frontiers | Frontiers in Communication

TYPE Original Research
PUBLISHED 12 January 2026
DOI 10.3389/fcomm.2025.1744432

Communication methods for aflatoxin management among farmers to facilitate food security in southwest, Nigeria

Tiwalola Alabi[1]*, Babatunde Okubena[2], Bukunmi Atilade[2], Abimbola Sabiyi[3] and Helen Hambly[1]

[1]School of Environmental Design and Rural Development, University of Guelph, ON, Canada, [2]Federal University of Agriculture, Abeokuta, Nigeria, [3]Lead City University, Ibadan, Nigeria

OPEN ACCESS

EDITED BY
Uttaran Dutta,
Arizona State University, United States

REVIEWED BY
Chukwukasi Kassy,
University of Nigeria Teaching Hospital, Nigeria
Panida Jongsuksomsakul,
Naresuan University, Thailand

*CORRESPONDENCE
Tiwalola Alabi
✉ alabitiwalola@gmail.com

RECEIVED 11 November 2025
REVISED 05 December 2025
ACCEPTED 22 December 2025
PUBLISHED 12 January 2026

CITATION
Alabi T, Okubena B, Atilade B, Sabiyi A and Hambly H (2026) Communication methods for aflatoxin management among farmers to facilitate food security in southwest, Nigeria. *Front. Commun.* 10:1744432.
doi: 10.3389/fcomm.2025.1744432

Purpose: Food security is a critical global concern, particularly in Africa where chronic hunger persists. Grain legumes are essential for nutrition but face threats like aflatoxin contamination. This study explores how communication methods influence the knowledge, attitudes, and practices (KAP) of grain legume farmers in managing aflatoxin in Southwest Nigeria.

Methodology: The study employed the Modified Delphi Method, Focus Group Discussions, and Photovoice. The Delphi process involved two rounds of interviews, with eight participants in round one ($N = 8$) and seven in round two ($N = 7$). In addition, three focus group discussions were held, comprising 13 participants in the first group, 12 in the second, and 10 in the third. The study also included two participants in the Photovoice component ($N = 2$). Data were thematically analyzed using NVivo software.

Findings: Farmers' knowledge of aflatoxin management is closely linked to their exposure to training. Although they show a positive attitude and willingness to use products like Aflasafe, its high cost remains a major barrier. Effective communication approaches include demonstrations, training of trainers (ToT), and peer-to-peer learning. The study further identifies media gaps, weak agenda-setting around aflatoxin, and the importance of how messages are framed.

Practical implications: Improving communication strategies and reducing the cost of Aflasafe can enhance adoption and food safety. Participatory and visually oriented communication methods were found to be especially effective in improving behavioral uptake of aflatoxin management.

Theoretical implications: The study extends the KAP model by emphasizing the role of communication and economic factors in shaping farmer behavior. It draws on communication and behavior change theories, including Diffusion of Innovations, agenda-setting, framing, and media functions, to explain how farmers' KAP are shaped by communication content, channels, and gaps.

Originality/value: This research offers new insights into aflatoxin management communication in Nigeria, contributing to food security efforts across Africa.

KEYWORDS

aflatoxin, attitudes, communication methods, knowledge, practices

1 Introduction

Food security remains a major development challenge across Africa, where agricultural productivity is hindered by multiple biophysical and economic constraints. According to the FAO, food security exists when all people have access to sufficient, safe, and nutritious food for an active and healthy life (FAO, 2012). At the national and regional levels, food security is closely linked to the performance of agricultural production systems, which must generate adequate quantities of safe and high-quality food. In 2024, around 673 million people globally experienced hunger, with 307 million in Africa alone. The lingering effects of COVID-19 disruptions on agri-food systems mean that by 2030, about 512 million people may still face chronic hunger (FAO, 2025). Enhancing agricultural production is therefore central to strengthening food supply, stabilizing markets, and ensuring regional resilience.

Grain legumes such as soybeans, chickpeas, cowpeas, and lentils play a significant role in agricultural productivity, household nutrition, and income generation. When intercropped with cereals like rice and wheat or with root crops such as cassava, they improve yields and offer numerous benefits, like enhanced soil fertility, erosion control, livestock feed, and income generation (De Ron, 2015; Vanlauwe et al., 2019). Nutritionally, they are valued as sources of protein and micronutrients. These agronomic and economic benefits make grain legume strategic crops for sustaining production growth and improving food availability at broader system levels. Despite this, grain legume production faces major constraints, notably aflatoxin contamination.

Aflatoxins, toxic substances produced by fungi *Aspergillus flavus* and *A. parasiticus*, reduce yields, threaten health, and hinder income generation (Achaglinkame et al., 2017; PACA, 2015). In Africa, aflatoxin contamination is widespread, fueled by humid climates and subsistence farming practices (Ortega-Beltran and Bandyopadhyay, 2021). In many farming communities, limited access to proper storage, inadequate knowledge of contamination risks, and reliance on traditional practices further increase the likelihood of aflatoxin accumulation in grain legume (Udomkun et al., 2017). These challenges compromise national and regional food supply systems by reducing the volume of safe, marketable produce, weakening food supply chains and household resilience.

Efforts to manage aflatoxin contamination span pre-harvest, peri-harvest, and postharvest stages, including improved agricultural practices, better storage, sorting, biological control products such as Aflasafe, and policy or market-based incentives (Bandyopadhyay et al., 2016; Falade, 2019; Michael et al., 2018; Odjo et al., 2022). However, the effectiveness of these interventions depends heavily on farmers' knowledge, attitudes, and practices (KAP). Studies show that although mitigation tools exist, their adoption remains limited, largely due to knowledge gaps, poor information flows, and ineffective communication pathways (Achaglinkame et al., 2017; Leslie et al., 2023). Although interventions such as good agricultural practices, improved storage technologies, and biocontrol products like Aflasafe have been introduced, their adoption remains limited largely due to knowledge gaps, poor information dissemination, and ineffective communication channels (Achaglinkame et al., 2017; Leslie et al., 2023).

In the Nigerian context, aflatoxin suffers from a weak communication agenda. Mainstream media rarely prioritize aflatoxin, resulting in limited public awareness (PACA, 2015; Stepman, 2018). When information is communicated, messages are often framed in technical or scientific terms that do not align with farmers lived experiences (Falade et al., 2025; Udomkun et al., 2017). Additionally, radio and print media often fail to reach rural households because of language barriers, poor signal coverage, and weak integration with extension systems, as documented in Nigerian agricultural communication studies (Ejem et al., 2023; Fasina et al., 2024; Otene et al., 2015; Yekinni and Afolabi, 2019). These issues reflect both an agenda-setting gap and a message-framing gap, which help explain why aflatoxin awareness remains uneven across farming communities in Nigeria and other parts of Africa (Leslie et al., 2023). Evidence suggests that the effectiveness of aflatoxin (and other agro-innovation) management is shaped not only by technical options, but also by how well communication is handled, including who delivers the message, which channels are used, and whether communication strategies are tailored to farmers' contexts and capacities (Ejem et al., 2023; Leslie et al., 2023). Behavior-change and communication theories further support this position. Diffusion of Innovations argues that adoption is higher when practices are simple, observable, and trialable (Rogers, 2003). Empirical studies applying this framework to smallholder farmers show that these attributes, together with effective communication channels, significantly shape adoption of agricultural innovations (Mahama et al., 2024; Zondo and Ndoro, 2023). Agenda-setting research shows that issues receiving limited and inconsistent media coverage tend to be perceived as less important by the public (McCombs and Shaw, 1972). Content analyses of African and other media similarly find that food-safety and food-security risks often receive weak or selective coverage (Lelisa, 2018; Metula and Osunkunle, 2022). Building on these observations, analyses of mycotoxin communication suggest that if aflatoxin is not consistently highlighted by media and institutions, farmers are unlikely to view it as an urgent issue (Leslie et al., 2023). Recent work further shows that farmers respond more strongly to messages that use concrete, visible examples and economic consequences rather than abstract scientific descriptions, which aligns with Framing Theory (Leslie et al., 2023; Ortega-Beltran and Bandyopadhyay, 2021). Together, these perspectives illustrate why communication emerges as a central determinant of farmers' knowledge, attitudes, and practices related to aflatoxin management (Asante et al., 2024; Msangi et al., 2025).

Communication plays a critical role in shaping farmers' awareness and behavioral responses to aflatoxin risks. Evidence from Nigeria shows that targeted awareness campaigns significantly improve farmers' understanding of aflatoxin hazards and management practices (Johnson et al., 2018). Yet many extension approaches still rely on linear communication models that overlook farmers lived realities and indigenous knowledge. Participatory communication approaches, by contrast, encourage dialogue, facilitate co-learning, and enhance community ownership, leading to better agricultural decision-making (Cahyono, 2019; Lauzon, 2013). Despite the growing use of communication campaigns, empirical evidence remains limited regarding how specific communication methods influence farmers' KAP toward aflatoxin management.

The Knowledge, Attitudes, and Practices (KAP) framework provides a useful lens for examining why farmers' awareness does not always translate into improved practices. While knowledge influences attitudes and attitudes shape practices, adoption is also affected by internal constraints such as skills and resources, and external factors including institutional support and market conditions (Ajzen and Fishbein, 2000; Muleme et al., 2017). Given these behavioral, structural, and informational complexities, understanding communication methods becomes essential for designing effective aflatoxin interventions.

Given these gaps, this study investigates how different communication methods influence grain legume farmers' knowledge, attitudes, and practices regarding aflatoxin management in Southwest Nigeria. Specifically, it seeks to: (1) evaluate farmers' knowledge, attitudes, and practices (KAP) regarding aflatoxin management in agricultural production (2) analyze the role of communication methods in shaping farmers' KAP toward aflatoxin management, with implications for agricultural extension and innovation diffusion.

2 Conceptual framework

This study employs the Knowledge, Attitudes, and Practices (KAP) model as its theoretical foundation to investigate how grain legume farmers respond to aflatoxin contamination. The research problem centers on the persistent gap between awareness campaigns and extension efforts on aflatoxin, and the actual practices farmers adopt in their production systems. By applying the KAP framework, the study seeks to unpack the relationship between what farmers know, how they perceive risks, and the practices they ultimately implement.

World Health Organization (2021) emphasizes that the KAP model remains a useful lens for exploring how knowledge, beliefs, and contextual factors shape behavior. In this study, knowledge is conceptualized as farmers' awareness and familiarity with aflatoxin risks and management strategies, including both scientific and local forms of knowledge (Hulme, 2018; Lin, 2019). Attitudes are examined in terms of cognitive, affective, and behavioral dimensions, which reflect farmers' motivations, risk perceptions, and outcome expectations (Vargas-Sánchez et al., 2016). Practices are defined as routine farming behaviors and decisions that are influenced by knowledge, attitudes, and prevailing social norms (Bourdieu, 1990; Razu et al., 2021).

The KAP model conceptualizes these three elements as interlinked: knowledge influences attitudes, attitudes inform practices, and practices may feed back into knowledge and attitudes (Ajzen and Fishbein, 2000). However, the translation of attitudes into actual practices is not always straightforward. As illustrated by Muleme et al. (2017), both internal barriers (such as farmers' skills, resources, and personal constraints) and external barriers (such as institutional support, policies, and market conditions) can hinder the adoption of improved practices, even when knowledge and attitudes are favorable. In addition, communication methods play a critical role in shaping knowledge, reinforcing attitudes, and supporting behavioral change.

Although the KAP model has been studied extensively in health and agricultural research (Adeloye et al., 2022; Effendi et al., 2019), its application to aflatoxin management among smallholder farmers offers an important extension of the framework. This study situates the KAP model within the broader context of behavioral change theories (Ajzen, 1991; Hungerford and Volk, 1990; Meijer et al., 2015) and the diffusion of innovation perspective (Liao et al., 2022), thereby providing a theoretically grounded basis for understanding why knowledge and awareness do not always translate into improved practices.

Figure 1 illustrates the conceptual framework used in this study, adapted from Muleme et al. (2017). It highlights the relationships among knowledge, attitudes, and practices, as well as the influence of communication methods on these dynamics.

3 Methodology

The study was carried out in the Southwest geopolitical zone of Nigeria. The choice of Southwest Nigeria as the study location was driven by the prevalent security issues in the Northeast region, primarily known for grain legume cultivation. These security issues have significantly impacted grain legume production, leading to a decline in output (Aluko et al., 2016). Consequently, there is a growing need to enhance grain legume production in alternative agroecologies, such as Southwest Nigeria.

Aflatoxin experts who are scientists in research institutes and grain legume farmers were purposively selected, as they were considered the most relevant participants for this study. The study focused on the Agricultural Development Program (ADP) zones within Oyo State, where the Oyo State ADP was established with the primary objective of efficiently delivering advancements in agricultural technologies to farmers. This initiative resulted in the state being divided into four distinct agricultural extension zones, namely Ibadan/Ibarapa, Ogbomoso, Oyo, and Saki. Two zones (Saki and Oyo) demonstrating a comparative advantage in grain legume production were chosen among these zones to gather comprehensive insights and data.

This study used different methods to collect sequential empirical evidence, including the Modified Delphi Method, Focus Group Discussion (FGD), and Photovoice.

3.1 Modified Delphi method

The Modified Delphi Method was used to gather asynchronous, anonymous feedback from a group of specialists in the field of aflatoxin research between March and April 2024. This technique, consistent with the approach described by Tiernan et al. (2014), is an iterative process designed to draw on expert insight and move toward consensus on issues that may initially generate varied perspectives. Building on the foundations of the original Delphi technique developed by the Rand Corporation in the 1970s and later expanded by Hasson et al. (2000), the modified form used in this study allowed for structured expert feedback through multiple rounds of review conducted online. As noted by Okoli and Pawlowski (2004), such adaptations provide flexibility in how information is presented, how experts participate, and how agreement is reached.

This method entailed two interview rounds with these experts on Microsoft Teams. During the initial stage, eight experts were asked to evaluate a set of focus group probing questions in Table 1 on a scale ranging from 1 (low priority) to 5 (high priority) and suggest how it could be improved, and the probing questions cut across the knowledge, attitudes and practices domains. The ratings were analyzed, and mean scores were calculated and presented in Table 2.

In the second round, seven experts evaluated the revised questions using an expanded scale from 1 (very low priority) to 10

FIGURE 1
The conceptual framework of the study adapted from Muleme et al. (2017).

(very high priority) to allow greater discrimination among items. They again suggested refinements where necessary. The second-round ratings were analyzed, and mean scores are presented in Table 3. Based on the experts' quantitative ratings and qualitative feedback across both rounds, the researcher prioritized and refined the questions into a final set of probes in Table 4, which was then used to guide the focus group discussions.

3.2 Focus group discussion

Three focus groups were conducted with 13 participants in the first group (F1), 12 in the second (F2), and 10 in the third (F3), all with group sizes ranging from 10 to 13 members. Participants had an average age of 45. Most participants lacked formal education and were members of a cooperative society. Besides farming, many were involved in petty trading and artisan work. A researcher moderated each session using a guide (see Table 4), prompting open, respectful dialogue. Discussions were audio-recorded to ensure accurate representation and enable thorough analysis of recurring themes.

3.3 Photovoice

To explore how participants manage aflatoxin contamination, the study used Photovoice, a participatory method. Two farmers used smartphones to take 13 photos each, highlighting their risk management practices. They later selected five key images to discuss in recorded sessions, explaining their significance. This method offered visual and verbal insights into their lived experiences and enabled pattern recognition across participants.

3.4 Data management

All data collected in this study, including audio recordings, transcripts, photographs, field notes, and expert feedback, were managed using a systematic and secure process to ensure accuracy, confidentiality, and traceability. Audio recordings from the Modified Delphi interviews, focus group discussions, and photovoice sessions were transferred to password-protected folders immediately after each session. These recordings were transcribed verbatim, and the transcripts were checked against the audio files to ensure transcription quality.

Photovoice images were stored in encrypted digital folders and anonymized by removing all identifying information such as faces, locations, or labels. Each image received a unique code that corresponded to the participant's identification number. This approach maintained confidentiality while supporting analysis.

Data from the Modified Delphi process were compiled in Microsoft Excel and organized according to expert ratings and qualitative suggestions. All qualitative data were imported into NVivo 12 for coding and thematic analysis. A consistent naming convention and metadata system were used to label files by method, date, and participant category, which supported efficient data retrieval and ensured transparency.

To maintain ethical standards, access to all data was restricted to the research team. Consent forms and participant identifiers were stored separately from the research data. Data backups were saved on

TABLE 1 Focus group probing questions and linkage with KAP.

KAP category	Theme	Probe
Knowledge	1. Are farmers growing grain legume in your area of SW Nigeria?	What types of grain legume do you cultivate, and what is the main purpose of your cultivation (e.g., for personal consumption, sale, or both)?
Knowledge	2. Is aflatoxin in grain legume a recognized problem among farmers in your area of SW Nigeria?	How familiar are you with the term 'aflatoxin' and its potential impact on grain legume crops? How serious is aflatoxin contamination in grain legume in your local area? Is it only farmers who recognize aflatoxins in grain legume? Do sellers and customers know about aflatoxicosis in grain legume sold in the local market?
Knowledge and practices	3. How is aflatoxin being managed?	Can you describe any experiences or challenges related to aflatoxin contamination in your grain legume crops? How do you currently store your grain legume crops after harvest? Are there any specific methods or precautions you take to prevent aflatoxin contamination during storage? What measures, if any, do you take during the cultivation and harvesting stages to reduce the risk of aflatoxin contamination in your grain legume crops? Are there any traditional or local practices that you or other farmers in the community use to manage aflatoxin contamination in grain legume? Please elaborate on these practices. How do you dispose of grain legume crops heavily contaminated with aflatoxins? Are there specific methods you use for safe disposal? Have you encountered any challenges or barriers in implementing aflatoxin management practices on your farm? If so, what are they, and how do you think they could be overcome? Are you aware of and open to adopting new technologies or practices related to aflatoxin management, and if yes, what kind of support or resources would you need to do so? Can you share any success stories or best practices related to aflatoxin management that you or other farmers in your community have adopted?
Knowledge and attitudes	4. What information about aflatoxicosis and other support to manage aflatoxicosis in grain legume is available to individual or groups of farmers in the local community?	Are you aware of the health risks to people or livestock associated with aflatoxin- contaminated crops? If yes, please share what you know about these risks. Have you received any training or information on aflatoxin management practices in the past? If so, from whom and what did you learn? What sources of information do you rely on to learn about aflatoxin management practices for your crops? Have you ever used any aflatoxin testing methods or kits to assess the level of contamination in your crops? If so, please describe your experience with these tools. Have farmers' attitudes towards aflatoxin management changed over time? If so, what influenced this change? Have you engaged with other farmers in your community to discuss aflatoxin management practices? Do you think there is a need for more community-based initiatives to address aflatoxin contamination? How can local communities and farmer groups play a role in promoting better aflatoxin management practices?

secure cloud storage and an external hard drive. In line with institutional ethical guidelines, all data will be retained for 5 years and then permanently deleted.

4 Findings and discussion

In this section, we present the study's findings based on data collected through focus group discussions and photovoice. A detailed summary of these results is provided in Tables 5, 6. This section also includes the discussion of the findings.

4.1 Findings

4.1.1 Focus group discussion findings

These components encompass the varieties of grain legumes cultivated and the underlying reasons for their production, the extent of farmers' knowledge, their attitudes toward aflatoxin mitigation, the existing practices employed to manage aflatoxin, and the communication methods influencing farmers' knowledge, attitudes, and practices (KAP).

4.1.1.1 Grain legume types and reason for cultivation

Three main grain legumes are cultivated in the study area: groundnuts (*Arachis hypogea*), cowpea (*Vigna unguiculata*), and soybeans (*Glycine max*). The findings show that these crops fulfill a wide range of functions within the communities. Farmers cultivate grain legumes not only for household consumption but also as a source of income, as gifts, for animal feed, and to improve soil fertility. They are prepared and consumed in several forms, including whole foods, cakes, soups, and oil.

Participants in Group F3 described soybeans as a valuable crop for oil production and noted that they are also processed into locally made soya milk. Farmers in Group F2 emphasized the role of grain legumes in enhancing soil fertility. Also, the income generated from these crops contributes significantly to household welfare, including supporting children's education. As one farmer in Group F1 explained, the crops are sold "to earn income to finance our children's studies."

TABLE 2 First-round interview findings.

Theme	Probes	Mean (n = 8)	Standard deviation (n = 8)
Are farmers growing grain legume in your area of SW Nigeria?	What types of grain legume do you cultivate, and what is the main purpose of your cultivation (e.g., for personal consumption, sale, or both)?	4.63	0.74402
Is aflatoxin in grain legume a recognized problem among farmers in your area of SW Nigeria?	How familiar are you with the term "aflatoxin" and its potential impact on grain legume crops?	4.25	1.03510
	How serious is aflatoxin contamination in grain legume in your local area?	3.88	1.64208
	Is it only farmers who recognize aflatoxins in grain legume?	3.00	1.51186
	Do sellers and customers know about aflatoxicosis in grain legume sold in the local market?	2.88	2.03101
How is aflatoxin being managed?	How do you currently store your grain legume crops after harvest? Are there any specific methods or precautions you take to prevent aflatoxin contamination during storage?	4.88	0.35355
	What measures, if any, do you take during the cultivation and harvesting stages to reduce the risk of aflatoxin contamination in your grain legume crops?	4.75	0.46291
	How do you dispose of grain legume crops heavily contaminated with aflatoxins? Are there specific methods you use for safe disposal?	4.63	0.51755
	Are there any traditional or local practices that you or other farmers in the community use to manage aflatoxin contamination in grain legume? Please elaborate on these practices.	4.50	0.53452
	Can you share any success stories or best practices related to aflatoxin management that you or other farmers in your community have adopted?	4.50	0.53452
	Have you encountered any challenges or barriers in implementing aflatoxin management practices on your farm? If so, what are they, and how do you think they could be overcome?	4.38	0.74402
	Are you aware of and open to adopting new technologies or practices related to aflatoxin management, and if yes, what kind of support or resources would you need to do so?	4.13	0.83452
	Can you describe any experiences or challenges related to aflatoxin contamination in your grain legume crops?	4.00	1.30931
What information about aflatoxicosis and other support to manage aflatoxicosis in grain legume is available to individual or groups of farmers in the local community?	Are you aware of the health risks to people or livestock associated with aflatoxin-contaminated crops? If yes, please share what you know about these risks.	4.63	0.51755
	Have you received any training or information on aflatoxin management practices in the past? If so, from whom and what did you learn?	4.38	0.51755
	What sources of information do you rely on to learn about aflatoxin management practices for your crops?	4.13	1.12599
	Have farmers' attitudes towards aflatoxin management changed over time? If so, what influenced this change?	4.13	0.83452
	Have you engaged with other farmers in your community to discuss aflatoxin management practices?	4.13	1.12599
	How can local communities and farmer groups play a role in promoting better aflatoxin management practices?	4.00	0.75593
	Do you think there is a need for more community-based initiatives to address aflatoxin contamination?	3.88	1.12599
	Have you ever used any aflatoxin testing methods or kits to assess the level of contamination in your crops? If so, please describe your experience with these tools.	3.75	0.88641

4.1.1.2 Knowledge level of grain legume farmers

Participants were asked about their knowledge of aflatoxin. They were asked about their familiarity with 'aflatoxin' and its potential impact on grain legume crops. It was discovered that the knowledge level of grain legume farmers about aflatoxin, its impact, predisposing factors, and management practices varies significantly across different agricultural zones due to their exposure to training on the topic. For example, farmers in the Saki zone, who received training on aflatoxin and its management practices, exhibited a high level of awareness about the issue. In contrast, farmers in the Oyo zone who did not receive such training showed less familiarity with aflatoxin and its management practices. Two groups (F1 and F2) from the Saki zone shared their insights, stating,

> 'Aflatoxin affects the quality of the crops,' 'Consumption of contaminated crops affects our health,' 'Buyers won't buy crops

TABLE 3 Second-round interview findings.

Theme	Probes	Mean (n = 7)	Standard deviation (n = 7)
Are farmers growing grain legume in your area of SW Nigeria?	What types of grain legume do you cultivate?	9.43	0.78680
	What is the main purpose of your cultivation (e.g., for personal consumption, sale, animal feed)?	9.43	0.78680
Is aflatoxin in grain legume a recognized problem among farmers in your area of SW Nigeria?	How familiar are you with the term "aflatoxin" and its potential impact on grain legume crops?	9.43	0.78680
	How common is aflatoxin contamination in grain legume in your local area?	8.57	1.71825
How is aflatoxin being managed?	What post-harvest measures are taken to reduce the risk of aflatoxin contamination in your grain legume?	9.43	0.53452
	Have you received any training or information on aflatoxin management practices in the past? If so, when, from whom, and what did you learn?	9.29	0.95119
	What measures, if any, do you take during the cultivation and harvesting stages to reduce the risk of aflatoxin contamination in your grain legume crops?	9.29	0.75593
	Have you encountered any challenges or barriers in implementing aflatoxin management practices on your farm? If so, what are they, and how do you think they could be overcome?	8.86	1.21499
	How do you currently store your grain legume crops after harvest? Are there any specific methods or precautions you take to prevent aflatoxin contamination during storage?	8.71	1.11270
	Can you share any success stories or best practices related to aflatoxin management that you or other farmers in your community have adopted?	8.29	1.38013
	Do you dispose of crops contaminated with aflatoxin? How do you dispose of grain legume with excess aflatoxin levels? Are there specific methods you use for disposal?	6.86	1.34519
What information about aflatoxin and other support to manage aflatoxin in grain legume is available to individuals or groups of farmers in the local community?	Has your attitude towards aflatoxin management changed over time? If so, what influenced this change?	8.71	1.11270
	Are you aware of the health risks to people or livestock associated with aflatoxin-contaminated crops? If yes, please share what you know about these risks.	8.57	1.27242
	Have you engaged with other farmers in your community to discuss aflatoxin management practices?	8.57	1.51186
	Who do you rely on to learn about aflatoxin management practices?	8.29	1.70434

TABLE 4 Final focus group questions and linkage with KAP.

KAP category	Theme	Final probes
Knowledge	1. Are farmers growing grain legume in your area of SW Nigeria?	What types of grain legume do you cultivate? What is the main purpose of your cultivation (e.g., for personal consumption, sale, animal feed)?
Knowledge	2. Is aflatoxin in grain legume a recognized problem among farmers in your area of SW Nigeria?	How familiar are you with the term 'aflatoxin' and its potential impact on grain legume crops?
Knowledge and practices	3. How is aflatoxin being managed?	Have you received any training or information on aflatoxin management practices in the past? If so, when, from whom, and what did you learn? What measures, if any, do you take during the cultivation and harvesting stages to reduce the risk of aflatoxin contamination in your grain legume crops? What post-harvest measures are taken to reduce the risk of aflatoxin contamination in your grain legume?
		Have you encountered any challenges or barriers in implementing aflatoxin management practices on your farm? If so, what are they, and how do you think they could be overcome?
Knowledge and attitude	4. What information about aflatoxin and other support to manage aflatoxin in grain legume is available to individuals or groups of farmers in the local community?	Are you aware of the health risks to people or livestock associated with aflatoxin-contaminated crops? If yes, please share what you know about these risks. Has your attitude towards aflatoxin management changed over time? If so, what influenced this change? Have you engaged with other farmers in your community to discuss aflatoxin management practices?

TABLE 5 Focus group discussion findings and linkage with KAP and communication.

Theme	F1 (Saki Zone)	F2 (Saki Zone)	F3 (Oyo Zone)
Grain legume types and reasons for cultivation	Cultivate groundnut, cowpea, soybean. Used for food, income, gifts, animal feed, and soil fertility.	Same crops. Emphasized soil fertility and income for children's education.	Same main crops. Soybean seen as important for oil and locally made soya milk.
Knowledge of aflatoxin—awareness and understanding	High awareness due to training. Know aflatoxin is invisible, a mycotoxin, affects crop quality and quantity, causes health problems (including cancer), and leads to low prices or rejected produce.	High awareness. Recognize aflatoxin symptoms in crops (e.g., cowpea flowers) and in animals (stunted birds prone to disease). Understand impact on yield and income.	No awareness. Never heard of aflatoxin, no knowledge of causes, impacts, or management; no known chemical or local control method.
Knowledge of predisposing factors	Identify late harvesting, rainfall at wrong time, and overpopulated cowpea plantations as factors increasing contamination.	Similar understanding of field conditions leading to contamination.	No knowledge of factors that predispose crops to aflatoxin.
Knowledge of management options (including Aflasafe)	Know Aflasafe and report better crop performance where it is used. Only a minority who attended training know the product.	Know and have used Aflasafe; recognize yield and quality benefits.	Do not know any chemical or local method to manage aflatoxin; no awareness of Aflasafe.
Attitudes toward aflatoxin management	Positive attitude; recognize importance of managing aflatoxin. However, perceive management as time-consuming and costly. Feel unsupported by government and researchers.	Positive attitude; value benefits of using Aflasafe but worry about additional costs and market constraints. Frustrated by lack of follow-through from institutions (e.g., IITA market promises).	Positive and open to management despite lack of information. Express willingness to adopt recommended practices if given access to information and inputs.
Perceived institutional support (government, researchers, organizations)	Feel abandoned by government and researchers; pay out-of-pocket to attend meetings; expect more material support (e.g., free chemicals).	Report that Aflasafe was introduced by IITA but complain about difficulty accessing it and lack of sustained support or market linkage.	Report no training or extension contact; OYSADEP agents do not come to their area.
Current preharvest practices for aflatoxin management	Thinning plant population, eliminating contaminated plants, using chemicals and Aflasafe.	Uprooting contaminated plants and using Aflasafe.	No specific preharvest aflatoxin management practices in use.
Current postharvest practices for aflatoxin management	Sun drying, bag storage, chemical spraying.	Grading, sun drying, sorting to remove visibly bad grains.	Storing grains in sealed containers and spraying chemicals (viewed as normal storage practice, not specifically for aflatoxin).
Use of traditional methods	Use ash and neem leaves; knowledge attributed to forefathers.	Do not currently use traditional methods, though they know ancestors used neem leaves.	Do not use traditional methods; only heard informally about neem trees as a possible method but never tried.
Cost and access issues (especially Aflasafe)	Management is financially demanding; chemicals and inputs are hard to afford.	Note that Aflasafe was initially free from IITA, later became costly. Have not discussed organized procurement via AFAN.	Cost not discussed specifically, but lack of access to any input or training is a major issue.
Information and communication channels	Receive information from IITA staff, extension agents, and AFAN farmer group. Training used demonstrations and flyers. Regular monthly meetings facilitate information sharing.	Similar channels: IITA and farmer group (AFAN). Note that radio stations used (BCOS, Oluyole FM, Gambari) do not reach their area effectively.	No training or extension contact; OYSADEP presence is distant. Rely on their own farmer network for general agricultural information, not specifically aflatoxin.
Frequency of communication	Trained about 4 years ago (2020). Farmer groups meet on set days (e.g., Saki West weekly; Oke Ogun monthly).	Last direct training from IITA about 2 years ago. Group meets regularly.	No formal aflatoxin-related communication history.
Overall willingness to adopt aflatoxin management	Very willing; explicitly ask researchers to provide solutions and disseminate them.	Will use Aflasafe and other methods if readily available and financially feasible; recognize improved taste and quality.	Willing to adopt any effective means (chemicals, techniques) if introduced by researchers/extension.

> that are contaminated with aflatoxin; they even offer to pay a ridiculously low price,' 'It is a mycotoxin that cannot be seen and can cause cancer,' and 'Aflatoxin reduces the quantity of crops and our income.'

Group F2 further elaborated, explaining,

> 'Cowpeas easily show aflatoxin contamination. We noticed that the flowers of contaminated cowpeas usually differ

TABLE 6 Photovoice findings and linkage with practices.

Theme/practice documented	Participant (Zone)	Photovoice description (what the photo shows)	Image placeholder
Application of Aflasafe	P1 (Saki Zone)	The participant applies Aflasafe by hand, broadcasting granules across the field during flowering or early pod formation. Granules resemble sorghum.	
Field coverage after Aflasafe use	P1 (Saki Zone)	Photograph shows areas of the field where Aflasafe granules have been applied.	
Weeding as a management practice	P2 (Oyo Zone)	Photo shows a weed-free groundnut farm	

> from those of non-contaminated cowpeas,' and 'Birds eating aflatoxin-contaminated crops experienced stunted growth and were prone to diseases. Even when one sees them, one would wonder what type of birds they are, while others that did not consume contaminated crops grew very well.'

Farmers in the Saki zone (F1 and F2) also knew the factors predisposing their crops to aflatoxin contamination. They noted,

> 'When we do not harvest early, our crops get contaminated,' 'Rain also affects our crops when we do not harvest at the right time,' and 'When a cowpea plantation is overpopulated, it is usually affected by aflatoxin.'

These farmers also understood how aflatoxin could be managed, stating,

> 'Using Aflasafe on our crops makes them grow well compared to the ones we did not use Aflasafe for.' However, they pointed out that only a few farmers who attended training sessions were familiar with Aflasafe.

In contrast, farmers in the Oyo zone (F3) did not know about aflatoxin, its impact, predisposing factors, or management practices. These farmers admitted,

> 'We have not heard of aflatoxin before,' and 'We do not know any chemical that can help manage aflatoxin on our crops. We do not have any local way of managing aflatoxin.'

4.1.1.3 Grain legume farmers' attitude towards aflatoxin management

Participants were asked if their attitude towards aflatoxin management has changed over time. If so, they were asked what influenced the change. The responses showed that grain legume farmers' attitudes towards aflatoxin management were the same across the two agricultural zones.

From their responses, Group F1 farmers exhibited a positive attitude towards aflatoxin management. They emphasized that managing aflatoxin in grain legume production is time-consuming and financially challenging. 'It wastes our time' and 'We find it difficult to get money to buy chemicals.'

They also highlighted issues with pest infestation on recently burnt land, stating, 'If we plant our crops on recently burnt land, some insects will come from the land and get attached to our crops. Even if we use chemicals, it will not work. So, we have no choice but to uproot the crop.'

Furthermore, they felt unsupported by the government and researchers, as they mentioned,

> 'The government does not assist us. We use our money to attend these meetings. We have not seen any assistance from the government and researchers. Researchers are supposed to assist us. For example, give us chemicals as gifts to use.'

Despite these challenges, they expressed a willingness to find ways to manage aflatoxin on their farm, saying,

> 'We are ready to find ways/means to manage aflatoxin on our farms because of the issues associated with it,' and 'Researchers should find a solution to the aflatoxin problem and disseminate it to us.'

Similarly, Group F2 farmers also showed a positive attitude towards aflatoxin management. They expressed their reluctance to invest time in separating contaminated crops from good ones, stating,

> 'We don't have the time to separate bad crops from good ones.' They also point out the difficulty in accessing the necessary resources, saying, 'The problem we farmers have is that once these researchers give us something to test on our farms, we find it difficult to get them whenever we want to use it.'

They recounted an experience with IITA, where promises of market assistance were unfulfilled:

> When IITA came, they told us they would help us get a market for our product because using Aflasafe is an additional expense for us, and we have to increase the sales price… people buy these crops since they do not know if we use Aflasafe, but they buy at a ridiculous price. Till now, we have not heard back from IITA.

Despite these issues, the farmers still acknowledged the benefits of aflatoxin management. They were ready to use Aflasafe if available, saying, '…once we see it, we will use it because it tastes different, and its quality is good.'

Furthermore, Group F3 farmers had a positive attitude toward aflatoxin management despite inadequate information or training on its management practices. They stated,

> 'We have not received any training or information on aflatoxin management,' and 'No one has come to discuss aflatoxin management practices with us in this area.'

However, during the discussion, they were willing to adopt aflatoxin management practices if provided with the necessary resources, saying, 'If we see any means of removing aflatoxin from our crops, we will get them. For instance, if researchers bring chemicals, we will buy them.'

4.1.1.4 Prevailing practices on aflatoxin management

Participants were asked about the practices they had adopted to manage aflatoxin on their farms, revealing a variety of preharvest, postharvest, and traditional methods.

The results revealed distinct differences among the groups. Group F1 had implemented different management practices to control aflatoxin. Their preharvest practices included thinning, eliminating contaminated crops, and using chemicals and Aflasafe. Group F1 used sun drying, bag storage, and chemical spraying for postharvest management. Additionally, they incorporated traditional methods such as using ash and neem leaves, which they attributed to have learned from their forefathers.

Conversely, Group F2 farmers did not adopt traditional methods for aflatoxin management. Although, they said their forefathers used traditional methods, such as neem leaves. Their preharvest practices involved uprooting contaminated crops and applying Aflasafe. For postharvest management, they focused on grading, sun drying, and sorting.

Group F3 farmers did not use any preharvest or traditional methods for managing aflatoxin. Instead, their postharvest practices involved storing crops in sealed containers and spraying them with chemicals, which was their normal way of storing their crops. Notably, Group F3 farmers mentioned,

> 'Some people told us that we can use neem trees to manage aflatoxin on our crops, but we have not used it before.'

One common observation among groups that utilized Aflasafe was its cost implications. Farmers in Group F2 noted, 'When IITA introduced Aflasafe, they provided it for free initially, but later mentioned its cost,' and added, 'We have not discussed with All Farmers Association of Nigeria (AFAN) about procuring Aflasafe from IITA.'

4.1.1.5 Communication methods and grain legume farmers' KAP

Participants were asked to reflect on the factors that shaped their understanding and approach to managing aflatoxin. They highlighted where they received their information, the ways in which it was communicated to them, and how frequently these interactions occurred. They noted that these were the primary factors because, prior to receiving training on aflatoxin, they had no prior knowledge of it. As a result of the training conducted using both visual enhancements (demonstrations) and flyers to teach farmers, participants in the Saki zone (F1 and F2) became aware of aflatoxin and its management practices, had a favorable attitude towards it and were willing to try out the management practices to control aflatoxin. Similarly, as a result of interaction with the farmer group, those who were not present for the training learned about aflatoxin through their interaction with the trained farmer group. This exposure enhanced their knowledge, a favorable attitude, and a readiness to adopt aflatoxin management practices. Participants attributed this change to the negative effects of aflatoxin exposure that they were informed about during the training.

Group F1 identified the International Institute of Tropical Agriculture (IITA) staff, extension agents, and their farmer group as key sources of information. They stated, 'We have the All Farmers' Association of Nigeria (AFAN), where we share information among ourselves. We meet monthly.'

Similarly, Group F2 cited IITA and their farmer group as information sources. They mentioned,

> 'In some years past, IITA visited us. They were the ones that allowed us to know about aflatoxin,' and 'IITA called us for a training program,' adding, 'We usually meet to discuss among ourselves. We have an association called AFAN.'

On the other hand, Group F3 reported, 'We have not received any training or information on aflatoxin management,' and 'Extension agents have never been to this location. The Oyo State Agricultural Development Program (OYSADEP) is in Saki, and they do not come to our area.' However, they noted, 'We have not talked with other farmers regarding aflatoxin management practices. Still, we have a good network where we share information among ourselves.'

Participants in Groups F1 and F2 highlighted the communication methods used during training on aflatoxin management as demonstrations and distribution of flyers. These methods significantly increased their awareness of aflatoxin, enhancing both their explicit and tacit knowledge on the subject. Group F2 farmers said, 'We've observed they use BCOS, Oluyole FM, and Gambari. However, once they are off the air, we no longer hear from those stations. It suggests their signals do not reach us.'

They elaborated that they had not received information about aflatoxin through radio broadcasts because the stations' wavelengths were inadequate for their area. They suggested, 'If they had utilized stations like Alaga, Asabari, Gravity, which cover our region,' they would have been able to receive information about aflatoxin management via radio.

The frequency of communication varied among the groups. Group F1 said, 'We were trained 4 years ago (2020),' and noted, 'Each farmer group has their meeting at different times. For instance, Saki West meets on Wednesday, and The Oke Ogun meeting is on the second Tuesday of the month.' Group F2 mentioned, 'We heard from IITA 2 years ago.'

4.1.2 Photovoice findings

The common methods used to manage aflatoxin were documented through photographs taken with an Android phone, shown in Figures 2–6. The main practices identified were the use of Aflasafe and regular weeding.

A participant from the Saki zone (P1) explained that Aflasafe was introduced during IITA training sessions. According to P1, Aflasafe resembles sorghum but contains an active substance that prevents aflatoxin contamination. It is broadcast on the field when crops begin to flower or form pods. After a few days, it produces a mushroom-like growth that spreads across the field and protects the crops.

P1 added that Aflasafe is applied by walking across the field and scattering it by hand. Any area where it lands becomes protected, and only a small quantity is required. Another participant from the Oyo zone (P2) highlighted the importance of weeding and noted that insect damage is often noticed during the second round of weeding.

4.2 Discussion

The research findings revealed that farmers who grow grain legume have different levels of knowledge about aflatoxin and its management, depending on whether they had received training. Those trained by IITA staff showed a strong understanding of aflatoxin and how to manage it, whereas those without training lacked this knowledge. This aligns with previous studies by Ortega-Beltran and Bandyopadhyay (2021), Falade (2019), Michael et al. (2018), and Stepman (2018), who emphasized that awareness is the starting point for successful aflatoxin management. Therefore, creating awareness is crucial for developing knowledge about aflatoxin.

Interestingly, a study by Johnson et al. (2018) reported that all (100%) surveyed farmers in Oyo State were aware of aflatoxin. However, this research finding showed varying levels of awareness among farmers, suggesting that the effectiveness of awareness programs and training can significantly influence farmers' knowledge and ability to manage aflatoxin.

The study also found that the methods used to raise awareness included demonstrations, flyers, and farmer-to-farmer communication. This approach is consistent with previous research by Falade (2019) and Michael et al. (2018), who mentioned demonstrations, mouth-to-mouth communication, and policy briefs as effective ways to disseminate information about aflatoxin. Notably, demonstrations were found to be the most effective communication method, which supports Sundsmo et al. (2015), who highlighted that the most impactful messages present simple and practical solutions.

Moreover, using multiple communication channels positively influenced the knowledge level of grain legume farmers. This is supported by Age et al. (2012) and Sundsmo et al. (2015), who noted that messages conveyed through various channels are more likely to be understood. Combining demonstrations, flyers, and interpersonal communication made information about aflatoxin more effective, enhancing farmers' understanding and awareness. These results align with Diffusion of Innovations theory, which emphasizes the importance of observability and relative advantage. Demonstrations provided farmers with visible proof that Aflasafe and proper drying improved crop quality. In addition, framing aflatoxin communication in economic terms such as loss of income, rejection of grain, or reduced livestock performance was more motivating for farmers than health-based or technical framing. This reflects Framing Theory and shows that message design significantly influences farmers' attitudes.

The findings of this study revealed that communication methods play a crucial role in grain legume farmers' knowledge, attitudes, and practices. This corresponds with Meijer et al. (2015), who stated that communication is pivotal in shaping individuals' knowledge and attitudes. Initially, the farmers were unaware of aflatoxin and the practices needed to manage it. However, after participating in a training session on aflatoxin and its management, their awareness significantly increased. They credited this improvement in their knowledge, attitudes, and practices to the effective communication methods employed during the training. For instance, demonstrations, which served as visual aids, played a crucial role in facilitating this transformation. This aligns with Sundsmo et al. (2015), who emphasized that the most impactful messages provide simple and

FIGURE 2
A 1-kilogram package of Aflasafe, priced at 2500 Naira.

FIGURE 3
A cowpea field ready for Aflasafe treatment.

practical solutions. Additionally, Atser et al. (2023) noted that farmers exposed to agricultural innovations through demonstrations

FIGURE 4
Applying Aflasafe using the broadcasting method on the farm.

FIGURE 5
A cowpea field treated with Aflasafe.

exhibited significantly higher levels of knowledge, attitude, practice, and behavior.

Furthermore, the research provides an evaluation of different communication media, noting that while some methods were highly effective, communication over the radio had a limited impact. This finding is significant for designing more effective communication methods in agricultural extension services, indicating that reliance on radio alone may not be sufficient. This perspective is supported by Falade et al. (2025), who emphasized that communication approaches in agricultural extension should be tailored to the specific context.

FIGURE 6
Aflatoxin prevention good practices: weed-free groundnut farm.

The limited effectiveness of radio also indicates that key media functions were not fulfilled. Farmers did not receive consistent aflatoxin information due to weak signal coverage and lack of localized programming. This contributes to an agenda setting gap, since aflatoxin is not presented as an issue of public importance in rural media spaces.

The farmers' knowledge of aflatoxin and its management significantly influenced their attitudes towards its control and, in turn, their practices. The training program's content was pivotal in driving this change. The findings revealed that the farmers were motivated to implement aflatoxin management practices primarily because they learned about the harmful effects of aflatoxin during the training. However, an interesting finding was that even farmers who lacked knowledge about aflatoxin still had favorable attitudes toward its management, possibly influenced by the discussion with the researchers. This highlights the critical role of explicit knowledge in fostering positive attitudinal changes among farmers. This also suggests that farmers are open to adopting new practices when provided with the right information and support, highlighting the potential for well-structured educational interventions to drive positive changes. The findings further suggest that certain communication characteristics are particularly influential in shaping farmers' behavior. Visual communication, including demonstrations, supported farmers in understanding a toxin that is otherwise invisible. In addition, messages that provided clear, step-by-step guidance on practices such as Aflasafe application, grain drying, and safe storage appeared to promote behavioral uptake more effectively than general or abstract warnings about aflatoxin.

The research findings also showed that grain legume farmers used various management practices to control aflatoxin contamination, from preharvest to postharvest. Preharvest practices included using Aflasafe, thinning, uprooting contaminated crops, and applying chemicals. Some of these practices, such as using Aflasafe and chemicals, align with Falade (2019), who highlighted these as preharvest measures to prevent aflatoxin contamination. Postharvest practices included sun drying, sorting, storing in bags or sealed containers, placing bagged crops on wooden pallets, grading, and using chemicals. These practices also align with Falade (2019), who mentioned similar methods.

Additionally, the results indicated that rainfall plays a significant role in predisposing food crops to aflatoxin contamination. This finding is supported by Achaglinkame et al. (2017), who noted that the timing of crop maturity and harvest at the end of the rainy season can worsen aflatoxin contamination.

Overall, these findings shows that behavior change was strongest when messages were visual, economically framed, locally translated, repeated across interpersonal channels, and delivered by trusted messengers such as fellow farmers. Such insights underscore the central role of communication theory in designing interventions that farmers can understand, trust, and adopt.

5 Conclusion and recommendations

The study concludes that farmers' knowledge of aflatoxin management varied significantly across the zones within the study area based on their exposure to training programs. Despite this variability, farmers generally exhibited a positive attitude towards managing aflatoxin, even among those who lacked awareness of the issue. This positive attitude can be attributed to the discussions held with the researcher during the study, highlighting the critical role of explicit knowledge in fostering attitudinal changes.

Moreover, grain legume farmers have adopted various practices to mitigate aflatoxin contamination. However, the high cost of aflatoxin management substances, such as Aflasafe, remained a significant barrier to widespread adoption. The study also reveals that certain communication methods, including farmer-to-farmer communication, training of trainers (ToT), demonstrations, and distributing informational flyers, have significantly enhanced farmers' knowledge, attitudes, and practices regarding aflatoxin management. Conversely, the use of radio as a communication medium for influencing farmers' knowledge, attitudes, and practices on aflatoxin management had a limited impact, largely due to the inaccessibility of the specific radio stations chosen for disseminating the information to all farmers across the zones.

To address the persistent challenge of aflatoxin contamination in grain legumes, this study highlights the need for coordinated strategies that strengthen farmer knowledge and practice across multiple levels of intervention. Effective management cannot rely on isolated efforts; it requires complementary actions at the micro (farm and household), meso (community and organizational), and macro (policy and national) levels.

At the micro level, interventions should focus on empowering individual farmers and households. Practical training programs are needed to enhance farmers' skills in recognizing and managing aflatoxin risks, while peer-to-peer learning can foster supportive networks for sharing experiences and reinforcing best practices. These efforts can be strengthened through the distribution of simple, accessible educational materials—such as flyers and visual guides—that translate technical recommendations into actionable steps. In addition, improving access to affordable management resources, including biocontrol products like Aflasafe, through subsidies or collective purchasing mechanisms, would lower adoption barriers for smallholder farmers.

At the meso level, community institutions and local organizations are well positioned to reinforce these practices. Interactive workshops and on-farm demonstrations led by extension workers and experts can translate knowledge into practice by offering farmers hands-on experience. Local input retailers, particularly those supplying Aflasafe, can contribute by collaborating on discount schemes or subsidies that make products more accessible. Community-based media outlets, including radio programs, provide an additional channel for sharing success stories, practical tips, and training opportunities, thereby extending outreach beyond direct training sessions. Local radio and community media should adopt message framing that emphasizes practical steps and economic consequences so that aflatoxin remains consistently visible on the community communication agenda.

At the macro level, supportive policies and sustained investment are critical for long-term impact. National frameworks that prioritize research and development can stimulate the creation of affordable, context-specific aflatoxin control methods. Such investments would not only expand the range of available solutions but also ensure their continued relevance to the realities of smallholder farming systems. National communication strategies should also ensure that aflatoxin becomes a consistent part of agricultural and public health discourse so that media outlets perform their surveillance and education functions more effectively.

Taken together, interventions at the micro, meso, and macro levels create a comprehensive framework for aflatoxin management. By working collaboratively across these levels, stakeholders can build a more resilient system that reduces contamination risks, safeguards farmer livelihoods, and promotes safer, more sustainable grain legume production.

Data availability statement

The datasets presented in this study can be found in online repositories. The names of the repository/repositories and accession number(s) can be found in the article/supplementary material.

Ethics statement

The studies involving humans were approved by University of Guelph Research Ethics Board. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

TA: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Software, Validation, Visualization, Writing – original draft, Writing – review & editing. BO: Investigation, Methodology, Writing – review & editing. BA: Investigation, Methodology, Writing – review & editing. AS: Investigation, Methodology, Writing – review & editing. HH: Conceptualization, Supervision, Writing – review & editing.

Funding

The author(s) declared that financial support was not received for this work and/or its publication.

Acknowledgments

I am grateful for the guidance, valuable input, and support provided throughout this research. I also acknowledge the contributions of an international agricultural research institute and the dedicated research assistants who supported the fieldwork. Special thanks go to the grain legume farmers who participated in the study and to the experts on food safety who generously shared their insights.

Conflict of interest

The author(s) declared that this work was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The author(s) declared that Generative AI was not used in the creation of this manuscript.

Any alternative text (alt text) provided alongside figures in this article has been generated by Frontiers with the support of artificial intelligence and reasonable efforts have been made to ensure accuracy, including review by the authors wherever possible. If you identify any issues, please contact us.

Publisher's note

References

Achaglinkame, M. A., Opoku, N., and Amagloh, F. K. (2017). Aflatoxin contamination in cereals and legumes to reconsider usage as complementary food ingredients for Ghanaian infants: a review. *J. Nutr. Intermed. Metab.* 10, 1–7. doi: 10.1016/j.jnim.2017.09.001

Adeloye, K. A., Torimiro, D. O., Omoboyede, D. A., Arowolo, B. D., Adedipe, I. E., and Alao, A. N. (2022). Knowledge, attitude and practice analysis of inclusive extension service among agricultural extension Workers in Southwestern Nigeria. *Contemp. Agricult.* 71, 81–86. doi: 10.2478/contagri-2022-0012

Age, A. I., Obinne, C. P. O., and Demenongu, T. S. (2012). Communication for sustainable rural and agricultural development in Benue state, Nigeria. *Sustain. Agric. Res.* 1:118. doi: 10.5539/sar.v1n1p118

Ajzen, I. (1991). The theory of planned behavior. *Organ. Behav. Hum. Decis. Process.* 50, 179–211. doi: 10.1016/0749-5978(91)90020-T

Ajzen, I., and Fishbein, M. (2000). Attitudes and the attitude-behavior relation: reasoned and automatic processes. *Eur. Rev. Soc. Psychol.* 11:33. doi: 10.1080/14792779943000116

Aluko, O. J., Osikabor, B., Adejumo, A. A., and Sumade, S. (2016). Perceived effect of Boko-haram insurgency on means of accessing cowpea from north-East Nigeria to Bodija market, Ibadan, Oyo state, Nigeria. *OALib* 3:723. doi: 10.4236/oalib.1102723

Asante, I. S., Aidoo, M., Prah, S., Asante, B. O., and Sackey, C. K. (2024). Managing aflatoxin contamination threats in groundnut (*Arachis hypogaea* L.) production in Ghana: the role of adoption of management strategies. *J. Stored Prod. Res.* 107:102335. doi: 10.1016/j.jspr.2024.102335

Atser, G. L., Dixon, A., Ekeleme, F., Hauser, S., Fadairo, O., Adekoya, A., et al. (2023). The effect of communication media on the uptake of agricultural innovations in selected states of Nigeria. *J. Agric. Educ. Extens.* 29, 583–604. doi: 10.1080/1389224X.2022.2120026

Bandyopadhyay, R., Ortega-Beltran, A., Akande, A., Mutegi, C., Atehnkeng, J., Kaptoge, L., et al. (2016). Biological control of aflatoxins in Africa: current status and potential challenges in the face of climate change. *World Mycotoxin J.* 9, 771–790. doi: 10.3920/WMJ2016.2130

Bourdieu, P. (1990). The logic of practice. Stanford, California (Stanford, CA): Stanford University Press.

Cahyono, E. D. (2019). "Participatory communication and extension for indigenous farmers: empowering local Paddy Rice growers in East Java" in eds. Dutta, M. J. and Zapata, D. B. Communicating for social change (Singapore: Springer Nature Singapore), 213–233.

De Ron, A. M. (2015). Grain Legumes. New York: Springer New York.

Effendi, I., Mutolib, A., Listiana, I., Yanfika, H., Rangga, K. K., and Rahmat, A. (2019). Knowledge level of agricultural extension agent and farmers' to response the climate change in Pringsewu Distric, Lampung Province, Indonesia. *Int. J. Multicult. Multirelig. Underst.* 6:423. doi: 10.18415/ijmmu.v6i1.993

Ejem, A. A., Aremu, C., Ajakaiye, O. O. P., Ben-Enukora, C., Akerele-Popoola, O. E., Ibiwoye, T. I., et al. (2023). Perspectives on communicating 21st-century agricultural innovations to Nigerian rural farmers. *J. Agric. Food Res.* 11:100511. doi: 10.1016/j.jafr.2023.100511

Falade, T. (2019). Aflatoxin management strategies in sub-Saharan Africa. In mycotoxins - impact and management strategies. London, United Kingdom: IntechOpen.

Falade, T., Kadjo, D., Ortega-Beltran, A., Atser, G., and Sanni, L. (2025). Knowledge, perceptions and practices regarding aflatoxins and aflatoxin management solutions among women: a perspective from two communities in Nigeria. *Cogent Food Agric.* 11:464. doi: 10.1080/23311932.2025.2460464

FAO (2012). Coming to terms with terminology: Food security, nutrition security, food security and nutrition, food and nutrition security. Available online at: https://www.fao.org/fileadmin/templates/cfs/Docs1112/CFS39Docs/CFS_FSN_Terminology_16_October_2012.pdf (Accessed December 3, 2025).

FAO (2025). The state of food security and nutrition in the world (SOFI). Rome, Italy: Food and Agriculture Organization.

Fasina, O. O., Tehinloju, O. A., Owolabi, K. E., and Adesida, I. E. (2024). Perception of cassava and maize farmers on the effectiveness of agricultural information channels in Southwest, Nigeria. *J. Agric. Ext.* 28, 13–19. Available at: https://aesonnigeria.org/ajm/index.php/jae/article/view/4211/829 (Accessed December 27, 2025).

Hasson, F., Keeney, S., and McKenna, H. (2000). Research guidelines for the Delphi survey technique. *J. Adv. Nurs.* 32, 1008–1015. doi: 10.1046/j.1365-2648.2000.t01-1-01567.x

Hulme, M. (2018). 'Gaps' in climate change knowledge. *Environ. Humanit.* 10, 330–337. doi: 10.1215/22011919-4385599

Hungerford, H. R., and Volk, T. L. (1990). Changing learner behavior through environmental education. *J. Environ. Educ.* 21, 8–21. doi: 10.1080/00958964.1990.10753743

Johnson, A. M., Fulton, J. R., Abdoulaye, T., Ayedun, B., Widmar, N. J. O., Akande, A., et al. (2018). Aflatoxin awareness and Aflasafe adoption potential of Nigerian smallholder maize farmers. *World Mycotoxin J.* 11, 437–446. doi: 10.3920/WMJ2018.2345

Lauzon, A. (2013). From agricultural extension to capacity development: exploring the foundations of an emergent form of practice. *Int. J. Lifelong Educ.* 32, 247–266. doi: 10.1080/02601370.2012.736087

Lelisa, M. A. (2018). Content analysis of media coverage of food safety issues/adulteration: The case of Addis Admas and Addis Zemen newspapers (master's thesis). Addis Ababa, Ethiopia: Addis Ababa University.

Leslie, J. F., Morris, J. B., Gurung, J. K., Harvey, J. J. W., Ayalew, A., Baker, R., et al. (2023). Mycotoxin communications: managing messages for different audiences. *Front. Sustain. Food Syst.* 6:1095256. doi: 10.3389/fsufs.2022.1095256

Liao, X., Nguyen, T. P. L., and Sasaki, N. (2022). Use of the knowledge, attitude, and practice (KAP) model to examine sustainable agriculture in Thailand. *Reg. Sustain.* 3, 41–52. doi: 10.1016/j.regsus.2022.03.005

Lin, X. (2019). Review of knowledge and knowledge management research. *Am. J. Ind. Bus. Manag.* 9, 1753–1760. doi: 10.4236/ajibm.2019.99114

Mahama, S. W., Abudu, J. I., Damwah, A. K., and Arhin, E. T. (2024). Influence of communication on smallholder farmers' adoption of agriculture innovations in Damongo of the Savannah region of Ghana. *Afr. J. Empir. Res.* 5, 1278–1295. doi: 10.51867/ajernet.5.4.105

McCombs, M. E., and Shaw, D. L. (1972). The agenda-setting function of mass media. *Public Opin. Q.* 36, 176–187. doi: 10.1086/267990

Meijer, S. S., Catacutan, D., Ajayi, O. C., Sileshi, G. W., and Nieuwenhuis, M. (2015). The role of knowledge, attitudes and perceptions in the uptake of agricultural and agroforestry innovations among smallholder farmers in sub-Saharan Africa. *Int. J. Agric. Sustain.* 13, 40–54. doi: 10.1080/14735903.2014.912493

Metula, N. T., and Osunkunle, O. O. (2022). A qualitative content analysis of web-based local newspapers' framing of channels for food security in eastern cape, South Africa. *Glob. Media J.* 20, 1–9. doi: 10.36648/1550-7521.20.54.319

Michael, B., Chris, O., Babu, N., Aisha, A., Salisu Sanusi, G., Gaya, S., et al. (2018). Towards a successful management of aflatoxin contamination in legume and cereal farming systems in northern Nigeria: a case study of the groundnut value chain. *Afr. J. Agric. Food Secur.* 6:7. Available at: https://oar.icrisat.org/10914/1/Towards%20a%20successful%20management%20of%20aflatoxin.pdf. (Accessed December 27, 2025).

Msangi, R. S., Mrema, M., Mdoe, N., and Kimanya, M. (2025). Assessment of knowledge, attitudes, and practices of maize farmers following post-intervention aflatoxin mitigation programs in Tanzania. *Food Safety Pack.* 1, 187–207. doi: 10.30466/fsp.2025.56686.1020

Muleme, J., Kankya, C., Ssempebwa, J. C., Mazeri, S., and Muwonge, A. (2017). A framework for integrating qualitative and quantitative data in knowledge, attitude, and practice studies: a case study of pesticide usage in eastern Uganda. *Front. Public Health* 5:318. doi: 10.3389/fpubh.2017.00318

Odjo, S., Alakonya, A. E., Rosales-Nolasco, A., Molina, A. L., Muñoz, C., and Palacios-Rojas, N. (2022). Occurrence and postharvest strategies to help mitigate aflatoxins and fumonisins in maize and their co-exposure to consumers in Mexico and Central America. *Food Control* 138:108968. doi: 10.1016/j.foodcont.2022.108968

Okoli, C., and Pawlowski, S. D. (2004). The delphi method as a research tool: an example, design considerations and applications. *Inf. Manag.* 42, 15–29. doi: 10.1016/j.im.2003.11.002

Ortega-Beltran, A., and Bandyopadhyay, R. (2021). Contributions of integrated aflatoxin management strategies to achieve the sustainable development goals in various African countries. *Glob. Food Secur.* 30:100559. doi: 10.1016/j.gfs.2021.100559

Otene, V. A., Okwu, J. O., and Gwaza, S. S. (2015). Barriers to the use of radio as a channel of agricultural information by farmers in Ushongo local government area of Benue state, Nigeria. *J. Agric. Food Inf.* 16, 326–336. doi: 10.1080/10496505.2015.1074077

PACA 2015. Aflatoxin impacts and potential solutions in agriculture, trade, and health: An introduction to aflatoxin impacts in Africa. United Nations. Available online at: https://www.un.org/esa/ffd/wp-content/uploads/sites/2/2015/10/PACA_aflatoxin-impacts-paper1.pdf (Accessed May 15, 2024).

Razu, S. R., Nishu, N. A., Rabbi, M. F., Talukder, A., and Ward, P. R. (2021). Knowledge, attitudes, and practices concerning COVID-19 in Bangladesh: a qualitative study of patients with chronic illnesses. *Front. Public Health* 9:628623. doi: 10.3389/fpubh.2021.628623

Rogers, E. M. (2003). Diffusion of innovations. 5th Edn. New York, NY, USA: Free Press.

Stepman, F. (2018). Scaling-up the impact of aflatoxin research in Africa. The role of social sciences. *Toxins* 10:136. doi: 10.3390/toxins10040136

Sundsmo, A., Gwinner, V., Nelson, F., Othieno, O., and Manyong, V. (2015) Five-year communication strategy for an aflatoxin safe east African community. Arusha, Tanzania: East African Community (EAC) Secretariat.

Tiernan, J., Cook, A., Geh, I., George, B., Magill, L., Northover, J., et al. (2014). Use of a modified Delphi approach to develop research priorities for the Association of Coloproctology of Great Britain and Ireland. *Color. Dis.* 16, 965–970. doi: 10.1111/codi.12790

Udomkun, P., Wiredu, A. N., Nagle, M., Bandyopadhyay, R., Müller, J., and Vanlauwe, B. (2017). Mycotoxins in sub-Saharan Africa: present situation, socio-economic impact, awareness, and outlook. *Food Control* 72, 110–122. doi: 10.1016/j.foodcont.2016.07.039

Vanlauwe, B., Hungria, M., Kanampiu, F., and Giller, K. E. (2019). The role of legumes in the sustainable intensification of African smallholder agriculture: lessons learnt and challenges for the future. *Agric. Ecosyst. Environ.* 284:106583. doi: 10.1016/j.agee.2019.106583

Vargas-Sánchez, A., Plaza-Mejía, M. Á., and Porras-Bueno, N. (2016). "Attitude" in Encyclopedia of tourism. (Cham, Switzerland: Springer International Publishing), 58–62.

World Health Organization (2021) Knowledge, attitudes, and practices (KAP) surveys during cholera vaccination campaigns: Guidance for Oral cholera vaccine stockpile campaigns. Geneva, Switzerland: World Health Organization (WHO).

Yekinni, O. T., and Afolabi, C. O. (2019). Farmers' assessment of the effectiveness of extension communication methods used in Ogbomoso agricultural zone of Oyo-state, Nigeria. *J. Agric. Ext.* 23:126. doi: 10.4314/jae.v23i3.11

Zondo, W. N. S., and Ndoro, J. T. (2023). Attributes of diffusion of innovation's influence on smallholder farmers' social media adoption in Mpumalanga Province, South Africa. *Sustainability* 15:4017. doi: 10.3390/su15054017