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NARRATIVE REVIEW

Black mould on stored onions in India: A socio-economic review of livelihoods, prices, food-service enforcement and consumer risk

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ABSTRACT

Background. Onion is both a daily staple and a politically sensitive commodity in India. Black mould, caused by *Aspergillus niger* and related species of *Aspergillus* section *Nigri*, is a post-harvest disease that adds to storage losses borne mainly by farmers and traders and that has surfaced in food-safety enforcement against hotels and restaurants. Public alarm is amplified by confusion with mucormycosis, popularly called "black fungus".

Objective. To examine black mould on onions as a socio-economic problem: Who bears the losses, how storage, prices and market structure shape them, how enforcement and public fear fall on small operators and low-income consumers and what policy options follow. Three scientific distinctions are kept explicit throughout: Fungal contamination is not mycotoxin contamination; surface growth is not internal infection; and India's mycotoxin provisions are not a black-mould limit for raw onion.

Methods. Narrative review of peer-reviewed papers, regulatory documents, extension publications, government replies and press reports retrieved through targeted web searches in October and November 2026. The search was not systematic.

Findings. Storage losses of 15% to 50% are reported for traditional and naturally ventilated storage, with microbial spoilage 15% to 20% of the total in one account. Improved low-cost structures are reported to cut losses and raise net returns (INR 6,021 *vs* INR 2,553 per tonne in one trial), but access for small farmers is uneven. In May 2026, mandi prices of INR 5 to 7 per kg coexisted with an all-India retail average of INR 25.36 per kg, and Maharashtra growers received about 43% of the retail price; in September 2026 prices rose steeply after crop damage and storage losses. Press-reported enforcement against fungal vegetables in Karnataka and Maharashtra rested on hygiene and unsafe-food provisions, not on a mycotoxin result. Black *aspergilli* were found in 92.5% to 98% of onions in surveys abroad, yet toxin signals were inconsistent, and I found no Indian onion mycotoxin survey and no black-mould or onion-specific limit in FSSAI's regulations. Costs of loss, licence suspension and fear fall unevenly on growers, small traders, small food businesses and low-income buyers.

Conclusions. Black mould on onions is chiefly a storage and market-structure problem with a modest, mostly unquantified health risk. Priorities are small-farm storage and curing, grading and sorting at the mandi, Indian toxin surveillance, proportionate and transparent enforcement and risk communication that separates onion mould from mucormycosis.

Keywords: Onion; black mould; *Aspergillus niger*; post-harvest loss; farmer income; price volatility; food safety enforcement; FSSAI; India.

1. Introduction

India is the world's largest onion producer in at least one recent account, which reports 26.91 million tonnes from 16.28 million hectares [16]. Official figures differ by source and year; a parliamentary reply gives 266.41 lakh metric tonnes for 2020-2021 against consumption of 160.50 lakh metric tonnes [23]. Maharashtra, Madhya Pradesh, Karnataka and Gujarat are reported to account for about 80% of production, and the rabi crop, about 65% of the harvest, stores for roughly five to seven months [34]. Onion is also a price-sensitive household item: its price swings reach household budgets, markets and policy within days [48].

Black mould belongs to this economic setting. It is one of the diseases that make stored onions rot and storage failure forces farmers to sell early, sorts out which bulbs reach the market, and decides which

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stock a hotel kitchen receives. Two developments make the topic timely. State food-safety departments have reported fungal growth on vegetables during inspections of hotels and restaurants [29-31,46], and the 2021 mucormycosis epidemic gave "black fungus" a powerful meaning in India; a Sri Lankan fact-check, for example, had to explain that the black coating on onions is *A. niger* and that no medical evidence links it to mucormycosis [32].

This review therefore asks socio-economic questions: How large and how uneven are the losses, who bears them, how do prices and market structure transmit them, how does enforcement fall on small operators and consumers, and what policies are proportionate. It first sets out, briefly, the scientific guardrails (Section 3) needed to avoid overstating the health risk.

2. Methods

This is a narrative review. In October 2026 I ran targeted web searches on onion black mould, post-harvest loss in India, mycotoxin surveys of onions, human infection by black *aspergilli*, ochratoxin A risk assessment, the burden of aspergillosis in India, and Indian food-safety law and enforcement. For this revision (November 2026) I added searches on onion prices and farm-gate margins in 2026, storage structures and their costs, the mycotoxin provisions of the FSSAI Contaminants, Toxins and Residues Regulations, the statutory definition of unsafe food, official guidance on trimming mould, and heat stability of ochratoxin A. I included peer-reviewed papers, official documents, extension pages, trade and press reports. DOIs are given only where they appeared in a retrieved record.

Sources are weighted by type. Peer-reviewed studies and risk assessments carry the most weight for health claims. Economic figures for 2026 come mostly from press and trade reports of government price data and are quoted as reported; I did not obtain the underlying Price Monitoring Cell tables. Statements that are my inference are labelled. Because searching was neither systematic nor run in bibliographic databases, relevant Indian studies, particularly in regional journals, may have been missed (Section 11).

3. Scientific guardrails

Three distinctions keep the evidence honest, and they matter for socio-economic argument because public fear, enforcement and price panic all depend on them. Table 1 and Figure 1 summarise them.

Table 1. The three distinctions: what can and cannot be concluded.

Distinction	What is observed or stated	What it does not establish	What would be needed
1. Fungal versus mycotoxin contamination	Visible black growth; section *Nigri* isolated	That a mycotoxin is present, or that a harmful concentration is present	Strain identification; toxin analysis of the sample (OTA, FB2) against a reference limit
2. Surface versus internal infection	Black spore mass on neck or outer scales	How far the fungus has grown; absence of interior infection	Cutting the bulb open; firmness, discolouration, softness, smell
3. Regulatory position in India	FSSAI limits for specified mycotoxins in specified foods; general unsafe-food and hygiene provisions	A numerical black-mould limit, or an onion-specific mycotoxin limit	Reading the current consolidated regulations and gazette notifications

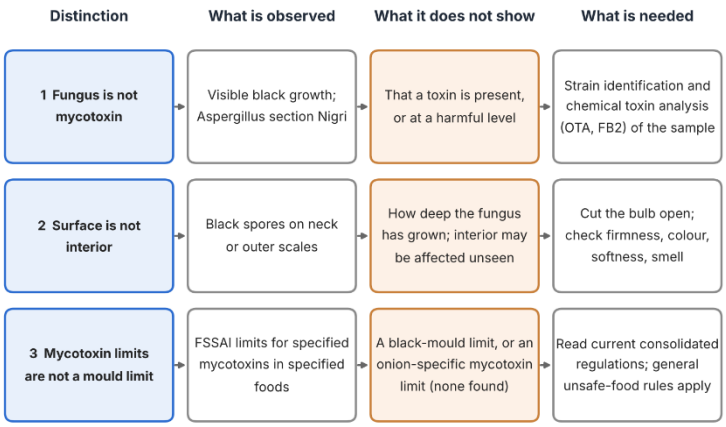

Figure 1. The three distinctions as a reasoning chain from observation to what can be concluded.

3.1 The organism and where it occurs

Black mould of onion is caused mainly by *A. niger* and morphologically similar species in section *Nigri*, which are difficult to distinguish without molecular methods [2,3,6]. Brazilian work found that *A. welwitschiae* predominated among isolates from onions [3,6]. The organism is common in soil and decaying plant matter and can travel on seed [20]. University of California extension guidance describes black sooty spore masses on the neck or outer scales, usually entering through injury, with disease mainly post-harvest, commoner in warm regions, and promoted by condensation after wide temperature swings [17]; infection is commonest above about 24 °C in storage and needs free moisture [18]. Indian data are consistent: Higher incidence in storehouses than in the field, spore counts in storehouse air that rose on handling, and greater susceptibility in white than red bulbs at Gulbarga, Karnataka [36]; fresh neck cutting raised disease intensity to 38.86% against 10.81% in uninjured controls [19]; and wind-row curing, hanging storage, carbendazim, sulphur dioxide fumigation and acetic acid dips reduced incidence [21]. Table 2 collects the surveys retrieved. None is Indian, and the widely shared claim that "98% of Indian onions carry the fungus" traces to a Brazilian supermarket study [3].

Table 2. Surveys of black aspergilli and toxin signals in onions (none from India).

Study	Setting and sample	Black aspergilli	Toxin findings
Massi et al. 2021 [3]	Brazil; 96 supermarket onion samples	Found in 98% (94/96); 97.4% of 500 strains typed as *A. niger*/*A. welwitschiae*	*fum8* (FB2 gene) in 36% of *A. welwitschiae* isolates; OTA genes in only 2.8%
Gherbawy et al. 2015 [1]	Taif, Saudi Arabia; 40 onion samples	Found in 37 of 40 samples	No ochratoxins detected; FB2 in 37.5% of samples; 18 of 37 *A. welwitschiae* isolates potential FB2 producers
Brazilian field-to-market survey [15]	Brazil; 48 samples (25 market, 23 field)	*A. welwitschiae* most prevalent in market samples	No FB2 or OTA contamination found
Front Fungal Biol 2025 [4]	Nigeria (local markets); 100 bulbs	Section *Nigri* isolates screened	22 isolates (11%) amplified at least two *fum* genes
El-Dawy et al. 2024 [2]	Qena, Egypt; 13 isolates from rotten market bulbs	Section *Nigri* isolates identified	3 isolates produced ochratoxins (1.5 to 15 ppm) in the laboratory; inoculated rot 55% to 80%, 0% under cement or zeolite cover for most isolates
Vanzela et al. 2020 [5] (garlic)	Brazil; 36 garlic samples	Section *Nigri* in 63% of 1,031 infections	32 of 36 samples carried fungal infection

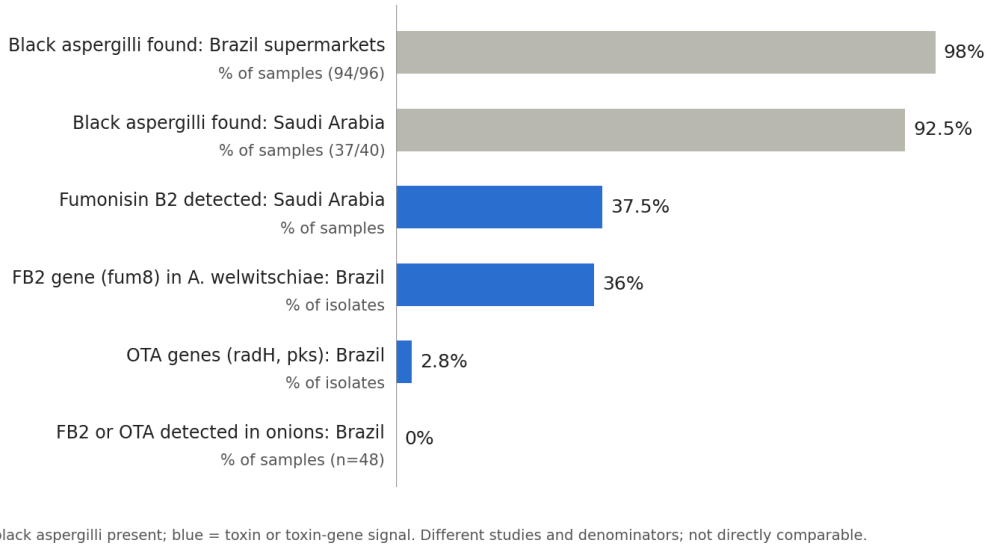

Figure 2. Presence of black aspergilli compared with toxin or toxin-gene signals in onion surveys from Brazil and Saudi Arabia [1,3,15].

3.2 Distinction 1: Fungal contamination is not mycotoxin contamination

Mould is the organism; a mycotoxin is a chemical it may or may not make. Section *Nigri* contains strains that make ochratoxin A (OTA) or fumonisin B2 (FB2), strains that make neither, and species used industrially, for example for citric acid and enzymes, so the name alone does not signal danger. Toxin production also depends on strain, substrate, temperature, water activity and time. The surveys show the gap: Black aspergilli in 92.5% to 98% of samples, yet no ochratoxin detected in the Saudi samples, no FB2 or OTA in the 48-sample Brazilian survey and OTA genes in only 2.8% of Brazilian strains [1,3,15]. Gene detection indicates potential, not production [3,4], and laboratory ochratoxin production by 3 of 13 Egyptian isolates [2] does not show that market onions carried measurable toxin. ***The presence of black mould therefore does not establish a mycotoxin, nor a harmful concentration***.

EFSA concluded in 2020 that OTA causes kidney toxicity in animals, kidney tumours in rodents and is genotoxic; it set no health-based guidance value and used a margin-of-exposure approach, finding low concern for most consumers but a possible concern for high consumers in younger age groups, with high uncertainty [7]. Those conclusions concern dietary exposure across foods, mainly cereals, not onion. OTA is heat stable and cooking removes only part of it [42], so cooking should not be treated as a way to make a mouldy onion safe (inference from the general OTA literature; no onion-specific cooking study was found). Equally, "toxin not shown" is not "safe": No Indian measurement of OTA or FB2 in onions was found, so the absence of Indian data is a gap, not evidence of absence.

3.3 Distinction 2: Surface contamination *vs* internal infection

Extension guidance describes spores often streaking along veins between dry outer scales and the first fleshy scale, and interior discolouration that can occur without external signs [17] (Figure 3). A clean outer surface therefore does not exclude internal involvement, and a sooty outer scale does not prove that fleshy scales are invaded. Visual identification is also imperfect, since species within section *Nigri* cannot be told apart by eye (inference).

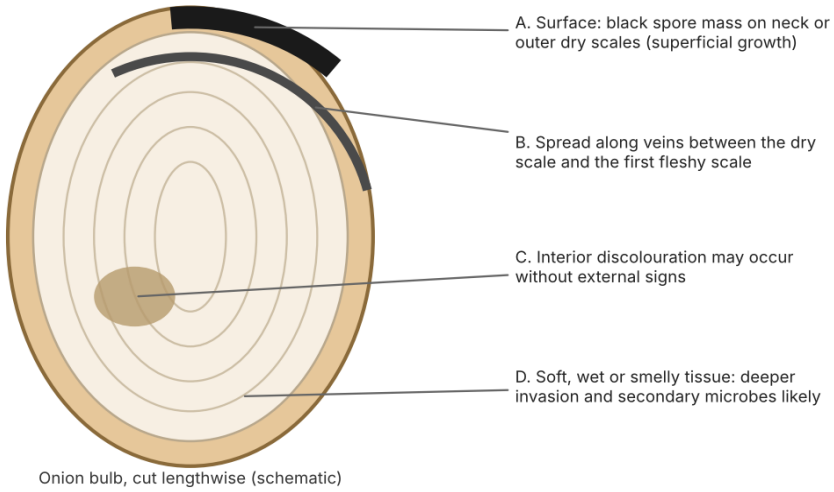

Figure 3. Surface growth, spread along veins and possible interior involvement in a mouldy onion (schematic based on [17,18]).

No Indian or onion-specific study of how far toxin or hyphae extend beyond visible mould was found, so advice on handling, cleaning, trimming and consumption is built from general guidance and the onion biology. The US Department of Agriculture advises cutting at least one inch (about 2.5 cm) around and below mould on firm fruit and vegetables such as cabbage, bell peppers and carrots and discarding soft, high-moisture produce [41]; its examples do not name onion, so applying them is an extrapolation. A consumer gardening source gives similar advice for onion (peel affected layers, cut about 2.5 cm beyond the black area from a firm onion) and advises discarding soft bulbs [33], but it is not clinical guidance. Table 3 turns this into an interpretive screening guide, not a regulatory standard. Handling matters separately: Spore counts rose when onions were handled [36], so staff with asthma, allergy or immunosuppression should not be assigned heavily mouldy stock (inference).

Table 3. Screening guide for onions with black mould (interpretive; not a regulatory standard).

Condition of bulb	Interpretation	Suggested action
Black powder on dry outer scales only; bulb firm; cut flesh clean	Probably superficial; interior not proven clear without cutting	Remove affected scales and peel; cut open to check; use promptly [17,33,41]
Black streaks beneath the dry scale, reaching the first fleshy scale	Spread along veins between scales [17]	Remove layers well beyond the discolouration, about 2.5 cm margin [33, 41]; discard if any doubt
Interior discolouration, softness, wetness or off smell	Probable deeper invasion and secondary microbes [17,33]	Discard the whole bulb
Many affected bulbs in a store or kitchen	Storage failure; elevated spore load [36]	Sort at receiving; discard affected stock; protect at-risk staff; review storage

3.4 Human health significance

The best-documented diseases caused by *A. niger* are not food-borne (Table 4, Figure 4). Otomycosis is the commonest, with *A. niger* the leading isolate in several series [9-11]; invasive aspergillosis is rare and is described mainly in severely immunocompromised people [8]; allergy and asthma from inhaled spores while peeling or handling are plausible but not studied in onion handlers [36]. India has a heavy fungal disease burden: 57.25 million people (4.1%) are estimated to suffer a serious fungal disease, with annual incidences of 250,900 for invasive aspergillosis and 195,000 for mucormycosis, and 1.74 million with chronic pulmonary aspergillosis and 2.0 million with allergic bronchopulmonary aspergillosis [13]. These numbers should not be attributed to onion mould: They are described as arising mainly from *A. fumigatus* [12,40], and mucormycosis is caused by a different group of fungi. A heavily mouldy onion handled by an at-risk person is a plausible but unquantified hazard.

Table 4. Health effects associated with black aspergilli, by route and strength of evidence for onion.

Effect	Route	People at risk	Evidence for onion	Severity
Invasive aspergillosis	Inhaled spores	Severely immunocompromised	Described for non-*fumigatus* species including *A. niger*, more often in milder disease [8]; no onion-linked case found	Rare; potentially fatal
Otomycosis (ear)	Spores entering ear canal	Damaged or moist ear canals	*A. niger* commonest isolate: 44.3% of 185 patients [11], 51% of 102 positives [10]; reviewed in [9]; not linked to eating onion	Painful, recurrent
Allergy and asthma	Inhaled spores while peeling or handling	Asthmatic, atopic, kitchen and market workers	Plausible; storehouse spores rise on handling [36]; no onion-specific clinical study found	Mild to moderate
Ochratoxin A toxicity	Eating contaminated food	High chronic consumers, young children	Kidney effects per EFSA [7]; onion OTA potential low and variable [1-3]	Chronic; possible cancer concern
Fumonisin B2 exposure	Eating contaminated food	Frequent consumers	Gene or in-vitro potential [1,3,4]; human effect from onion not established in sources	Unclear
Gastrointestinal upset	Eating spoiled, soft onion	Anyone	Anecdotal; other microbes may be involved	Usually self-limiting

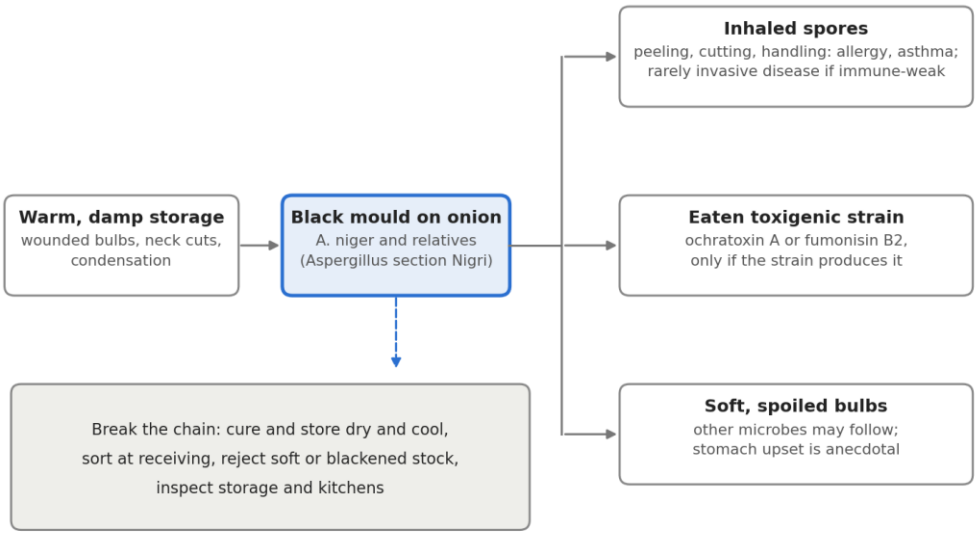

Figure 4. Routes from mouldy onion to human harm and points where the chain can be broken; likelihood differs by route.

4. The economic setting: Storage, losses and who can afford to prevent them

4.1 Scale of loss

Post-harvest loss estimates for onion vary widely and are not strictly comparable. One recent paper reports losses of up to 40%, with microbial spoilage accounting for 15% to 20% of the total [16], and quotes an estimate of up to INR 11,000 crore in annual losses in India (I did not trace the original source of that figure). A supply-chain survey in Ambala district, Haryana, estimated total losses of 10.86% [35]. A 2026 systematic review reports storage losses of 15% to 40% under traditional ambient methods, against under 5% over 6 to 10 months in humidity-controlled storage [53]. ICAR describes losses of 30% to 50% in conventional naturally ventilated structures and over 50% in some trials [52]. Black mould is only one cause (sprouting, weight loss and bacterial soft rot are others), so its own economic share cannot be isolated from these figures. What the figures show is that spoilage is common and that rot, including mould, is a standing cost of holding onions.

4.2 Storage options, costs and access

Storage choice is an economic decision, and it sorts farmers by capital. Traditional ventilated structures (kanda chawls and hanging storage) are cheap but lose more; humidity-controlled cold storage loses little but, in an Indian study, rent is high and cold storage is not normally preferred for onion [54]. Between the two sit improved structures. In a field trial of an evaporative-cooled structure, net profit per tonne stored from May to September was INR 6,021 against INR 2,553 for a traditional structure [16]. ICAR reports a 9-tonne multi-module system costing INR 1.5 lakh, with a net benefit of INR 20,320 per tonne under the assumption of a rise from INR 10 to INR 40 per kg over six months, and describes it as affordable to small and marginal farmers [52]; that benefit depends on the assumed price rise and was reported by the developer. Maharashtra is reported to have created 42,282 low-cost onion storage structures with a capacity of 9.65 lakh tonnes under central schemes, while hardly any storage exists in Madhya Pradesh [51]; against the 266.41 lakh tonne production figure in [23] that is roughly 3.6% (my arithmetic; the years differ and the comparison is only illustrative).

Table 5. Storage options for onion: Reported losses, cost and who can use them.

Option	Reported storage loss	Cost and returns reported	Who can realistically use it
Traditional ambient or hanging storage	15% to 40% [53]; 30% to 50% in conventional ventilated structures [52]	Low capital; INR 2,553 net profit per tonne in one trial [16]	Most small and marginal farmers
Improved ventilated or multi-module structure	Up to about 25% [52]	9 t system INR 1.5 lakh; net benefit INR 20,320 per tonne under assumed price rise [52]	Farmers with some capital or subsidy
Evaporative-cooled structure	Designed to mitigate postharvest losses, rotting and sprouting [16]	INR 6,021 net profit per tonne, May to September [16]	Farmers with capital or group access
Humidity-controlled cold storage	Below 5% over 6 to 10 months [53]	High rent; not normally preferred for onion in India [54]	Large traders, processors, cooperatives

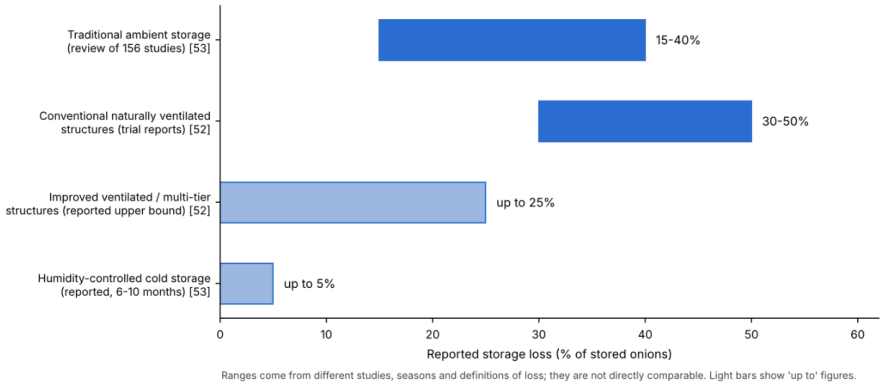

Figure 5. Reported storage losses by storage type (ranges from different studies; not directly comparable) [52,53].

When storage is inadequate, behaviour follows. A trade report states that farmers, fearing losses, usually unload their entire stock within a month of harvest, and that prices then rule low because of the glut [51]. Black mould and other rots are part of that fear: Where a farmer cannot keep onions dry, cured and ventilated, the safe economic choice is to sell early at whatever price is offered. The 2026 coverage is consistent: Farmers lacking storage for late kharif lots were forced into distress sales [50].

5. Prices, farmers' share and market structure

Reports in 2026 show how far grower and consumer prices can diverge. In May 2026, government price data reported in the press gave an all-India average retail price of INR 25.36 per kg while farmers in some mandis sold at INR 5 to 7 per kg; in Maharashtra, growers received about 43% of the retail price (Figure 6) [47]. A farmer share of around 37% was reported for another date in May [55]. In the Paithan-area district mandis the average wholesale price was INR 578.08 per quintal, about INR 5.78 per kg [47]. Cost of production was reported as up to INR 2,500 per quintal in Maharashtra, against a price of INR 100 per quintal at Chandvad and a state average of INR 1,013.78 per quintal at the end of March 2026 [50]; in Andhra Pradesh, costs of INR 800 to INR 1,000 per quintal were reported when prices fell to INR 200 to INR 400 per quintal in 2025 [49]. Press and trade sources are secondary and the cost figures are as reported.

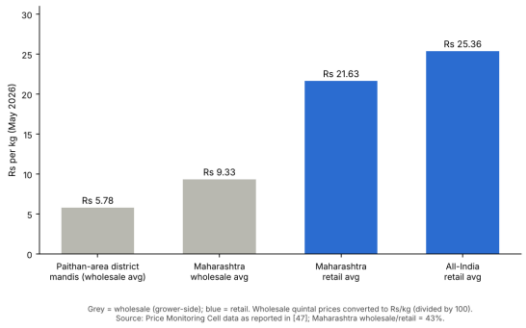

Figure 6. Wholesale and retail onion prices, May 2026, showing the gap between grower-side and consumer prices (data as reported in [47]).

The reverse also happens. In September 2026, onion prices rose steeply after weather-related crop damage and storage losses, with one trader quoting INR 60 per kg, and the Centre, through NCCF and NAFED, reportedly held a buffer stock of 1.21 lakh tonnes to supply onions at controlled prices [48]. Traders attributed May and June stock damage to rain and excessive heat that caused stored onions to rot [48]. Rot in storage thus links directly to the supply gap and consumer price spike. Procurement is limited: Onion procurement under the Price Stabilisation Fund is reported at only 1% to 2% of production [47], and farmers in Maharashtra have asked for price deficiency payments because the Market Intervention Scheme requires states to bear half of any loss [50].

Three points follow: First, storage failure, including mould, hurts farmers when prices are low (they cannot hold stock) and hurts consumers when prices are high (rot shrinks supply). Second, the gap between farm and retail prices is often attributed to transport, labour, storage losses and intermediary margins [56]; mould-related sorting and discard is one more cost that must be paid somewhere in the chain. Third, because ordinary price fluctuations are so large, a modest mould-related loss is easily lost in the noise, which makes the mould's own economic share hard to measure.

6. Who bears the cost

No one gains legitimately from mould on onions, but costs fall unevenly (Table 6). Items marked "inference" are my reasoning from the evidence, not documented findings.

Table 6. Stakeholders, how mould affects them and capacity to respond.

Group	How black mould and its aftermath affect them	Capacity to respond	Notes
Small and marginal farmers	Storage loss, early distress sales, low price at glut [51]	Low: limited capital for improved storage [52,54]	Cure, avoid neck injury, improve ventilation [17-21]
Traders and mandi operators	Sorting losses, price risk, reputational loss	Moderate	Hold stock; may sell weaker lots on (inference)
Packing, market and kitchen workers	Highest exposure to spores during handling [36]	Low (inference)	Occupational data absent
Small restaurants and street food businesses	Licence suspension, notices, loss of business after viral photographs [29-31]	Low to moderate	Inference: less storage and sorting capacity than hotels
Large hotels and chains	Penalties and reputational damage [29,30]	Higher	Inspection drives have reached 3-star and 5-star hotels [29,46]
Low-income buyers and cheap eateries	Less ability to inspect or reject stock	Low	Inference: older stock is cheaper
Consumers generally	Price spikes when rot shrinks supply [48]; discard cost	Moderate	See household illustration below
Sellers or kitchens that salvage spoiled stock	Short-term gain, legal and health risk	Not applicable	Inference: trimming or hiding spoiled onion in cooked dishes
Storage-technology and testing providers	Commercial beneficiaries	Not applicable	Not wrongdoing; the market exists because the loss exists

A household illustration. At the May 2026 all-India average retail price of INR 25.36 per kg [47], discarding a doubtful 100 g bulb costs about INR 2.5 (my arithmetic). Against that small sum, the avoidable costs of eating a visibly soft, discoloured or smelly onion, even if probably low, are not obviously worth risking; for a firm bulb with surface spots that is cut open and trimmed, the economics of trimming are reasonable (Table 3). The calculation also shows an incentive problem at scale: A kitchen buying 50 kg of onions at that price holds about INR 1,268 of stock, and a salvage decision multiplied across days and outlets is where the temptation to keep doubtful stock arises (inference).

Waste versus safety. Households and kitchens balance waste against risk. The screening guide in Table 3 is intended to help that judgement, but it is interpretive and not clinical guidance.

7. Regulation and enforcement: Distinction 3 and its economic consequences

7.1 Legal framework

The Food Safety and Standards Act, 2006 (Act 34 of 2006) created the Food Safety and Standards Authority of India (FSSAI), places responsibilities on food business operators (FBOs), and requires licensing or registration. Section 3(1)(zz) defines unsafe food as food whose nature, substance or quality is so affected as to render it injurious to health, and its listed grounds include food consisting wholly or in part of filthy, putrid, rotten, decomposed or diseased vegetable substance [45]. Section 59 provides punishment for unsafe food [24,38]. These general provisions allow action against rotten or decomposed vegetables without a measured toxin level, but they state no black-mould threshold.

Under section 32, a Designated Officer who has reasonable grounds to believe that an FBO has not complied with applicable regulations may serve an improvement notice requiring corrective measures within a reasonable period of not less than fourteen days. Failure to comply may lead to licence suspension and continued failure to cancellation after an opportunity to show cause. The Designated Officer may suspend a licence forthwith in the interest of public health, with reasons recorded in writing, and a person aggrieved may appeal to the Commissioner of Food Safety [24,37]. Sections 60 to 64 set offences for interfering with seized items, false information, obstructing a Food Safety Officer, operating without a licence and repeat offences [24,38]. I did not retrieve the full text of section 59 or the hygiene schedules, so penalty levels and hygiene conditions should be verified against the statute.

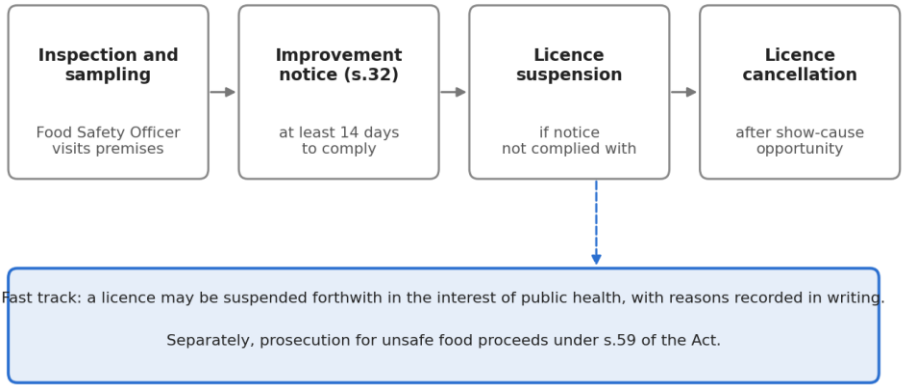

Figure 7. Enforcement ladder under section 32 of the Food Safety and Standards Act, 2006, with the fast-track suspension power and the separate section 59 prosecution route [24,37].

7.2 Contaminant and mycotoxin standards

FSSAI's Contaminants, Toxins and Residues Regulations, 2011 set limits for metals, crop contaminants and naturally occurring toxins, and residues, in listed foods [43]. The specified mycotoxins are aflatoxins (total, B1 and M1), ochratoxin A, patulin and deoxynivalenol, each for named food categories: examples in the regulatory record are aflatoxin M1 in milk, ochratoxin A in wheat, barley and rye, patulin in apple juice and deoxynivalenol in wheat [27,43,44]. The FSSAI website lists amendment 16 (17 October 2024) and amendment 17 (25 May 2026) [25]; a trade summary reports that the October 2024 amendment, effective 1 April 2025, tightened limits including for OTA [39], and a

legal summary reports further amendments notified on 14 May 2026 and gazetted on 19 May 2026 [26]. The limits I could verify concern cereals and other listed commodities [27,28,43].

These provisions should not be represented as a specific black-mould limit for raw onions. I found no entry for onion, no limit for *Aspergillus* section *Nigri* on fresh produce and no onion-specific limit for OTA or FB2 in the sources retrieved. I could not read every amendment in full, so this should be confirmed against the current consolidated regulations and gazette notifications. A laboratory result for a mycotoxin in onion would have no onion-specific limit to be compared with, and any enforcement view would depend on the general unsafe-food provisions and on how officers read them (inference).

Table 7. What the Indian provisions do and do not say about mouldy onion.

Provision	What it covers	Applicability to raw-onion black mould
Section 3(1)(zz), FSS Act: unsafe food [45]	Food injurious to health, including rotten, decomposed or diseased vegetable substance	General basis for action against rotten produce; no black-mould threshold
Section 32: improvement notice, suspension, cancellation [37]	Graded enforcement against FBOs for non-compliance	Procedural route used in kitchen inspections
Section 59: punishment for unsafe food [24,38]	Prosecution route for unsafe food	Depends on a finding of unsafe food; penalty text to be verified
Contaminants, Toxins and Residues Regulations, 2011 [43]	Specified limits for metals, aflatoxins, OTA, patulin, DON and residues in listed foods	No onion or black-mould entry found; cannot be cited as an onion limit

7.3 Reported enforcement and its economic weight

Table 8. Reported enforcement involving fungal growth on vegetables (press reports; underlying orders not seen).

Jurisdiction	What was reported	Source
Karnataka (Bengaluru)	30 teams inspected 26 hotels and collected 35 samples; violations included fungal growth on vegetables, expired food, misbranding and unhygienic storage; notices and penalties followed. The drive followed public complaints, including on social media.	Tribune India [29]; Deccan Chronicle [30]; India TV [46]
Maharashtra (Mumbai)	The FDA suspended the FSSAI licence of a well-known Fort restaurant after inspectors found fungal growth on vegetables, flies, stagnant water and other lapses and ordered operations to stop until compliance was verified.	Free Press Journal [31]

None of these reports identifies onions specifically or reports a mycotoxin test, so they show enforcement against mouldy vegetables on hygiene grounds, not onion-specific or toxin-based action.

Economically, a suspension or stop-work order has asymmetric effects. A large hotel can absorb a notice and a penalty; a small eatery that loses its licence loses income each day it is closed, and staff wages and perishable stock are lost with it (inference). Compliance also costs money: Sorting, ventilated storage, short purchase cycles and trained staff all cost more than buying and holding bulk stock. I found no data on the number of premises inspected, the penalties imposed or the proportion of produce-related violations that involved onions, so the scale of this burden cannot be judged.

Table 9. Allocation of responsibility along the onion chain (functional summary).

Actor	Responsibility
Farmer	Harvest at maturity, avoid wounds, cure and dry properly [17,18,21]
Trader, cold store, mandi operator	Ventilation, temperature and humidity control; sort out affected bulbs; storage infrastructure (central programmes address onion storage, per a parliamentary reply [23])
Restaurant, hotel or caterer (FBO)	Responsible for the food served; must reject and discard mouldy produce and keep hygienic storage; exposed to notices, suspension, cancellation and prosecution [24,37]
State Food Safety Officers and Designated Officers	Inspection, sampling, improvement notices, suspension and cancellation [37]
FSSAI	National standards, contaminant limits, guidance and policy [25,26]
Consumer	Inspect and cut open; trim only if the onion is firm; discard if soft or heavily affected [17,33,41]

The division of duties is drawn from the structure of the Act and the cited documents and should be confirmed against current statutory text.

8. Public perception, equity and trust

Trust and fear. Photographs of black-spotted produce in premium hotels spread quickly and "black fungus" carries the weight of the 2021 mucormycosis epidemic. Fact-checkers have had to separate the two [32], and the Karnataka drive itself followed complaints shared on social media [29]. Public pressure and enforcement therefore reinforce each other. Risk communication that blurs fungal growth, toxin and infection feeds alarm, which can in turn hurt sellers of sound produce; the distinctions in Section 3 are meant to prevent that.

Equity. People who eat at low-cost eateries or buy cheap loose onions have less ability to inspect storage or demand rejection of stock, and they spend a larger share of income on food, so they are most exposed both to price spikes [48] and to salvage practices (inference). Workers in handling and kitchens bear the spore exposure but have the least say in what they handle.

Livelihoods. Licence suspension can threaten small operators, while farmers and traders bear storage losses upstream. Enforcement without storage support moves the cost to the weakest link. India's official response on storage has included a central onion-storage initiative described in a parliamentary reply [23] and a proposal to irradiate rabi onion to cut sprouting losses, reported in a secondary source [34].

A product with two faces. *A. niger* is also used industrially and processed onion (powder and flakes) trades at stable export prices even when fresh mandi prices collapse [57]. Value addition and better storage can therefore cushion growers, but only where they can access them.

9. Policy options and recommendations

Table 10 sets policy options against who pays and who gains. The options are my synthesis of the cited evidence and are not tested by cost-benefit analysis.

Table 10. Policy options, who pays and who gains.

Option	Mechanism	Who pays	Who gains
Subsidised small-farm storage and curing support [52,16,17]	Ventilated structures, curing training, avoiding neck injury	Public budget; farmers' co-payment	Small farmers, consumers (steadier supply)
Grading and sorting at mandi and receiving [17]	Reject soft and heavily blackened bulbs before sale	Traders, mandi operators (cost of sorting)	Kitchens, consumers, honest sellers
Price stabilisation and procurement [47,50]	Wider procurement and price deficiency payments	Public budget	Farmers at glut; consumers at shortage
Toxin surveillance of onion and garlic	Survey OTA and FB2 with molecular identification; publish results	Public budget; research funds	Regulators, public (evidence for any limit)
Proportionate and transparent enforcement [29-31,37]	Publish inspection data; graded response; guidance to small FBOs	Regulator capacity	Small FBOs, public trust
Risk communication [32]	Separate onion mould from mucormycosis; explain surface versus interior	Public information budget	Public, sellers of sound produce

9.1 For regulators and policymakers

- Support small-farm storage, curing and ventilation, since storage performance is where black mould is economically produced [16,17,52].
- Issue plain guidance on rejection criteria for visible mould at receiving and in storage, with illustrations that separate surface spotting on a firm bulb from soft rot and interior discolouration.
- State clearly which provisions apply to mouldy vegetables (unsafe-food and hygiene provisions) and which do not (the specified-mycotoxin limits), so that no limit is implied for raw onion.
- Add onion and garlic to targeted mycotoxin surveillance for OTA and FB2 and publish the results; without Indian data no onion-specific limit can be judged.
- Publish enforcement data (premises inspected, produce-related violations, actions taken) so that scale and distributional effects can be judged; today the evidence is press reports.
- Run risk communication that states clearly that onion black mould (*A. niger*) is not mucormycosis.

9.2 For the trade and kitchens

- Cure fully, store cool, dry and ventilated, and avoid neck injury and condensation [17-19, 21].
- Sort at receiving, cut open doubtful bulbs, discard soft, discoloured or heavily blackened bulbs, and never blend mouldy onion into pastes (inference).
- Avoid assigning heavy mould handling to staff with immunosuppression or asthma, and reduce spore release when peeling (inference).

9.3 For researchers

- An Indian multi-state survey of black aspergilli species and OTA and FB2 in market onions and garlic, reporting fungal and toxin results separately.
- Economic studies that isolate the share of storage loss due to black mould and compare costs of improved storage with losses avoided, for small and marginal farmers.
- Studies of how far toxin and hyphae extend beyond visible mould in onion tissue, to support evidence-based trimming guidance.

- Occupational studies of respiratory sensitisation among onion handlers, and studies of the effect of inspection drives on small food businesses.

10. Limitations

This review was not systematic and did not search PubMed, Embase or Scopus. Indian regional literature may be under-represented. No Indian survey of mycotoxins in onions was found, so the toxin evidence is foreign and may not transfer to Indian cultivars, climates and storage. No study of toxin or hyphal extension beyond visible mould in onion was found, so trimming advice rests on extension guidance, general food-safety advice and inference. The 2026 price, cost and procurement figures come from press and trade reports of government data, and some are single-day or single-district observations; they illustrate patterns and should not be read as national averages or trends. No study isolating the economic loss attributable to black mould in India was found. Some regulatory details (the text of section 59, hygiene schedules and full amendments) were not read, and the absence of an onion or black-mould limit reflects the sources I could read, not a complete check of every notification. Several sources are extension, trade or consumer pages rather than peer-reviewed papers.

11. Conclusions

Black mould on onions is chiefly a storage-quality and market-structure problem. Its economic cost falls first on farmers and traders who cannot afford improved storage and are pushed into early or distress sales, then on consumers through price spikes when rot shrinks supply, and on small food businesses through enforcement and loss of trust. Its health significance is real but narrower than public alarm suggests, and three distinctions keep it in proportion: fungal contamination is not mycotoxin contamination; surface growth is not internal infection, so bulbs should be cut open, trimmed only when firm and discarded when soft or discoloured; and FSSAI has set limits for specified mycotoxins in specified foods and has general unsafe-food and hygiene powers, but I found no black-mould or onion-specific mycotoxin limit, and recent drives acted on hygiene grounds. Policies that support small-farm storage, grading at the mandi, Indian toxin surveillance, proportionate enforcement and clear public communication address the problem at its economic root, without overstating its health risk.

Declarations

1. Use of Artificial Intelligence (AI) Tools: Artificial intelligence (AI)-assisted tools were used during the preparation of this manuscript to support literature organisation, language refinement, structuring of the review and improvement of presentation. These tools were not considered substitutes for scientific judgement, critical analysis or independent verification of evidence. The author critically reviewed and edited the AI-assisted content and accepts full responsibility for the accuracy, originality, interpretation and integrity of the manuscript, including its references, conclusions and recommendations.

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3. Conflict of Interest: The author declares that there are no financial, personal, professional or institutional conflicts of interest that could have influenced the preparation, interpretation or presentation of this manuscript.

4. Ethical Approval: Ethical approval was not required for this narrative review because it is based on previously published literature, publicly available reports, regulatory documents and secondary information. No experiments involving humans or animals, clinical investigations or direct interventions were conducted.

5. Informed Consent: Not applicable. This manuscript does not involve human participants, identifiable personal information or individual patient data.

6. Data Availability: No new experimental or primary datasets were generated during this review. The information discussed is derived from published research articles, publicly available reports, official regulatory documents and other cited sources. The corresponding references are provided in the manuscript.

7. Author Contributions: The author was responsible for conceptualisation, literature identification, review and interpretation of available evidence, socio-economic analysis, manuscript preparation,

critical revision and final approval of the manuscript. The author takes full responsibility for the content and agrees to be accountable for all aspects of the work.

8. Use of Previously Published Material: All information, findings and interpretations obtained from previously published literature and publicly available sources have been appropriately acknowledged and cited. Any third-party figures, tables or other copyrighted material reproduced or adapted in the manuscript must have the necessary permissions, where applicable.

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