#Eggs: social and online media-derived perceptions of egg-laying hen housing

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ABSTRACT Enormous quantities of data are generated through social and online media in the era of Web 2.0. Understanding consumer perceptions or demand efficiently and cost effectively remains a focus for economists, retailer/consumer sciences, and production industries. Most of the efforts to understand demand for food products rely on reports of past market performance along with survey data. Given the movement of content-generation online to lay users via social media, the potential to capture market-influencing shifts in sentiment exists in online data. This analysis presents a novel approach to studying consumer perceptions of production system attributes using eggs and laying hen housing, which have received significant attention in recent years. The housing systems cage-free and free-range had the greatest number of online hits in the searches conducted, compared with the other laying hen housing types. Less online discussion surrounded enriched cages, which were found by other methods/researchers to meet many key consumer preferences. These results, in conjunction with insights into net sentiment and words associated with different laying hen housing in online and social media, exemplify how social media listening may complement traditional methods to inform decision-makers regarding agribusiness marketing, food systems, management, and regulation. Employing web-derived data for decision-making within agrifood firms offers the opportunity for actionable insights tailored to individual businesses or products.

Key words: big data, consumer demand, consumer perceptions, egg production, social media analytics

INTRODUCTION

The sociological and technical shifts to fundamentally user-created content facilitate the generation of online media which reflects the work, thoughts, and opinions of a large swatch of society, as opposed to a few media generators posting for others to consume. Second generation, referred to as Web 2.0, Internet technologies shifted activity from the desktop to the Web, shifted value production from the firm to the consumer, and shifted the locus of power away from the firm to the consumer (Berthon et al., 2012). With these shifts, online media data may inform decision-making in food industries and regulatory entities. However, precisely how to employ social media listening data presents challenges such as how to employ sentiment analysis (Taylor et al., 2014).

According to Clement (2018), the number of social media users around the globe increased from 1 billion in 2010 to 2.62 billion in 2018. In the United States, 76% of people who have Internet access used at least 1 social network platform in 2015, up from 10% in 2005 (Perrin, 2015). Government and nonprofit organizations make up a prominent sector of social media user groups for their campaigns to convey important, valuable, or persuasive messages (Mickoleit, 2019). Today, even public officials employ social media, notably Twitter, for communication with the general public. Social media can act as a complementary information channel for a segment of the public (Kuttschreuter et al., 2014). Forty percent of social network users in a Canadian sample (n = 1,600) received news from people they follow on social media and one-fifth obtained news from news organizations/journalists they follow (Hermida et al., 2012).

Entire industries are now devoted to discovering and using social media–derived insights. Social media is

used in healthcare to increase interactions with others, provide more available information, for peer/emotional support, public health surveillance, and potentially to influence policy (Moorhead et al., 2013). In tourism, it is used to evaluate traveler's intentions (Zeng and Gerritsen, 2014). Private companies have been employing large data sets generated from social media sources to gain market insights. However, these methods have been underutilized in agricultural and food markets for commoditized products, such as eggs. While the individual named brand-building and marketing may be easy to envision, common staples and commodities may find it more difficult to monetize an investment in online or large-scale consumer data analytics.

Social media data allows market-relevant data collection in real-time with great efficiency compared with traditional methods of measuring perceptions, like surveys and focus groups. This analysis employs social media listening to understand perceptions of egg-laying hen housing systems in the United States. Four housing systems for egg-laying hens were investigated, including free-range, enriched colony, battery cage, and cage-free housing. It was hypothesized that top search terms on social media surrounding eggs revolved around consumer usage of eggs, such as in cooking or for breakfast, rather than around animal housing or rearing practices. The overall sentiment was hypothesized to be highest for free-range and cage-free hen housing, given the prevalence of labeling and marketing dedicated to those systems. Assessing large-scale data sets from comprehensive social media and Web searches allows for a robust summary of the current state of understanding of public perceptions of egg-laying hen housing systems.

Eggs and Hen Housing in the Modern Marketplace

Eggs are an affordable source of high-quality protein and key nutrients including folate, iodine, selenium, and long-chain n-3 polyunsaturated fatty acids (omega-3 fatty acids) (Ruxton, 2013; Watson, 2018). Eggs are also one of the few natural sources of choline in diets and remain the subject of study for maternal and early childhood diets because of their dense nutrient value in a regularly available and low-cost form (Ruxton, 2013). Total table egg production in the U.S. was 8.067 billion in October 2018, which was 104% of 2017 production (USDA NASS, 2018). Per capita consumption estimated by the 2018 World Agricultural Supply and Demand Estimates report was 279.2 eggs per person annually.

Housing options for egg-laying hens were summarized by the American Veterinary Medical Association (2012) as consisting of conventional cages, enriched/furnished housing, barn or aviary housing, and free-range housing. The American Veterinary Medical Association (2012) provided advantages and disadvantages of hen housing types, along with succinct definitions. Conventional cages were defined as "A wire enclosure housing 3 to 6 birds and having a sloped floor. In commercial production, however, birds are commonly housed at the density of 7 to 8 birds per cage." Enriched/furnished housing consists of "Housing that provides additional features often including perches, a nest box/area, litter or scratch area and more space per hen. Size and construction vary, including colony housing for up to 60 birds." Barn or aviary style housing consists of "(Barn): A shed in which hens are housed on the floor and typically have access to litter and nest boxes. (Aviary): As for 'barn' with the addition of multi-tiered platforms or perches." Free-range housing is provided the definition "The key feature of free-range housing is access to an outdoor area during the day."

Regulation, legislation, and ballot initiatives, related to animal welfare, including minimum standards for livestock animal housing, remain capricious. In a United States nationwide sample, Byrd et al. (2017) documented 93% of respondents reporting the production of eggs an acceptable use of animals, yet significant debate has been raised in recent years with regard to *how* and sometimes *where* eggs are produced. The debate and challenges surrounding California Propositions 2 and 12 are examples of complicated public debates impacting egg-laying hen housing and production systems. Proposition 2, passed in 2008, put into place a statute, effective on January 1st, 2015, that prohibited the confinement of farm animals in a manner that does not allow them to turn around freely, lie down, stand up, and fully extend their limbs (California Proposition 2, 2008). On November 6th, 2018, California voters passed Proposition 12 requiring all eggs sold in the state of California to come from cage-free hens by 2020 (California Proposition 12, 2018).

Consumer demand for eggs produced in alternative laying hen housing systems have been studied using methods ranging from estimating willingness to pay (WTP) through hypothetical choice experiments (Ochs et al., 2019b) to employing supermarket scanner data (Chang et al., 2010). Ochs et al. (2019b) estimated WTP for egg production system attributes, focusing on housing both introducing the study of enriched colony housing in a sample of U.S. respondents and incorporating information treatments in the form of educational videos. Video information treatments were associated with preferences for enriched colony housing, and statistical differences in mean WTP estimates were found between those viewing and not viewing the videos (Ochs et al., 2019b). "A series of studies on hen confinement housing systems found that no one system is perfect and that there are often trade-offs among animal welfare, environmental impact, food affordability, food safety, and worker health and safety" (Larkin, 2019). A March 2015 Summary Research Report from the Coalition for Sustainable Egg Supply, a multistakeholder group, sought to summarize findings from a commercial-scale study on housing alternatives for egg-laying hens in North America (Coalition for Sustainable Egg Supply, 2015). Fundamentally, the
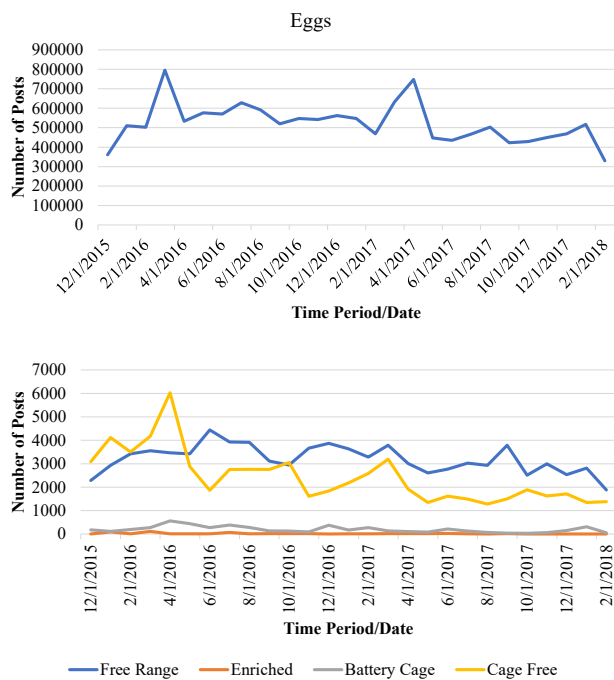
Figure 1. Monthly numbers of posts for egg search and subsearches across time period studied.

report summarized cage-free aviary, enriched colony, and conventional cage housing options. Importantly, the findings refer to tradeoffs in animal health and well-being, production use, physical assessment, resource use, hen physical condition and health, physiological stress, food safety, environmental impact, worker health and safety, and food affordability (Coalition for Sustainable Egg Supply, 2015). The mention of worker health and safety is of particular interest given the relative lack of discussion about workers on livestock

operations in debates surrounding production and housing systems. Ochs et al. (2019a) included worker health and safety in a series of attributes of housing systems, which were sourced from the Coalition for Sustainable Egg Supply in the study design. Ochs et al. (2019a) found that including worker health and safety changed the preferred hen housing system to enriched colony away from cage-free.

MATERIALS AND METHODS

"Listening" on social media is relatively new in the realm of social science research. Social media listening allows searches and amassing of data from social media platforms, most notably Twitter. The Netbase platform, a leader in social media analytics, listening, and intelligence (Netbase, 2018a,b) was employed to study online posts related to eggs and specifically egg housing types in December 2015 through February 2018. Researcher interface with the Netbase platform is similar to that of a search engine which allows for inputting of search terms, as well as exclusions of search terms, specific domains, and even authors. Account holders on social media platforms may remove or reinstate postings which leads to a fluid nature of data and necessitates date stamps of data entries. For this research, data from the time period of December 2015 through February 2018 was collected on March 5th, 2018.

Social media posts occur in many languages, and individual platforms, such as Facebook and Twitter, offer multiple translation methods to facilitate across-language communication online (Facebook, 2019; Twitter, 2019). While data collected from social media platforms could technically take place in multiple languages, limitations in language interpretation, and in

Table 1. Inferred demographics of posters and posts by time of day and day of week.

	Eggs	Free-range	Enriched colony	Battery cage	Cage-free
Gender (n)	5,440,121	28,882	109	2,313	27,632
Male	47%	45%	46%	28%	43%
Female	53%	55%	54%	72%	57%
(Inferred) Age (n)	5,244,345	27,586	63	2,121	26,662
<18	10%	8%	8%	6%	8%
18–24	14%	11%	13%	9%	11%
25–34	19%	17%	16%	15%	18%
35–44	16%	16%	16%	15%	16%
45–54	16%	17%	16%	19%	17%
55–64	17%	19%	19%	22%	18%
65+	10%	11%	13%	14%	11%
Posts by day of week (n)	6,483,820	26,340	50	1,850	29,300
Monday	14%	13%	20%	15%	15%
Tuesday	14%	15%	0%	23%	19%
Wednesday	15%	16%	0%	17%	18%
Thursday	14%	15%	20%	17%	17%
Friday	14%	16%	60%	14%	14%
Saturday	14%	14%	0%	6%	8%
Sunday	15%	12%	0%	9%	9%
Posts by time of day (n)	6,483,820	26,340	50	1,850	29,300
12 am–6 am	11%	11%	0%	7%	8%
6 am–12 pm	29%	32%	0%	41%	36%
12 pm–6 pm	32%	34%	80%	34%	36%
6pm–12am	28%	24%	20%	18%	21%
Mentions (n)	1.7E + 07	125,763	1,219	9,005	107,947
All posts (n)	1.4E + 07	86,530	533	5,294	65,475

Table 2. Top domains and sources.

	Eggs		Free-range		Enriched colony		Battery cage		Cage-free	
Domains	twitter.com	60%	twitter.com	55%	reddit.com	32%	twitter.com	75%	twitter.com	80%
	reddit.com	4%	backyardchickens.com	25%	wattagnet.com	26%	reddit.com	11%	reddit.com	5%
	backyardchickens.com	4%	reddit.com	9%	twitter.com	11%	hsi.org	4%	instagram.com	5%
	instagram.com	2%	instagram.com	4%	egg-cite.com	8%	huffingtonpost.com	2%	wattagnet.com	4%
	tripadvisor.com	1%	theguardian.com	2%	thepoultrysite.com	7%	triplepundit.com	2%	marketwatch.com	1%
Sources	News	69%	Twitter	31%	News	69%	News	44%	News	44%
	Twitter	18%	Forums	30%	Forums	17%	Twitter	38%	Twitter	41%
	Blogs	11%	News	24%	Blogs	9%	Forums	9%	Blogs	7%
	Forums	2%	Blogs	12%	Twitter	5%	Blogs	9%	Forums	6%
			Instagram	2%					Instagram	2%
Domains (n)	16,838,733		72,661		571		4,106		55,771	
Sources (n)	16,838,837		126,920		1,219		8,100		109,016	

particular, slang, shorthand, and local vernacular, create challenges associated with interpretation. Similarly, data collection is possible across multiple countries, but cultural context of social media posts, in particular those on Twitter in which the number of characters is limited in a single post, make interpretation precarious. Given the intent of this study to focus on eggs produced for human consumption, additional considerations about cultural norms for egg consumption may cloud interpretation of posts. Thus, the data collected and analyzed were limited to the geography of the United States, using the Netbase filters surrounding geography, and posts in English were exclusively studied.

To collect a data set encompassing social media posts referencing eggs, researchers developed search terms for inclusionary and exclusionary terms to eliminate invalid references or search hits. The data collected for this analysis were intended to be inclusive of all social media referencing chicken eggs, which are typically produced with the potential of being food and/or being consumed as food. Total numbers of posts and mentions were quantified. Things that are mentioned in each of the searches conducted are summarized, in addition to attributes, emotions, behaviors, terms, and hashtags for all searches. The gender and inferred age, when available, were collected for each search conducted. Estimated ages were available for sources that include a first name and used the methods employed by Netbase which imposed estimated ages based on names and Social Security Administration name data. "Age classification is based on the popularity of first names by year of birth according to U.S. Social Security Administration data, which makes this feature more relevant for U.S. markets. These data include about 65,000 of the most popular first names, covering more than 80% of the U.S. population" (Netbase, 2018a,b). Domains and sources for posts were collected when available. Domains are specific web addresses of the posts, while sources generalize the domains to a category. For example, cbs.com would be considered a domain, whereas all news sources such as cbs.com or abc.com would be categorized within sources as news.

Data collection was completed in a 3-stage sequence. First, researchers developed a set of inclusionary and exclusionary terms aimed at casting a wide net around livestock agriculture. Inclusionary terms employed in the first step of screening are displayed in the Appendix. Importantly, references to celebrities such as Mia Farrow were excluded explicitly to avoid capturing unrelated posts. Exclusion terms can be even more nuanced, for example, the term "Easter egg" when referenced as part of computer software, media, or games. In the context of computer software, gaming software, television, and movies, an "Easter egg" is notably a reference to an intentionally hidden message, secret feature, or inside joke. Given the focus of this analysis and desire to ensure that social media posts analyzed and counted were referencing an actual, literal, egg, including eggs purchased or consumed for the Christian holiday Easter, but excluding "Easter eggs" when referencing hidden items in media, search terms were carefully crafted. In total, stage 1 involved a total of 105 inclusionary terms and 360 exclusionary terms, 135 excluded authors (the bulk of which were identified automated software programs or robots), as well as 14 Facebook channels.

Second, researchers added egg-laying hen and egg terms explicitly, both as inclusionary terms, specifically "egg, hen, pullet, eggs, #eggs, #egg, #hen, #pullet" and exclusionary terms, specifically "bad egg subscribers, Little Red Hen, robin's egg blue, #biggreenegg, Big green egg" to develop a general egg-specific data set. Fundamentally, this egg-specific data set is a subset of the data collected in the intentionally much wider set of search terms devoted to livestock agriculture broadly.

Researchers added a third layer of search terms, both inclusionary and exclusionary, to capture social media which specifically mentioned the housing types of free-range, enriched colony housing, battery cages, or cage-free. Given the significant efforts to develop a closely tuned data set in stage 1, relatively few terms were necessary to develop the 4 subcategory searches studied. Specifically, inclusionary terms for battery cages included "battery cage, #batterycage, conventional cage, #conventionalcage", whereas "pork, pig" were excluded. Inclusionary terms for cage-free were "Cage-Free, #Cage-Free, #cagefree, cage free", whereas "pork, pig, sow" were excluded. Inclusionary terms for enriched colony housing were "Enriched Colony, #enrichedcolony, enriched cage, #enrichedcage", whereas no exclusionary terms were

Table 3. Top words used for interests and self-biographical.

Top words used for:	N	Eggs	n	Free-range	n	Enriched colony	n	Battery cage	n	Cage-free
Interests	3,008,116	Family 23%	14,481	Food and Drink 31%			1,160	Pets 34%	16,532	Food and Drink 35%
		Food and Drink 22%		Family 28%				Food and Drink 23%		Family 21%
		Music 13%		Politics 10%				Family 20%		Music 10%
		Religion 11%		Music 10%				Politics 15%		Politics 10%
		Politics 8%		Religion 9%				Music 9%		Pets 10%
Self-biographical	14,215,995	love 5%	87,360	love 3%	534	own 4%	4,985	VEGAN 12%	66,237	Love 5%
		life 3%		food 3%		@TheHumaneLeague 4%		love 8%		Vegan 4%
		like 2%		life 2%		views 4%		dog 5%		Lover 3%
		food 2%		Writer 2%		mine 2%		life 5%		Life 3%
		Music 2%		lover 2%		Spiritual 2%		rights 5%		Writer 2%
		Writer 2%		Mom 2%		#vegan 2%		advocates 4%		Advocate 2%

Grayed out boxes indicate too little data to report.

added. Inclusionary terms for free-range included "Free-Range, Free Range, #Free-Range", whereas exclusionary terms of "#reijmerstok, Beef, bully stick, Cow" were used.

To determine the sentiment associated with the searches, including both the general egg search and the subsearches that looked specifically at the different housing types, a sentiment score was assessed. Researchers employed Netbase's patented Natural Language Processing engine, a "robust Natural Language engine that surfaces and analyzes sentiment for every subject in the sentence" (Netbase–Natural Language Processing, 2018). While sentiment was primarily measured using the Natural Language Processing capabilities of the Netbase platform, researchers analyzed initial search results and the keywords driving sentiment associated with media hits, both negative and positive, to determine "contextual correctness" within the subject matter context. Sentiment, or general positivity/negativity for each of the searches, in addition to the total numbers of posts, mentions, impressions, and the passion of the language employed were all analyzed to provide insight into the tone of conversations around this topic of study.

RESULTS

Total timeline mentions for eggs over the time period exceeded 16 million, whereas the total number of posts exceeded 14 million. In addition to mentions, the actual number of posts can be informative in discerning unique posts vs. mentions. For example, if there was a forum discussing the best egg farm or brand, the entire forum would be considered a post. However, the sentences referencing specific examples about eggs from individuals within the forum would appear as mentions. Figure 1 depicts the total number of posts over time for both the general egg search and the 4 subsearches quantifying posts by each housing type studied. In total, posts about eggs followed a predictable pattern in which measurable and noticeable spikes in posts occur for the Easter holiday. Easter took place on Sunday, March 27th in 2016, which explained the pre-April spike in total posts related to eggs. Easter 2017 took place on Sunday, April 16th, resulting in the more typical (expected) April spike in discussions/posts about eggs. The egg posts can be summarized as relatively steady, decreasing slightly over the total time period, with easily discerned spikes in posts for the Easter holiday weekend. While the first and second quarter of 2016 saw ramping up in total posts in the cage-free and free-range subsearches, cage-free peaked in April 2016 and free-range peaked in June 2016, with neither returning to those peak levels of total posts over the time period studied. Certainly, judging by total scale of chatter, the focus over this time period was on free-range eggs, followed by cage-free eggs, with nearly no mention of the industry preferred selection of enriched colony housing.

Table 1 displays the gender, inferred age, and timing of posts for the general egg search, along with the 4 housing type subsearches. In totality, across the time period studied, the largest total posts and mentions were for

Table 4. Top positive terms used.

Top words used for:	N	Eggs		n	Free-range		n	Enriched colony		n	Battery cage		n	Cage-free	
Attributes	976,131	breakfast	35%	7,133	free range	50%	263	enriched cage	11%	632	cage-free egg	7%	11,728	cage-free egg	31%
		viable egg	10%		taste	4%		house	6%		cage-free	3%		cage-free	15%
		dinner	7%		organic	4%		sustainable egg production	6%		Canada's egg-laying hen	3%		make	8%
Emotions	416	Love	17%	5,241	better	17%	26	prefer	19%	226	better	16%	3,388	proud	16%
		great	14%		love	10%		better	12%		opt for	12%		best	15%
		good	12%		good	9%		ideal	8%		happy	6%		cheaper	4%
Behaviors	230	Eat	30%	4,964	buy	25%	29	buy	31%	488	use	22%	8,081	switch	34%
		want	16%		eat	13%		ongoing commitment	28%		buy	4%		use	16%
		Use	8%		use	9%		not lose sight of	3%		switch	4%		buy	10%
Terms	3,904	Eat	12%	60,301	range	27%	1,219	system	8%	5,811	battery cages	8%	43,845	cage-free eggs	25%
		breakfast	11%		free-range chickens	8%		Enriched	5%		uses	2%		switch	7%
		Like	9%		Free range eggs	6%		cage-free eggs	5%		cage-free eggs	2%		using	5%
Hashtags	180	#breakfast	10%	2,471	#organic	7%	94[1]	#bwgcruelty	32%	358	#harpshenhell	3%	43,845	#cagefree	18%
		#food	7%		#freerange	7%		#eggmonth	11%		#animalcruelty	3%		#organic	5%
		#bakelite	6%		#ad	5%		#wimpycruelty	11%		#healthydiet	1%		#breakfast	3%
Things	915	scrambled egg	11%	9,320	free range chicken	28%	274	cage-free egg	21%	683	about 2 billion egg a year	13%	14,822	cage-free egg	42%
		bacon	10%		free range egg	19%		enriched cage	7%		cage-free egg	11%		organic egg	7%
		boiled egg	7%		taste	3%		Coalition for Sustainable Egg Supply	5%		Canada	3%		brown egg	6%

[1]Hashtags listed do not have sentiment.

the free-range subsearch, followed closely by cage-free. Far behind, with less than 10% of the total posts of the top 2 subsearches were battery cages (total 5,294) and enriched colony housing (total posts of 533). Fifty-three percent of posts were from females with respect to the general egg search, but the percentage of female posts ranged from 54 to 57% across the subsearches, with the exception of battery cages which arose from 72% female posters but represent such a small total number of posts that the statistic must be interpreted with great caution. Across all searches, the smallest percentage of posts occurred between midnight and 6 am, whereas the majority of posts occurred between 6 am and 6 pm. In regard to days of the week, the overall egg search yielded nearly even distribution across all 7 d, whereas the most notable deviation was that battery cages and cage-free subsearches each had less than 10% of their posts occur on each weekend day (Saturday and Sunday), thus revealing a slight skew toward weekday conversation on these topics.

Table 2 summarizes top domains and sources. The top source for information for the general search and all subsearches, except free-range, was news, which accounted for 44 to 69% of the sources in each search conducted. The top sources of information for free-range were Twitter (31%), followed by forums (30%) and news with 24%. In terms of top domains, all searches except for enriched colony had Twitter as their top domain, ranging from 55% for free-range to 80% for cage-free. Enriched colony revealed reddit.com being the top domain at 32%, wattagnet.com being second with 26%, and Twitter third (11%).

The top terms that appeared for stated interests for the general egg search were largely generic (family, food and drink, music) and noninformative (Table 3). But, as hypothesized, variation across subsearches in top terms and self-biographical descriptors were found. The subsearches yielded top interests for free-range and cage-free of food and drink (first) and family (second). Notably different were the top interests in the battery cage subsearch of pets (first, 34%) and food and drink (second, 23%). Politics appeared no lower than fourth for any of the subcategories and fifth for eggs overall. Moving from stated interests to self-biographical terms yielded less consistency across subsearches with love and food ranking top 2 for free-range, own, and @TheHumaneLeague for enriched colony, VEGAN and love for battery cage, and love and vegan for cage free. Vegan appeared as a top self-biographical term for all subcategories with the exception of free-range.

Going a bit further than simply quantifying posts or analyzing posters, topics that are most commonly being discussed or talked about can be discerned by evaluating words used in the posts. Table 4 depicts positively labeled words, whereas Table 5 outlines negative words for each search conducted. The general egg search found the most common positive word identified as "breakfast" (35%) (attribute), whereas "eat" (30%) was the top behavior. As hypothesized above, the overall chatter

Table 5. Top negative terms used.

Top words used for:	Eggs	n	Free-range	n	Enriched colony	n	Battery cage	n	Cage-free	n
Attributes	crack 13%	976,131	no free range 2%	7,133	expensive from cage system 22%	263	no cage-free hen 15%	632	cage free 2%	11,728
	egg allergy 10%		expensive 1%		live size 3%		cram 14%		trample each other 1%	
	Die 6%		cram 1%		make 2%		kill 3%		expensive from cage system 1%	
Emotions	not like 17%	416	nutritionally inferior 4%	5,241	a bit worse 12%	26	better 14%	226	nutritionally inferior 9%	3,388
	Hate 12%		not best 3%		shitty condition 8%		filthy condition 10%		sue 3%	
	Bad 8%		poor 1%		lesser evil 4%		pretty unpleasant 5%		height 2%	
Behaviors	not eat 34%	230	not eat 6%	4,964	stop 7%	29	use 25%	488	not buy 2%	8,081
	not get 14%		not buy 5%		not choose 3%		stop 19%		use 2%	
	not want 10%		ban 3%		not consume 3%		end 4%		eat 2%	
Terms	likes 12%	3,904	range 8%	60,301	cage systems 5%	1,219	cages 12%	5,811	cage-free eggs 4%	43,845
	Eat 12%		free range 8%		Cage-free eggs 5%		battery 10%		caged hens 2%	
	out 6%		free range chickens 2%		American egg producers 5%		battery cages 10%		stop 1%	
Hashtags	#vegan 8%	180	#fda 4%	2,471		94[1]	#easter 11%	358	#sup 8%	43,845
	#drseuss 8%		#vegan 3%				#compassion 9%		#walmartdoublestandards 6%	
	#govegan 7%		#cancer 3%				#vegan 9%		#henhell 4%	
Things	green egg 10%	915	free range chicken 7%	9,320	cage-free egg 22%	683	Selling Egg 22%	274	cage-free egg 4%	14,822
	scrambled egg 8%		free range egg 5%		unlikely caged egg 1%		5–11 hen 1%		caged hen 7%	
	egg nog 7%		caged hen 3%		egg industry 1%		Purchasing Eggs From Battery-Cage Farms 1%		no egg 1%	

online surrounding eggs was dominated by consumer usage of eggs for consumption as food as top terms mentioned. Other terms such as scrambled eggs and boiled eggs, along with bacon were also identified as top words used in posts. On the negative side were expected words such as crack, egg allergy, and not like. Other negatively connoted posts yielded #vegan, #govegan, and egg nog as negative words. The free-range subsearch had top positives associated with free-range, better, and #organic. Interestingly, free-range chicken (28%) was the top positive word (thing) mentioned as well as being the top negative thing mentioned, whereas free range egg was the second most common positive (19%) as well as second most common negative thing (5%).

The simultaneous topping of both the negative and positive words list highlights the divergent nature of public opinion on hen housing types, which then continues in the enriched colony subsearch which yields cage-free egg as both the top positive (21%) and negative (22%) *thing* mentioned. The term, enriched cages, was the second most common positive word mentioned for the enriched colony searches, with Coalition for a Sustainable Egg Supply being third. Interestingly, while not in a large proportion of posts, 1% of posts did have the negative of "trample each other" in the cage-free subsearch, suggesting at least some conversation surrounding the negatives or even generally positively rated, by the general public, systems. Interestingly, the second and third *things* mentioned in positive connotation for cage-free were organic egg (7%) and brown egg (6%). The subsearch for battery cage housing is the most difficult to interpret because of the unlikely use of the terminology by the general public. Nonetheless, top terms yielded thoughts about filthy conditions, cram, #compassion, and chatter related to cage-free although accumulating in the battery cage search because of dual-mentioning of terms.

The net sentiment on a monthly basis is graphed in Figure 2 for the general egg search, as well as the 4 housing-focused subsearches. The null hypothesis was that net sentiment for cage-free and free-range would be higher than the other housing types' subsearches. While the total number of posts was indeed higher for these 2 housing types, the net sentiment was not higher for cage-free or free-range so much as lower for battery cages. Net sentiment for battery cages is distinctly lower with a higher variance than any of the other searches completed. In 2016, the minimum sentiment was 43 for the general egg search, 39 for free-range, 8 for enriched cages, -58 for battery cages, and 39 for cage-free. A similar pattern was found in 2017 with battery cages having a minimum of -39 and all other search minimums ranging from 8 to 34. The mean sentiment for battery cage was -10 in 2016 and -8 in 2017, whereas all other sentiment means were positive, ranging from the low of enriched colony housing (31 in 2017, 34 in 2016) to the high of cage-free (56 in both 2016 and 2017).
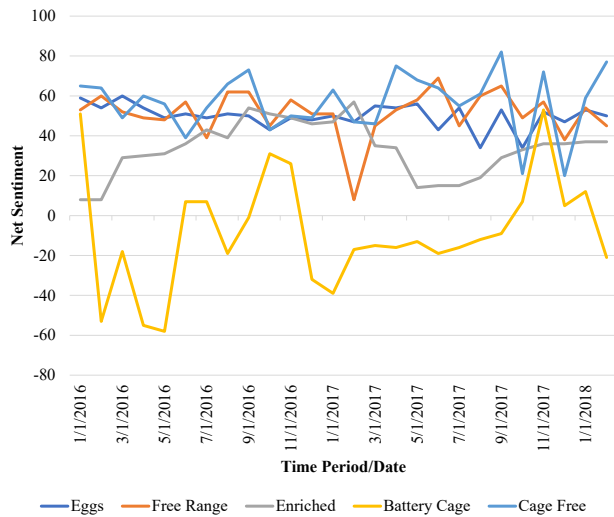
Figure 2. Monthly net sentiment across time period studied.

DISCUSSION

Streamlining discovery of public sentiments and demand for hen housing and rearing practices would be constructive. Survey data and in-person experiments are often used to measure consumer support of housing types (Chang et al., 2010; Norwood and Lusk, 2011; Ochs et al., 2019a,b), and additional information can be garnered through the evaluation of housing types from the standpoint of producer profitability (Bir et al., 2018) and legislation (Lusk, 2010). However, such studies rely on costly and time-consuming data collection, after significant investment in research to ensure the most relevant and informative questions are being addressed. In addition, web-derived data offer the potential for continuous or near-continuous data collection, rather than in discrete blocks.

Assuming total posts are a proxy for the public interest, the general interest in eggs trended downward in terms of monthly web chatter over the time period studied. The timing of posts or communications is an interesting aspect of social media and online communication. As posited by Daniel H. Pink in his book *When: The scientific secrets of perfect timing*, Twitter is a reasonable approach to measuring the world's emotional state on a continuous basis using global scale (social media) data. Fundamentally, the data support that individuals begin the day in a good mood that often deteriorates as the day goes on (Golder and Macy, 2011). Perhaps predictably, people are happier on the weekends, and given the peak in morning happiness is delayed by 2 h on weekend days, they also begin their day later than on weekdays (Golder and Macy, 2011). Given the attention of eggs with reference to breakfast foods, it was hypothesized that the general search would have yielded increased attention in the (local time zone) morning hours, but posting in the general egg search was nearly evenly distributed in the 6 am to noon, noon to 6 pm, and 6 pm to midnight time periods.

While differences in the sample size cloud the potential for broad interpretability, it is apparent that gender was slightly skewed toward more female posters across all searches. The inferred or imposed ages of posters were found to be rather consistent across searches, perhaps with a slight skew away from younger posters for the battery cage subsearch. Enriched colony behaved very differently from the others with reddit.com being the top domain at 32%, wattagnet.com being second with 26%, and Twitter third with only 11%. Wattagnet.com is "news and analysis on the global poultry and animal feed industries", pointing to the idea that enriched colony posts are fundamentally different in terms of where they appear. Notably, egg-cite.com was the fourth top domain, and the poultrysite.com was the fifth top domain, further documenting the production-oriented spin on postings about enriched colonies as opposed to the more consumer or noncommercial agriculture focused domains that even free-range experienced, with twitter.com at 55%, backyardchickens.com at 25%, reddit.com at 9%, instagram.com at 4%, and theguardian.com at 2%.

The top terms that appeared for stated interests for the general egg search were largely generic (family, food and drink, music) and noninformative. The top interests for free-range and cage-free subsearches were food and drink (first) and family (second). Markedly different were the top interests in the battery cage subsearch of pets (first, 34%) and food and drink (second, 23%). A potential explanation is an affinity for one's pets, or simply possessing pets, serving as a linkage or conduit for caring for—or having an interest in—animals more generally (McKendree et al., 2014). It may not be surprising that politics would be of interest to those posting and discussing laying hen cage types given the prominent legislation surrounding livestock animal housing. Incorporating self-biographical terms reveals vegan as a top descriptor across multiple searches. While vegans do not eat milk, meat, or eggs, they often participate in Internet discussions explaining why they believe changing animal housing and improving animal welfare is not enough to make the consumption of eggs ethical (The Vegan Society, 2019; Vegan.com, 2019). These biographical and interest insights are helpful in determining the context of the conversation and possibly the motivation by those driving the conversation.

Positive and negative words varied significantly across searches and subsearches, but notably, the association of cage-free with organic and brown eggs offers an opportunity for improved communication by producers in terms of labeling. It is interesting that both the term organic and brown egg appear as top words (things) mentioned in the cage-free search. Chang et al. (2010) posited that the premium associated with cage-free over conventional and organic over nonorganic could be attributed to the color of the egg, with consumer preference being for brown eggs (Fearne and Lavelle, 1996; Lusk and Norwood, 2010). Existing literature supports the notion that confounding investigation into demand for hen housing systems and/or egg production systems are egg attributes outside of housing, such as color or size. Chang et al. (2010) determined that 42% of the typically observed premium for cage-free eggs over conventional (as well as 36% of the organic egg premium) could be

attributed to the color of the eggs rather than the housing or production system. Chang et al. (2010) found that consumers were willing to pay a $0.73 premium per dozen for brown eggs, which supported the notion of general preference of brown eggs to white ones (Fearne and Lavelle, 1996). Housing systems remain the main focus of egg-laying hen discussions, likely impacting perceptions of other egg attributes because of the common association of brown eggs, for example, with organic-fed or cage-free eggs in marketing materials (Heng et al., 2013). As Chang et al. (2010) suggest, retailer/scanner data analysis may result in a higher premium for brown egg color than those estimated from survey responses because they do not control for the organic-fed or cage-free attributes. Heng et al. (2013) did not estimate a positive mean WTP for brown eggs in their survey-based choice experiment, and only 29% of their sample was willing to pay any premium at all.

Both cage-free and free-range had the greatest volume of posts when compared with the other housing types. Although enriched cages meet many of the preferences of consumers (Ochs et al., 2018; Ochs et al., 2019a), discussion surrounding enriched colonies was rare. Cage-free has been previously found to have the highest preference among respondents with a mean premium of $0.49 per dozen eggs (Heng et al., 2013), perhaps explaining some of the relative popularity of cage-free relative to other housing systems. The was a distinct deviation of the net sentiment of the battery cage subsearch vs. all others. Battery cages, which were historically the industry baseline/standard, had the lowest net-sentiment. Most respondents in Heng et al. (2013) perceived that conventional layer management practices worsened hen welfare, and over 85% of respondents were willing to pay a premium to improve their welfare attributes, including outdoor access, cage-free housing, and noninduced molting.

The distinct rise and fall of enriched colony housing, in terms of sentiment, is revealing. Even though the total scale of the chatter, relative to the other searches, was quite small, the overall sentiment did experience a series of 6 mo straight where values were in the 40s and 50s, from September 2016 until February of 2017. While Easter drove sizeable jumps in total posts and mentions of eggs in the general search, the impact of the holiday on sentiment is not clear. The net sentiment of the general egg search peaked at 60 in 2016, coinciding with Easter. But, none of the subsearches experienced their highest sentiment of the year (2016) in March. In 2017, none of the searches experienced their minimum or maximum sentiment coinciding with the Easter holiday in April, suggesting sentiment about eggs is not being driven by the holiday, even if total posts in the general search were more abundant.

CONCLUSIONS

While individual brands or companies have been employing social media listening as part of their marketing and public relations across numerous industries, the uptake in such practices has been slow in commodity agricultural products from which the return to the significant investment required is more difficult to capture. The importance of the laying hen housing debate is illustrated by the fact that people are communicating about specific housing options unprompted on social media. Many nuances were found when considering chatter surrounding the individual housing types. For example, the term vegan was likely to be listed in the Twitter profiles of those talking about all housing types with the exception of free-range.

The potential for commodity-level social media sentiment analysis to contribute to the understanding of consumer food choices are numerous. This research illustrates the potential for near-immediate implementation of the insights gleaned by retailers, marketers, and public relations professionals. Observational and descriptive data about questions of economic importance, especially to commodity industries in agriculture, can aid in efficiently honing studies to aid researchers in developing actionable, timely, and industry-relevant insights. For researchers and those attempting to cultivate deeper understanding about human behavior, social media sentiment is an efficient and cost-effective starting point to aid in framing survey instruments or priming focus group discussions.

ACKNOWLEDGMENTS

SUPPLEMENTARY DATA

Supplementary data associated with this article can be found in the online version at https://doi.org/10.1016/j.psj.2020.07.011.

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