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Assessment of aflatoxin risk in Groundnut (*Arachis hypogaea* L.): Insights from a regional survey in Kalyana Karnataka, India

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Abstract
Groundnut (*Arachis hypogaea* L.) is one of the most important oilseed and food legumes globally, serving as a major source of edible oil and plant-based protein. However, its production and quality are severely constrained by contamination from *Aspergillus flavus* and its toxic secondary metabolites, aflatoxins particularly aflatoxin B1 (AfB1), a potent carcinogen. The present study was conducted during 2024-25 to assess the incidence of *A. flavus* in groundnut kernels across five major groundnut-growing districts of the Kalyana Karnataka region Raichur, Ballari, Vijayanagara, Koppal and Yadgir. Groundnut pods were collected from farmer's fields, storage units and local markets and infection incidence was recorded based on visual assessment of 100 seeds per sample. A total of 24 *A. flavus* isolates were recovered from the collected samples. The incidence of *A. flavus* infection varied widely among locations, ranging from 14 per cent (Kudligi, Vijayanagara) to 55 per cent (Kurgodu, Ballari). Among districts, Ballari recorded the highest mean infection (36.65 %), followed by Yadgir (31.60 %), Raichur (29.20 %), and Koppal and Vijayanagara (27.62% each). The variation in infection intensity could be attributed to differences in environmental conditions, pod moisture and post-harvest storage practices. The widespread occurrence of A. *flavus* indicates a significant risk of aflatoxin contamination in groundnut from this region, necessitating location-specific management strategies to ensure safer production, improved oil quality and enhanced market value.

Keywords: *Arachis hypogaea*, *Aspergillus flavus*, aflatoxin B1, storage infection

Introduction
Groundnut (*Arachis hypogaea* L.), a key oilseed and food legume of the Fabaceae family, holds immense global significance for both nutrition and agriculture. Its kernels are an excellent source of edible oil (40-56 %) and protein (20-30 %), making it one of the world's most valuable crops for dietary energy and plant-based protein (Dean *et al*., 2009) [9]. Globally, China leads groundnut production, contributing about 37 per cent of total output, followed by India, which cultivates approximately 4.7 million hectares with an average productivity of 21.63 q/ha (Anon., 2024). In India, groundnut plays a vital role in ensuring food and nutritional security, particularly across semi-arid regions, while serving as an important source of income for small and marginal farmers. In Karnataka, it is a cornerstone of dryland farming systems, predominantly grown in Raichur, Ballari, and Vijayapura, Dharwad, and Belagavi districts, sustaining both livelihood and commercial agriculture.
However, groundnut production faces a major challenge from contamination by *Aspergillus flavus* and *Aspergillus parasiticus*, fungi known to produce aflatoxins highly toxic secondary metabolites. Among these, aflatoxin B1 (AfB1) is the most potent and has been classified as a Group 1 carcinogen by WHO and IARC (1993). Contamination may occur during both pre and post-harvest stages, aggravated by environmental factors such as drought, elevated temperatures, insect infestation and poor storage conditions (Alcaide-Molina *et al*., 2009) [3]. Even minimal levels of aflatoxin consumption can cause severe health issues, including liver cancer, immune suppression and growth retardation (Butler, 1969; Anon., 1997) [7]. On a global scale, aflatoxins are estimated to contaminate 60-80 per cent of food crops (Eskola *et al*., 2020) [10], posing a serious threat to food safety, public health, international trade and economic stability.
The Kalyana Karnataka region represents one of the major groundnut-producing belts of southern India, where the crop plays a vital role in rural livelihoods and regional food security. Its semi-arid climate, characterized by high temperatures, irregular rainfall and recurrent droughts, can favour *A. flavus* infection and aflatoxin contamination, particularly under traditional post-harvest conditions such as open drying, storage in gunny bags and inadequate moisture control. Since a large section of farmers in this region depend on groundnut for income and nutrition, understanding the extent and variability of contamination is crucial for improving grain quality, oil safety, and marketability.
Therefore, conducting a survey to assess the prevalence and toxigenicity of *A. flavus* in the Kalyana Karnataka region is important to generate baseline information on the distribution and contamination status. Such data will aid in identifying potential hotspots, supporting location-specific management practices and ensuring safer groundnut production and improved oil quality, ultimately contributing to sustainable agriculture and rural economic growth.

1. Material and methods
Collection of Contaminated Groundnut Kernel Samples
Groundnut pods were collected from farmer's storage units, local markets and freshly harvested field sites across five major groundnut-growing districts of the Kalyana Karnataka region (Table 1). The samples were packed in brown paper bags and transported to the laboratory, where they were stored at 4 °C until further analysis. The geographical coordinates of each sampling site (field, storage unit and

market) were recorded using a Global Positioning System (GPS) device.

The per cent incidence of *Aspergillus* infection in groundnut kernels was assessed visually such as greenish discolouration, powdery fungal growth and shrivelling of kernels that indicated fungal contamination. From each sample, 100 seeds were examined, with 25 seeds per replication and four replications in total to ensure accuracy and uniformity. The number of infected seeds showing visible *Aspergillus* symptoms was recorded, and the per cent infection was calculated using the formula suggested by Wheeler (1969) [15].

$$\text{Per cent } A.\ flavus \text{ infection in groundnut kernels} = \frac{\text{Number of kernels infected}}{\text{Total number of kernels observed}}$$

2. Results and discussion

A roving survey was conducted during 2024-25 across major groundnut-growing districts of the Kalyana Karnataka region to assess the incidence of *Aspergillus flavus* in groundnut kernels. Samples of groundnut pods were collected from farmer's storage units, local marketplaces and freshly harvested field sites. Kernels were obtained from pods and analyzed for the presence of *A. flavus*. The details of sample collection, including geographical coordinates and isolate designations, are presented in Table 2. The survey confirmed the presence of *A. flavus* infection in groundnut kernels across all five districts of the region (Table 3). The per cent incidence was calculated based on visual observation, as described in the Material and Methods. Infection incidence ranged from 16 per cent (Lingasugur town, Raichur) to 55 per cent (Kurgodu, Ballari), indicating considerable variability among sampling sites. In total, 24 isolates of *A. flavus* were recovered and characterized from the collected samples.

The distribution pattern revealed marked differences in *A. flavus* incidence among locations. The highest infection was recorded in Kurgodu (55 %) of Ballari district, followed by Handral (46 %) in Koppal and Sanduru local (44 %) in Ballari. Moderate incidences were observed in Koppal local (42 %), Manginhal (40 %), and Kamalapura (38 %), whereas lower infection levels were found in Shahpur local (28 %)**,** Lingasugur town (16 %) of Raichur, Kudligi (14 %) of Vijayanagara and R. Hosahalli (18 %) of Yadgir. At the district level, the mean incidence was maximum in Ballari (36.65 %), followed by Yadgir (31.60 %)**,** Raichur (29.20 %)**,** Koppal (27.62 %) and Vijayanagara (27.62 %). This variation in incidence may be attributed to differences in agro-climatic conditions, pod moisture content and storage practices among the surveyed locations.

The widespread detection of *A. flavus* across Raichur, Ballari, Vijayanagara, Koppal, and Yadgir districts highlights its predominance as a seed contaminant in groundnut. These observations are consistent with earlier findings that identify *A. flavus* as the most common aflatoxigenic fungus associated with groundnut and other oilseed crops.

Similar trends have been reported in previous studies across India and abroad. In Karnataka, Kumar *et al*. (2001) [12] reported high *A. flavus* population densities in groundnut from Tumkur under the National Agricultural Technology Project, supporting the current findings. Likewise, Ajithkumar and Naik (2006) [2] observed aflatoxin contamination in chilli samples from Kalaburagi, Ballari, and Raichur, where *A. flavus* was the predominant causal organism. Guruprasad (2014) [11] isolated *A. flavus* from both chilli and groundnut across Karnataka, Andhra Pradesh, Maharashtra and Tamil Nadu, obtaining 59 isolates from chilli and 65 from groundnut, with identification confirmed by colony morphology and microscopic features. These results reaffirm the consistent association of *A. flavus* with groundnut kernels and other susceptible crops under diverse agro-climatic conditions. Similarly, Chidanand (2014) [8] also documented its presence across all surveyed locations during *kharif* 2013 and *Rabi* 2013-14 seasons. Surveys conducted outside India also demonstrate the cosmopolitan distribution of *A. flavus* in major groundnut-growing regions. Mutiga *et al*. (2015) [13] reported widespread contamination of maize with *A. flavus* and aflatoxins in western Kenya, particularly in drought-prone areas. In Ghana, Agbetiameh *et al*. (2018) [1] and Bediako *et al*. (2019) [6] confirmed *A. flavus* dominance among fungal isolates from maize and groundnut, with a significant proportion of samples exceeding permissible aflatoxin limits. Similarly, Waliyar *et al*. (2015) [14] identified *A. flavus* as the principal aflatoxin-producing fungus in groundnut from Mali, with contamination levels varying by district and risk zone.

Collectively, these findings reaffirm the ubiquitous nature of *A. flavus* and its strong association with groundnut under warm, humid and stress-prone conditions. The current survey provides valuable baseline information on the prevalence, distribution and diversity of *A. flavus* in Kalyana Karnataka, which is essential for developing effective region-specific management strategies to reduce aflatoxin contamination and ensure safer groundnut production.

Conclusion

The present survey clearly demonstrated the widespread occurrence of *A. flavus* in groundnut kernels across major districts of the Kalyana Karnataka region, indicating its strong association with groundnut production environments. Considerable variation in infection incidence among locations suggests the influence of agro-climatic factors, storage conditions, and post-harvest handling practices. The recovery of multiple isolates from diverse sources highlights the persistence and adaptability of the pathogen. These findings provide essential baseline information for developing region-specific management strategies to minimize fungal contamination and safeguard groundnut quality and oil safety.

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Table 1: Collection of groundnut samples from major groundnut-growing districts of Kalyana Karnataka

District	Taluks/Towns	No. of Samples (Field/Market/Godown)
Raichur	Raichur, Devdurga, Lingasugur	6
Ballari	Ballari, Sandur	5
Vijayanagara	Hosapete, Hagari Bommanahalli, Kudligi	4
Koppal	Kustagi, Koppal	4
Yadgir	Yadgir, Gurmitkal, Shahpur	5

Table 2: Survey for aflatoxin contamination of groundnut in major groundnut growing regions of Kalyana Karnataka

Sl. No.	District	Taluk	Village	Latitude	Longitude	Isolate designation
1	Raichur	Raichur	Nelhal	16.15404	77.29171	AFG1
				16.200883	77.331119	AFG2
				16.199223	77.331182	AFG3
			Mamadapur	16.16998	77.30621	AFG4
		Devadurga	Bankaldoddi	16.36945	76.69427	AFG5
		Lingasugur	Lingasugur town	16.1588	76.5199	AFG6
2	Ballari	Ballari	Kurgodu	15.13855	76.91872	AFG7
			Ballari	15.13939	76.92144	AFG8
			Sirivwaram	15.18892	76.98681	AFG9
		Sanduru	Retail shop	15.0874	76.5477	AFG10
		Siruguppa	Sirigeri	15.416959	76.835887	AFG11
3	Vijayanagara	Hosapete	Kamalapura	15.2009	76.6611	AFG12
				15.3075	76.4793	AFG13
		Hagari Bommanahalli	Anekal	76.272775	76.272775	AFG14
		Kudligi	Sivapura	14.957942	76.353595	AFG15
4	Koppal	Koppal	Retail shop	15.35050	76.15670	AFG16
				15.3531	76.1536	AFG17
			Handral	15.3069	76.0421	AFG18
		Kustagi	Retail shop	15.7517	76.1924	AFG19
5	Yadgir	Yadgir	R. Hosahalli	16.724641	77.242297	AFG20
		Gurmitkal	Gurmitkal	16.8656	77.3927	AFG21
		Shahpur	Manginhal	16.71629	77.03441	AFG22
				16.7159	77.0363	AFG23
			Retail shop	16.7025	76.8424	AFG24

Table 3: Assessment of the incidence of *Aspergillus flavus* in groundnut kernels

Sl. No.	District	Taluk	Village/Shops	*Aspergillus flavus* isolates	Total no. of kernels infected	Per cent infection
1	Raichur	Raichur	Nelhal	AFG1	24	25.00
				AFG2	36	36.00
				AFG3	18	18.00
			Mamadapur	AFG4	30	30.25
		Devadurga	Bankaldoddi	AFG5	50	50.00
		Lingasugur	Lingasugur town	AFG6	16	16.00
District Mean						29.20
2	Ballari	Ballari	Kurgodu	AFG7	55	55.00
			Ballari	AFG8	34	34.00
			Sirivaram	AFG9	20	20.25
		Sandur	Retail shop	AFG10	44	44.00
		Siruguppa	Sirigeri	AFG11	22	30.00
District Mean						36.65
3	Vijayanagara	Hosapete	Kamalapura	AFG12	38	38.00
				AFG13	26	26.50
		Hagari Bommanahalli	Anekal	AFG14	32	32.00
		Kudligi	Sivapura	AFG15	14	14.00
District Mean						27.62
4	Koppal	Koppal	Retail shop	AFG16	42	42.00
				AFG17	34	34.00
			Handral	AFG18	46	46.00
		Kustagi	Retail shop	AFG19	18	18.00
District Mean						35.00
5	Yadgir	Yadgir	R. Hosahalli	AFG20	24	24.00
		Gurmitkal	Gurmitkal	AFG21	30	30.00
		Shahpur	Manginhal	AFG22	40	40.00
				AFG23	36	36.00
			Retail shop	AFG24	28	28.00
District Mean						31.60

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