How are genetically modified foods discussed on TikTok? An analysis of #GMOFOODS

Sawyer I. Basch[1], Deborah Gomez[1]
[1] Avenues: The World School New York, New York, New York

SUMMARY

Social media is an eminent form of expression of views on all topics, including dietary choices. We set out to look at what aspects of genetically modified foods (GMFs) drive the most engagement on the #GMOFOODS TikTok hashtag. Our main hypotheses were that content focused on the negative aspects of genetically modified organisms (GMOs) would receive more interaction and would be highly driven by consumers rather than professionals. We used videos that were viewed a total of 2,933,577 times collectively by TikTok users. Consumers had uploaded nearly all videos in our sample (n = 91). The most common content category was disadvantages for nutrition and health, noted in 71% of videos, followed by featuring an example of a specific GMO food or crop (68%). All categories that mentioned benefits of GMOs were low (4-6%). Mean number of views were significantly lower for videos that contained information on unintended biological effects (ecology, species of animals, insects or plants, gene transfer) ($p = 0.05$). Mean number of comments were significantly lower for videos that contained uncertainty of long-term effects on the human population ($p = 0.01$). Mean number of shares were significantly lower for videos that contained information on unintended biological effects ($p = 0.03$), antibiotic resistance, toxicity, allergenicity ($p = 0.05$), and environmental sustainability ($p = 0.03$). Further research is needed to determine TikTok influences on consumer food choices.

INTRODUCTION

Genetically modified organisms (GMOs) are plants, animals, or microbes that have had their genome altered in one or more ways through genetic engineering in an effort to modify their attributes (1). Mechanisms for genetically modifying organisms can take on a variety of processes which include deletion, introduction, or augmentation of genes (1). GMOs can be used for a number of different applications, ranging from drug production to modifying foods with a specific purpose in mind (e.g., increased growth rate, pest resistance, nutrition, etc.) (1). The World Health Organization (WHO) indicates that genetically modified foods (GMFs) that are available today are largely derived from plants (2). However, in the coming years, there will likely be an uptick in foods produced from genetically modified (GM) organisms (2).

Like many instances where scientific innovation is involved, there are benefits and risks to GM food production. One of the main benefits of GM food production includes aiding farmers to prevent crop loss (1). Commonly known mechanisms to prevent this loss are described by the United States Food and Drug Administration (FDA) as resistance to insect damage and plant viruses, as well as tolerance to herbicides (3). Researchers suggest that such measures to prevent crop loss may have specific benefits to farm workers by decreasing exposure to pesticides and protecting farmers from the financial and mental fallout of poor crop yields (4). In addition to disease resistance and herbicide tolerance, GMFs can be created to grow more quickly and require fewer water and soil resources (1). Scientists can also modify the genetic composition of foods so crops produce a product that is higher in nutritional value. All of these factors could potentially influence improved global availability of food at lower costs (5–6).

Conversely, there are questions about several aspects of GM food production that drive conversations around its widespread availability. First, there are unknown consequences of gene alteration in foods including gene transfer (7–11). Gene transfer refers to instances where a gene from a different organism is introduced to the genome of a GMO (12). Specific concerns with GMFs include allergens (allergic reactions to GMFs) and antibiotic resistance (7). In addition, there are possible unintended consequences on other species, potential threats to biodiversity, and potential for economic issues related to respect for consumer choice and other factors (7,13).

Given these benefits and risks, consumers are faced with difficult decisions when it comes to GMFs in their food supply. Consumers tend to express views toward GMFs despite limited knowledge or scientific insight on the benefits and risks (14-16). For those with limited understanding of GMFs, these views tend to skew towards less acceptance (15). These perceptions, like most that require a risk-benefit analysis, are often socially constructed (17). Research suggests that trust in the informational source is important in perceptions of GMFs (17). Sources that prove to be honest, responsible, trustworthy, and balanced are more likely to be well-received (17–18).

Almost 30% of Americans surveyed have heard a lot about GMO foods and over half have heard a little (19). Social media is an eminent form of expression of views on all topics, including dietary choices such as consumption of GMFs. TikTok is an incredibly popular social media outlet with one billion people using the app each month (20). There is no research to date that describes the content of videos regarding GMFs on TikTok, thus we sought to answer what aspects of GMFs drive the most engagement on the #GMOFOODS TikTok hashtag? We hypothesized that content focused on the

negative aspects of GMOs would receive more interaction, and content would be highly driven by consumers rather than professionals. We predicted these relationships due to the fact that social media tends to highlight negative or dramatic news and the overwhelming majority of social media research suggests that content would be highly driven by consumers (members of the general public) rather than professionals (credentialed experts) (21). Based on this data, we expected that GMF-related content would follow this pattern.

RESULTS
Sample Metadata
We sampled 100 videos with the hashtag #GMOFOODS. We categorized the videos by content and measured engagement using the number of views, likes, comments, and shares **(Table 1)**. The videos in this sample were viewed a total of 2,933,577 times. Nearly all videos were uploaded by TikTok consumers (n = 91, data not shown).

Sample Content Analysis
The most common content category was 'disadvantages for nutrition and health', noted in 71% of videos, followed by 'featuring an example of a specific GMF or crop' (68%) **(Table 1)**. The frequencies of videos falling under all categories that mentioned benefits of GMOs were quite low (4-6%). The content category with the most associated views was 'unintended economic consequences' with 1,312,806 views, followed by 'disadvantages for nutrition and health' with 1,039,919 views. The content category with the most associated likes was also 'unintended economic consequences' with 167,591 likes, followed by 'explaining the meaning of GMOs' with 73,246 likes. The content category with the most associated comments was 'features an example of a specific GMO food or crop' with 4,019 comments, followed by 'disadvantages for nutrition and health' with 2,609 likes. The content category with the most associated shares was 'features an example of a specific GMO food or crop' with 8,155 shares, followed by 'explanations of the meaning of GMOs' with 5,759 shares.

We found no significant differences when we compared the average number of likes for each content category to the average number of likes for all other categories (two-tailed t-tests were conducted at a significance level of $p < 0.05$). When compared to mean number of likes in all other categories, the mean number of views was significantly lower for videos that contained information on unintended biological effects (on ecology, species of animals, insects or plants, gene transfer) (two-tailed t-test, $p = 0.05$) and unintended biological effects (on ecology, species of animals, insects or plants, gene transfer) ($p = 0.01$). The mean number of comments was significantly lower for videos that contained information about uncertainty of long-term effects on the human population ($p = 0.01$). Mean number of shares was significantly lower for videos that contained information on unintended biological effects ($p = 0.03$), antibiotic resistance, toxicity, allergenicity ($p = 0.05$), and environmental sustainability ($p = 0.03$).

DISCUSSION
To our knowledge, this is the first study that examines the content and viewing patterns of videos related to GMFs on TikTok. This study aimed to determine which aspects of GMFs drive the most engagement on the #GMOFOODS

TikTok hashtag. We hypothesized that there would be more interaction with videos that had content highlighting the negative aspects of GMFs and that content would be largely posted by consumers rather than professionals. As predicted, there was a higher frequency of videos posted by consumers as compared to any other source. This is not surprising due to the fact that the mission of TikTok is "to inspire creativity and bring joy" (22). This platform is driven by entertainment despite what content people post. Studies suggest that people engage in politicized and regulatory issues around GMFs despite a potential lack of knowledge (23–25). The question remains whether or not scientists should have a greater presence on this platform to be sure that all sides of the story are represented.

The most popular content in these videos was focused on a specific food. It should be noted that consumers often raise suspicion that a food was GM even if that crop is not indicated as a GM crop (26). This is supported by research from Blancke and colleagues who researched the appeal of negative images of GMOs (26). Conclusions from this research suggest that even if this is being done subconsciously, consumers are relying on intuitions that are formed, and in the case of GMOs, oppositional messages are easier to hold onto. These messages are often rooted in disgust (26).

Another study confirmed that disgust sensitivity influences the perception of risk from GMFs (27). TikTok videos may be mislabeling foods as GMFs if there is an abnormality with the food rather than verifying that the food is actually GM. These negative images and preformed ideas are part of the reason why the European Commission states that "GM food is still the Achilles' heel of biotechnology" (28).

Research indicates that TikTok users use the platform to gain understanding about healthy eating and healthy foods (29). The most common content category in the sample of videos included in this study was 'disadvantages for nutrition and health'. This aligns with findings from a large consumer study, which investigated 16 major consumer markets and found that 87% of consumers worldwide feel that non-GMO foods are 'somewhat', or 'a lot' healthier (30). Concerns about content validity and reliability on TikTok have been raised, and further research should focus on the polarization of views on social media related to GMFs (31). Recent research points to the fact that polarization of information on social media is happening at a rapid pace (32).

Interactions with videos containing information on disadvantages of nutrition and health were notable across all categories (views, likes, comments, and shares). Research shows that nutrition-related TikTok videos can contribute to disordered eating (33). Social media platforms like TikTok are designed with engagement features to keep consumers scrolling for as long as possible, but concern has been raised by researchers that content on TikTok is often presented without context (34-35). It seems as if views are the most important indicator that a video is "worthwhile" on TikTok, while the number of likes can be thought of as a proxy of social acceptability. However, the two are intertwined. The more a user likes videos of a certain nature, the more likely similar videos will appear in the 'for you' feed of a user according to the TikTok algorithm. If a content creator has several videos regarding GMFs, they will likely continue to be seen and liked by the user. This social currency can ultimately propel a content creator on the platform. This occurs by

Content Category	N	%	Views	%	Likes	%	Comments	%	Shares	%
Cumulative numbers of views, likes, comments, and shares		100	2,933,577	100	284,216	100	7,514	100	15,586	100
Explains the meaning of GMOs	17	17%	512,178	17.5%	73,246	25.8%	1,977	26.3%	5,759	36.9%
Features an example of a specific GMO food or crop	68	68%	1,194,882	40.7%	62,347	21.9%	4,019	53.5%	8,155	52.3%
Does it provide information as to how consumers can identify GMO's?	9	9%	293,340	10.0%	24,786	8.7%	1,325	17.6%	3,672	23.6%
Regulations and laws	10	10%	349,486	11.9%	47,033	16.5%	1,610	21.4%	2,618	16.8%
Unintended biological effects (on ecology, species of animals, insects or plants, gene transfer)	7	7%	16,978	0.6%	1,055	0.4%	70	0.9%	88	0.6%
Antibiotic resistance, toxicity, allergenicity	5	5%	21,135	0.7%	12,142	4.3%	81	1.1%	116	0.7%
Unintended economic effects (e.g., creating economic dependencies on multinational corporations	7	7%	1,312,806	44.8%	167,591	59.0%	1,562	20.8%	4,624	29.7%
Uncertainty about long-term effects on human populations	13	13%	18,9052	6.4%	3,456	1.2%	187	2.5%	614	3.9%
Benefits regarding increasing crop yields, reducing hunger, improving crop resilience to changing environmental conditions (e.g., drought, climate change)	6	6%	65,810	2.2%	8,428	3.0%	723	9.6%	536	3.4%
Benefits regarding environmental sustainability	4	4%	11,018	0.4%	1,227	0.4%	132	1.8%	41	0.3%
Benefits regarding nutritional value of foods	6	6%	58,335	2.0%	6,714	2.4%	733	9.8%	489	3.1%
Disadvantages for nutrition and health	71	71%	1,039,919	35.4%	38,988	13.7%	2,609	34.7%	5,212	34.4%

Table 1: Views, likes, comments, and shares of the 100 TikTok videos mentioning information about GMOs. These categories are not mutually exclusive.

increasing popularity and followers and ultimately could lead to monetization (36). Shares are also recorded as part of TikTok's algorithm and will impact the 'for you' feed that a user will see because a share is a point of interaction indicating the user engaged positively with the video. This is a data point for TikTok to then add this video to the 'for you' feed of others with similar interests (37). Therefore, the downstream impacts are that this inundation of information with similar content could potentially change one's belief or strongly reaffirm preconceived beliefs when exposed to information in such a repetitive way (38–40). This concept is known as the illusory truth effect, whereby there is a tendency to perceive repeated information as more trustworthy than new information (38). It takes place as a result of enhanced processing efficiency

caused by repetition. Therefore, regardless of the accuracy or the completeness of the information being viewed, the powerful algorithms of TikTok could influence the viewpoint of a consumer. Given what we know about how information spreads on social media and impacts public opinion, findings from this study suggest that GMF-related information on TikTok is one-sided. This may result in a dilemma since social media strongly influences public opinion

Due to the similar nature of postings, it would benefit TikTok users to have a more robust selection of videos made by both professionals and consumers. This will enable them to learn about the positive and negative aspects of GMFs in a well-rounded way. At the present time, many videos are composed of personal stories and experiences. Having additional videos that provide factual information or open a dialogue about the pros, cons, and ethical implications of GMFs would be extremely valuable.

The limitations of the study include the fact that we assigned only one researcher to collect data, and they collected it at only one point in time. The same holds true for coding the data, whereby having only a single researcher limits the reliability of the results. Having additional researchers complete the coding could help reduce the subjectivity of the process. This study also only focused on one hashtag with the most cumulative views, even though there are other hashtags that could be of interest. Including only English language videos was also limiting. The sample size in this study was small and there are videos being uploaded to TikTok constantly. Further, random selection of videos may yield different results in terms of the content that is being disseminated.

Remaining questions on this topic are abundant. Future research should focus on what attracts consumers to GMF-related videos and compels them to engage with the content. Because the popularity of TikTok lies within a younger age bracket (most users are between the ages of 16-24), it is important to begin to understand how exposure to these videos may or may not influence food choices now or later in life (40). It is also of interest to think about how scientists might present information differently than consumers regarding GMFs in general, and their benefits and risks more specifically should they be compelled to use TikTok for educational purposes. It would also be helpful to look at this information over time to determine if the content of GMF TikTok videos changes. An additional suggestion for future research would be to examine whether or not videos that fall into multiple content categories have more engagement than videos that only fall into one content category.

MATERIALS AND METHODS
Hashtag Determination
Hashtags were searched to determine which one related to GMFs and had the most cumulative views on 10/31/22. This was determined to be #GMOFOODS with 4.4 million views. Using this hashtag, a sample of 100 videos was taken. The first applicable 100 English-language videos were garnered for this sample.

Data Collection
All videos were watched repeatedly until it could be concluded whether content was present or not present. This was completed using the coding sheet that was created while watching each video. The number of views, likes, comments, and shares were present along the periphery of the video and were recorded on the coding sheet.

Outcome Variables
The main outcome variable for this cross-sectional study was number of views. The secondary outcome variables were the number of likes, comments, and shares. There were two main categories of predictor variables. One was descriptive information about the source of the video source (professional agency, news, consumer, or other). The second, and more important predictor variable, is the content conveyed. The content variables are based on a prior study and included whether each video does (coded as 1) or does not (coded as 0) cover each of the content categories **(Table 1)** (41).

Descriptive Statistics
Descriptive statistics and t-tests were conducted in Excel. The t-tests were conducted to assess differences between the number of likes for videos that included a content category versus those that did not. Similarly, t-tests were conducted for assessing significance of difference between mean number of likes for videos covering a specific content category in comparison to mean number of likes for videos that did not cover that category.

REFERENCES
1. "Genetically Modified Organisms." *National Human Genome Research Institute.* www.genome.gov/genetics-glossary/Genetically-Modified-Organism. Accessed 3 January 2023.
2. "Food, Genetically Modified." *World Health Organization.* www.who.int/health-topics/food-genetically-modified#tab=tab_1. Accessed 2 January 2023.
3. Center for Food Safety and Applied Nutrition. "How GMO Crops Impact Our World." *U.S. Food and Drug Administration,* FDA, https://www.fda.gov/food/agricultural-biotechnology/how-gmo-crops-impact-our-world.
4. Smyth, Stuart J. "The Human Health Benefits from GM Cops." *Plant Biotechnology Journal* vol. 18, no. 4. 2020, https://https://doi.org/10.1111/pbi.13261.
5. R, Sendhil *et al.* "Genetically Modified Foods: Bibliometric Analysis on Consumer Perception and Preference." *GM Crops & Food,* vol. 13, no. 1, 2022, https://doi.org/10.1080/21645698.2022.2038525.
6. Hefferon, Kathleen L. "Nutritionally Enhanced Food Crops; Progress and Perspectives." *International Journal of Molecular Sciences,* vol. 16, no. 2, Feb. 2015, https://https://doi.org/10.3390/ijms16023895.
7. Phillips, T. "Genetically modified organisms (GMOs): Transgenic crops and recombinant DNA technology." *Nature Education,* vol.1,1 (2008):213
8. Philips, JG *et al.* "Horizontal gene transfer from

genetically modified plants - Regulatory considerations." *Frontiers in Bioengineering and Biotechnology,* vol. 10 971402. 31 Aug. 2022, https://https://doi.org/10.3389/fbioe.2022.971402.

9. Keese, P. "Risks from GMOs due to horizontal gene transfer." *Environmental Biosafety Research,* vol. 7, no. 3 (2008): 123-49. https://https://doi.org/10.1051/ebr:2008014.

10. Muir, W M, and R D Howard. "Possible ecological risks of transgenic organism release when transgenes affect mating success: sexual selection and the Trojan gene hypothesis." *Proceedings of the National Academy of Sciences of the United States of America,* vol. 96,24 (1999): 13853-6. https://doi.org/10.1073/pnas.96.24.13853.

11. Phipps, RH., Beever, DE., Einspanier, R. "Risks of Gene Transfer from GMOs to Livestock, and Consequences for Health and Nutrition." In: Makkar, H.P., Viljoen, G.J. (eds) Applications of Gene-Based Technologies for Improving Animal Production and Health in Developing Countries. (2005) Springer, Dordrecht. https://doi.org/10.1007/1-4020-3312-5_34.

12. National Research Council (US) Board on Agriculture. Genetic Engineering of Plants: Agricultural Research Opportunities and Policy Concerns. Washington (DC): National Academies Press (US); 1984.

13. Maghari, BM, Ardekani AM. "Genetically modified foods and social concerns." *Avicenna Journal of Medical Biotechnology,* vol. 3, no.3 (2011): 109-17.

14. Kromka, NJ. "GMOs, genetically modified organisms or genuinely mixed opinions? A reasonable Consumer's understanding of the terms "GMO" and "non-GMO," and the struggle to set a Standard." *Seton Hall Law Review,* vol. 48, no.1 (2017): 221-48.

15. Wunderlich S. and Gatto KA. "Consumer perception of genetically modified organisms and sources of information." *Advances in Nutrition,* vol. 6, no.6 842-51. 13 Nov. 2015, https://doi.org/10.3945/an.115.008870.

16. Scott, SE *et al.* "An Overview of Attitudes Toward Genetically Engineered Food." *Annual Review of Nutrition,* vol. 38 (2018): 459-479. https://doi.org/10.1146/annurev-nutr-071715-051223.

17. Frewer, Lynn J *et al.* "Communicating about the risks and benefits of genetically modified foods: the mediating role of trust." *Risk Analysis,* vol. 23, no.6 (2003): 1117-33. https://doi.org/10.1111/j.0272-4332.2003.00385.x.

18. Costa-Font, J, Mossialos E. Are perceptions of 'risks' and 'benefits' of genetically modified food (in)dependent?, *Food Quality and Preference,* vol. 18, no. 6, (2007), 173-182.

19. "Public opinion about genetically modified foods and trust in scientists connected with these foods." *Pew Research Center* Accessed 29 January 2023. www.pewresearch.org/science/2016/12/01/public-opinion-about-genetically-modified-foods-and-trust-in-scientists-connected-with-these-foods/

20. Bursztynsky, Jessica. "TikTok Says 1 Billion People Use the App Each Month." CNBC, 27 Sept. 2021, www.cnbc.com/2021/09/27/tiktok-reaches-1-billion-monthly-users.html.

21. American Psychological Association. (n.d.). *Media overload is hurting our mental health. here are ways to manage headline stress.* Monitor on Psychology. www.apa.org/monitor/2022/11/strain-media-overload#:~:text=To%20drive%20%E2%80%9Cclickbait%2C%E2%80%9D%20news,this%20specialized%20type%20of%20stress.

22. "Our Mission." *TikTok.* www.tiktok.com/about?lang=en Accessed 31 January 2023.

23. Lucht, JM. "Public Acceptance of Plant Biotechnology and GM Crops." *Viruses,* vol. 7, no.8 4254-81. 30 Jul. 2015, https://doi.org/10.3390/v7082819.

24. Lusk JL. et al. "Effect of information about benefits of biotechnology on consumer acceptance of genetically modified food: Evidence from experimental auctions in the United States, England, and France." *Eur. Rev. Agric. Econ.* vol. 31 (2004): 179–204.

25. International Food Information Council IFIC Foundation. *Food Biotechnology: A Study of U.S. Consumer Attitudinal Trends, 2006 Report.* International Food Information Council IFIC Foundation; Washington, DC, USA: 2006.

26. Blancke, S. *et al.,* "Fatal attraction: the intuitive appeal of GMO opposition." *Trends in Plant Science,* vol. 20, no. 7, (2015), 414 – 418.

27. Chinn, S, Hasell, A. "Uniquely disgusting? Physiological disgust and attitudes toward GM food and other food and health technologies." *Journal of Science Communication* vol. 20,7, (2021), A05

28. "Europeans and Biotechnology in 2010." European Commission. https://repository.essex.ac.uk/2291/1/ebs_341_winds_en.pdf Accessed 1 February 2023.

29. Wang, C-H, *et al.* "TikTok Made Me Do It: Teenagers' Perception and Use of Food Content on TikTok." Interaction Design and Children (2022), 458-463.

30. "87% of consumers globally think non-GMO is 'healthier'. But where's the evidence?" *Food Navigator.* www.foodnavigator-usa.com/Article/2015/08/13/87-of-consumers-globally-think-non-GMO-is-healthier. Accessed 28 January 2023.

31. "Wasn't TikTok Supposed to Be Fun?" *New York Times.* www.nytimes.com/2022/08/17/technology/tiktok-elections-politics.html Accessed 28 January 2023.

32. "How the polarizing effect of social media is speeding up" *National Public Radio.* www.npr.org/2022/09/09/1121295499/facebook-twitter-youtube-instagram-tiktok-social-media. Accessed 31 January 2023.

33. Minadeo, M, Pope L. "Weight-normative messaging predominates on TikTok-A qualitative content analysis." *PloS One,* vol. 17, no. 11 e0267997. 1 Nov. 2022, https://doi.org/10.1371/journal.pone.0267997.

34. "How the TikTok Algorithm Works" Hootsuite. https://blog.hootsuite.com/tiktok-algorithm/

35. Bhandari, A., Bimo, S. "Why's Everyone on TikTok Now? The Algorithmized Self and the Future of Self-Making on Social Media." *Social Media + Society,* vol. 8, no.1 (2022). https://doi.org/10.1177/20563051221086241.

36. "How to Get More Likes on TikTok: 4 Easy Tips." Social Media Marketing & Management Dashboard, 17 Nov. 2021, blog.hootsuite.com/how-to-get-more-likes-on-tiktok/.

37. Matsakis, Louise. "How TikTok's 'for You' Algorithm Actually Works." *Wired,* 18 June 2020, www.wired.com/story/tiktok-finally-explains-for-you-algorithm-works/.

38. Hassan, A., Barber, S.J. "The effects of repetition frequency on the illusory truth effect." *Cogn. Research,* 6, 38 (2021). https://doi.org/10.1186/s41235-021-00301-5.

39. Udry, J *et al.* "The effects of repetition spacing on the illusory truth effect." *Cognition,* vol. 225 (2022): 105157. https://doi.org/10.1016/j.cognition.2022.105157.

40. Calvillo, Dustin P, and Thomas J Smelter. "An initial accuracy focus reduces the effect of prior exposure on perceived accuracy of news headlines." *Cognitive Research: Principles and Implications,* vol. 5,1 55. 5 Nov. 2020, https://doi.org/10.1186/s41235-020-00257-y.

41. "TikTok Statistics-Updated January 2023" *Wallaroomedia*. https://wallaroomedia.com/blog/social-media/tiktok-statistics/ Accessed 28 January 2023.

42. Samuel, L, and Basch SI. "The landscape of online news regarding genetically modified foods: A cross-sectional study." *Nutrition and Health,* 2601060221136917. 4 Nov. 2022, https://doi.org/10.1177/02601060221136917.