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Unlocking the potential of social media on food additives for effective science communication

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Ultra-processed foods dominate modern diets, often containing numerous additives to enhance flavor, texture, and shelf life. Concerns about the potential health risks of daily or excessive consumption have sparked online discussions. This study analyzed perceptions of food additives on Zhihu, a popular Chinese social platform. The findings revealed no significant difference in attitudes between experts and non-experts ($p > 0.05$), with experts relying on statistical data and non-experts drawing from personal experiences. An independent *t*-test indicated no significance in comment engagement ($p > 0.05$) among them. However, a chi-square test showed that experts were significantly more interactive, frequently replying directly to original posts and commenters ($p < 0.05$). This suggests that experts actively facilitate discussions, moving away from reliance on influencers and instead prioritizing high-quality, accessible scientific communication. The findings highlight the crucial role of interactive online platforms in bridging the gap between science and the public.

The emergence of Web 2.0, commonly referred to as the second iteration of the Internet, has revolutionized the communication environment and presents much more innovative and interactive ways for science communicators to engage with the public.

Heretofore, communication was a one-way flow of authoritative information from the professionals to the public; however, communication is now a two-way process and individuals can generate and share information within an online context in real time[1] with innovative components such as video and podcasts, interaction, and accessibility[2]. The current scope of engagement with the public has expanded to include interactive dialogues that involve professionals, institutions, and organizations of different levels, facilitated by widely used online platforms[3].

Social media is now enabling online debates and facilitating the dissemination of scientific knowledge[3]. The expansion of numerous digital platforms has significantly widened the avenues of communication among professionals, while also enabling interactions between professionals and the general public[4]. The positive advocates claim that the Internet facilitates platforms for experts and non-experts to engage in communication[5,6]. However, there are also detractors who caution against the potential formation of echo chambers through new media[7–9], where communities with the same biases associate and interact with each and reinforce their biases. They also highlight that social media is facilitating the rapid and widespread dissemination of rumors and misinformation[10].

Risk communication is a major component of the risk analysis framework used in food safety, the others being risk assessment and risk management. Advances in food technology and innovative approaches to food production present challenges to food safety risk communicators. Many innovations such as GMOs, lab-cultured meats, precision fermented proteins, etc., are examples where the perceptions of the public and those of the food professionals may be very different. The widespread use of additives in processed food is a further example where a divergence of views often exists[11]. Additives contribute to both food safety and quality and are also used to modify the sensory properties of foods, including taste, smell, texture and appearance. Numerous scholarly investigations have been conducted to examine the viewpoints and apprehensions of both professionals and the broader populace with regard to food additives[12]. The scientific community regularly highlights the substantial scientific data that substantiates the safety of food additives[13]. Conversely, members of the general public who lack scientific expertise frequently voice apprehensions over potential health hazards, adverse effects, and the enduring consequences on overall health[14].

This study looks at the perception of the public and professionals in China toward food additives by analyzing the dialogue in social media between the public and the professionals. Why have we chosen China? In

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Fig. 1 | Structure of social media Zhihu platform. This page includes the logo of the Zhihu platform, and the main components: (1) Question and its description, (2) Answer and its description, (3) Content of answer, (4) Number of likes and comments on the answer, (5) Number of followers and viewers of the question, (6) Information about the answer.

2008, there was a major crisis where melamine was illegally added to infant formula resulting in illness in over 60,000 infants. This event left an indelible mark on public trust in the credibility of the food industry, and also the regulatory oversight[14,15]. This crisis significantly eroded the confidence of consumers in the safety of the food supply, the prioritization of public health over profit by the Chinese food industry, and the efficacy of governing authorities in overseeing an increasingly intricate supply chain[16].

The Chinese authorities have engaged in many awareness and education campaigns attempting to rebuild trust and generate confidence in approved additives. Lack of confidence and public concern regarding additives is not only a Chinese issue and it is garnering significant attention in many jurisdictions where the existence of a communication gap between experts and the general public regarding food safety-related issues has been highlighted by several researchers[17–19]. Research has indicated that those with scientific expertise prefer to employ specialized terminology and place reliance on empirical data[20], whereas the general public commonly expresses apprehensions, beliefs based on misinformation, and draw upon personal experiences or anecdotal evidence[21,22]. The worldwide web is awash with rumors, and often when a mistruth is repeated often enough, and by many different sources, it is perceived as true by the public.

Many Chinese question-and-answer (Q&A) websites have arisen as platforms that facilitate the observation and analysis of communication dynamics. Why have we chosen Zhihu? Zhihu (https://www.zhihu.com/), similar to Quora, is a widely used social Q&A platform in China. It organizes discussions hierarchically, starting with a main theme that spawns various interconnected questions. Users contribute numerous answers under each question and then engage in debates and comments within specific comment boxes (Fig. 1). Zhihu is particularly valuable for exploring discussions about food additives on the Chinese Internet due to three key features.

Firstly, Zhihu hosts a wealth of user-generated content on food additives, drawing in a substantial audience and fostering diverse interactions. By July 31st, 2023, discussions on “food additives” had amassed 213,000 conversations, reaching 180 million viewers.

Secondly, the platform’s design enhances digital social engagement, cementing Zhihu’s reputation as a space for open and comprehensive dialogue.

Thirdly, Zhihu’s user base, which includes many from the scientific community, allows for an examination of disparities between specialists and the general public. This platform affords us the opportunity to identify professionals and lay people. Upon completing the official identification verification process, users will have their username displayed alongside their institutional name, position, and a blue mark indicating the verification of this information. Verified users display their expertise through institutional affiliations and positions, although not all opt for verification, potentially due to concerns about anonymity affecting accountability and user engagement. Therefore, it’s more apt to categorize these individuals as “self-identified experts” based on their profile information and contributions.

The discussion surrounding food additives and their impact on human health has garnered significant attention worldwide, yet online discussions on the topic remain underexplored despite heated debates. With the integration of the latest artificial intelligence technologies, a substantial body of literature has explored the role of online interaction in science communication and the public’s opinion toward food safety[23–25]. However, the

specifics of interpersonal interactions—particularly the nature of the information exchanged—remain insufficiently examined.

This study aims to address this gap by examining the content and format of interactions pertaining to the topic of food additives on a popular Chinese Q&A platform. Key questions include: What are individuals' attitudes toward food additives? What types of evidence do they use to support their views? Additionally, this research investigates variations in dialogue characteristics and writing styles between experts and the general public. Prior studies indicate that the general public often possesses a limited understanding of scientific issues and may interpret complex topics through biased lenses or cognitive shortcuts[26]. Consequently, it is likely that scientists and non-experts exhibit distinct traits in their discussions about food additives. Analyzing these differences could enhance our understanding of the persistent divide between scientists and the public and inform strategies for bridging that gap.

The current study used content analysis as its chosen research approach and focused its investigation on the dialogue that occurs between experts and the general public on the Chinese social Q&A platform, Zhihu. The objective of this study was to analyze the differences between experts and the general public in several aspects of their dialogue, specifically focusing on attitudes, writing style, and interaction characteristics. A content analysis was conducted because of its appropriateness for examining large amounts of textual data in order to determine characteristics of messages, such as word frequency and patterns, as well as communication structures and trends[27].

Research Question 1: What is the attitude, writing style and interaction features when users discuss about food additives on Zhihu?

Research Question 2: What are the differences, if any, in the attitude, writing style and interaction features between experts and non-experts when they discuss about food additives on Zhihu?

Results

Characteristics of answers

Each answer generated at least 11 comments in their comment sections. Significantly, it is worth mentioning that one of the answers initiated a fervent discussion, amassing a considerable number of 1811 comments. Out of the total 43 answerers, 46.5% were classified as experts, while the remaining 53.5% were categorized as non-experts. Regarding individuals' perspectives on food additives, the results indicated that the majority of the answerers (51.2%) expressed a neutral stance, while a significant proportion (44.2%) maintained a favorable attitude. Conversely, a small minority (4.7%) exhibited a negative perception toward food additives.

Regarding the writing style, the majority of the answerers (74%) substantiated their viewpoints by presenting supporting evidence. Notably, several answerers referenced diverse forms of evidence obtained from various sources. According to Jamieson's (2017) assertion regarding the importance of considering pertinent evidence in scientific discourse, the aforementioned proportion is deemed satisfactory. The predominant kind of evidence utilized by the respondents in their answers was "visualized evidence" (diagrams, charts, tables, illustrations, pictures) (N = 17). This was closely followed by "statistical evidence" (N = 13). Regarding the sources of evidence, 22 answerers mentioned "external sources—nonacademic". Furthermore, 10 answerers referred to "personal experience-self", in which they offered personal tales or firsthand narratives. Figures 2 and 3 illustrate the graphical representation of the frequency of evidence types and evidence sources employed in the answers.

Characteristics of comments

As stated in the methodology, we gathered 10 comments for each answer, resulting in a dataset containing a total of 430 comments collected from the comment sections of 43 individual answers. The most popular comment achieved 1245 "likes". In order to facilitate analysis, the study did not exclude duplicate commenters. Out of the total number of commenters, namely 430 individuals, it was observed that the general public constituted a majority of 94.2% (N = 405), while experts accounted for a smaller proportion of 5.8% (N = 25).

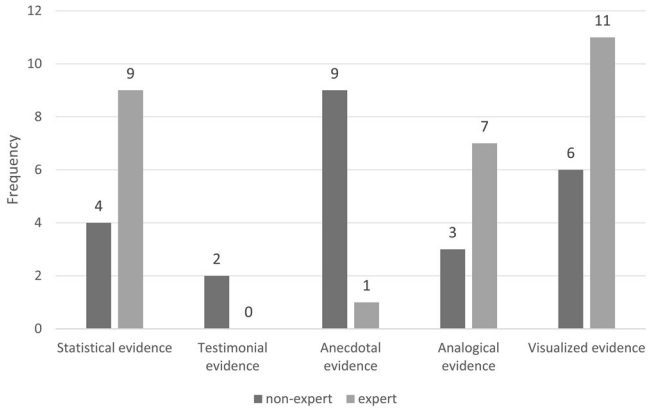

Fig. 2 | Frequency of evidence type—answers. The types of evidence include Statistical evidence, Testimonial evidence, Anecdotal evidence, Analogical evidence, and Visualized evidence. Dark gray bars: Non-Expert Contributions. Light gray bars: Expert Contributions.

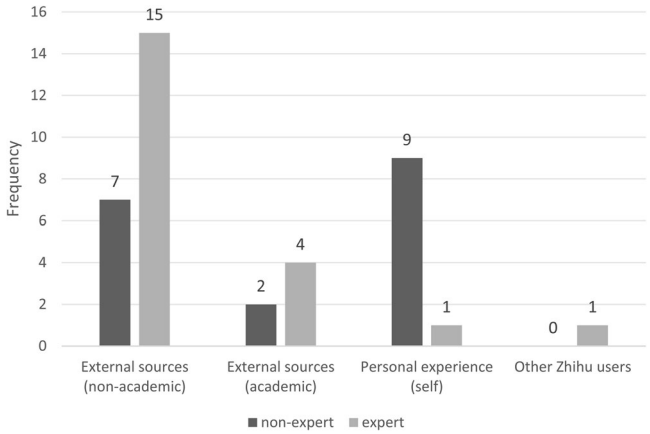

Fig. 3 | Frequency of evidence source—answers. The sources of evidence include External sources (non-academic), External sources (academic), Personal experience (self), and Other Zhihu users. Dark gray bars: Non-Expert Contributions. Light gray bars: Expert Contributions.

Regarding the perspectives on food additives, it was observed that the majority of comments (90.7%) expressed a neutral stance, a smaller proportion (5.8%) held a favorable viewpoint, and a minority (3.5%) exhibited a negative attitude toward food additives. It suggested that the majority of individuals had either neutral or favorable attitudes toward food additives. A minority of respondents, specifically fewer than 5%, expressed negative sentiments toward food additives.

During the course of the interaction, it was seen that around 15.6% of the commenters (N = 67) presented proof in their comments to justify their viewpoint. The majority of these commenters relied on a single form of evidence obtained from several sources. The relatively small proportion can be mainly attributed to the length disparity between answers and comments. Answers often resemble articles, whereas comments tend to be more concise and informal in style, often only a sentence or two. The primary type of evidence utilized by the commenters in their comments was "anecdotal evidence", amounting to a cumulative count of 52 occurrences. Subsequently, the application of "statistical evidence" occurred in 7 occurrences, while "analogical evidence (from a related phenomenon can effectively prove parallels when information is scarce)" was employed on 5 occasions. In contrast to the aforementioned responses, the analysis revealed that the

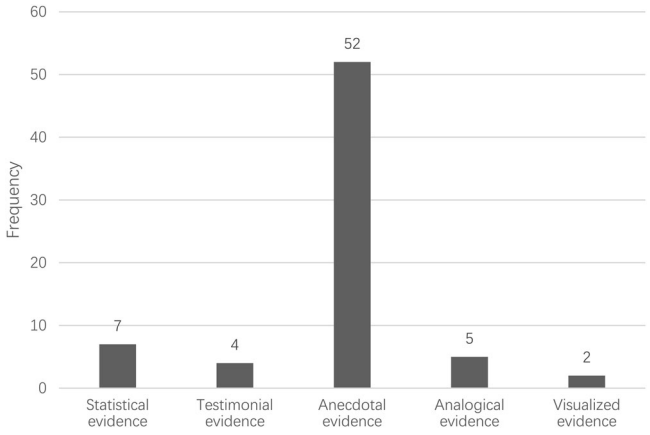

Fig. 4 | Frequency of evidence type—comments. The types involved include Statistical evidence, Testimonial evidence, Anecdotal evidence, Analogical evidence and Visualized evidence.

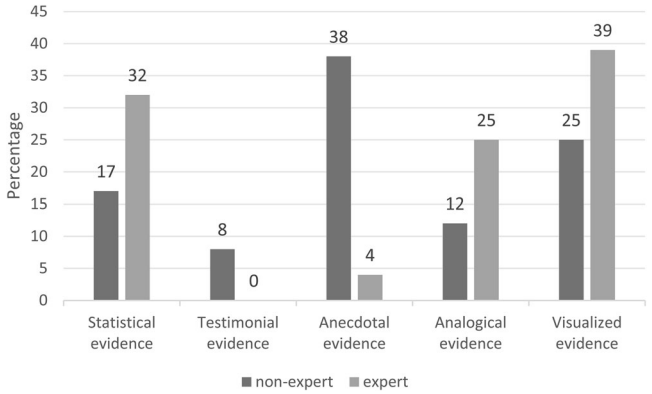

Fig. 6 | Comparison between expert and non-expert users on evidence type—answers. The types involved include Statistical evidence, Testimonial evidence, Anecdotal evidence, Analogical evidence and Visualized evidence. Dark gray bars: Non-Expert Contributions. Light gray bars: Expert Contributions.

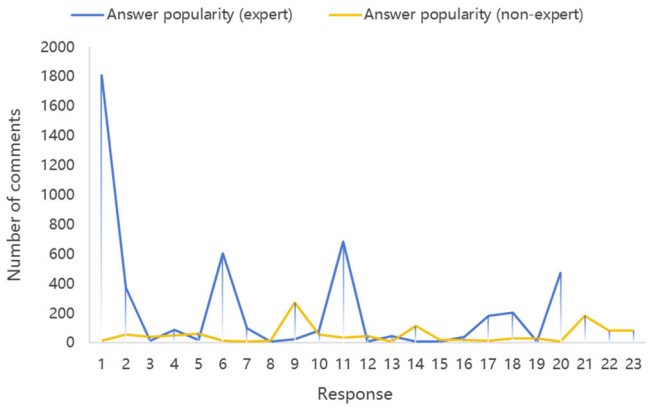

Fig. 5 | The number of comments received under posts provided by experts and the general public. Blue line: Answer popularity (Expert). Yellow line: Answer popularity (Non-Expert).

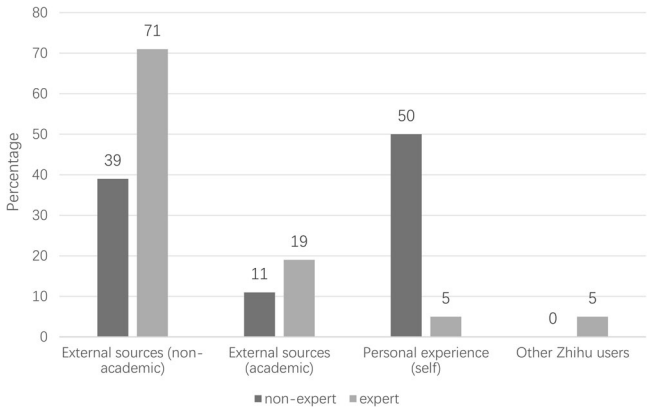

Fig. 7 | Comparison between expert and non-expert users on evidence source—answers. The sources of evidence include External sources (non-academic), External sources (academic), Personal experience (self), and Other Zhihu users. Dark gray bars: Non-Expert Contributions. Light gray bars: Expert Contributions.

primary source of evidence given by commentators ($N = 52$) was "personal experience (self)". Figure 4 illustrates the frequency with which different types of evidence were utilized in the comments. While there are various options for "evidence" in the comments section, it is common for a single comment to consist of only one form of evidence, which is derived from the researcher's observations throughout the coding process.

Interaction features in comments

Among the 430 comments, it is worth noting that almost two-thirds of the participants (254) in the study responded directly to the individuals providing answers or others' comments. Among the 254 participants engaged in the debate, a notable proportion of 45.7% ($N = 116$) were seen to have diverged from the original topic of the comment and introduced a novel subject matter. Furthermore, a total of 39.4% ($N = 100$) of respondents indicated their dissatisfaction with the individuals they were addressing, whereas 9.8% showed agreement with them. Only a small proportion, specifically 5.1% ($N = 25$), of the individuals who provided comments maintained a state of impartiality.

Regarding the categorization of dialogue styles, the prevailing attribute was that of "persuasive dialogue", closely followed by "eristic dialogue" (refers to a style of argumentation or debate that focuses more on winning or scoring points rather than seeking truth or understanding). In contrast, dialogue forms that exhibit a more cooperative orientation, such as "deliberation/negotiation", was employed with lower frequency.

Differences between expert and non-expert users

As shown in Fig. 5, the results of an independent t-test indicate that there is no statistically significant difference in the number of comments received under answers provided by experts compared to those written by the general public ($t(19.712) = -1.928$, $p > 0.05$). However, after plotting the two sets of data, we observed that some expert-provided answers received exceptionally high numbers of comments, which contributed to the wide distribution and large standard deviation. These data points are not outliers but reflect genuine engagement and higher popularity. Their impact on the mean has made it challenging to distinguish differences between the two groups; however, they offer valuable insights into the overall trends. The analysis of the number of "likes" received by answerers indicates that there is no statistically significant difference between the two groups. The t-test findings reveal a t-value of -1.409 with 22.695 degrees of freedom, and a p-value greater than 0.05.

Regarding attitudes toward food additives in answers, our results showed that 55% of experts had a positive attitude toward food additives, compared to 34.8% of non-experts. Additionally, 40% of experts were neutral, while 60.9% of non-experts were neutral, and only 5% of experts expressed negative sentiments, versus 4.3% of non-experts.

In relation to the writing style, the findings indicated that there is not a statistically significant distinction between individuals classified as expert users and those classified as non-expert users with respect to their utilization of evidence. In contrast to expert users, non-expert users also presented

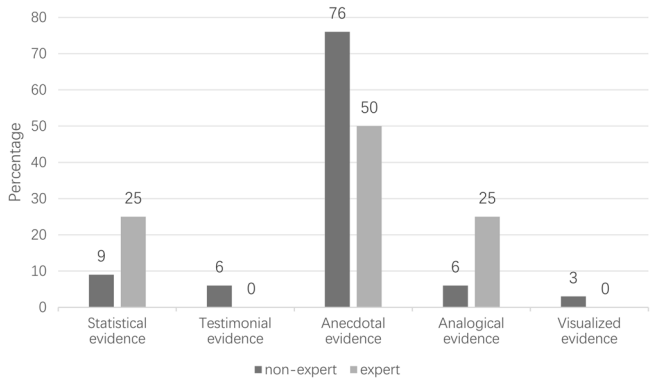

Fig. 8 | Comparison between expert and non-expert users on evidence type—comments. The types involved include Statistical evidence, Testimonial evidence, Anecdotal evidence, Analogical evidence and Visualized evidence. Dark gray bars: Non-Expert Contributions. Light gray bars: Expert Contributions.

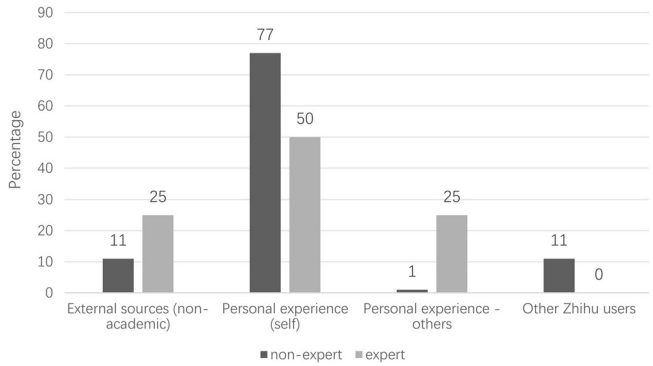

Fig. 9 | Comparison of expert and non-expert users' evidence source—comments. The sources of evidence include External sources (non-academic), External sources (academic), Personal experience (self), and Other Zhihu users. Dark gray bars: Non-Expert Contributions. Light gray bars: Expert Contributions.

supporting evidence in their responses. Figures 6 and 7 illustrate the distribution of evidence sources and types as percentages within the two categories. It is evident that individuals lacking expertise often rely on anecdotal evidence and personal experiences as sources of evidence, whereas experts are more inclined to utilize statistical evidence and visualized data.

There is a notable divergence observed in the viewpoints expressed by expert and non-expert users inside the comments section, as indicated by the statistical analysis (χ^2 (2) = 24, $p < 0.001$). Figures 8 and 9 illustrate the distribution of evidence types and sources employed by each respective group, expressed as percentages. In a similar vein to previous responses, it is evident that non-expert users often rely on anecdotal evidence and personal experiences as substantiation, whereas professionals are more inclined to utilize statistical evidence and visual representations as sources of evidence.

The interaction aspect of comments encompassed two key indicators: interactivity and dialogue type. Regarding the aspect of interaction, it is evident that there exists a notable distinction between the two groups, as indicated by the chi-square test statistic (χ^2) value of 4.809 with 1 degree of freedom, yielding a p-value less than 0.05. In the comment section, it was observed that expert users exhibited a higher tendency to engage in direct replies with both answerers and other commenters, as opposed to non-expert users. However, in terms of users' attitudes regarding the original information to which they were responding, there were no significant variations observed between expert users and non-expert users.

Discussion

In both answers and comments, there were more than 95 percent of respondents with a neutral or positive attitude toward food additives. When we look into the contents of the discussion, our findings suggest that the public's concerns about food additives are not necessarily about the additives themselves or a scientific understanding of them, but rather about the regulatory and commercial context in which they are used. In contrast to other scholarly works suggesting that consumers have negative perceptions of food additives due to a dearth of information[28,29], it is evident that, at least in China, consumers' lack of faith in the food sector and government regulating procedures is a significant contributing factor. For example, one of the "top questions" in our study is, "Since sodium nitrite is highly carcinogenic, why is it added to ham? Why can't we omit it? Why don't food companies put human health first?". One non-expert user wrote, "How could you talk about toxicity without considering the dose? Nitrites are bad for your health, but the amount in ham and sausage isn't any worse than what you would get from smoking". Another expert user wrote, "As long as you purchase processed meat products from regular manufacturers, you don't have to worry too much about excessive nitrite levels". Experts and non-experts alike have seen that food chemicals have a lot of benefits, including making food safer. One user wrote, "For food safety, nitrite has to be added". It is very interesting to find that even with the understanding of the necessity of food additives to ensure food safety, the public is still not positive about food additives and cites the example of melamine to illustrate the misuse of food additives and the negligence of the food regulatory authorities. One user wrote, "There are relevant laws and regulations, so what? The melamine incident still happened?".

Food additives continue to be a prominent subject of public concern, despite ongoing educational efforts by the Chinese Authorities. This study reveals a more intricate scenario within real-life conversational contexts. Several instances of food safety concerns, such as the presence of melamine in infant milk powder, the Sudan red event, and the utilization of cooking oil derived from food waste[30], had substantial implications for public confidence, the credibility of the food industry, and regulatory oversight[15]. Our findings are consistent with those reported by Li et al.[31], which indicate the public's primary concern revolves around the illicit addition or misuse of additives in food and highlight the insufficient level of public confidence in food-producing firms. This statement suggests that the contemporary understanding of science encompasses a broader range of perspectives, incorporating multiple dimensions such as political, moral, and cultural aspects[32].

The results indicated that experts did not have a dominant influence in online discussions, as answers and comments provided by expert users did not receive a higher number of "likes" in comparison to those authored by non-experts. In essence, the influence of the author's identity on the popularity of the content they have written is rather insignificant on Zhihu. The present discovery challenges the claim put forth in prior scholarly literature that new media platforms have provided professionals with unparalleled authority to disseminate scientific discoveries and exert direct influence over audiences[4,6]. In the past, professionals had a patronizing style in their dialogue with the public, but the internet is the great equalizer, and now everyone can generate content and air their views.

Zhihu has disrupted the usual scientific communication style, which relies on expert specialists stating their views, by creating an online forum for informal scientific debates[33]. Scientific knowledge credibility challenges have been studied extensively[34,35], and the scrutiny of scientific authority is expanding as many factors as possible outside empirical proof are considered.

While experts did not function as opinion influencers, they actively participated in enabling the discourse on Zhihu. It was observed that expert users exhibited a higher tendency to engage in direct replies with both answerers and other commenters, as opposed to non-expert users. In particular, individuals with expertise demonstrated a higher propensity to engage in direct responses to fellow users within the comment section. It appears that experts on Zhihu allocate a significant amount of time and effort to elucidating their viewpoints and actively participating in discussions with other users. According to Peters, those who possess extensive knowledge and expertise in a certain field might be referred to as "public

experts"[36]. In addition to their responsibilities as scientific researchers, individuals in this field also assume the role of public communicators for certain scientifically contentious matters. Public experts who have dual roles play a crucial role in facilitating scientific communication by serving as intermediaries between the scientific community and the general public[19]. Consequently, they possess the capacity to contribute to the collaborative development of scientific knowledge[3].

This study pioneers the examination of food additive discussions on Zhihu, a popular social media platform in China. It emphasizes the need to shift from a deficit to a dialogue model in scientific communication supported by empirical evidence. The concept of the "extended peer community", proposed by Funtowicz and Ravetz[37], suggested that the wider public can actively participate in scientific dialogue alongside experts. This study also highlighted the evolving role of experts into "public experts," who not only provide information but also foster discussions[36]. The internet, as noted by MacKuen[38], enhances democratic connections, particularly on platforms like Zhihu, where uncertainty can be openly shared. Specialists play a crucial role in facilitating discussions and providing high-quality content. Policymakers can leverage platforms like Zhihu to understand public sentiment, identify public concerns and thereby make more informed decisions. The absence of substantial comments or inadequate reactions from regulatory bodies and food experts frequently results in a void that is often filled by the propagation of speculation, disinformation, and rumors. Addressing and correcting these issues becomes challenging once they have gained momentum[39]. Experts, as both facilitators of discussions and suppliers of high-quality content, should recognize their dual positionality as experts and members of their community and engage in respectful conversations with community members about science[19].

It's essential to acknowledge the study's limitations regarding the generalizability of its findings. The examination focused on how scientific information is shared on Zhihu, potentially limiting applicability to other platforms or contexts. Exploring platforms in different linguistic contexts, like Quora, could provide deeper insights into how platform characteristics impact online debates. The study solely analyzed discussions related to food additives on Zhihu and didn't address the ability to monitor changes in attitudes and behaviors over time. Despite limitations, this study provides initial insights into digital scientific discourse's content and format, offering opportunities to analyze online communication attitudes and styles.

The digital platforms are here to stay, and the pace of change is creating a revolution in the communication environment. It affords a wonderful opportunity for both scientists and regulators to engage with the public and introduce new innovations and developments in the areas of food safety and nutrition, which will increase the likelihood of their acceptability. Feeding the growing world population in a sustainable way is essential, but without consumer acceptance, society will not reap the benefit of many of the scientific advances associated with the food supply.

Methods

The initial phase of examining discourse about food additives on Zhihu involves distinguishing between users with scientific expertise and those without. According to the definition presented in the Cambridge Dictionary, an expert is "a person with a high level of knowledge or skill relating to a particular subject or activity" (https://dictionary.cambridge.org/dictionary/english/expert). The current study follows a broad interpretation of experts, including persons involved in scientific research, as well as those working in government, industry, cooperative extension, science museums, or other science-related professions. Based on a prior study conducted by Liang, Liu, and Zhang[36], the term "expert" is attributed to a Zhihu user who openly discloses their name in their profile or post, specifically identifying themselves as belonging to one of the subsequent categories: (1) An individual who is associated with an academic institution in the capacity of a teaching or research fellow in the fields of food engineering, agriculture, nutrition, chemistry, food safety, biology, or medicine. (2) A student who is pursuing an undergraduate or graduate degree, such as a master's, PhD, or post-doctoral, in the aforementioned fields. (3) A professional who is employed in the food additives-related industry or the government sector. (4) An individual who lacks a conventional scientific background or is not presently involved in any scientific occupation, but actively assumes the traditional societal responsibility of experts to communicate and disseminate scientific knowledge or science-related information on digital platforms such as Zhihu. The inclusion of the fourth category was prompted by the emergence of the "citizen expert" idea within the framework of the novel model of public engagement in scientific research[40,41]. The general populace can be divided into two distinct groups: (1) persons who openly declare their non-scientific professional roles, such as architects or store managers, and (2) those who do not explicitly divulge their professional identity. It is important to highlight that, within the context of this study, individuals from disciplines such as physics or astronomy are also regarded as non-experts when it comes to the topic of food additives. The population subset falling inside this specific category is relatively small, consisting of only one individual within the sample.

Sampling procedure

The Zhihu platform operates with a hierarchical structure, encompassing three levels: questions, answers, and comments. This study concentrates on analyzing the content within answers and comments. The research began by identifying the top five questions (as shown in Table 1) on the food additives topic page. On the Zhihu platform, users possess the capability to allocate one or more labels to their questions as a means of acquiring information. The current analysis exclusively examined enquiries classified as "food additives", while excluding those that are related to the research topic but lack explicit labeling. The "top question" page of the food additives topic on Zhihu showcases all five questions, attracting people with a particular interest who are seeking further knowledge. Each of the five questions has received at least 4000 likes for at least one of their respective answers, with the most popular response accumulating an impressive 26,000 likes. The

Table 1 | The top five questions about the food additives topic page on the Zhihu social media

No.	Top five questions selected
1	奶茶里的奶和茶分别是什么成分? 对人体有危害吗? What are the specific components of the milk and tea in bubble tea? Do these components pose any potential harm to human health?
2	既然亚硝酸钠致癌级别非常高, 为什么火腿等还要加这个? 为什么不能不加? Considering the high carcinogenic risk associated with sodium nitrite, why is it still used as an additive in products like ham? Why is it not possible to eliminate its use?
3	火腿肠里真的有肉吗? Is there actually meat in ham sausages?
4	为啥国内饼干配料上写满了食品添加剂, 国外的却几乎没有? Why do ingredient labels on domestic biscuits list numerous food additives, whereas those on foreign biscuits contain very few?
5	如果把中国 2400 种合法添加剂用食品安全最低标准放到一杯水里面, 能喝吗? If you were to put all 2400 legally approved food additives in China into a glass of water at the minimum safety standard, would it be drinkable?

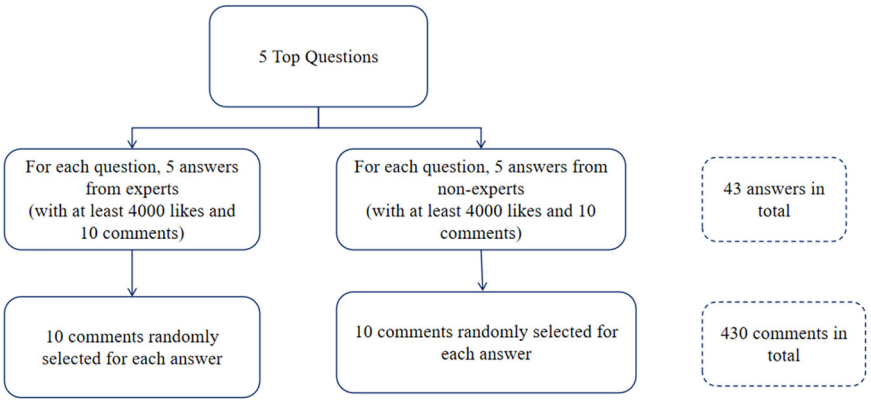

Fig. 10 | Sampling procedure for answers and comments. This diagram illustrates the sampling framework used for the analysis. A total of 5 top questions were selected. For each question, 5 answers from experts (with at least 4000 likes and 10 comments) and 5 answers from non-experts (with at least 4000 likes and 10 comments) were chosen. From each answer, 10 comments were randomly selected. In total, 43 answers and 430 comments were included in the analysis.

Table 2 | Different indicators in the answers and comments coding systems

	Profile information	Attitude	Writing style	Interaction features
Answer	User identity Answer popularity	Answer attitude	Evidence	NA
Comment	User identity Comment popularity	Comment attitude	Evidence	Interactivity Dialogue type

selection of these top five questions was based on two main reasons: firstly, they require thorough consideration to ensure a sufficient number of answers and comments; secondly, these questions attract the largest audience of users interested in food additives, making them highly influential.

The number of comments on the five questions fell between the range of 182 to 695. In order to ensure an appropriate sample size of comments for subsequent analysis, a random selection was made consisting of five answers authored by experts and five answers authored by members of the general public. Each answer contained a minimum of ten comments. In the event that a question has less than five answers accompanied by a minimum of ten comments each, all answers falling under said question will be chosen. The procedure entailed the selection of 5 answers from each group, resulting in a cumulative total of 10 answers being chosen for a specific question. Nevertheless, in instances where a question yields 5 or fewer viable answers in either group, all the answers from that group were incorporated, leading to a reduced number of answers, specifically less than 10, for that specific question. Following these procedures, a total of 43 responses were gathered from the subset of five questions, with 20 from experts and 23 from non-experts.

Due to the large volume of comments associated with some responses, it was not feasible to include all of them. Therefore, ten comments were randomly selected for each answer, resulting in a total of 430 comments (see Fig. 10), with 94.2% coming from the general public and 5.8% from experts.

Coding procedure

Both answers and comments contribute to the discussion on food additives, each with its own style. Answers resemble articles, while comments are typically shorter and more informal. Therefore, the discussion structure may not fully capture all aspects present in both. For instance, comments exhibit clear interaction aspects. To effectively capture these unique attributes, two separate coding systems were devised. The indicators used for both answers and comments are detailed in Table 2.

The coding process as depicted in Table 3 was conducted by two independent coders between July 31st, 2023, and August 31st, 2023. Discrepancies in item scoring were resolved through face-to-face discussions until an acceptable level of inter-coder agreement was achieved. For answers, profile information includes whether the answerer identified as an expert (0 = no, 1 = yes), and the answer's popularity measured by likes and comments. Similarly, for comments, profile information covers the commenter's identity and comment popularity indicated by likes. Attitude assessment involves evaluating the respondent's stance in their entire response. Evaluators identify pivotal sentences indicating the stance as "0 = neutral," "1 = negative," or "2 = positive." A neutral attitude is characterized by answers that neither favor nor oppose the use of food additives. These responses often lack explicit comments on the benefits or drawbacks, or they present both sides equally. When both advantages and disadvantages are mentioned, they are balanced without showing a clear preference. A positive attitude emphasizes the benefits of food additives, such as enhancing flavor, extending shelf life, improving texture, or contributing to future innovations in food safety or nutrition. While drawbacks may be acknowledged, the focus remains on the positive aspects, resulting in an overall optimistic tone. In contrast, a negative attitude centers on the risks or potential harms of food additives. Answers in this category highlight concerns such as health risks, the presence of artificial ingredients, allergies, or the lack of naturalness in food. Even if some benefits are mentioned, the discussion is largely dominated by caution or criticism.

Evidence evaluation checks if the answer or comment provides supporting evidence, coded as 0 = no, 1 = yes. Different types of evidence are coded as follows: 1 for statistical, 2 for testimonial, 3 for anecdotal, 4 for analogical, and 5 for visualized evidence. The source of evidence is categorized into five codes: 1 for non-academic external sources, 2 for academic external sources, 3 for personal experiences from oneself, 4 for personal experiences from others, and 5 for evidence from other respondents.

Based on the findings of Liang, Liu, and Zhang[42], the study focused on coding two distinct indicators of interaction features, specifically interactivity and dialogue style, only for comments. The concept of interactivity is a metric used to evaluate the level of involvement and politeness exhibited in a conversation[43,44]. The evaluation criterion considered whether the commenter engages in direct interaction with the answerer or other commenters within the comment section. This was assessed using a binary scale, where a score of 0 indicates no direct interaction, and a score of 1 indicates the presence of direct interaction. Examples of direct interaction include using the "@" symbol followed by the answerer's name, referring to the answerer by name, quoting the original answer, using the "@" symbol followed by other commenters' names, referring to other commenters by name, or quoting other commenters' comments. The categorization of dialogue types serves to establish the beginning context and end aim of the dialogue. If so, what is the commenter's stance regarding the original text, categorized as either agreement (1), disagreement (2), neutrality (3), or irrelevance (4)? Drawing upon existing dialogue typologies, we categorized each comment into one of eight dialogical categories: (1) "discovery", (2)"Inquiry",(3)"information-seeking",(4)"Persuasion",(5) "deliberation/negotiation", (6) "Eristic" (refers to a style of argumentation or debate that focuses

Table 3 | Measurement of different indicators in the answers and comments

Variables	Measurements
Answer	
User identity	0 = non-expert, 1 = expert
Answer popularity	likes and comments
Answer attitude	0 = neutral, 1 = negative, 2 = positive
Evidence	0 = no, 1 = yes
Type of evidence	1 = statistical evidence, 2 = testimonial evidence, 3 = anecdotal evidence, 4 = analogical evidence, 5 = visualized evidence
Source of evidence	1 = non-academic external sources, 2 = academic external sources, 3 = personal experiences from oneself, 4 = personal experiences from others, 5 = other Zhihu users
Comment	
User identity	0 = non-expert, 1 = expert
Comment popularity	likes and comments
Comment attitude	0 = neutral, 1 = negative, 2 = positive
Evidence	0 = no, 1 = yes
Type of evidence	1 = statistical evidence, 2 = testimonial evidence, 3 = anecdotal evidence, 4 = analogical evidence, 5 = visualized evidence
Source of evidence	1 = non-academic external sources, 2 = academic external sources, 3 = personal experiences from oneself, 4 = personal experiences from others, 5 = evidence from other respondents
Interactivity	0 = no direct interaction, 1 = presence of direct interaction
Attitude toward the original comment	1 = agreement, 2 = disagreement, 3 = neutrality, 4 = irrelevance
Dialogue type	1 = discovery, 2 = Inquiry, 3 = information-seeking, 4 = Persuasion, 5 = deliberation/negotiation, 6 = Eristic (refers to a style of argumentation or debate that focuses more on winning or scoring points rather than seeking truth or understanding), 7 = Agreement, 8 = Others

more on winning or scoring points rather than seeking truth or understanding), (7) "Agreement", (8) "Others"[42,45,46].

To address our research question, we employed both *t*-tests and chi-square analyses to assess potential differences between expert and non-expert users during the dialogue. The *t*-test was applied to evaluate differences in the number of likes, comments and attitudes, while the chi-square test was used to examine interaction characteristics between the two groups.

Data availability

The authors declare that all data supporting the findings of this study are presented in the article. The raw data are available on request.

Code availability

The study involved only basic calculations described in the "Methods" section, and no specific code or software scripts in R or other programming languages were used.

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Ting Lu: Investigation, Data curation, Methodology, Writing—original draft. Zhaohui Mo: Data curation, Writing—review & editing. Fangzhou He: Methodology, Validation. Yiping Wang: Data curation. Zhaoshuo Yu: Funding acquisition, Methodology, Validation, Writing—review & editing. Li Li: Conceptualization, Supervision. Patrick Wall: Writing—review & editing.

Competing interests

The authors declare no competing interests.

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