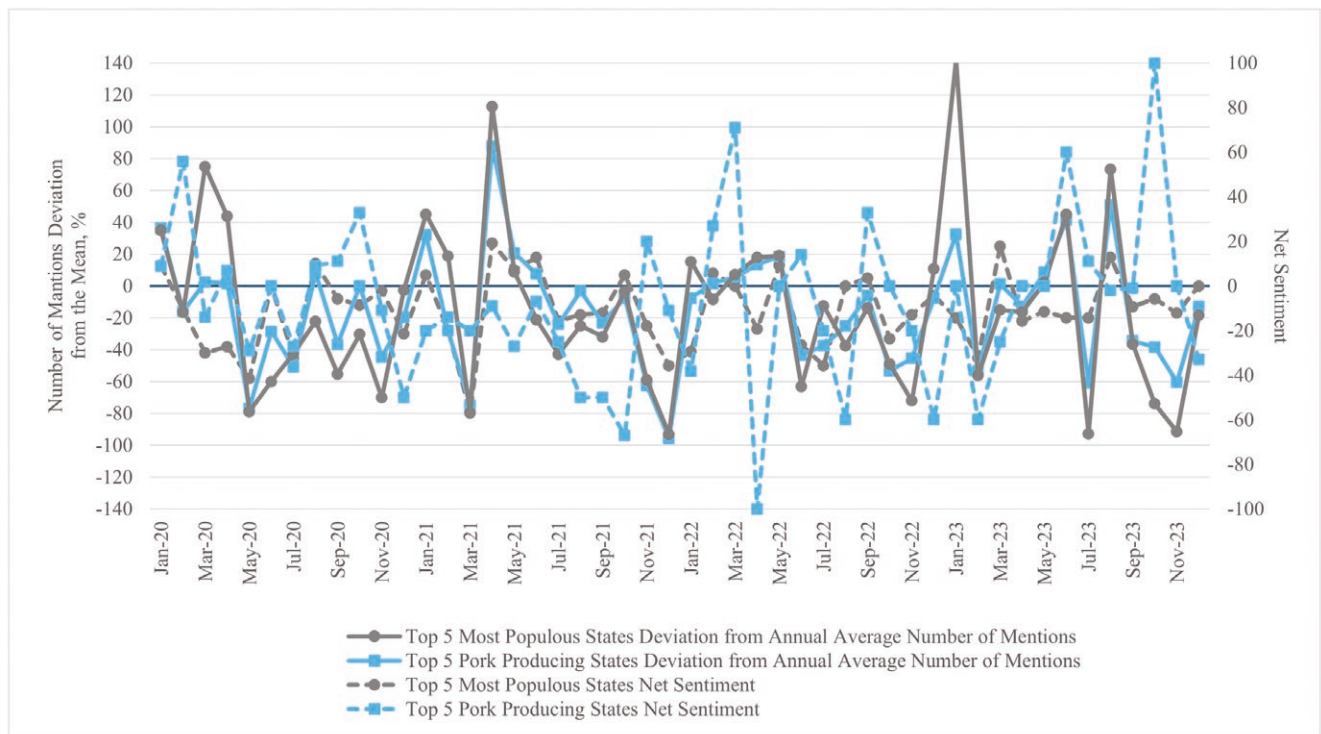
Figure 11. Overall deviation from the mean for number of mentions and overall net sentiment by month for posts related to sustainability with the geography limited to the top 5 most populous states and top 5 pork-producing states during the period of January 1, 2020 – 0000 hours, to December 31, 2023 – 2359 hours.

of mentions, the complete detailed results related to the top authors selected for this study are available upon request.

Conclusions

Online and social media data can fuel analyses that drive market-relevant, real-time insights more efficiently than surveys and focus groups. Online and social media allow a glimpse into the shared/stated thoughts of individuals, particularly younger people who are more likely to use social media (Hruska and Maresova, 2020), to understand public perceptions. Food and cooking are the most referenced topics related to pork and pigs in online and social media from 2020 to 2023. The top 5 most populous states have an increased conversation regarding pork as an addition to dishes compared to the top 5 pork-producing states more frequently referencing "center plate" pork products. The topic of price is the second most discussed topics related to pork and pigs, indicating the importance of price to consumers. Welfare and sustainability appear to be of bigger concern to the top 5 pork-producing states compared to the top 5 most populous states, but the entire US is still responsive to major events associated with welfare and sustainability in the U.S. swine industry. The major organizations designed to bridge the gap between producers and consumers showed up very little in top pork-producing states and not at all in top-populated states in search results for online and social media about the U.S. swine industry.

Compiling this information provides a glimpse into public sentiment and conversations on various topics related to the U.S. swine industry. U.S. swine industry organizations may want to reevaluate their efforts in marketing on X/Twitter as this is where the majority of the overall US, and top 5 most populous states, were discussing pork and pigs of the platforms studied in

this analysis. Additionally, efforts to focus on food and cooking may improve engagement on social media platforms, as this is where the majority of conversation/interest was found.

Public perceptions and values can shape future processes and outcomes of pork production making it vital to maximize the use of available social media data to adapt to the current demands of the public (von Keyserlingk et al., 2024). The U.S. swine industry is increasingly required to evolve with societal values to maintain consumer demand. Public perception, particularly from millennials, emphasizes the importance of animal care, environmental compliance, workers' welfare, and pork consumption. Understanding consumer insights and evaluating areas of growth for producers can help avoid disruptive legislative changes while meeting the growing demands of consumers. Social media listening offers opportunities to understand and respond to consumer preferences more effectively. By analyzing social media data, the U.S. swine industry can better navigate uncertainties, adapt to trends, and optimize production practices. Future research should be conducted to identify terms and phrases that increase interactions on social media across different demographics to understand how to best reach target demographics.

Supplementary Data

Supplementary data are available at *Translational Animal Science* online.

Acknowledgments

Conflict of interest statement

The authors declare that there are no conflicts of interest.

Author contributions

Alexandra Fisk (Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Validation, Visualization, Writing—original draft, Writing—review & editing), Michael Smith (Conceptualization, Data curation, Investigation, Resources, Supervision, Writing—review & editing), Brian Richert (Conceptualization, Supervision, Writing—review & editing), and Nicole Olynk Widmar (Conceptualization, Data curation, Formal analysis, Methodology, Project administration, Resources, Software, Supervision, Validation, Writing—review & editing)

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