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Phosphine fumigation of stored turmeric in India

Ujjwal Kumar

UPL Ltd., Mumbai, India.

Corresponding author's email: ujjwal.kumar@upl-ltd.com

Abstract

Among spices, turmeric (*Curcuma longa* L.) is significant for its role in culinary arts, cosmetics, medicine, and as a natural colouring agent (curcumin) for foodstuffs and fabrics. India is the major producer (0.93 million tonnes in 2020, global production 1.1 million tonnes), consumer (domestic consumption nearly 80%), and exporter (whole turmeric, turmeric powder and oil, oleoresins). Processed dried rhizomes of turmeric are stored as bulbs, fingers, and splits in gunny sacks in India. Around 20% is held by the farmers at their own premises, the balance stored by the entrepreneurs in private as well as government warehouses/market complexes and to a limited extent under cold storage. Storage period varies from a few months to five years.

Despite its claimed bio-pesticidal potency, during storage at farm and warehouse levels turmeric is still vulnerable to two major pests: the cigarette beetle, *Lasioderma serricornis* (F.) and the drug-store beetle, *Stegobium paniceum* (L.) along with threats from the red flour beetle, *Tribolium castaneum* (Herbst). Insect pest activity in stored turmeric affects its quality and marketability.

Fumigation with phosphine released from aluminum phosphide tablets and/or powder formulations (in sachets) is the common practice for the disinfestation of stored turmeric intended for the domestic market. Surveys in major production regions revealed that turmeric fumigations are carried out by farmers and unauthorized fumigators (routinely with improper phosphine dosages) and under poor quality gas-proof sheets and floor sealings. Due to these factors, control failures of repeated phosphine applications were noticed. In this context, awareness programs on Good Fumigation Practices in Stored Turmeric involving practical demonstrations were conducted by UPL Ltd., Mumbai, India, at selected centres in predominant turmeric storage areas for farmers as well as prominent turmeric traders. With supportive awareness programs being offered to farmers and other stakeholders, phosphine will continue to play a vital role in the protection of stored turmeric in India.

Keywords: Turmeric storage, India, Insect infestation, Phosphine treatment, Good fumigation practices in stored turmeric, Approaches and awareness programs

Introduction

Turmeric, *Curcuma longa*, is an herbaceous plant, belonging to the Zingiberaceae family. Turmeric crops take about 180-200 d to mature and need another 10-15 d for on-farm, post-harvest activities to make the rhizomes acceptable for consumption. As well as having medicinal applications as an antiseptic for skin abrasions and cuts, the rhizomes of the plant are used in a wide variety of foods of the cuisines of Southern Asia. Turmeric is consumed in powder form used in cooking, and as oleoresin in the medicinal industry (Table 1.). In India, turmeric is used whole or as a powder for its characteristic colour, and also as an ingredient for various spice mixes (Ragavan and Sujeetha, 2015).

Table 1. Turmeric and its value-added products

Category	Product
Whole turmeric	Bulb or rhizome
	Fingers
	Grits
Processed turmeric	Turmeric powder
	Ingredient in spice mixes
Extracts /Value added products	Curcumin
	Oleoresin

In 2019-20, the global production of turmeric was around 1.1 million tonnes. India dominates production by contributing 80% to the world supply, followed by China (8%) and Myanmar (4%). As well as being the largest producer and consumer of turmeric and its products in the world, India is also a leading exporter of this commodity (Table 2.). Major importers of India's turmeric supply include Bangladesh (15,889 tonnes), Iran (11,859 tonnes), Morocco (7,226 tonnes), USA (6,318 tonnes) and UAE (5,938 tonnes). There are other countries that import small quantities. Indian turmeric is considered to be the best in the world market because of its high curcumin content.

Table 2. Turmeric production and export from India (thousand tonnes)

Year	2017	2018	2019	2020
Production	952.97	862.77	972.97	926.91
Export-Quantity	116.50	107.30	133.60	136.00

The important turmeric growing states in India are Telangana (55,443 ha), Odisha (27,864 ha), Tamil Nadu (18,296 ha), West Bengal (17,711 ha), Karnataka (17,598 ha), Assam (16,550 ha), Maharashtra (14,511 ha), and Andhra Pradesh (13,223 ha) (PJ TSAU 2020). The harvesting of

fresh turmeric in India starts from mid-January and ends in June. Stored turmeric is available for the market throughout the year. In light of the significance of this commodity, current turmeric storage and infestation control practices in India have been reviewed, and subsequently, the need and mode of good phosphine fumigation awareness programs for the farmer, trader and warehouse managers were elaborated.

Current storage practice

Harvested and cured turmeric rhizomes are stored at three stages: farmer, trader/*mandi*, and central storage (Fig. 1.). Turmeric is stored by farmers at their premises according to the requirement and as per the available space in their storerooms, and represents about 20% of total production. When there is inadequate space, farmers store the commodity in the Turmeric Market Complex/Private/Govt Market Committee warehouses, which accounts for the remaining 80% of the production. In certain areas (e.g., Nizamabad districts in Telangana) turmeric is stored by farmers and traders in cold storage units.



Fig. 1. Storage locations: farmer; trader/*mandi*; central storage.

Insect pest infestation

Turmeric, whether it be raw or processed/whole or ground, is vulnerable to insect pest attacks during storage. The quality, and hence the market value of stored turmeric, is decreased by insect infestation and microorganism infection (Gunasekaran et al., 2003). Besides consuming valuable product, these insect pests also contaminate the commodity with their excreta and body fragments, and disseminate microorganisms causing unacceptable levels of filth and mycotoxins. In India, stored turmeric is attacked predominantly by the Cigarette beetle, *Lasioderma serricorne* (F.) and the Drugstore beetle, *Stegobium paniceum* (L.). Turmeric fingers and bulbs are quite susceptible to *L. serricorne* (Jha and Yadav, 1991). Adult Cigarette beetles are active fliers and are short lived (2-6 wk) depending on the temperature and humidity. Both beetle species leave small round emergence holes in turmeric fingers/bulbs. The Red flour beetle, *Tribolium castaneum* (Herbst), the Coffee bean weevil, *Araecerus fasciculatus* (De Geer), the Lesser grain borer, *Rhyzopertha dominica* (F.), the Saw-toothed grain beetle, *Oryzaephilus surinamensis* (L.), the Almond moth, *Ephestia cautella* (Cautella), and the Rice moth, *Corcyra cephalonica* (Stainton) all occur as minor pests of stored turmeric and its products (Gunasekaran and Rajendran, 1999; Rajendran, 2003).

Current fumigation practice

Fumigation plays a vital role in the control of insect pests of stored turmeric. Phosphine released from metallic phosphide formulations is the only fumigant available for use on turmeric intended for the domestic market in India. Because of its high vapour pressure (29, 260 mm of Hg at 25°C), low molecular weight (34 g/mol), and gas density (1.17 kg/m³), phosphine can distribute rapidly and evenly to act on all life stages of insect pests during fumigation. Furthermore, it is the least problematic fumigant in terms of residues in the treated commodity. At the central storage level, phosphine fumigation of commodities must be carried out by government storage agencies or accredited/approved commercial pest control agencies/operators as per NSPM-22 (Anon. 2017). Nevertheless, for the exclusive use of farmers, the Government of India has approved 10 g granular/powder formulation sachets or pouches containing 56% aluminum phosphide, as well as 12 g tablets in small flask packing containing 15% aluminum phosphide.

It has been observed that there is inappropriate selection of aluminum phosphide formulations which are not approved for use by farmers. These products are either approved for use by licensed operators only, or are counterfeit illegal packings sold to farmers through illegal channels.

The dosage applied is also on a per tonne basis, and the sealing integrity is not enforced either. Exposure periods vary from 15-30 d. The quality of the fumigation cover sheets is also not very good seeing as these sheets can rarely retain enough phosphine, thus leading to ineffective fumigation due to sub-lethal fumigant concentrations during the exposure period. Because of these failed attempts, fumigation has to be repeated every two months, despite which, the turmeric rhizomes are still damaged to a great extent.

After our interaction with turmeric growers and our subsequent assessment of storage locations, UPL Ltd. decided to organize training programs in the Erode District where farmers were suffering huge losses, not to mention being at high risk of phosphine exposure themselves.

Training/awareness programs

As one of the leading global manufacturers of aluminum phosphide formulations, UPL Ltd. felt/realized the need to organize training/awareness programs on Good Fumigation Practices in Stored Turmeric for farmers, traders and warehousing agencies. Accordingly, in the first instance, Good Fumigation Practices in Turmeric Storage was conducted at the selected centers viz., Turmeric Market Complex, Semmapalyam, near Erode Otthakadai, and Kodumudi in Tamil Nadu, India.



Fig. 2. Training activities, lectures and live demonstrations.

The objectives of the training/awareness programs were to:

1. Create awareness on safe usage of aluminum phosphide formulations for turmeric fumigation.
2. Display/demonstrate good fumigation practices to farmers for effective insect control.
3. Differentiate between genuine and spurious phosphine releasing aluminum phosphide products available in the market.

The training was imparted to about 1500 farmers and turmeric traders. The program was comprised of lectures followed by live demonstrations of the fumigation of turmeric bags with aluminum phosphide tablets and sachets (Fig. 2.). Farmers were made aware of approved aluminum phosphide formulations and brands in India which could be legally purchased for use by farmers. Certificates were distributed to the farmers/traders who participated in the training program. During these training sessions, there was open interaction with farmers and all queries were addressed for more clarity with regard to aluminum phosphide. Feedback was taken from the farmers regarding the relevance of the training and content, as well as any benefits they felt they had received from the sessions.

Way forward

Farmers and traders benefitted from the training on Good Fumigation Practices in Stored Turmeric and it created awareness on the safe and effective usage of approved aluminum phosphide formulations in turmeric storage. Learning these safe practices resulted in the wiser and more informed use of aluminum phosphide. Similar training sessions have been planned in other turmeric growing areas in the future.

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