



Influence of Indigenous Post-Harvest Handling Practices on Storage Fungal Contamination of Common Bean (*Phaseolus vulgaris* L.) in Cameroon

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Abstract

Common bean (*Phaseolus vulgaris* L.) represents a staple legume crop in many tropical and subtropical regions typically Cameroon, serving as a major source of protein, income, and food security for rural households. In Cameroon, Common bean is usually stored by most farmers after harvest as a source of food and for sale. From the stored bean, the surplus from that meant for food is sold by some small-holder farmers to earn income. However, post-harvest losses due to storage fungi significantly compromise grain quality and safety. Traditional post-harvest practices; including manual harvesting, inadequate drying, and low-level storage structures create conditions favorable for fungal infection and proliferation. This review examines how prevailing indigenous post-harvest practices in Cameroon contribute to common bean infection by storage fungi. Evidence from studies carried out in Cameroon indicates that incidence of fungal infection increases substantially during storage and involves genera such as *Aspergillus*, *Penicillium*, *Fusarium*, and *Xylaria* spp. Poor drying, exposure to moisture and pests, and insufficient storage hygiene exacerbate these infections. Improved drying methods, sanitation, hermetic storage technologies, and farmer education are discussed as strategies to reduce fungal contamination and associated mycotoxin risks. The review underscores the need for targeted farmer education, accessible storage technologies, and contextualized extension services to reduce post-harvest fungal losses in common bean production systems. Strengthening post-harvest management practices is essential for reducing fungal contamination, improving food safety, and enhancing the overall value chain of common beans in Cameroon. It is paramount that effective common bean fungal management strategies be implemented by farmers.

Key words – Cameroon – Common bean – mycotoxins – post-harvest practices – storage fungi

Introduction

Common bean (*Phaseolus vulgaris* L.) is one of the most widely consumed legumes globally. It is the most widely grown staple food crop in Africa (Beebe et al. 2013). It plays a key role in

food security, especially in sub-Saharan Africa, Latin America, and parts of Asia, where it contributes to protein intake and income for smallholder households (Akwa et al. 2020). Common bean is among the most important legumes in Cameroon's agricultural systems, particularly in highland and rainforest agro-ecologies where smallholder farmers rely on beans for food and income. Due to its relatively short growing cycle and adaptability, common bean is an important crop for poverty alleviation. It plays a central role in the diets and livelihoods of rural and urban populations in Cameroon (Kamtchoum et al. 2018). This is probably because it is suited to wide variety of agro ecological zones and can be grown in quantities enough to last through the off growing season after harvest. It is used to make bean cake which is a staple food consumed by nearly all the communities in Cameroon. In Cameroon, some farmers grow more common beans than they need for personal consumption. The excess is stored and sold when market prices are favorable, providing essential income for resource-limited rural farmers. The condition of the beans at sale depends on both their state before storage and the quality of the storage facility. Over time, beans can deteriorate during drying and storage, particularly if rodents or other pests access insecure storage structures.

Post-harvest management of beans which is a necessity is often constrained by traditional practices that inadvertently encourage fungal infestation during storage leading to losses. Post-harvest losses along the value chain substantially reduce the quantity and quality of beans available for consumption and sale. Among these losses, fungal infection during storage stands out as particularly damaging, often resulting in extensive spoilage, discoloured grains, off-flavours, and potential contamination with hazardous mycotoxins.

In many traditional farming systems, beans are dried and stored using low-tech or indigenous methods that were developed under conditions of limited resources. While these methods have served communities for decades, several aspects of traditional post-harvest management inadvertently create environments conducive to fungal growth. Most farmers in Cameroon use pesticides in fumigating their common bean stores. Unfortunately, these pesticides inhibit insect activity and not pathogens such as fungi. A limited attention has been given to storage fungi, their control and management practices in Cameroon. Research conducted by Akwa et al. (2020) in the Menoua Division- Cameroon indicates that the incidence of fungal contamination is higher in stored beans than at harvest, highlighting the role of storage conditions in post-harvest losses. Understanding the interaction between post-harvest handling practices and storage fungi is essential for developing sustainable post-harvest management strategies.

The objective of this paper is to review and analyse how traditional practices in Cameroon by small- and large-scale farmers contribute to storage fungal infection in common bean, and to propose practical recommendations for reducing these losses in resource-limited settings. Fungal infection not only reduces bean grain quality and market value but can also lead to mycotoxin contamination, presenting health risks to consumers

Fungi associated with Common Bean and sources of contamination

Diversity of post-harvest and storage fungi in common bean

The fungal populations that dominate stored common bean grains largely depend on the condition of the grains at the time they enter storage. When beans are harvested prematurely or under moist conditions, they are more likely to be infected by field fungi such as *Rhizopus*, *Mucor*, *Rhizoctonia*, *Cladosporium*, *Trichothecium*, *Fusarium*, and *Alternaria*. These fungi typically thrive at high moisture levels (Richard 2007). Infections by post-harvest fungi generally occur after harvesting, either during transportation or while the grains are in storage. Storage fungi are adapted to survive and grow under low moisture conditions, with *Aspergillus* and *Penicillium* being the most common representatives (Richard 2007). Research conducted by Kator et al. (2016) in markets in Makurdi, Nigeria, reported the presence of *Aspergillus niger*, *Aspergillus flavus*, *Fusarium oxysporum*, and *Botryodiplodia theobromae* as major post-harvest fungal contaminants of common bean. Similarly, studies in Cuba by Martinez et al. (2014) identified *Fusarium spp.*,

Penicillium spp., and *Aspergillus flavus* as the predominant fungi affecting stored beans. Additionally, *Macrophomina phaseolina* has been recognized as a widespread and highly polyphagous pathogen of common bean, capable of infecting numerous plant species. This pathogen persists in the soil as microsclerotia and in residues of infected plant material (Marcenaro 2016, Sexton et al. 2016). Studies conducted by Akwa et al. (2020) on the characterization of post-harvest fungi affecting common bean in the Menoua Division of the West Region of Cameroon identified *Aspergillus flavus*, *Fusarium oxysporum*, *Penicillium aethiopicum*, and *Xylaria hypoxylon* as the main fungal contaminants of stored common bean cultivars. Although the quality of common bean generally declines during prolonged storage, evidence suggests that certain cultivars possess inherent resistance to storage fungi. Findings from Akwa et al. (2020) further revealed that Pinto bean, Navy bean, and Pea bean cultivars exhibited lower susceptibility to fungal infestation during extended storage periods.

Field and Storage Sources of contamination

Fungal contamination of beans may originate in the field but often intensifies during storage. Beans that are inadequately dried or mechanically damaged during harvesting and handling are more susceptible to fungal colonization. Traditional post-harvest practices therefore play a critical role in determining the extent of fungal growth during storage.

Traditional Post-Harvest Practices in Cameroon

Post-harvest activities include handling, storage, processing, packaging, transportation and marketing. The harvesting methods, means of transport, kind of storage facilities and the state, in which they are, influence the quality of the common bean that is in store.

Common bean harvesting methods

In Cameroon, common bean harvesting is carried out either manually or mechanically, and each method can increase the risk of fungal contamination depending on how it is managed. Manual harvesting typically involves uprooting plants or removing pods and arranging them in rows or, more commonly, in heaps at designated locations within the farm. These locations may be bare ground or covered with weeds. During uprooting, some pods may split open and, when placed on the ground, come into contact with soil or rub against weeds. Since soil is a rich reservoir of fungal organisms, some of which are capable of infecting bean pods, this contact increases the likelihood of contamination. Weeds can also harbor fungi that may be transferred to the beans. In addition, delays in manual harvesting due to labor shortages can prolong field exposure, increasing the risk of infection from rain and field-borne fungi.

In contrast, mechanical harvesting may cause physical injuries to the beans, creating entry points that facilitate fungal invasion. Harvest conditions further influence the susceptibility of beans to fungal infection. Beans harvested under wet conditions are particularly vulnerable, as moisture favors fungal growth. The stage of maturity at harvest also plays a critical role; beans harvested while pods are still immature and moist are more easily infected. Conversely, beans harvested too late may suffer damage from birds and small mammals that open the pods to feed on the grains. Subsequent rainfall can then penetrate the damaged pods, increasing grain moisture and providing favorable conditions for rapid fungal proliferation.

Common bean transportation after harvest

Beans harvested from small-scale farms are often transported manually in gunny bags or conveyed using hand-pulled carts. This mode of handling typically results in minimal mechanical damage, thereby reducing the likelihood of fungal infection. As a result, beans transported in this manner usually reach storage facilities in good condition and are less susceptible to fungal development, since the handling process does not create injury sites on the grains.

In contrast, large-scale bean producers commonly transport their harvest using tractor-drawn trailers, pickup trucks, or lorries, which are often open or inadequately covered. During transit,

exposure to dust, soil particles, and ambient moisture facilitates the deposition of fungal spores on the beans, increasing the initial contamination level that may later develop under favorable storage conditions. Furthermore, travel over rough terrain and poorly maintained roads causes excessive vibration and swaying of the vehicles, leading to repeated impact of the beans against one another and the vehicle walls. This mechanical stress can result in cracking or splitting of the grains, creating entry points that promote fungal infection.

Common bean drying methods

When beans after harvest are exposed to moisture (>12–14% grain moisture content), high relative humidity, and temperatures between 20–35°C, fungal development accelerates. After harvest and transportation from the field, the common bean is then taken for drying. Drying of the bean plants aims at reducing the moisture content of the plant to safe storage levels. In traditional systems in Cameroon, beans are most often sun-dried on open grounds, house floors, or on woven mats. While sun drying is feasible without sophisticated infrastructure, it has several limitations: Inconsistent Drying: Uneven exposure to sunlight results in beans with variable moisture content, leaving pockets of damp grains making them a hotspot for fungal growth.

Rewetting Risk – Unexpected rain or high morning dew may reintroduce moisture before adequate drying is achieved.

Contaminated Surfaces – Drying bean on bare ground exposes them to soil-borne fungal spores and dirt.

These conditions create a moisture gradient within drying lots, enabling fungi to thrive in microenvironments that remain moist for extended periods.

Smaller scale farmers also use ceiling spaces or roofs in kitchens in houses to dry the bean plant by stacking them together and attaching with ropes (Fig. 1A). These kitchens sometimes have limited protection against moisture, insects, and rodents. Ventilation is often inadequate leading to high humidity and temperature fluctuations.



Fig. 1 – Common bean plant drying structures in Cameroon (Pictures taken by author during survey. A. Common bean plant drying on ceiling spaces. B. wooden granary for large scale drying.

Bean plants that are highly stacked together has a decrease in amount of air circulation within them. This causes a heating effect between the plants.

Large scale farmers use drying silos or wooden granaries (Fig. 1B) to dry the bean. Common bean drying in these structures is vulnerable to entry of water and rodents. The rodents mechanically damage the grains by nibbling on them as they feed thus creates ports of entry by fungi. The growth of fungi is promoted by the moisture arising from leaking roofs and walls as well as from urine and droppings from the rodents. The drying process usually last between two weeks to a month, after which the dried plant is then removed and threshed.

Common bean threshing

Threshing is a method used after drying of common bean plant to separate the bean grains from their pods. Various methods are used in threshing the common bean plant. Large scale farmers in Cameroon use calibrated machinery in threshing. On the other hand, small scale farmers thresh manually, usually by piling the dried bean plants in gunny bags or on the floor surface and thresh with sticks or by foot trampling (Fig. 2).



Fig. 2 – Threshing of dry common bean plant using sticks (picture taken by author).

These practices can cause physical damage to grains, creating entry points for fungi, mix dust and chaff with grain, retaining moisture and harbouring spores. Studies carried out by Jyoti & Malik. (2013) on threshed soybean plants showed that a large proportion of the soybean grains resulting from threshing by beating with sticks were infected with fungal pathogens like *Aspergillus niger*, *Aspergillus flavus*, *Penicillium* spp. and *Cercospora kikuchii* after storage. Common bean is best threshed by hand because this method causes minimal damage to the seeds. This is supported by El-Abady et al. (2012), who showed that hand threshing led to less reduction in soybean seed quality compared with mechanical techniques. However, hand threshing is labor-intensive and time-consuming, making it practical only for small quantities.

Common bean storage

Farmers in Cameroon store common beans after harvest for several key purposes, including ensuring food safety for consumption, reserving seeds for subsequent planting seasons, and holding the produce for sale in anticipation of favorable market prices. The quality and durability of stored beans are strongly influenced by the condition of the storage facilities. Well-designed stores that are spacious, properly ventilated, and fitted with leak-free roofs help to maintain bean quality and extend storage life. In contrast, poorly constructed or inadequately maintained storage structures allow the entry of pests and small mammals that damage bean grains through nibbling and boring. The type of storage facility used by farmers varies with the scale of production. Large-scale producers commonly rely on structures such as silos, wooden granaries, and grass-lined storage units. However, wooden storage facilities, especially when aged, may develop gaps that permit rodent infestation, leading to grain spoilage. In some cases, beans stored in these facilities are exposed to environmental factors that favor fungal contamination. For example, water leaking through damaged roofs can increase grain moisture levels, creating favorable conditions for fungal growth and subsequent infection. In addition, inadequate security of large storage structures allows

small mammals such as rats, mice, and squirrels to enter and damage the grains, while also introducing fungal spores. These animals further contribute to fungal proliferation by depositing urine and droppings on the beans, which increase moisture levels, particularly on already damaged grains. Similarly, insect pests that gain access to storage facilities can elevate localized humidity through their activity and waste products, indirectly promoting fungal development.

On the other hand, small scale common bean farmers in Cameroon use different types of containers or bags, with the most commonly used common bean storage bag being gunny bags (Fig. 3) which is made of fibre.



Fig. 3 – Gunny bags used in common bean storage in Cameroon.

Although accessible, these storage bags frequently lack features that inhibit fungal growth, affecting the quality of the grains. For example, the sides of these storage bags are often destroyed by rodents or small mammals such as rats, squirrels and mice because they are capable of biting and breaking the fibres used in making the bags. As a result, these rodents gain access into the bag and consequently damage the bean as they feed on the grains, thereby predisposing the grains to fungi infection. Furthermore, the bean can also be damaged by insect pests such as weevils if they are not well controlled. Infestation by insects such as weevils bore holes on the grains thereby creating avenues through which fungi infect the grains. Poor sealing of the bags also allows exchange of air and moisture with the external environment. Inadequate cleaning of the bags retains old residues from previous seasons thereby providing reservoirs of spores. High ambient humidity of these bags especially in tropical regions, poorly ventilated structures retain moisture which as a result, fungal infection can spread rapidly once initial colonization occurs.

Impacts of post-harvest fungal contamination on common bean

Post harvest fungal contamination on common bean can bring about nutritional implications, health implications, economic losses and seed quality reduction.

Nutritional Implications

Post-harvest fungal infection of common bean can trigger significant biochemical alterations in the grains. Botelho et al. (2013) reported that infestation of stored common bean by *Sclerotinia sclerotiorum* resulted in reduced germination percentage, along with declines in oil and protein contents, increased protein breakdown, and elevated fatty acid levels. Such protein degradation and nutrient loss diminish the overall nutritional quality of the crop. The presence of *Fusarium oxysporum* in legume seeds has also been associated with reductions in reducing sugars, carbohydrates, and crude fat content (Embaby et al. 2013). Similarly, research by Kakde & Chavan

(2011) demonstrated that *Aspergillus flavus* was a primary factor contributing to decreased fat levels and reduced sugar content in both common bean and safflower. In addition, Kator et al. (2016) documented poor germination of common bean seeds caused by fungal infection in selected markets in Makurdi, Nigeria.

Health implications

In addition to causing biochemical alterations in common bean, certain fungi isolated from stored beans are capable of producing secondary metabolites known as mycotoxins. These compounds are toxic to both humans and animals when ingested. Mycotoxins are considered among the most hazardous fungal products, as they can induce severe illnesses even at very low concentrations (Bhatnagar et al. 2002). Their high toxicity has been attributed to two main factors. First, mycotoxins are resistant to heat and therefore remain intact despite conventional cooking or thermal processing of contaminated seeds. Second, they are rapidly transferred from fungal colonies into food substrates. The presence of fungal toxins in common bean poses a significant public health concern due to their serious adverse health effects following consumption (Tseng et al. 1995). Alkahtani et al. (2011) reported the occurrence of *Aspergillus parasiticus*, *Alternaria alternata*, and *Fusarium oxysporum* in three common bean cultivars, with these fungi producing aflatoxins, alternariol, and zearalenone, respectively. Additionally, *Fusarium* species are known to produce fumonisins in several field crops, including common bean (Diepeningen 2016). Consumption of these mycotoxins has been associated with severe health outcomes such as liver cancer from aflatoxin exposure, reproductive disorders including abortion linked to zearalenone intake, and oesophageal cancer caused by fumonisins (Omotayo et al. 2019). Kumar et al. (2007) further estimated that approximately five million people in developing countries have been exposed to aflatoxin-contaminated common bean.

Seed quality reduction and economic losses

Fungal infections in stored beans cause a decline in both quality (affecting color, taste, and flavor) and quantity, contributing to post-harvest losses. As a result, heavily damaged beans may be thrown away, while those with moderate damage tend to sell at lower prices than unaffected grains. Infected beans intended for seed may exhibit poor germination and vigor, affecting future crop yields. Fungal infection results in visible spoilage of beans, including moldy appearance, discoloration, and off-flavors, reducing their market value. For households relying on stored beans for income throughout off-season months, these losses have direct economic consequences. Fungal spoilage reduces marketable yield and price, undermining farmer profitability and household income.

Strategies for mitigating fungal contamination on common bean

To mitigate the impact of traditional practices on bean contamination, the following strategies should be adopted:

Improved Drying Techniques

Improve drying can be achieved through the following

By Raising drying Platforms such as drying beans on elevated mats or tarpaulins. This method reduces contact with soil and facilitates better air circulation. It also reduces bean contamination further leading to an improve airflow.

By using solar dryers through sheltered designs with protective covers that help reduce moisture content more consistently, accelerate drying while protecting from dew and rain. Solar dryers will also help to achieve more uniform moisture reduction of the bean before storage.

By monitoring moisture with use of simple moisture indicators to ensure safe storage moisture levels.

Hygiene and Sanitation

This can be achieved by cleaning storage units and removing residues before storage. Also, implementing use of sanitizing tools to reduce fungal spore load. Combining hygienic storage with other safe pest deterrents (e.g., neem leaves, diatomaceous earth) will reduce the compounded damage of insects and fungi.

Storage innovations

Here, strong hermetic storage technology should be adopted such as triple-layer plastic bags that restrict moisture and oxygen, limiting fungal growth and insect activity. Furthermore, improvement in granaries such as better ventilation and protection from environmental moisture.

Farmer Education and Extension

This can be achieved by training common bean farmers on moisture measurement, proper sanitation of storage facilities, and integrated pest management to help reduce the conditions that favour fungal infection. Also, farmers education be done through disseminating simple guidelines for sorting and removing damaged grains before storage so as to reduce fungal inoculum.

Research Gaps and Future Perspectives

Despite existing studies, there is limited nationwide data on the prevalence of storage fungi and mycotoxins in common beans in Cameroon. Future research should focus on regional assessments, evaluation of traditional practices across agro-ecological zones, and cost-effective storage solutions suitable for smallholder farmers. Integrating post-harvest management into agricultural development programs is essential for sustainable bean production.

Conclusion and Recommendation

Traditional post-harvest practices in Cameroon, while rooted in long-standing cultural norms and being economically important, contribute significantly to common bean infection by storage fungi. The interplay of inadequate drying, environmental moisture, contaminated surfaces, and suboptimal storage conditions creates favourable environments for fungal proliferation. Addressing these challenges requires a blend of low-cost technical innovations, farmer training, and supportive policies to enable adoption of improved practices without compromising local realities. Through targeted interventions, post-harvest losses and associated health risks can be substantially reduced, enhancing food security and livelihoods in bean-producing communities.

Hand threshing of common bean plant after drying should be encouraged as this reduces the damage of the bean grains and as such reduces the extent of fungal infection. Policy makers should advice farmers to construct storage structures which ensures that there is enough air circulation to dry the bean, secured enough to prevent rodents from accessing the stores and roofs safe enough not to allow leakage of rain water. It also is advisable for farmers to use fungal resistant common bean cultivars such as Pinto bean for long term storage.

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Competing Interests

Authors declare no competing interest in the writing of this article

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