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Revealing Underreported Food Quality and Safety Malpractices among Black Pepper Farmers in Sri Lanka

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ABSTRACT

Food quality and safety malpractices pose significant risks to consumers. Spices are among the most susceptible food commodities to adulteration and fraud globally, with black pepper (*Piper nigrum* L.) being particularly vulnerable due to its high value. It also faces a safety threat from contamination by mold, which can produce harmful mycotoxins, and practices of washing mold-contaminated pepper to enhance appearance can increase the food safety risks. Although advanced detection methods exist, they remain costly and inaccessible in many developing countries, leading to underreporting of such practices. The objective of this study was to evaluate the prevalence and extent of underreporting of food quality and safety malpractices among black pepper farmers in the Matale District of Sri Lanka. Data were collected from 810 farmers using structured questionnaires administered in person during August–September 2024.The study employed a List Experiment that included both direct and indirect questioning to reduce response bias. Direct questioning revealed that 17.4% of farmers engaged in pinhead mixing and 10.5% washed mold-contaminated pepper. In contrast, indirect questioning estimated prevalence rates of 45.5% for pinhead mixing (28.1 percentage points higher, $p < 0.01$) and 34.9% for washing mold-contaminated pepper (24.4 percentage points higher, $p < 0.05$), indicating substantial underreporting of these malpractices. These findings underscore the value of indirect questioning methods in uncovering hidden food quality and safety malpractices within agricultural value chains, particularly in the black pepper sector, and provide critical evidence to support the development of effective food quality and safety policies.

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1. Introduction

Food malpractices are a broad range of intentional, deceptive, and economically motivated misconduct within the food system that causes serious harm to both the economy and public health by introducing unsafe products into the food supply chain (Gwenzi et al., 2023; Onyeaka et al., 2023). It has emerged over the years and remains a global issue today, especially in low-income countries, highlighting an urgent need for action and research (Gwenzi et al., 2023). Recent evidence shows that spices are among the most frequently adulterated and fraud-affected food commodities globally, particularly in Asia (Brooks et al., 2021; Gwenzi et al., 2023; Owolabi & Olayinka, 2021).

Black pepper (*Piper nigrum* L.), a high-value commodity in the global spice trade, is highly vulnerable to adulteration, a risk intensified by its frequent trade and consumption in ground or crushed forms that hide visual authenticity (Orrillo et al., 2019). Adulteration typically involves the incorporation of cheaper substitutes, mainly papaya seeds (Carica papaya L.), due to their physical resemblance, low cost, and availability (Orrillo et al., 2019). In addition, the mixing of pinheads (immature pepper berries) is commonly reported in the Sri Lankan context, though this practice remains undocumented in the formal literature. The extent and proportion of such adulteration have not been systematically quantified. These practices reduce quality by diminishing the characteristic aroma, pungency, and piperine content of black pepper (Orrillo et al., 2019). In addition, washing mold-contaminated pepper is another malpractice in the black pepper sector, which is directly associated with mold contamination and the subsequent mycotoxin production. Mycotoxins are toxic fungal secondary metabolites that pose a significant global food safety concern due to their ability to induce both acute and chronic health effects, including cancer and immune suppression (Ntungwe et al., 2024; Neme & Mohammed, 2017).

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The true extent of food malpractices remains largely hidden, as consumers and resource-limited communities often lack the capacity to detect or report such behaviors (Nji et al., 2022). Individuals who are engaged in these practices generally aim to remain undetected to sustain their financial benefits (Galvin-King et al., 2018). Consequently, responses regarding malpractice behaviors are often susceptible to social desirability bias and misreporting, with the extent of bias varying by survey method and being more pronounced under direct questioning. To minimize deliberate misreporting, the use of indirect questioning techniques is more appropriate (Imai, 2011; Tsai, 2019). One such approach is the list experiment, also known as the item count technique or unmatched count technique, is a survey approach developed to receive truthful reporting of sensitive behaviors (Imai, 2011). Respondents in a list experiment are randomly assigned to a treatment group or a control group. The control group is presented with a list of nonsensitive statements, while the treatment group is given the same list with the inclusion of one sensitive statement. Respondents are requested to report only the total number of statements they agreed with, rather than their response to each statement. The randomized design permits estimation of the prevalence of the sensitive item from the difference in mean counts between the two groups, assuming comparable responses to the nonsensitive items across groups (Blair and Imai, 2012).

A key advantage of the indirect questioning approach is that it reduces bias and encourages more honest reporting by protecting respondent anonymity compared with direct questioning. This makes it particularly suitable for studying sensitive behaviors that are prone to underreporting in direct surveys. However, the indirect questioning method also has drawbacks, notably the requirement for larger sample sizes due to increased variance in estimates. Furthermore, the technique relies on several assumptions, including baseline balance, the absence of design effects, and the absence of ceiling or floor effects; violations of these assumptions may introduce bias (Imai, 2011; Blair and Imai, 2012; Blair et al., 2020).

Although indirect questioning methods have been applied across various fields, such as politics, health, marketing, violence, immigration, and natural resource conservation (Nicholson & Huang, 2022; Lépine et al., 2020; De Jong et al., 2019; Asadullah et al., 2020; Song et al., 2022; Hinsley et al., 2019), empirical research using these methods remains limited in the agriculture and food sectors. Existing studies in this sector highlight the usefulness of indirect questioning methods in uncovering hidden behaviors. For example, Hung et al. (2025) found that farmers reported lower levels of noncompliance with pesticide guidelines in direct questioning surveys than in a list experiment, indicating the presence of underreporting. Similarly, Kloepfer et al. (2025) demonstrated that the sale of cannabis husks, a sensitive and illicit practice, was noticeably underreported in direct questioning but revealed through a list experiment, underscoring the effectiveness of indirect methods in uncovering concealed agricultural behaviors. Tadesse et al. (2020) found that direct questioning produced more biased and inaccurate responses on food insecurity than indirect questioning methods, highlighting the value of indirect approaches for eliciting sensitive information. Moreover, while indirect questioning could be used to examine the prevalence of food quality and safety malpractices, the extent of underreporting in these malpractices has not yet been investigated. Therefore, the objective of this study was to evaluate the prevalence and extent of underreporting of two food quality and safety malpractices, mixing pinheads and washing mold-contaminated pepper, among black pepper farmers in Sri Lanka.

2. Methods

2.1. Study Site

The study focused on the food quality and safety malpractices among black pepper farmers in Matale District, which was the pioneering district for commercial pepper cultivation in Sri Lanka. Matale accounted for 3,576 metric tons of annual production and 5,862 hectares under cultivation, making it the second largest pepper-producing region in the country (Department of Export Agriculture (DEA), 2023). The spice sector was a key component of Sri Lanka's economy, including black pepper and was identified as a priority crop under the National Export Strategy (NES, 2018) to enhance export performance. However, achieving higher export earnings depended on accessing premium markets that demanded higher quality and safety standards. Approximately 75% of Sri Lanka's black pepper exports were directed to India, while exports to the European Union and other high-value markets remained limited (Department of Export Agriculture, 2023). This export concentration reflected persistent challenges in meeting required quality and safety standards, constraining the country's ability to capture greater value in global markets.

2.2. Sampling Method

A total of 810 black pepper farmers were randomly selected from a pool of 1127 registered black pepper farmers in the study district. They were then randomly allocated to two treatment groups and a control group, with 266, 267, and 277 farmers in each group, respectively. The list experiment was conducted with one representative from each household, generally the household head, spouse, or another member who was actively involved in black pepper production. This study received ethical approval from the Institutional Review Board of Hiroshima University (approval no. HR-LPES-001384), and all participating farmers provided written informed consent before participation.

2.3. Study Design

The study included three groups: Treatment group 1, which focused on the practice of mixing pinheads; Treatment group 2, which addressed the practice of washing mold-contaminated black pepper; and a control group, which measured the prevalence of these practices through direct questioning. The list experiment design consisted of two phases (Table 1). In the first phase, farmers across all three groups were presented with four non-sensitive statements related to black pepper production. Expected prevalence for these statements was estimated using baseline survey data and expert consultation. The data were collected between 7 August and 25 September 2024 from registered black pepper farmers, using structured questionnaires administered by trained enumerators. The structured questionnaire consisted of two main components: (i) baseline information on household and respondent socioeconomic characteristics and (ii) the List Experiment, including both indirect and direct questioning components designed to assess food quality and safety malpractices. Expert consultation involved directors and Extension officers from the Department of Export Agriculture, the government agency responsible for spice crop development in Sri Lanka, who have extensive expertise in black pepper.

Control group farmers were presented with four non-sensitive statements only. The selection of the two sensitive statements was guided by the study objectives, which focused on two key malpractices: (i) mixing pinheads and (ii) washing mold-contaminated black pepper. Each treatment

group received one additional sensitive statement, resulting in a total of five statements. Treatment Group 1 (T1) received the sensitive statement on mixing pinheads (food quality malpractice), while Treatment Group 2 (T2) received the sensitive statement on washing mold-contaminated black pepper (food safety malpractice). Farmers were asked to report only the total number of statements they agreed with, without identifying which specific statements they agreed with. In the second phase of the list experiment, the direct questioning phase, we focused exclusively on the control group. Farmers in the control group were asked to respond "Yes" or "No" to two sensitive questions corresponding to the food quality and safety statements examined in Phase 1, allowing comparisons between indirect and direct responses.

2.4. Data Analysis

Several diagnostic checks were conducted to ensure the validity of the List Experiment estimates. First, balance tests were performed using two-sample *t*-tests to compare baseline household and respondent characteristics across the assigned groups to verify the success of randomization. Second, the order of statements was randomized for each respondent within each group to minimize potential design effects and ensure that the inclusion of the sensitive item did not influence responses to the non-sensitive items. Third, the non-sensitive statements were selected based on baseline prevalence and expert consultation to ensure sufficient variation in responses and reduce the likelihood of ceiling and floor effects, which occur when respondents agree with all or none of the non-sensitive statements.

A linear regression model presented below was applied to estimate the prevalence of food quality and safety malpractices using responses from the list experiment. The model estimated differences in the number of agreed statements between the control and treatment groups while controlling baseline covariates.

$$Y_i = \alpha_0 + \beta_1 T_{1i} + \beta_2 T_{2i} + \sigma_0 X_i + \varepsilon_i$$

Y_{it} denotes the response value, stated as the number of statements that respondent i agreed with. T_{1i} and T_{2i} represent the binary treatment variables, indicated as 1 for the respective treatment group and 0 for the control group. β_1 and β_2 are the regression coefficients related to the prevalence of each malpractice, displaying how response values differ between the treatment and control groups. X_i represents baseline covariates related to household and respondent characteristics, and ε_i is the error term.

Table 1 *List experiment design for estimating food quality and safety malpractices among black pepper farmers in Matale District, Sri Lanka (2024).*

Procedure	Control	Treatment 1	Treatment 2
Phase 1 List experiment	• You have practiced shade tree pruning in your Black pepper field at least once a year • You have practiced mulching at least during early stage of Black pepper planting • You have practiced chemical pesticide application for your Black pepper field during last year • You have used only family labour for Black pepper production during the last year	• You have practiced shade tree pruning in your Black pepper field at least once a year • You have practiced mulching at least during early stage of Black pepper planting • You have practiced chemical pesticide application for your Black pepper field during last year • You have used only family labour for Black pepper production during the last year • You have practiced mixing of pinheads to Black pepper during last year	• You have practiced shade tree pruning in your Black pepper field at least once a year • You have practiced mulching at least during early stage of Black pepper planting • You have practiced chemical pesticide application for your Black pepper field during last year • You have used only family labour for Black pepper production during the last year • You have practiced washing mould-contaminated Black pepper during last year
Phase 2 Direct Questioning	Please answer (YES/NO) to the following questions • Have you practiced mixing pinheads with Black pepper during last year? • Have you practiced washing mould-contaminated Black pepper during last year?	Not required to participate	Not required to participate

3. Results

3.1. Descriptive Statistics

The descriptive statistics of key socio-economic characteristics and farming practices across the Control, Treatment 1, and Treatment 2 groups were generally well balanced. Household heads were, on average, 58–59 years old, with 10–15% being female. More than 50% had completed secondary education, and 35–40% reported farming as their main occupation. The average age of respondents was 51–52 years, with 32–35% being female and more than 50% having completed secondary education. Farming was the main occupation for 26–28% of respondents, while approximately 65–67% were household heads, indicating that most respondents were primary decision-makers.

Land and farming characteristics were also comparable across groups. Average land size ranged from approximately 1.1 to 1.2 acres, and more than 92% of farmers cultivated local pepper varieties. Land ownership exceeded 95% across all groups, and around 62–64% of farmers cultivated additional crops. Income levels were broadly similar, with annual pepper

income ranging from LKR 0.14 to 0.17 million. Non-agricultural income was slightly higher ($p < 0.1$) in Treatment 2 (approximately LKR 0.56 million) than in the control group (approximately LKR 0.50 million). Most farmers sold their produce to nearby town markets, accounting for around 80% in the Control and Treatment 1 groups and 76% in Treatment 2. Access to information was also similar across groups, with the average distance to the Agrarian Service Centre ranging from 8 to 9 km, while 44–50% of farmers relied on Extension Officers (EOs) as their primary source of information.

3.2. Results of List Experiment Diagnostic Tests

The results showed that covariates were generally well balanced across groups, except for only two of the eighteen covariates (Table 2). Specifically, non-agricultural income differed between respondents who received the sensitive statement related to food safety malpractices (T2) and respondents in the control group ($p < 0.1$). Land ownership differed between respondents who received the sensitive statement related to food quality malpractices (T1) and those who received the sensitive statement related to food safety malpractices (T2) ($p < 0.1$).

Regarding design effect, the Bonferroni-adjusted p-values for both sensitive statement groups exceeded 0.05. Regarding ceiling and floor effect, fewer than 1.5 percent of respondents agreed with all five statements. Similarly, only a very small proportion of farmers reported agreeing with none of the non-sensitive statements (less than 3 percent), with no such responses observed in the control group.

Table 2. *Baseline comparison among the groups in the study sample of black pepper farmers in Matale District, Sri Lanka (2024).*

Variable	T1- Control		T2-Control		T1-T2	
	Diff	SE	Diff	SE	Diff	SE
Household Head Characteristics						
Age	0.160	1.039	-1.242	1.109	1.402	1.083
Gender (female dummy)	-0.031	0.029	-0.039	0.029	0.008	0.27
Secondary education dummy (yes = 1)	0.001	0.043	-0.050	0.043	0.051	0.043
Occupation farmer dummy (yes = 1)	0.019	0.042	-0.027	0.041	0.046	0.042
Respondent Characteristics						
Age	0.37	1.195	-0.453	1.189	0.823	1.202
Gender (female dummy)	0.010	0.041	-0.017	0.040	0.028	0.041
Secondary education dummy (yes = 1)	0.000	0.043	-0.017	0.043	0.017	0.043
Occupation farmer dummy (yes = 1)	0.018	0.038	0.018	0.038	0.014	0.038
Respondent is household head (yes = 1)	0.012	0.041	0.024	0.041	-0.013	0.041
Land Information						
Land size (Ac)	0.064	0.080	-0.018	0.079	0.081	0.086
Local pepper variety dummy (yes = 1)	0.005	0.022	0.024	0.020	0.003	0.012
Land ownership: own land dummy (yes = 1)	0.003*	0.012	-0.023	0.015	0.026	0.015
Other crop dummy (yes = 1)	0.014	0.412	0.019	0.042	-0.005	0.042
Income and Market						
Annual income from pepper (Rs.mn)	0.013	0.016	-0.006	0.014	0.019	0.016
Total annual non-agricultural income (Rs.mn)	0.032	0.041	0.057*	0.034	-0.025	0.042
Main market near town dummy (yes = 1)	0.018	0.034	-0.038	0.036	0.055	0.036
Information Facts						
Distance to the ASC[φ] (km)	-0.698	0.528	-0.283	0.546	-0.415	0.523
Extension officer main information source dummy (yes = 1)	-0.044	0.043	0.018	0.043	-0.062	0.043

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$, [φ]Agrarian Service Centre.

3.3. Prevalence of Malpractices

Table 3 shows that, based on direct questioning, 17.4% of respondents were engaged in pinhead mixing, and 10.5% were washing mold-contaminated pepper. In contrast, indirect questioning indicated substantially higher prevalence rates, with 45.5% of respondents engaged in pinhead mixing and 34.9% engaged in washing mold-contaminated pepper. These estimates are 28.1 percentage points ($p < 0.01$) and 24.4 percentage points ($p < 0.05$) higher, respectively, than those obtained from direct questioning.

3.4. Heterogeneity in Malpractice Prevalence

Table 4 shows the heterogeneous impacts of demographic and socio-economic characteristics on the prevalence of two malpractices, i.e., mixing pinheads and washing mold-contaminated pepper. Our analysis showed that the prevalence of these malpractices did not differ across age groups, gender, and education groups. However, farmers with higher non-agricultural income, ranging from 0.53 to 2 million LKR, had a lower prevalence of washing mould-contaminated pepper, with a 41.3 percentage-point reduction compared to those with lower non-agricultural income ($p < 0.05$). Similarly, farmers with a high adoption of post-harvest quality improvement practices showed a reduction of forty-one percentage points in the prevalence of washing mold-contaminated pepper relative to low adopters (< 0.05).

Table 3. *Prevalence of quality and safety malpractices among black pepper farmers in Matale District, Sri Lanka (2024).*

	List experiment			Direct questioning	Misreporting magnitude
	Mean of response		Estimated prevalence		
	Treatment	Control			
	(a)	(b)	(1) = (a)-(b)	(2)	(1) – (2)
Mixing of pinheads (T1)	2.282	1.830	0.455***	0.174***	0.281***
	(0.062)	(0.058)	(0.085)	(0.023)	(0.098)
Observations	266	277	543	277	
Washing mould-contaminated Black pepper (T2)	2.187	1.830	0.349***	0.105***	0.244**
	(0.062)	(0.058)	(0.085)	(0.018)	(0.092)
Observations	267	277	544	277	

Note: Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$
Covariates (18): Household head characteristics (age, gender -female dummy, secondary education dummy, farmer dummy); respondent characteristics (age, female dummy, respondent is household head dummy, secondary education dummy, farmer dummy); land information (land size, pepper variety local dummy, land ownership dummy, crop other than pepper dummy); income and market (annual income from pepper, annual non-agricultural income, main market near town dummy); and information-related facts (distance to Agrarian Service Center, Extension officer main information source dummy).

Table 4. *Heterogeneous effects on the prevalence of quality and safety malpractices among black pepper farmers in Matale District, Sri Lanka (2024).*

	>= Mean Household head age	Household head is female	Household head completed secondary education	>= Mean non-agricultural income	High adoption of post-harvest quality improvement practices
Mixing of pinheads (T1)	0.508***	0.472***	0.514***	0.542***	0.632***
	(0.123)	(0.092)	(0.124)	(0.112)	(0.139)
Washing mould-contaminated black pepper (T2)	0.451***	0.367***	0.377***	0.525***	0.581***
	(0.116)	(0.093)	(0.124)	(0.115)	(0.140)
Interaction terms					
Treatment 1 Characteristics	-0.101	-0.125	-0.11	-0.227	-0.291
	(0.170)	(0.244)	(0.170)	(0.177)	(0.177)
Treatment 2 Characteristics	-0.176	0.032	-0.037	-0.413**	-0.410**
	(0.171)	(0.227)	(0.170)	(0.172)	(0.176)

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.
The category "≥ mean non-agricultural income" denotes farmers with non-agricultural income at or above the sample mean, corresponding to the range of 0.53–2 million LKR.

4. Discussion

The lower prevalence estimates obtained through direct questioning may be due to concerns about potential negative effects on sales or damage to their reputation if they openly admit to being involved in such practices. These results are consistent with prior evidence from list experiments. For instance, Hung et al. (2025) reported that farmers underreported noncompliance with pesticide-use guidelines when asked directly. Similarly, Tadesse et al. (2020) demonstrated that responses to sensitive topics such as food insecurity are highly susceptible to bias and misreporting under direct questioning. The absence of gender differences in malpractice prevalence found from the current study contrasts with the findings of Hung et al. (2025), who reported higher noncompliance with

pesticide-use guidelines among female farmers. This difference may reflect variations in the specific types of malpractices examined and differences in farming systems between black pepper production in the present study and tea production in the study by Hung et al. (2025).

The lower prevalence of washing mold-contaminated pepper in the current study (34.9%) compared with the 63% mycotoxin contamination rate reported by Yogendrarajah et al. (2014) may reflect increased adoption of post-harvest quality improvement practices. The lower prevalence of washing mold-contaminated pepper among farmers with higher adoption of recommended quality improvement practices suggests greater awareness of food safety risks associated with mold contamination, consistent with previous findings showing that improved access to information and technology promotes the adoption of practices that reduce mycotoxin contamination (Magnan et al., 2021; Neme & Mohammed, 2017). This reduced prevalence of washing mold-contaminated pepper and its association with training-induced adoption of improved post-harvest practices is further supported by Amarawansha et al. (2026). They reported that training programs conducted by the Department of Export Agriculture of Sri Lanka, the national agency responsible for promoting spice crop development, including black pepper, improved the adoption of post-harvest quality and safety practices among black pepper farmers in Sri Lanka.

The low prevalence of washing mold-contaminated pepper among farmers with high non-agriculture income suggests that they may face less economic pressure to recover losses from contaminated pepper, consistent with Hoffmann and Jones (2021), who reported that economic incentives can encourage farmers to shift from riskier practices toward safer production systems. The findings of this study suggest that government agencies and relevant authorities should design targeted training and awareness programs to reduce malpractices and increase the adoption of quality improvement practices. These programs should particularly focus on farmers with low non-agricultural income, as they may be more vulnerable to engaging in food quality and safety malpractices. In addition, the study highlights the usefulness of indirect questioning techniques in identifying hidden or sensitive practices. Therefore, these techniques can be applied in future agricultural and food sector studies to obtain more accurate information not only on underreported malpractices, but also on other sensitive and potentially hidden practices.

As key limitation, this study mainly relied on quantitative survey data and lacked qualitative insights. Therefore, the underlying motivations, behavioral drivers, and risk factors influencing farmers' engagement in malpractices could not be explored in depth. Future research should incorporate qualitative approaches such as in-depth interviews, focus group discussions, and case studies to better understand why farmers engage in such practices and how socio-economic, institutional, and cultural factors shape their decisions. Such insights would support the design of more targeted and effective interventions to reduce food safety and quality malpractices.

5. Conclusions

This study identified the prevalence of key food quality and safety malpractices among black pepper farmers in Sri Lanka. Based on direct questioning, 17.4% of farmers were engaged in pinhead mixing and 10.5% were washing mold-contaminated pepper. Indirect questioning revealed substantially higher prevalence rates, with 45.5% of farmers engaging in pinhead mixing and 34.9% washing mold-contaminated pepper. The prevalence estimates obtained through indirect questioning were 28.1 percentage points ($p < 0.01$) and 24.4 percentage points ($p < 0.05$) higher, respectively, than those obtained through direct questioning, indicating substantial underreporting of these practices in conventional surveys. The findings further showed that washing mold-contaminated pepper was less prevalent among farmers with higher non-agricultural income (41.3 percentage-point reduction, $p < 0.05$) compared with those with less such income and among those who adopted post-harvest quality improvement practices (41.0 percentage point reduction, $p < 0.05$) compared with non-adopters. These results suggest that both improved economic stability and technical knowledge are associated with reduced engagement in unsafe processing practices. Overall, the study demonstrates the value of indirect elicitation methods in capturing sensitive food safety behaviors that are likely to be underreported.

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