Introduction

Accepting the 1970 Nobel Peace Prize, Norman Borlaug said, "It is true that the tide of the battle against hunger has changed for the better...but tides have a way of flowing and then ebbing again…For we are dealing with two opposing forces, the scientific power of food production and the biological power of human reproduction" (Nobel Media AB, 2018, para. 5). The United Nations (2017) predicts that the world population will reach 9.8 billion in 2050, and 11.2 billion by 2100. A population growth of such magnitude will require the innovation and adoption of new technologies to feed and sustain the human race (Lindner, Rodriguez, Strong, Jones, & Layfield, 2016).

Meat is a protein source that provides nutrients essential to the human body, nutrients in which more than 2 billion people worldwide are deficient (Food and Drug Administration [FDA], 2018; Food and Agriculture Organization [FAO], 2018). In the future, meat may become more difficult to source as incomes rise and urbanization increases (FAO, 2018; World Health Organization [WHO], 2018). The global demand for meat is expected to outpace supply and result in a spike in meat prices (Post, 2012). Meanwhile, in developed countries such as the United States, the quality of meat is predicted to impact consumer meat consumption trends more than price and disposable income (Henchion, McCarthy, Resconi, & Troy, 2014).

Cultured meat, or meat grown through stem cell technology (Post, 2012), has been promoted as a possible solution for meeting future economic and nutritional demands. Cultured meat is produced from the cells of animals without the need to harvest the animal (Post, 2012) using methods pioneered by biomedical researchers for therapeutic treatments in humans (Stephens, Di Silvio, Dunsford, Ellis, Glencross, & Sextion, 2018). In 2013, a Dutch scientist made headlines when, in a televised event, a "hamburger" he grew from bovine stem cells was cooked and consumed by food experts (Zaraska, 2013). The cost of the single burger patty, which was colored with beet juice and saffron to better mimic real ground beef, was $330,000 (Zaraska, 2013).

Since cultured meat's dramatic emergence on the world's stage, startup companies with financial backing from the likes of Bill Gates and Richard Branson are in the process of developing lab-grown beef, chicken, pork, and seafood (Damm, 2018), and scientists have suggested that commercially viable products will be on store shelves within the next four years (Knapton, 2017). There is a growing interest in consumer acceptance of cultured meat (Bryant & Barnett, 2018) because consumer acceptance and willingness to consume cultured meat is imperative to the potential long-term feasibility of the technology (Sharma, Thind, & Kaur, 2015).

Cultured meat may also represent a solution to Western consumers' concerns with the humane and ethical treatment of animals, the environmental impacts of livestock production, food safety, and the impact of high meat consumption on human health (Hocquette, 2016). However, in an already competitive marketplace with a variety of meat options available, including local, organic, grass-fed, certified humane, and plant-based substitutes, marketers do not know how consumers will receive cultured meat (Johnson, Maynard, & Kirshenbaum, 2018). To date, U.S. consumers' opinions of cultured meat have been measured by a handful of studies. In 2013, Goodwin and Shoulders analyzed news articles about the topic; these articles discussed problems with current livestock production practices, the benefits of cultured meat, its development process and history, the timeframe for a marketable product, and skepticism toward cultured meat. Researchers, academics, People for the Ethical Treatment of Animals (PETA), and restaurant owners and chefs were commonly quoted sources (Goodwin & Shoulders, 2013).

Next, Laestadius and Caldwell (2015) assessed U.S. consumer comments on online news stories about cultured meat. They found that the majority of comments contained negative statements about cultured meat, and many of the commentators described the product as unnatural and unappealing (Laestadius & Caldwell, 2015). More recently, Wilks and Phillips (2017) surveyed 673 U.S. adults, over half of whom indicated that they were willing to try cultured meat, but only one-third of whom reported willingness to eat cultured meat regularly. Men and those who identified as politically liberal had more positive attitudes toward and a greater willingness to eat cultured meat. Respondents identified taste, price, and unnaturalness as barriers to consumption (Bryant & Barnett, 2018; Wilks & Phillips, 2017). Finally, a recent experimental study exposed U.S. consumers to different communication frames on cultured meat (Bryant & Dillard, 2019). Consumers were found to have significantly more negative attitudes when a "high tech" frame was used to discussed cultured meat (Bryant & Dillard, 2019).

Cultured meat is becoming an increasingly hot-button issue for consumers, commodity producers, and government regulators alike. Recent events have fueled the attention given to cultured meat. In February 2018, the U.S. Cattlemen's Association (USCA) petitioned the USDA Food Safety and Inspection Service to limit the definition of "meat" to "the tissue or flesh of animals that have been harvested in the traditional manner" (USCA, 2018, p. 2). In July of that year, the United States Food and Drug Administration hosted a summit to discuss the implications of cultured meat for consumers and producers (Thomas, 2018; Johnson et al., 2018). The meeting was attended by representatives from agricultural commodity groups, such as the National Milk Producers Federation and the USCA; university researchers and professors; environmental groups like Food and Water Watch; and companies developing lab-grown meat products. By December 2018, Missouri had enacted a controversial law outlawing the use of the term "meat" for products that are not animal-derived. Other cattle-producing states, such as Iowa and Montana, may follow suit (Povich, 2018). Such regulatory moves have already prompted legal action and driven cultured meat into headlines across the country. As cultured meat gains notoriety in the media, it is unknown how consumers will respond. Additionally, it is unknown how social media conversations around cultured meat have evolved in light of recent events and attention given to cultured meat. While previous studies have examined traditional and online news coverage of cultured meat, no study has examined social media discourse. To communicate proactively about cultured meat in an existing food and agricultural landscape, more research is needed to understand current conversations, perceptions, and the influence of communication on perceptions.

Purpose and Research Questions

The purpose of this study was to investigate social-media discourse surrounding the topic of cultured meat in the U.S. This study represents our attempts to establish a baseline of consumer perceptions of and communities surrounding cultured or lab-grown meat for use in future studies tracking these products through the issues-management cycle. To fulfill this purpose, we developed the following research questions:

RQ1: How has the issue of cultured meat been discussed on Twitter in the past six months (August 1, 2018-January 31, 2019)?

RQ2: What organizations or individuals act as influencers in this conversation?

RQ3: What online communities have been formed as a result of participating in this conversation?

Literature Review/Theoretical Framework

To explore the aforementioned research questions, the research team developed a conceptual framework based on the tenets of social cognitive theory and its application to social media and public opinion and the issues-management cycle.

Social Cognitive Theory

Social cognitive theory explains how individuals form opinions, attitudes, and behaviors through a process of "triadic reciprocal causation" (Bandura, 2001, p. 265; Bandura, 1986). The three elements, in Bandura's (2001) model, comprise personal, behavioral, and environmental determinants. These elements are related bidirectionally: "Individuals learn new things from their environment, cognitively process them, retain them, and then use them at a later point [in] time" (Goodwin, Chiarelli, & Irani, 2011, pp. 3-4). For the purposes of this study, we will focus on environmental factors (for example, the content of a conversation in which a social media user engages).

According to Bandura, an individual's understanding of the world does not strictly come from firsthand experience or innate familiarity with the world around him or her. Social cognitive theory "emphasizes that human behavior is shaped and controlled by personal cognition in a social environment" (Lin & Chang, 2018, p. 772). "People gain understanding of causal relationships and expand their knowledge by operating symbolically on the wealth of information derived from personal and vicarious experiences" (Bandura, 2001, p. 267). Observational learning may lead to the adoption of new beliefs, attitudes, and behaviors based on the behaviors—and influence—of others (Goodwin et al., 2011).

A 2011 study used social cognitive theory as a guiding framework for a content analysis of YouTube videos about livestock housing legislation (Goodwin & Rhoades, 2011). The study concluded that the high frequency of emotional appeals used in the videos likely led to the formation of cognitive connections between the viewers and videos, thus creating the social environment that could influence behavior under the tenants of social cognitive theory. Similarly, the theory was used in an examination of food waste conversations on Twitter (Specht & Buck, 2019). The researchers inferred that the information sharing observed in the study may represent action spurred by participants' social environment. Additionally, the authors concluded that social media users may feel empowered while in the presence of like-minded users, thus again displaying elements of social cognitive theory (Specht & Buck, 2019)

Social cognitive theory and social media. An emergent body of literature has examined the ways in which social media influences real-world beliefs and behaviors through the lens of social cognitive theory, spurred in part by the rise of social media as an information source. In 2018, more than two-thirds (69%) of U.S. adults used at least one form of social media, and nearly a quarter have a Twitter account (Pew Research Center, 2018). A growing number of Americans use social media platforms to read news: Approximately 20% of adults get their information from social media, surpassing print news readership (16%) (Shearer, 2018; Mitchell, 2018).

"[As] social media enables not only the diffusion of news but also the expression of opinions, some people use it as a place for public expression and discussion of ideas and to influence others' views" (Velasquez & Quenette, 2018, p. 764; Smith, 2013; Anderson, 2016). Velasquz and Quenette (2018) examined the relationships between Hispanic social media users' online engagement in political conversations and their involvement in real-life political activities. The authors discovered that a combination of personal experiences and observation of their contacts' online political activities contributed to users taking part in offline political discourse

and actions. Study participants seemed to indicate a degree of behavioral modeling based on their contacts' activities and the perceived beneficial outcomes of those activities. This finding supports Bandura's (1997) assertion that such modeling occurs when individuals observe peers behaving in a manner that garners positive results.

Issues Management

Issues management literature suggests that issues develop through a predictable cycle (Mahon & Waddock, 1992). This cycle helps stakeholders understand how an issue evolves and how to manage the issue through strategic communication. The issue life cycle model comprises four stages (Buchholz, 1990; Post, 1978; Meng, 1992). In the first stage, a gap between public and industry expectations regarding an issue is identified. Public perceptions are known to change during this stage (Buchholz, 1990; Mahon & Waddock, 1992; Post, 1978). In this first stage, industry must anticipate these and offer goodwill strategies to strengthen relationships and trust (Rakich & Feit, 2001).

Typically, some form of "triggering event" will lead to the second stage. For cultured meat, a triggering event could be published research or targeted media coverage. In the second stage, the issue emerges in the public realm and is identified on the political agenda, with proponents and opponents jockeying for position. Media coverage goes from sporadic to regular with stakeholders trying to attract media attention (Rakich & Feit, 2001).

In Stage 3, the issue has matured, and stakeholders, the public, and key influencers begin to further push for political and government involvement. While media coverage is still common, social media discussions heat up at this stage as well. In the final stage, which some call the "crisis stage," political or government action (e.g., regulations) has been imposed or attempted. Stakeholders' options have decreased and policy is set (Meng, 1992). Throughout this process it is important to identify the stakeholders involved and the organizational pressures being felt. Through analysis of media and online conversations, one can track where the issue falls and what next steps could be best.

Social media are increasingly becoming a key element of issues management practice and research. Consumers, businesses, government agencies and a host of other entities now use social media platforms to share and gather information (Eriksson, 2018). Such information is "key to ensuring decision making and to increasing their capacity to anticipate, influence and collaborate" (Santa Soriano, Lorenzo Álvarez, & Torres Valdés, 2018, p. 1592). In 2012, Stieglitz and Dang-Xuan proposed a framework for monitoring social media for the purposes of issues management and strategic communication in a political context. Included in this methodology was exploratory monitoring of the social web: "For example, [political entities] might be interested in knowing about what kind of political topics or issues are discussed and how such discussions take place in social media. In addition, early detection of upcoming 'hot' topics or issues might enable political institutions to react timely to such trends" (Stieglitz & Dang-Xuan, 2012, p. 9).

Cultured meat joins a litany of agriculture- and biotechnology-related topics that agricultural communications scholars have studied (Wingenbach, Rutherford, & Dunsford, 2002; Miller, Annou, & Wailes, 2003). Subjects include genetically modified (GM) food (Randolph, Rumble, & Carter, 2018; Ruth & Rumble, 2017; Meyers & Miller, 2007), organic and conventional production practices (Abrams, Meyers, & Irani, 2010), and the use of biotechnology to prevent and eradicate crop and livestock diseases (D'Angelo, Ellis, Burke, & Ruth, 2018; Ruth, Lamm, Rumble, & Ellis, 2017).

Irani and Doerfert (2013) called for the future of agricultural communication research to examine how social media can influence behavior related to agricultural issues. They further recommended that this research be done in the context of a multidisciplinary issues response team (Irani & Doerfert, 2013). As an emerging technology with potential to disrupt the livestock and crop markets, use of social media to discuss cultured meat warrants further investigation and is an integral piece to informing the multidisciplinary conversation around the issue of cultured meat.

Methods

To describe the Twitter conversation surrounding cultured meat, the research team used a combination of qualitative methods and quantitative analysis provided by a social media monitoring platform to assess Twitter content including posts, participant demographics, communities involved, top influencers, and emergent themes. Twitter was selected as the platform for investigation due to its ubiquity—nearly a quarter of U.S. adults use Twitter regularly (Pew Research Center, 2018)—and the open nature of both the platform and its users. Information created and shared on Twitter acts as an unfiltered view into the attitudes and beliefs of its users, and Twitter content is publicly visible unless protected by individual users.

Data Collection

Data collection was completed using the subscription service Sysomos Media Analysis Platform (MAP). This tool allows users to "listen" to the conversation by identifying, analyzing, and archiving social media, blogs, news media, and video content related to key words, hashtags, and individual pages or users. This platform has been used in previous studies by researchers to explore food waste, water quality, foodborne illness, and extreme weather events (Specht & Buck, 2019; Seeloff & Specht, 2016; Wickstrom & Specht, 2016; Wagler & Cannon, 2015).

Sysomos MAP provides a Boolean search function that will identify content based on search terms identified by the user. Data can be refined further by timelines, user location, user gender, and other demographics. Sysomos MAP provides tools, or "widgets," that can be added to project "dashboards," discrete portions of the user interface from which researchers can generate infographics and full reports based on social or traditional media activity surrounding the keyword search. These tools are proprietary to the Sysomos platform.

For this study, the query ("cultured meat" OR "lab grown meat") was entered. Results were narrowed down to posts within the U.S. between August 1, 2018, and January 31, 2019. This timeline was selected for recency, as Sysomos searches are limited to one year prior to the search date, and because it represented a period of increased legal and political activity surrounding cultured meat.

Data Analysis

The search resulted in 3,114 tweets, which were downloaded in .csv format and opened in Microsoft Excel 2011 for Mac for filtering. Data were manually explored and any tweets unrelated to "cultured meat" or "lab grown meat," along with any tweets not offering any content beyond a link or event, were filtered out of the sample for a final sample of 2,763. To analyze objective one, the resulting file was uploaded into MaxQDA12, a qualitative analysis tool, and the remaining data were analyzed to uncover themes related to conversations surrounding cultured meat. One researcher used a systematic thematic analysis to search for emergent themes (Fereday & Muir-Cochrane, 2006; Daly, Kellehear, & Gliksman, 1997). A series of codes was developed based on the collected tweets. Once initial themes were developed, the researcher completed a secondary coding process to clarify, collapse, and group sub-codes under broader

themes. An audit trail recorded the coding process and code refinement in MaxQDA. Additionally, the rest of the research team confirmed the emergent codes through peer debriefing. In addition to examining emergent themes, the buzz graph generated by Sysomos MAP contributed to the findings for objective one.

For objective 2, the researchers utilized the community analysis function in Sysomos MAP. This function examines ties between conversation participants based on mutual followership and engagement. Sysomos MAP generates an influence score for those with the highest level of activity and engagement on the search subject. Using Sysomos MAP, the researchers pulled data for those with the highest influence score and described them based on their Twitter profiles.

To analyze objective 3, the researchers utilized the network analysis tool in Sysomos MAP. This tool shows how communities and users interact with each other in relation to the search term and filters. For each community identified by Sysomos MAP, the research team described the participants in each community, the average influencer score, and the top influencers in each community.

Findings

The Sysomos MAP "cultured meat" or "lab grown meat" search generated 3,114 total Twitter mentions during the selected timeline. *Figure 1* denotes the popularity of the terms over the six-month period.

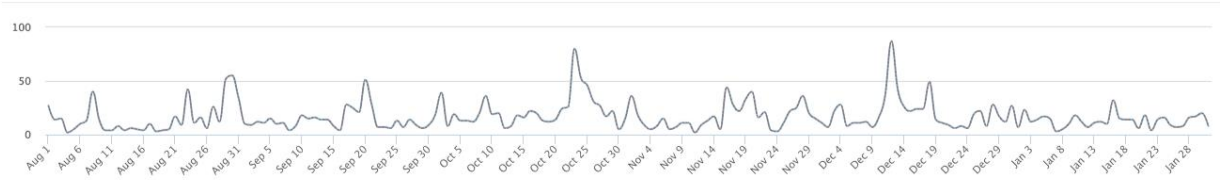

Figure 1. Popularity of the search terms "cultured meat" or "lab grown meat" on Twitter between August 1, 2018, and January 31, 2019. The y-axis represents the number of tweets posted per day.

Spikes between October 20-25 show Twitter users were very active during a two-day joint meeting between the USDA and FDA to discuss regulation needs for the new meat technology based on tweets posted at this time. Higher mentions were also found during early December 2018 due to a convergence of meat-related stories: On December 4, CNN reported on the recall of 5.1 million pounds of beef possibly tainted with salmonella (Goldschmidt, 2018). The following week, CNN published a health article that discussed various substitutes for beef consumption, including cultured meat and alternative proteins like insect- or plant-based options (Lewis, 2018).

The research team conducted our thematic analysis on the 2,763 tweets (out of the original 3,114) deemed relevant to the study. Of these, 45.2% (n = 1,249) were native tweets, while 20.8% (n = 575) were found to be reply tweets and 34% (n = 939) retweets. Sysomos MAP reports demographics of users engaged in the conversation based on available user-provided biographical data. Of the participants, 68.6% were male and 31.4% were female.

RQ1: How has the issue of cultured meat been discussed on Twitter in the past six months (August 1, 2018- January 31, 2019)?

A buzz graph was developed to identify the key terms among the 3,114 tweets generated by the Sysomos search and the relationship between those words (*Figure 2*). The weight of the line indicates the strength of the relationship between words. While the terms *meat*, *cultured*, *lab*, *grown meat*, *lab grown*, and *lab* were highly related, other terms emerged as popular in the conversations. *Food*, *consumers*, *future*, *USDA*, *FDA*, *clean*, *animal*, *eat*, and *animals* were all common words used in association with the search terms.

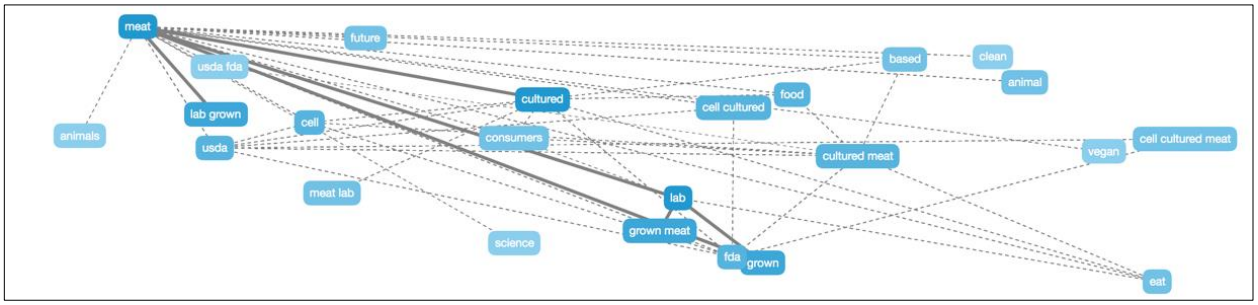

Figure 2. Buzz graph of keywords used in tweets around cultured meat and lab-grown meat and the strength of the relationship between them.

A thematic analysis revealed that the conversation focused around eight major themes: *legality and marketing*, *sustainability*, *acceptance*, *business*, *animal concerns*, *science and technology*, *health concerns*, and *timeline*. Many of the prevalent words clearly fell into each of these themes.

Legality and Marketing. Tweets falling in this theme fit into *need for regulations*, *regulations*, and *labeling* (Table 1). Many questions surrounding who would regulate cultured meat when it enters the market were posted and included in the *need for regulations* subtheme. Several users called for rules on *labeling* or discussed regulations passed in Missouri that limit how cultured meat could be marketed. During the data-collection period a joint meeting was held between the USDA and FDA to discuss who is in charge of *regulations.* Several posts led up to this meeting, discussed it live, and provided results.

Table 1
Legality and Marketing Theme and Subthemes Produced by a Content Analysis of Topic-Related Twitter Conversations

Theme and Subthemes	Tweet Examples
Legality and Marketing	
Regulations	RT @BRNAgNews_Ken: #USDA @SecretarySonny and #FDA commissioner Scott Gottlieb kick off a joint USDA-FDA meeting on the regulation of lab-grown, cell-cultured meat. "We fully expect both the USDA and FDA will have roles in oversight," Gottlieb says. Stay tuned for reports on @Brownfield #fakemeat https://t.co/sJHkSfJlMz
Labels	RT@_ nicholewilson: S/O to Missouri for passing legislation preventing cultured “meat” to be labeled as meat.

Need for Regulation	With #cell-cultured #meat potentially being thee future, the general #public has raised concerns in three major areas- jurisdiction, oversight, and labeling: https://t.co/M4ORvm8e9k https://t.co/VvYHQJ0IDs
	If @USDA regulates meat at "point of slaughter" then which govt agency should regulate fake meat? . Damn good question from @chasepurdy who is writing a book about cell-cultured meat.

Sustainability. Environmental concerns were voiced on all sides of the issue, but it was evident most felt cultured meat is *good for the environment* (Table 2). Beyond praising it, a subtheme of curbing agriculture's *carbon footprint* through decreased livestock production was noted frequently.

Table 2
Sustainability Theme and Subthemes Produced by a Content Analysis of Topic-Related Twitter Conversations

Theme and Subthemes	**Tweet Examples**
Sustainability	
Carbon Footprint	QT @SteakAndIron: Those who do not know the history of oleo margarine will eat the lab meat… carbon footprints and disease…; Oh boy wait until they see the total carbon footprint of lab grown meat https://t.co/FTpxbf0ir
Good for Environment	QT @ExistentialEnso: 🤔 ; Lab grown meat: - doesn't cause suffering - has a fraction of the environmental impact - is free of antibiotics - is projected to be cheaper than "natural" meat I know some folks are skeeved out, but this is very good technology

Acceptance. This theme was broken into several subthemes around how and if there will be acceptance of cultured meat (Table 3). Both positive and negative comments were voiced in the various subthemes. *Consumers* were the most discussed in this theme with participants asking if they will accept cultured meat. Some participants surfaced the contradiction of consumers' selective acceptance of science, as some consumers support cultured meat but not genetically modified foods, or reject cultured meat but embrace smartphones and other new technology. *Farmers* were also a topic of discussion. Participants either discussed how farmers could benefit from and be supportive of this new technology or how farmers may not accept an alternative that could affect meat production in the U.S. Beyond these two specific groups, the subtheme of *ethics and values* was raised multiple times in relation to the science behind the product. *Taste* was also discussed by many participants who either knew firsthand or guessed that the meat tasted bad. Some tweets also referenced the product tasting delicious.

Table 3
Acceptance Theme and Subthemes Produced by a Content Analysis of Topic-Related Twitter Conversations

Theme and Subthemes	Tweet Examples
Acceptance	
Consumers	@CarlLippert Yes. One thing that is always brought up is consumers acceptance of lab grown meat. What if it's just another way to produce a protein source to replace soybean meal or another feed protein source. Needs to be economical of course.
	QT @GHGGuru: Also: “GMOs are evil, but I can’t wait to try lab-cultured meat!” ; “Paradox of innovation: same person who will wait overnight for new iphone wants food grown with 2 mules.”
Farmers	@CarlLippert Will be interesting watching farmers response to lab grown, after screaming that consumers should trust science on GMOs and chemicals, yet many will go strait anti-science to bash lab grown meat I predict
	QT @voxdotcom: I am very curious as to how the lab grown meat industry will develop. ; Lab-grown meat is years away from your supermarket, but its potential to radically change animal agriculture as we know it is stirring up tensions. https://t.co/rJ1dbXk7bS
Ethics and Values	Weird how some analysts identify the problems with "factory farming" including the ethical and ecological issues Then recommend a full conversion toward greater industrialization with "lab grown meat". Like recommending an extra pack a day for lung cancer treatment.
Taste	QT @Seeker: I want to try lab grown meat so bad; Lab-grown “clean meat” is coming, and it supposedly tastes delicious. https://t.co/ipeIBlEaIt

Health Concerns. Most discussion on health was deemed to be positive; however, in the subtheme *clean meat*, several users questioned how “clean” something could be after being lab-grown (Table 4). Most of the tweets fell under the subtheme of *healthy,* as participants discussed the how clean meat could be healthier because it does not come from animals given antibiotics.

Table 4
Health Concerns Theme and Subthemes Produced by a Content Analysis of Topic-Related Twitter Conversations

Theme and Subthemes	Tweet Examples
Health Concerns	
Healthy	@NegusX3 @meemanmevegan With lab grown meat we can assume the harmful side effects would be removed if not lessened. Also, if it did cause health risks that's not really our concern, that's a personal choice. Because in that case we should ban all harmful substances like cigarettes, alcohol, etc.
Clean Meat	RT @awright4645: #Carnivores, would you eat cultured meat, if it matched conventional meat in terms of nutrition? If concerned about it being "unnatural", consider how "natural" conventional meat production is, reliant on selective breeding, supplements, antibiotics, etc. https://t.co/qIS8651KHg https://t.co/u5ohrOnZxP

Animal Concerns. Beyond consumer acceptance, this theme was the next most highly prevalent (Table 5). *Animal welfare* was of top concern, with users saying the development of cultured meat could mean a decline in the use (and abuse) of animals for meat consumption. Users also discussed the end of factory farming and traditional animal agriculture with the advent of lab grown meat. *Slaughter* was discussed so many times it warranted its own subtheme. The killing of animals was of concern for many who claimed to be vegan. Several users took it a step further and discussed *pet food* options that would allow pets to become vegan. One user even asked if this would be available for lions.

Table 5
Animal Concerns Theme and Subthemes Produced by a Content Analysis of Topic-Related Twitter Conversations

Theme and Subthemes	Tweet Examples
Animal Concerns	
Welfare	QT @specterm: Michael, please meet @BioBeef. You two can debate this one and let me know who wins. 😉 ; Peter thoughtful as always on this essential topic. Time to start seriously discussing cultured meat as a way to lessen the impact of climate change and reduce the massive suffering of animals that live only to be eaten. https://t.co/GX9qU4lX5d If scientists could go ahead and finish up and perfect lab grown meat so we can end traditional commercial farming, that would be great.
Slaughter	@Dipdil Ok good to know. From my perspective, once lab grown meat (cultured cells) becomes a certified reality in the near future, with no

	difference in harms or benefits, then there will be no need to kill animals for food. I hope this will be within the next couple of years.
Pet Food	i love her more than anything and i would never feed her something i think would make her sick. if i had to feed her meat until lab grown meat is available to buy i would in a heartbeat, however her digestion has improved from before and our vet says she's in perfect health and-

Science and Technology. This theme discussed *logistics* of the technology and science behind cultured meat (Table 6). Discussions on research and the specific cell science were prevalent in this theme.

Table 6
Science and Technology Theme and Subthemes Produced by a Content Analysis of Topic-Related Twitter Conversations

Theme and Subthemes	Tweet Examples
Science and Technology	
Logistics	QT @foundmyfitness: And this is similar to a process of how lab grown meat can be created. I can't imagine this process isn't energy intensive tho. ; Researchers were able to grow human blood vessels as organoids in a petri dish and when transplanted into animals the blood vessel organoids developed into perfectly functional human blood vessels including arteries and capillaries. https://t.co/aKDWW3hf1d

Timeline. Users fell into one of two subthemes in terms of how soon this technology would hit the market: Some felt the technology was *now* available or would be within the next year (Table 7). Other users predicted a *future* release of the technology into the market.

Table 7
Timeline Theme and Subthemes Produced by a Content Analysis of Topic-Related Twitter Conversations

Theme and Subthemes	Tweet Examples
Timeline	
Now	A cultured chicken nugget could hit the market by the end of the year You may know Just (formerly Hampton Creek) for its vegan cookie dough and mayo, but the company has also been working on cultured meat -- real meat that https://t.co/j2jmlvdFKa
Future	@erbrod @GoodFoodInst @joshtetrick @justforall @UmaValeti @MemphisMeats This link might give you a few ideas “Cultured Meat Will Not Be Realistic Anytime Soon: The Numbers Behind the Hype” https://t.co/TfLvpw1S5h

Business. The business and potential business implications of cultured meat were discussed in relation to many of the other themes (Table 8). Discussion of the *economics* of cultured meat included tweets about how traditional meat prices would drop, as well as some users who felt farmers aimed to benefit from it. *Start-ups* were also widely discussed. Several Silicon Valley start-ups and other new meat companies were mentioned or praised in many of the posts. Some participants even discussed investing in these companies and the companies' need for regulations and marketing direction.

Table 8
Business Theme and Subthemes Produced by a Content Analysis of Topic-Related Twitter Conversations

Theme and Subthemes	Tweet Examples
Business	
Start-Ups	RT @indbio: @arvndgpta IndieBio's founder "After we met the @NewAgeMeats team and saw what they could do, we had to invest in them. This is the most product and the fastest production from any cultured meat startup we've seen so far," https://t.co/zpO8mqfxEX
Economics	@erbrod @GoodFoodInst @joshtetrick @justforall @UmaValeti @MemphisMeats This link might give you a few ideas "Cultured Meat Will Not Be Realistic Anytime Soon: The Numbers Behind the Hype" https://t.co/TfLvpw1S5h

RQ2: What organizations or individuals act as influencers in this conversation?

Sysomos MAP identifies users with a high level of activity and engagement in the conversation as influencers in the Twittersphere on the searched subject. These influencers not only discuss the topic, but are also retweeted and engaged with the topic most often. Users who have the most mentions of the query terms and highest influence score include Alex Shirazi, the organizer of the Cultured Meat Symposium; Andrew Noyes, the head of communications for Just, a company aimed at making food, including meat, from plant products; and Jessica Almy, an employee of the Good Food Institute. Beyond food organizations, five of the top 12 influencers included writers interested in food and healthcare, including Garrett Broad, author of *More than Just Food*. Other top influencers include U.S. Secretary of Agriculture Sonny Perdue and NYFarmer, a fourth-generation dairy farmer and lawyer who shares an authority rating of 9 out of 10 with Secretary Perdue. Other top influencers include the Cultured Meat Symposium and its organizer; New Age Meats and Balletic Foods, which are both cultured meat start-ups; James Stout, a cultured meat researcher; a writer developing a book about cell-cultured meat; and the cell-based meat podcast titled Future Food Show.

RQ3: What online communities have been formed as a result of participating in this conversation?

Sysomos MAP uses network analysis to show communities of users that interact with each other in relation to the search terms and filters. The ("cultured meat" OR "lab-grown meat") search generated five user communities (*Figure 3*). Because one community was based in the United Kingdom, and this study was concerned with the U.S., we only analyzed four of these main communities.

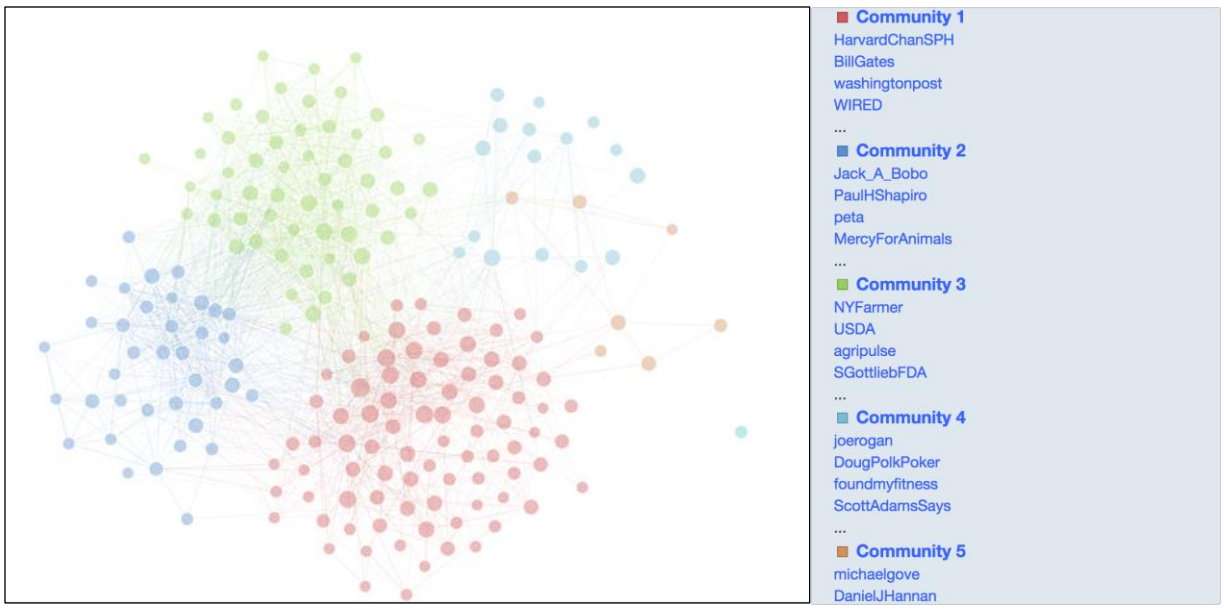

Figure 3. Community graph of influencers discussing cultured meat.

Community 1: Community 1 comprised top news and technology influencers. With an average influencer score of 68%, users in this group are focused on sharing news and science, especially around technology. Top influencers in this community include Harvard Public Health, Bill Gates, the *Washington Post*, *WIRED*, the United Nations, Bloomberg Business, Now This News, and Huffington Post.

Community 2: Community 2 held the lowest influencer score of 61% and, according to members' Twitter biographies, are focused on a vegan lifestyle, clean meat, and protecting animals. Members include PETA, Mercy for Animals, and individuals such as Jacy Reese, author of *The End of Animal Farming*; Paul Shapiro, the best-selling author of *Clean Meat*; and Dr. Martin Bloem, a professor at Johns Hopkins.

Community 3: Community 3 had an influencer score of 64%. Agricultural policy organizations including the USDA, FDA, and North American Meat Institute are joined with agricultural media such as The New Food Economy and AgriPulse. Highly engaged politicians and agricultural advocates include NYFarmer, a female dairy farmer with an influencer score of 9; Alison Van Eenennaam, an animal science researcher at the University of California-Davis; the President of the United States; and Secretary of Agriculture Sonny Perdue.

Community 4: This community was composed of individuals with lower influence scores overall but an average influencer score of 66%. Users include individuals like comedian Joe Rogan, and all users indicated a food, meat, or paleo diet interest in their bios. This community is visibly less connected to each other than Communities 1, 2, and 3.

Discussion

Though cultured meat has existed in the public consciousness since 2013, awareness of and conversations about the issue are very much news-driven. The activity displayed in *Figure 1* demonstrates peaks and valleys of Twitter activity that are closely attuned to newsworthy events related to cultured meat and other meat-related stories. Government activities, such as meetings and hearings, tend to precipitate increased online activity, and crises like the December 2018 beef recall seem to raise cultured meat as a potential alternative for traditionally harvested animal

proteins. The low level of activity in fallow periods of cultured-meat news indicates that cultured meat is not a pressing issue for general consumers; rather, the conversation is propelled by interest groups and influencers.

In terms of the issues lifecycle, cultured meat seems to fall into Stage 2. As Rakich and Feit (2001) would predict, triggering events—in this case, policy actions and food-related crises—spur issue activity among stakeholders who compete for attention and political position. Here, we see political and industry actors responding to each other's statements and political maneuvering in the Twittersphere. The short duration of these periods of conversation, however, indicate that cultured meat has yet to enter Stage 3, wherein coverage is consistent and sustained.

The manner in which cultured meat is discussed on Twitter illuminates pathways for agricultural communications professionals to enter and engage in the conversation. First, the terminology of cultured meat varies: "Cell grown," "lab grown," and "cultured meat" are all descriptors of the same product, and professionals and researchers monitoring this issue must be aware of the varied nomenclature. Future research should consider expanding search terms to include common terms identified in Objective 1. The results of the current manuscript were limited by the search terms "cultured meat" or "lab grown meat."

Our thematic analysis of conversation content reveals a lack of consensus about the viability and implications of cultured meat for consumers and agricultural producers alike. The eight conversation themes—*legality and marketing*, *sustainability*, *acceptance*, *business*, *animal concerns*, *science and technology*, *health concerns*, and *timeline*—represent topics for which agribusinesses, commodity groups, and researchers should have talking points prepared if precipitating events that encourage online activity and awareness occur. Additionally, agribusinesses, commodity groups, and researchers should develop strategic talking points and social media strategies to engage in online conversations about cultured meat. These themes show some similarities to themes and perceptions identified in previous studies (Bryant & Barnett, 2018; Bryant & Dillard, 2019; Goodwin & Shoulders, 2013; Laestadius & Caldwell, 2015; Wilks & Phillips, 2017). However, researchers in the different studies elected different names for similar themes. Further examination should determine whether the differences are due to communication frames or researcher bias and preference. The theme of *Legality and Marketing* seems to be an evolving theme in the conversation of cultured meat as it had not been identified in prior research.

Identifying influencers and communities is key for tracking issues through the development cycle, especially given the propensity of social media users to model attitudes and behaviors of those they follow (Freberg, Graham, McGaughey, & Frebeerg, 2011). Considering that the cultured-meat conversation is largely propelled by news-making events and government activity, it is no surprise that the influencers involved in the conversation represent companies producing cultured meat and other alternative protein foods, writers and journalists who cover science and food topics, government officials, and interest groups. These influencers demonstrate some overlap with the sources used in traditional media (Goodwin & Shoulders, 2013), but government officials and writer/journalist influencers provide a unique contribution to the social media conversation that may be due to issue progress and/or differences in social media and traditional media. Users like NYFarmer, a private citizen whose Twitter account ranks high in Sysomos's engagement scale, could be an interesting case study for communications professionals who want to break into these conversations but are unsure of best practices for doing so.

Community analysis, like influencer analysis, gives us an understanding of who is driving the issue of cultured meat in the media and how those users correspond with each other. The largest, densest, and most influential of the identified communities includes opinion leaders like Bill Gates and media outlets like *WIRED* and the *Washington Post*. These are individuals and organizations that interact with members of the other identified communities. This high level of involvement could have serious implications for social influence (Bandura, 2001; Goodwin et al., 2011; Lin & Chang, 2018): If, as Velazquez and Quenette (2018) posit, observation is crucial for attitude and behavior formation in online contexts, pushing messages to as many users as possible is key to managing an issue on social media. Engaging Community 1 should, therefore, place communicators at the crux of the cultured-meat conversation. Community 2, on the other hand, represents a group of users who should be closely monitored by agricultural organizations but engaged with only when necessary, as their support of cultured meat as an alternative to livestock production is a message agricultural proponents may not want to amplify. Based on the minimal amount of visible overlap between Community 2 (animal-welfare proponents) and Community 3 (agricultural organizations and government agencies), such separation is already occurring.

This study is a first look into the cultured meat issue as it exists on social media. The results of this study represent a baseline for understanding how private citizens, government officials, researchers, and other interested parties communicate about cultured meat. These findings will be used to further study the issue as cultured meat becomes a reality for consumers. Continued monitoring should examine how the conversation and influencers evolve as cultured meat moves through the issues management cycle. Additionally, research connecting the political, media, and public agenda could provide insight to modern-day development of agricultural and natural resource issues. Themes and subthemes could be transformed into questionnaire items for surveys of consumers.

Cultured meat will be one of many issues that society encounters as we search for ways to feed a growing population. The conversation, influencers, and resulting opinions of online and real-world conversations will provide insight to the long-term feasibility of the technology among consumers and within the existing marketplace. As we study consumer perceptions of and communities surrounding cultured meat and track this product through the issues lifecycle, we hope to develop techniques that can help future communicators and researchers better understand how to manage agricultural and natural resource issues.

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