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Traditional knowledge on post-harvest practices used by maize farmers against infestation by maize weevils *Sitophilus zeamais* and *Prostephanus truncatus* in Arumeru district, Tanzania

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Abstract

Introduction: Maize (*Zea mays* L.) is a crucial staple crop in Tanzania and Africa. However, post-harvest losses of maize grains due to insect pests, particularly *Sitophilus zeamais* and *Prostephanus truncatus,* pose significant economic challenges. Traditional knowledge and practices among farmers play a pivotal role in mitigating these losses. The present study explored the conventional understanding of post-harvest practices used by maize farmers against infestation by maize weevils in the Arumeru district, Tanzania.

Methods: A qualitative cross-sectional study was conducted in Ngongongare village, Arumeru district, in the Arusha region of Tanzania. Key informants participated in in-depth interviews and focus group discussions. Data were collected using interview schedules, observation checklists, and focused group discussion guides. Pesticidal plants used by the community were taxonomically identified.

Results: 53 participants were interviewed, with the majority (47.2%) aged 18-35 years, and 54.7% were female. Participants demonstrated knowledge of common post-harvest insect pests of maize, which severely affect maize quality. Traditional methods for maize storage, such as hanging cobs and using traditional silos (kihenge), were commonly practiced. Indigenous pesticidal plants, animal by-products, and mineral dust were used for pest control. Participants highlighted the effectiveness of traditional methods compared to synthetic pesticides, which were perceived as less efficient, expensive, and associated with health risks.

Conclusion: Traditional maize storage practices were preferred due to their accessibility, cost-effectiveness, and perceived safety. Variability in herbal preparations' efficacy and modernization's impact on traditional practices were highlighted. The study underscores the importance of documenting and validating indigenous knowledge to enhance food security strategies, particularly in protecting maize grains against storage pests. Strengthening local capacities in pest management through scientific validation and community involvement is crucial for minimizing postharvest losses, sustainable agricultural development, and food security in Tanzania.

Keywords: Traditional knowledge, maize farmers, maize weevils. *Sitophilus zeamais, Prostephanus truncatus*, Arumeru, Tanzania

Introduction

Maize (*Zea mais, L.*) is the most important cereal crop in the world after wheat and rice (Negasa *et al.*, 2021). Insect pest damage to the field and stored maize grains results in major economic losses

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in Tanzania and other African countries, whereby subsistence grain production supports the livelihoods of most of the population (Makundi, 2006). For resource-poor farmers living at or near subsistence, losses of grains due to destruction by pests have profound negative implications for household food security (Negasa *et al.*, 2021). Insect infestation of maize grains is responsible for the reduction in both the quality and quantity of harvested crops and, in most cases, predisposes the infested grains to secondary attack by disease-causing pathogens (Anderson *et al.*, 1975; Markham *et al.*, 1994; Beti *et al.*, 1995).

Post-harvest losses due to storage insect pests, mainly the maize weevil, *Sitophilus zeamais* and larger grain borer, *Prostephanus truncatus* have been recognized as an increasingly important problem in Tanzania (Swai, 2019). Approximately 35% of stored maize grains in Tanzania are damaged by storage pests, the most common being *Sitophilus zeamais* and *Prostephanus truncatus* (Makundi, 2006). Infestation of maize by insect pests commences in the field, but most damage occurs during storage. Damaged grains have reduced nutritional values, low percent germination, reduced weight, and low market values, respectively (Beti *et al.*, 1995; Makundi, 2006).

Farmers in different parts of Tanzania have been using traditional ways of preserving their maize grains for a long time, including using locally available pesticidal plants. Some conventional pest control using pesticidal plants have been reported to have comparative effectiveness to synthetic pesticides and are cheap, easy, and locally available (Bekele *et al.*, 2001; Makundi, 2006). The traditional use of pesticidal plants to control stored maize grains is much more accepted by local communities (Makundi, 2006). Knowledge of the pesticidal properties of plants has been known and practiced by farmers since ancient times. The insecticidal effects of plant extracts such as rotenone from *Derris* spp., *Lonchocarpus* spp., *Tephrosia* spp., nicotine from *Nicotiana tabacum* and *Duboisia hopwoodii* and pyrethrin from *Chrysanthemum cinerariifolium* have been commonly used in pest control since the first half of the 19th century (Berger, 1994).

The success story of the pyrethroids in controlling insect pests indicated the great potential of plant-derived substances and has revitalized research interest in plants that contain chemical compounds with pesticidal properties. On this realization, there is a need to document traditional post-harvest knowledge and practices used by farmers to protect field-stored crops against infestation by pests. We conceived and carried out this investigation to document traditional post-harvest understanding and practices in the protection and minimization of postharvest losses in stored maize grains due to *Sitophilus zeamais* and *Prostephanus truncatus* by community members in the Arumeru district in Tanzania.

Methods

Study Area

The study was conducted at Ngongongare village in Arumeru district in Arusha Region, Tanzania (Figure 1). It is bordered to the north, west, and southwest by Monduli District, to the southeast by Arusha District, and the east by the Kilimanjaro Region. Ngongongare village is a high rainfall sub-humid site in Arumeru district. Maize is the dominant crop cultivated in Arumeru district. The rainfall pattern is bimodal, with long rains from March to May and short rains from November to December. Residents of Ngongongare village are subsistence farmers and pastoralists. They grow mainly maize, legumes, and leafy vegetables. They also keep domestic animals, such as cattle, goats, sheep, and poultry. Most of their houses have earthen and burnt-brick walls with corrugated iron sheets and are thatched with grass or banana leaves on roofs. The dominant Ethnic group is the Meru tribe. Other tribes residing in this village include the Maasai, Pare, and Chagga.

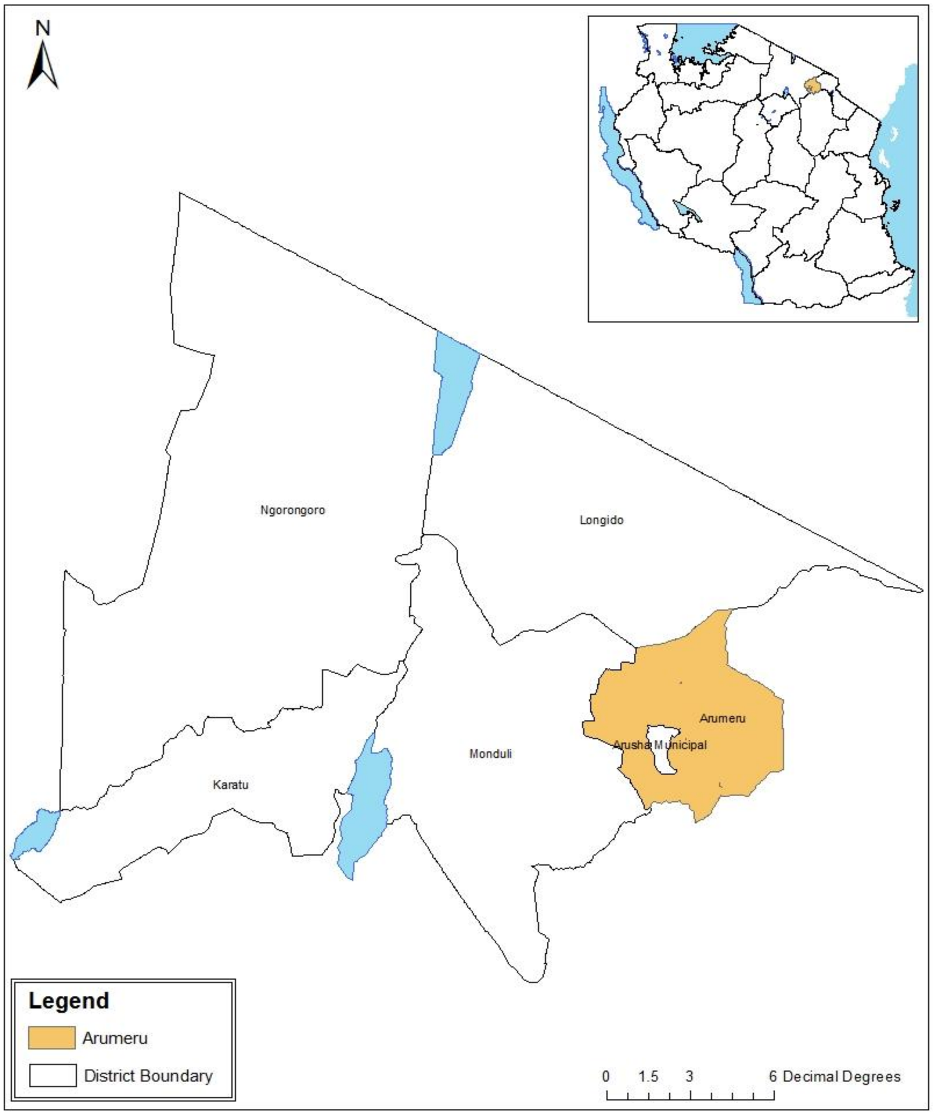

Figure1: Map of Arusha region showing Arumeru district

Study Design

This was a cross-sectional survey design conducted in 2013 that employed qualitative and observational data collection and analysis. Key informants constituted the study sample of respondents of mixture of females and males in four randomly selected hamlets of Ngongongare village in Arumeru district in Tanzania. The district was purposively selected due to its high maize production in the Arusha region. Data collection using interview guides, observation checklists and focus group discussion guides allowed the final triangulation of data obtained in terms of analysis and results from the mixed methods.

Data collection methods and tools

The team involved the ward and Village Executive Officers (VEOs) for the smooth execution of the study. A questionnaire guiding in-depth interviews (IDIs) and focused group discussions (FGDs) were prepared to collect information on respondent's farming experience. In particular, the questionnaire was intended to collect the following information: (a) problems faced by farmers in their village as regards the storage pests of maize, (b) common types of pests affecting stored maize, (c) features which indicate pests have destroyed maize, (d) efforts made by farmers in the village to protect stored maize from pest attack and as well as (e) traditional methods used to control maize pests. The questionnaire was administered to farmers in their area and/or residence.

Qualitative data were collected through various techniques, namely, FGDs and IDIs, using special guides and participant observation. The IDI and FGD guides had separate but related themes and subthemes aimed at collecting the necessary experiences and suggestions from the participants regarding stored maize pests and the availability, reliability, safety and efficacy of traditionally stored maize protectants in the study area. In-depth Interview (IDI) and Group Discussions (GD) transcripts were identified after each quote. Quotations in double inverted commas and italics are translations of informants' speech, either quoted in field notes or recorded in GD. Non-English italics are Swahili, the local language. Respondent codes are anonymized; 'f' or 'm' denotes gender, whereas f- denotes female and m -male.

Collection and identification of pesticidal plants

Information on pesticidal plants from IDI was validated during FGDs. Farmers collected samples of pesticidal plants, which a qualified plant taxonomist, taxonomically identified. Voucher specimens were authenticated at the herbarium in the Botany Department at the University of Dar es Salaam in Tanzania.

Data management and analysis

All the qualitative data collected from the IDIs and FGDs were recorded, transcribed and translated from Swahili into English. Two independent researchers reviewed each transcript to validate the accuracy of the translation and transcription. Identifiable personal information was removed to ensure participant anonymity. The data were analyzed based on themes. The transcripts were coded by themes related to traditional maize storage methods, common pests, and pesticidal plant usage. The codes were grouped into broad categories that reflect the main topics of interest, such as traditional knowledge and modern and traditional pest control methods. Quotes from study participants were used to highlight key findings and identify patterns and insights from the narratives shared by the participants. Quantitative data from observational checklists and respondent interviews regarding the pesticidal plants used and common maize grain pests in their area were summarized into tables.

Ethical considerations

Ethical approval for the present study was obtained from Tanzania's National Health Research Ethics Committee (NatHREC). The local authorities granted permission to conduct research in Ngongongare village. Study participants were fully informed of the purpose and obtained written consent. They were assured of their right to withdraw at any time without penalty. Privacy and confidentiality were safeguarded. Individuals' Indigenous knowledge regarding pesticidal plants and traditional methods was documented with acknowledgment.

Results

Participants in socio-demographic characteristics

A total of 53 study participants were interviewed. Table 1 presents the socio-demographic characteristics of the study participants. Most participants were aged 18-35. Fifty-four percent were female participants. Most of the study participants had a primary education level and were married.

Table 1 Participants in socio-demographic characteristics

Characteristics	Total (N=53)
Age	n (%)
18-35	25 (47.2)
36-50	23 (43.4)
50+	5 (9.4)
Sex	
Female	29 (54.7)
Male	24 (45.3)
Education Level	
No formal education	2 (3.8)
Primary education	43 (81.1)
Secondary education	7 (13.2)
Tertiary and higher education	3 (5.7)
Marital Status	
Single	9 (17.0)
Married	42 (79.2)
Divorced	1 (1.9)
Widow/Widower	1 (1.9)

Common maize pests

The findings have revealed that participants understand the most common types of post-harvest insect pests of maize grains in their area. Among the mentioned insect pests include the larger grain borer locally known as *dumuzi* or *scania; Prostephanus truncatus* (Coleoptera: Bostrichidae), the maize weevil; *Sitophilus spp* (Coleoptera: Curculionidae) and flour beetles (*Tribolium castaneum* and *Tribolium confusum*) (Coleoptera: Tenebrionidae). The participants were able to describe the morphology of the common insect pests. The *Sitophilus zeamais* was described as an insect with a black colour and a tiny head, called "*Kiseso*" in the local language. The *Tribolium castaneum* was described as an insect with a red colour and a big head, locally called "*Scania*" in the local language. *Sitophilus zeamais* and *Tribolium castaneum* destroy maize largely by feeding on the kernel, resulting in poor quality of the maize floor, as narrated by one participant.

> *"Insects with black in colour and tiny heads start feeding on maize even before harvesting; if you get a maize cob, you find the pest. Once the maize is harvested, Scania feeds on it in the sack and grinds them into flour"* IDI-18-A-m.

It was further added by one participant that.

> "*Insects with black in colour and tiny heads are very destructive within three months destroy the whole plantation no matter how large it is or if there are any remains, then the maize will not be fit for human consumption*" FGD-3-Y-m.

And another participant narrated that.

> *"The remains are just like dust, not fit to be taken to millers to be ground to get maize flour or to be sown as seeds"* FGD-5-Y-m.

Traditional knowledge and methods of protecting stored maize

Farmers in Ngongongare village were found to practice traditional and modern postharvest maize storage methods. Key informants mentioned two traditional methods commonly used in the town.

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In the conventional method, maize grains are left within the cob, hung on a roof, or put on a rack outside the house. The storage was found to vary, as some households stored above fireplaces; others were hanging in tree racks or stored in an elevated thatch house mainly for grain storage. In the second method, maize grains were observed stored in a traditional silo called *kihenge*. *Kihenge* is constructed from *Allanblackia stuhlmannii* (*Msambu*) tree and sealed with fresh cow dungs. *Msambu* tree sticks have high bending flexibility and do not break easily. *Kihenge* is usually a round and large chamber with a lid that can store up to ten bags of maize (approximately 1,000 kgs). Modern methods included storing threshed maize grain in woven fibre or poly sacks and an air-tight plastic drum. One female participant stated the proper use of containers in grain storage; she narrated that.

> "*We use containers or barrels with tight lids to ensure the pests do not get air. If the containers or barrels are dry, well covered and not opened often, the maize grains will not be destroyed. The storage containers must be dry and properly covered to prevent maize from being destroyed by the maize weevils"* (IDI-18-A-f).

Another participant added,

> *"Some people store the maize in airtight jerry cans, which suffocates the pests; hence, they can't infest the maize. Maize stored in this manner is free from chemicals. Some people use ash, which is also chemical-free. The ash is put into a jerry can with a lid. If chemicals are used, they can be fed upon when the maize has not been handled well before being used or processed for human consumption. Such maize could endanger human health. The traditional ways are safer". (FGD*-7-Y-f)

During FGD with a young female, one participant pointed out her opinion as she added that.

> *"In my opinion, the best method is the one of storing the maize in an airtight container to suffocate the pests; hence, they won't survive to attack the maize, though people have to be educated on this as most people are not aware of the traditional ways." (FGD*-7-Y-f)

Key informants' interview findings have revealed the existence of indigenous knowledge of pesticidal products commonly used by maize farmers in the community. Respondents identified three types of products in everyday use in their community: pesticide plants, animal by-products, and mineral dust. A total of 14 kinds of pesticidal plants were used against stored maize pests in Ngongongare village, as shown in Table 2. Others mentioned included rice husks and powdered red maize cobs.

Table 2: List of pesticidal plants used in the protection of stored maize grain

Pesticidal plant Vernacular name (local) and Kiswahili names	Scientific name	Part used
Ipapaa	*Aloe vera*	Leaves
Muarobaini	*Azadirachta indica*	Leaves
Mangunn'u	*Chenopodium alba*	leaves
Malumba	*Chenopodium opulifolium*	Leaves
Mkaratusi	*Eucalyptus* spp	Leaves
Mahindi	*Zea mais*	Cob
Mpunga	*Oryza sativa*	Husk
Mabangi	*Tagetes minuta*	Leaves

Alizeti pori	*Tithonia somnifera*	Leaves
Ensindii	*Ocimum kilimandischaricum*	Leaves
Msindano	*Pinus patula*	Leaves
Nsingo	*Cupressus lusitanica*	Leaves
Pilipili	*Capsicum frutescens*	Fruits
Katani	*Agave sisalana*	Leaves

Respondents also identified animal by-products, mainly cow's urine and dung, which were used to control storage pests. Others hang maize cobs on a tree during the dry season. Spreading the maize on a mat and exposing the grains to sunlight or smoke eliminates the pests. The grains exposed to smoke were mentioned to be effective as the grains don't get destroyed. The two most frequently used types of mineral dust in Ngongongare village are plant ashes and inert earth from powdered burnt mud bricks, as narrated by one participant.

> *"I have seen people storing maize in large quantities by grinding burnt laid bricks and putting the grounded brick into the maize to prevent the maize from being spoilt"*. (FGD-6-Y-f)

During FGD, participants reflected a strong belief in the power of traditional knowledge and practices in maize storage within the community. It highlights the reliance on individuals perceived to have specialized skills or a unique ability to protect stored maize from pests. This person is entrusted with the responsibility of safeguarding the maize because of the community's belief that, under their care, the maize will not be destroyed by pests. This underscores the role of trust and indigenous expertise in local food security practices, where specific individuals can prevent post-harvest losses through traditional, perhaps even spiritual, protection methods. Such practices could be key to understanding the intersection between cultural beliefs and practical pest management strategies in rural settings. This was revealed by one of the participants during the discussion, as narrated below;

> *"At home, the maize is stored in a warehouse by a person we perceive that once he/she stores the maize, it won't be attacked by pests. Once such a person does the storage, the maize is not destroyed". (FGD-4-Y-f)*

The most familiar source of ashes was mentioned to be the rice husks, red maize cobs and sometimes the general firewood ashes. Most of these products were used singly or in combination in different ratios. However, the formulation ratios differed depending on the consideration of the farmer and the availability of enough amounts for the preparation, considering crop/ crop product treated, preparation times, modes and rates of application. Table 3 summarizes the pesticidal preparations used by farmers in Ngongongare village.

Table 3: Pesticidal plants and products used to protect stored maize grain in Ngongongare village, Arumeru.

Local name	Scientific name	Preparation and Uses
Alizeti pori (Swahili)	*Tithonia somnifera*	Dried leaves mixed with grain during storage
Mabangii (Meru)	*Tagetes minuta*	Dried leaves mixed with grain during storage
Msindano (Maasai-Olpaina)	*Pinus patula*	Dried leaves mixed with grain during storage

Mangunn'u (Meru) Engasiijoi (Maasai)	*Chenopodium alba*	Dried leaves mixed with grain during storage
Malumba (Kiswahili)	*Chenopodium opulifolium*	The whole shrub is collected and soaked in water for a given time, followed by decantation. The clear solution obtained is then sprayed onto maize grains and allowed to dry before being stored.
Cyprus (Maasai-Oltarakwai) Mierenzi (Swahili)	*Cupressus lusitanica*	One *Sadolin (volume of 5L) of Christmas/Cyprus tree Leaves is mixed with a sack of maize. This is effective* as it kills the pest insects.
Mkaratusi (Swahili)	Eucalyptus spp (Myrtaceae)	Dried leaves are mixed with a sack of maize. Effective as it kills the pest insects.
Storage using bricks' powder	-	Maize grains are mixed with brick powder and stored.
Ipapaa (Meru)	Aloe spp (Asphodelaceae),	Ipapaa is made by grinding Aloe vera and drying it in the sun. It doesn't smell, but it is bitter. Maize has to be washed before use. It is very effective, as it is used once a year.
Neem tree leaves	*Azadirachta indica*	The seeds or leaves of neem are ground and soaked in a litre of water for one day. Thereafter, the mixture is filtered. The filtrate is applied by spraying on the maize. In most cases this formulation is intended for maize and/ or rice. Maize storage: used every after 3 months and a half.
Sisal	*Agave sisalana*	The stem of sisal is burnt, and the ash is mixed with maize. Sometimes, pieces of sisal leaves are sun-dried to reduce dampness and maintain quality, and then burnt to obtain the ashes.
Red pepper powder	*Capsicum* spp (Solanaceae),	Use of red pepper powder by mixing with maize grains.

The present study has found that farmers in the village setting are trying to protect maize from pest attacks during storage in the field and households. These include general ashes, fresh and dry cattle dung, *Tagetes minuta* leaves, *Tithonia somnifera* (wild sunflower) and *Eucalyptus* species. A mixture of ashes with water was reported to be used in the maize at the farm as a natural pesticide to destroy caterpillars. An adult male participant stated that;

> *"Ash mixed with water, then the mixture can be sprayed on maize grains to control pests" (IDI-01-A-m).*

These traditional methods have been employed due to the lack of efficient and effective synthetic pesticides. An adult male stated that;

> *"Back in the 1980s, we used to get a powerful pesticide which was a white powder, but it is no longer available these days"* (IDI-01-A-m).

The white pesticidal powder referred to by the respondent is the dichloro-diphenyl-trichloroethane (DDT), which was once developed as the first of the modern synthetic insecticides in the 1940s. The production and use of DDT have been banned since the Stockholm Convention went into force in 2004. But instead, the traditional pesticides are readily available in the village, as narrated by one participant that;

> *"Ipapaa [Aloe] is plenty enough for use by the whole village"* (IDI-05-A-f).

Ipapaa belongs to the genus *Aloe*. There are many methods which farmers use when they store maize. Most participants reported the following being the most appropriate traditional methods. These include Cyprus (Mwerezi), whereby maize grains mixed with fresh leaves can be stored for a year despite no specific measures on the amount of Cyprus fresh leaves, the use of air-tight containers or barrels, and the use of powdered burnt mud brick to mix with maize. The use of traditional knowledge and the transfer of that knowledge regarding pesticidal plants such as pines and neem were pointed out by several participants that;

> *"Branches of the Christmas tree [Pines] are also broken down and dried, then mixed with maize. My mother used to do this. Then, you can store the maize in a bag, bucket, barrel or elsewhere. Pests won't attack the maize even if the vessel is not covered. When you need to use the maize, you wash them with water; the branch pieces float and are removed. We do this at home". (FGD-4-A-f)*

The use of medicinal plants such as neem was also mentioned by several participants as pointed out by this participant that;

> *"The Neem tree is what people currently prefer. People use neem tree leaves; they dry and grind them, then mix the powder with maize, which acts as a pesticide. The other method uses local leaves, which I can't recall the Kiswahili name; the leaves were used back then. The leaves were mixed with the maize cob during storage. These are the main methods in addition to the modern ones". (FGD-6-Y-m)*

The use of Morden Pesticides

The use of synthetic pesticides has also been reported. Among them is Actellic super, a broad-spectrum insecticidal dust used to control stored maize and other cereal pests, including the control of larger grain borer. Actellic super has fumigant, stomach and contact activity against insect pests. Farmers have already recognized that such pesticides protect stored maize for a maximum of 3 months, and after that, infestations of maize weevils and larger grain borers resume. This makes synthetic pesticides more expensive due to the need for repeated applications, as supported by one male youth who stated that,

> *"Synthetic pesticides are less efficient and of low quality" (IDI-05-Y-m).*

Participants also reported the perceived associated adverse health effects as narrated by another participant.

> "*My grandfather used synthetic pesticides for a long time; he suffered and died from lung cancer"* (IDI-01-A-m).

Another man added,

> "*People suffer from toxic effects of pesticides as they don't use them following instructions for use such as adhering to the times of when the pesticide should be applied and washing it off well before eating anything*)" (IDI-14-A-m).

Perceived prolonged health problems and frequent pesticidal failures exemplified by maize weevils' infestation of treated maize have made people think of alternatives, a woman explained.

> "*I use burnt mud bricks powder to store the maize because when I eat maize which synthetic pesticides have stored, I suffer from severe stomach pain*" IDI-03-A-f).

Discussion

Common Maize Pests

The findings highlight the significant challenges faced by farmers in Ngongongare village regarding postharvest protection of stored maize, primarily due to pest infestations. The most prevalent pests identified by the farmers include the larger grain borer (*Prostephanus truncatus*), commonly known locally as "dumuzi" or "scania," the maize weevil (*Sitophilus spp*), and flour beetles (*Tribolium castaneum* and *Tribolium confusum*). Similar studies conducted in Tanzania and elsewhere have also reported challenges in the control of common maize weevils (Abass *et al.*, 2017; Swai, 2019; Negasa *et al.*, 2021). These pests are notorious for causing substantial post-harvest losses, thereby threatening food security and the economic well-being of the community. Their persistence and prevalence necessitate an effective and sustainable approach to improving maize storage and pest control.

Traditional Knowledge and Methods of Protecting Stored Maize

Farmers in Ngongongare have developed a range of traditional methods for maize storage, demonstrating the community's deep-rooted indigenous knowledge, which needs to be documented and improved to prevent weevils' and larger grain borer infestations. These methods vary significantly, reflecting the local ecological conditions and cultural practices. One of the traditional storage methods involves leaving maize on the cob and hanging it on the roof or on a rack outside the house. This method is further diversified by storing maize above fireplaces, in tree racks, or elevated thatch houses specifically designed for grain storage. These practices highlight the community's adaptive strategies to minimize pest infestations by utilizing smoke and elevation to protect the grains. The importance of improving farmers' practices has been documented by a previous study conducted in Benin (Samba *et al.*, 2022).

Another traditional storage method is the use of a conventional silo called *kihenge*, constructed from the *Allanblackia stuhlmannii* tree and sealed with fresh cow dung. The structural integrity of *kihenge* and its large storage capacity (up to ten bags of maize) make it a vital resource in preventing pest infestations. The use of cow dung as a sealing material not only provides a physical barrier but may also have pesticide properties due to bioactive compounds. Cow dungs are used as manure to improve crops (Prasad and Kothari, 2022). This practice also calls for further research to ensure food safety and security.

Modern Storage Methods

Modern methods of maize storage observed in the village include woven fibre or poly sacks and air-tight plastic drums (hermetic containers). These methods minimize air exposure, critical in controlling pests like maize weevils. Participants emphasized the effectiveness of air-tight containers and noted that proper use—ensuring dryness, covering, and minimizing frequent openings—can significantly reduce pest infestations. However, modern methods are not without challenges, including the cost and availability of these materials. The makes the maize farmers community to use alternative methods which are accessible in their community (Abass *et al.*, 2017; Swai, 2019; Negasa *et al.*, 2021; Prasad and Kothari, 2022; Samba *et al.*, 2022).

Indigenous Knowledge of Pesticidal Products

The study reveals a rich repository of indigenous knowledge among the Ngongongare villagers regarding pesticidal products derived from plants, animal by-products, and minerals. Fourteen types of plants are utilized against stored maize pests, with various parts such as leaves, fruits, and husks being employed. Notable examples include *Aloe vera* (Ipapaa), *Azadirachta indica* (Muarobaini), and *Tagetes minuta* (Mabangii) (Karunamoorthi, Ilango and Endale, 2009). Other studies have reported similar findings (Mihale *et al., 2009; Guruprasad et al.*, 2013).

Previous studies have listed products for protecting stored maize grain and provided scientific evidence of their effectiveness and safety for human health. The listed pesticidal plants were previously tested and found effective in repelling and/or killing adult maize weevils and larger grain borers (Adhikary, 1981; Omotoso & Oso, 2005). These plants are either mixed with grains during storage or processed into formulations sprayed onto the maize grains.

Another study reported that, various parts exhibited mortality action against maize and bean weevils (Ogunsina et al*.,* 2011). Using such plants provides a sustainable alternative to synthetic pesticides and leverages locally available resources, ensuring accessibility and affordability. Animal by-products like cow urine and dung are also employed, reflecting the community's resourcefulness in utilizing all available materials. Applying cow dung in sealing *kihenge* or spreading ashes derived from rice husks and burnt mud bricks demonstrates a holistic approach to pest control, integrating various natural resources.

Perceptions and Challenges of Synthetic Pesticides

Despite the availability of synthetic pesticides such as Actellic Super, farmers expressed significant reservations about their use. The perceived inefficiency and low quality of these pesticides and the need for repeated applications make them an unattractive option for many. Furthermore, the reported adverse health effects, including severe stomach pain and lung cancer, have led to a growing distrust of synthetic pesticides. The experiences of farmers who have suffered health issues, such as stomach discomfort and pains after consuming maize treated with synthetic pesticides, reinforce the community's preference for traditional methods. The findings also suggest that the ineffectiveness of synthetic pesticides has led to an increased reliance on traditional techniques and indigenous knowledge. The repeated infestations, even after applying synthetic pesticides, have prompted farmers to seek alternative solutions, such as using burnt mud bricks powder, which they perceive as safer and more effective against postharvest maize pests.

Limitations of the study

The study was conducted in one village setting; therefore, the findings can limit the representation to other village settings. Although farmers use various pest control measures in the field and against storage insect pests, their determinations were hampered by a lack of precise estimates of the application dosages and efficacies of their homemade formulations.

Conclusion

The study has revealed the importance of integrating traditional knowledge with modern agricultural practices to develop sustainable pest control strategies. The reliance on indigenous methods in Ngongongare village reflects a deep cultural heritage and a practical response to the limitations of synthetic pesticides. As the challenges of pest infestations and post-harvest losses persist, there is a critical need for further research and support to enhance the efficacy of traditional methods and explore the potential for combining them with modern technologies. This approach could offer a more sustainable and health-conscious solution to maize storage and pest control in the community and beyond.

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