REPORT | OPEN ACCESS

International journal of
adulteration

To Cite:
Sahoo JP, Samal KC. Adulteration in Indian spices: An alarming concern and a silent health hazard. *International journal of adulteration*, 2024; 8: e4ijad3043
doi: https://doi.org/10.54905/disssi.v8i9.e4ijad3043

Author Affiliation:
[1]Faculty of Agriculture and Allied Sciences, C.V. Raman Global University, Bhubaneswar - 752054, India
[2]College of Horticulture, Odisha University of Agriculture and Technology, Chiplima - 768026, India

[*]**Corresponding Author**
Faculty of Agriculture and Allied Sciences, C.V. Raman Global University, Bhubaneswar - 752054, College of Horticulture, Odisha University of Agriculture and Technology, Chiplima – 768026, India
Email: jyotiprakashsahoo2010@gmail.com; samalkcouat@gmail.com

Peer-Review History
Received: 29 March 2024
Reviewed & Revised: 02/April/2024 to 18/June/2024
Accepted: 22 June 2024
Published: 03 July 2024

Peer-Review Model
External peer-review was done through double-blind method.

International journal of adulteration
eISSN (Online) 2456 – 0294

DISCOVERY
SCIENTIFIC SOCIETY

Adulteration in Indian spices: An alarming concern and a silent health hazard

Jyoti Prakash Sahoo[1*], **Kailash Chandra Samal**[2*]

ABSTRACT

Adulteration of Indian spices is a critical issue with profound health, economic, and cultural implications. This practice involves the addition of inferior or harmful substances to spices, compromising their purity and safety. Common adulterants include artificial colors, toxic chemicals, and non-food substances, which pose significant health risks such as toxicity, allergic reactions, and nutritional deficiencies. The economic impact is equally concerning, as adulteration erodes consumer trust, damages India's international reputation, and causes financial losses for genuine producers. Despite regulatory frameworks like the Food Safety and Standards Authority of India (FSSAI) and the Prevention of Food Adulteration Act, enforcement challenges persist. Combating this issue requires stricter regulatory enforcement, consumer education, technological innovations, and support for farmers. Addressing spice adulteration is essential to safeguarding public health, maintaining economic stability, and preserving India's rich culinary heritage.

Keywords: Adulteration, Indian spices, quality, health risks

1. INTRODUCTION

India is renowned for its rich culinary heritage, deeply rooted in its diverse and flavourful spices (Malik, 2019). These spices are not just the soul of Indian cuisine but also hold significant medicinal, cultural, and economic value (Choudhary et al., 2020). However, the integrity of these spices is under threat due to widespread adulteration (Tomar and Alka, 2022). Adulteration refers to the process of adding inferior, cheaper, or harmful substances to food products, compromising their quality and safety (Chachan et al., 2021). This practice is particularly concerning in the spice industry, given the critical role spices play in health, nutrition, and cultural traditions (Kaavya et al., 2020). The history of spices in India dates back thousands of years. They were once considered as precious as gold and played a vital role in trade and the economy (Tomar and Alka, 2022).

Black pepper, turmeric, cardamom, and saffron have been integral to Indian cuisine, traditional medicine, and religious rituals (Srirama et al., 2017). India

stands as a global spice powerhouse, exporting nearly $4 billion worth of spices, constituting a substantial 12% of the world's spice exports (Biswas, 2024). Among its key exports are chilli powder, cumin, turmeric, cardamom, and mixed spice blends, while also boasting notable exports such as asafoetida, saffron, anise, nutmeg, clove, and cinnamon (Biswas, 2024). The largest consumers of Indian spices are China, the US, and Bangladesh, with additional significant markets found in the UAE, Thailand, Malaysia, Indonesia, the UK, Australia, Singapore, and Hong Kong (Kushwaha et al., 2021).

However, with the advent of mass production and commercialization, the purity of these spices has increasingly come under scrutiny (Cilak et al., 2021). A recent EU study Maquet et al., (2021) revealed that nearly one in every five herbs and spices were adulterated or altered. Oregano was the most commonly adulterated herb, with approximately 48% of collected samples containing other ingredients, primarily olive leaves. Other adulterated herbs and spices included pepper (17%), cumin (14%), turmeric (11%), paprika (6%), and saffron (11%) (Maquet et al., 2021). The study analysed 1,885 samples of herbs and spices, finding that over half of them contained undisclosed plant material, while unauthorized food dyes were present in about one in fifty samples (Maquet et al., 2021).

Moreover, adulteration in Indian spices poses significant risks to health and quality (Cilak et al., 2021). Therefore, this article aims to explore the various dimensions of spice adulteration in India, shedding light on its causes, implications, detection methods, and regulatory framework. By delving into this complex issue, this article endeavours to underscore the urgent need for concerted action to combat spice adulteration and safeguard the integrity of India's spices, ensuring a flavourful culinary experience for generations to come.

2. THE SPICE FRAUD: INVESTIGATING ADULTERATION IN INDIAN SPICE MARKETS

India's ascent as a global spice giant has been accompanied by a surge in health-related concerns (Galvin-King et al., 2018). The recent revelation regarding the suspension of sales of certain spices manufactured by Indian companies MDH and Everest due to suspected high levels of ethylene oxide, a carcinogenic pesticide, serves as a stark illustration of this trend (Osman et al., 2019). Furthermore, reports indicate that the European Union (EU) has voiced apprehensions after detecting the same cancer-causing substance in samples of chili peppers and peppercorns sourced from India (Negi et al., 2021).

Moreover, these investigative piece sheds light on the pervasive practices of tampering with spice products, raising concerns about the integrity of India's spice markets. From chili powder to turmeric and beyond, the cases, retrieved from Times of India website, indexed in Table 1, explores how unsuspecting consumers may fall victim to adulterated spices, compromising both taste and health. By uncovering the intricate web of deceit within the spice supply chain, this exposé seeks to spark awareness and prompt action to safeguard the authenticity of India's spice.

Table 1 Adulterated Spices News Headlines Obtained from Times of India

Timeline	News Headlines (Featured in Times of India)
May 21, 2024	Government takes strict action against Everest, MDH for selling contaminated spices
May 06, 2024	International agency finds cancer-causing chemicals in popular Indian spice brands
May 06, 2024	15 tonnes of fake masala seized; wood dust, acid used in them
May 04, 2024	Food ‘poisoning’: Industrial dye mixed in spices at this Ghaziabad mill
Apr 23, 2024	Countries have banned the sale of cancer-causing MDH and Everest masalas
Nov 13, 2023	Why you need to be worried about toxic turmeric
Nov 11, 2023	Trendy to toxic: Is turmeric losing its golden hue?
Jul 21, 2023	Adulterated spices seized in factory raid
May 14, 2023	3,057kg of adulterated spice powders seized in Surat
Feb 28, 2023	600kg 'adulterated' spices seized in Meerut, processing unit sealed
Apr 10, 2022	Adulterated garam masala found in unit
Feb 05, 2022	Indore: Adulterated hing powder making unit busted, 1 held
Jan 22, 2021	Three detained for adulterated spice business in Ganjam

Reasons for adulteration and common adulterants in spices

Several factors contribute to the adulteration of spices in India. Producers and sellers often adulterate spices to increase volume and reduce costs, thus maximizing profits (Sasikumar et al., 2016). The immense global and domestic demand for Indian spices also encourages unscrupulous practices to meet supply needs (Essuman et al., 2022). Insufficient regulatory oversight and enforcement in some areas further allow adulteration to thrive, while the complex supply chains, where spices pass through multiple intermediaries, increase opportunities for tampering. Common adulterants in spices vary widely. Artificial colors and dyes, such as lead chromate and metanil yellow, are used to enhance the color of spices like turmeric and chili powder (Essuman et al., 2022).

Starches like wheat flour and rice flour are added to coriander powder to increase weight. Sawdust and sand are mixed with ground spices to bulk up the quantity. Synthetic aromas and flavors are used to imitate the natural aroma and flavor of spices. Additionally, ground and dyed used tea leaves are added to black pepper, and papaya seeds are mixed with black pepper seeds to increase bulk. Some adulterants, like lead chromate in turmeric, are particularly harmful to health (Negi et al., 2021). These practices deceive consumers and can pose serious health risks. Moreover, some common adulteration in spices are indexed in (Table 2).

Table 2 Common adulteration in spices

Spices	Common adulterants
Black pepper powder	Papaya Seed, starch, sawdust
Turmeric powder	Lead chromate, metanil yellow, chalk powder, yellow shop stone powder, starch
Chilli Powder	Brick powder, salt powder, artificial dyes, sand, saw dust, dried tomato skin
Hing	Soap stone, starch, foreign resin
Coriander powder	Animal dung powder, seed removed coriander
Oregano	Similar types of plant leaves or herbs
Curry Powder	Starch powder, sawdust
Cinnamon	Cassia substitution
Cumin	Grass seeds coloured wit charcoal, immature fennel
Saffron	Dried tendrils of maize cob, sandalwood dust, tartrazine, coconut threads
Cardamom	Artificial colorant i.e., apple green and malachite green

Health Risks, Economic and Cultural Impact of Adulteration in Indian Spice

The health risks associated with spice adulteration are severe and multifaceted (Manasha and Janani, 2016). Consuming adulterated spices can lead to acute and chronic health issues due to the presence of toxic substances such as lead chromate and metanil yellow, which are used to enhance color but are carcinogenic and can cause poisoning (Mohiuddin, 2020). Additionally, non-food adulterants like sawdust, sand, and artificial flavors can cause gastrointestinal distress, allergic reactions, and other digestive problems (Harke et al., 2023). The presence of unauthorized food dyes and elevated levels of heavy metals like copper further exacerbates the risk, potentially leading to neurological damage, kidney failure, and other serious health conditions (Harke et al., 2023). Over time, the consumption of such compromised spices can also result in nutritional deficiencies, as adulterated products often lack the essential nutrients and beneficial compounds found in pure spices (Mohiuddin, 2020). The economic and cultural impact of spice adulteration in India is profound and far-reaching.

Economically, adulteration undermines consumer trust in spice quality, leading to reduced demand and potential market losses for authentic producers who adhere to quality standards (Mohiuddin, 2020). It tarnishes India's reputation as a leading global spice exporter, which can result in decreased export revenues and increased scrutiny from international markets (Mohiuddin, 2020). This unfair competition also disadvantages genuine farmers and producers, causing financial strain and discouraging quality production (Mohiuddin, 2020). Culturally, spices hold immense significance in Indian traditions, cuisine, and medicinal practices Adulteration erodes this cultural heritage, as the compromised quality of spices affects the authenticity and integrity of culinary and traditional practices, diminishing the cultural value associated with these ingredients (Manasha and Janani, 2016).

Methods for Detection of Adulteration in Indian Spice

Various techniques have been developed for the detection of adulteration in spices, encompassing physical, biochemical, immunological, and molecular methods (Bharathi et al., 2018). Molecular methods are particularly favored for identifying biological adulterants, while physical and biochemical techniques are preferred for detecting other types of adulterants (Sasikumar et al., 2016). For instance, in the case of foreign resin in asafoetida (hing), burning a small amount can reveal purity, as pure asafoetida burns similarly to camphor, while adulterated versions do not produce a bright flame (Pantola and Agarwal, 2021). Similarly, for detecting soapstone or other earthy matter in asafoetida, shaking a sample with water can reveal adulteration if sediment settles at the bottom (Pantola and Agarwal, 2021). Another example involves testing for starch in asafoetida by adding water to the sample and observing color changes.

Similarly, adulteration of black pepper with papaya seeds can be detected by observing flotation in water and examining physical characteristics under a magnifying glass (Jaiswal et al., 2016). For identifying light berries in black pepper, manual pressure or flotation in alcohol can distinguish between light and mature black pepper berries (Modupalli et al., 2021). Furthermore, synthetic colors in chili powder can be detected by sprinkling the powder in water and observing color streaks, while sawdust in chili powder can be identified by observing flotation in water (Rani et al., 2015). Chalk in common salt can be detected by stirring a salt solution, where the presence of chalk will settle down as insoluble impurities (Kaavya et al., 2020). Exhausted cloves in cloves can be identified by observing settling behavior in water, while cassia bark in cinnamon can be distinguished by visual inspection of bark characteristics and scent. These methods contribute to the efforts to combat spice adulteration and ensure the integrity and safety of spice products for consumers. Moreover, a list of methods for detection of adulteration in Indian spices and condiments are indexed in (Table 3).

Table 3 Methods for Detection of Adulteration in Indian Spices and Condiments

Spices with adulteration	Reagent	Safety precautions	Procedure	Inference
Lead Salts in Turmeric Powder	Conc. HCl	Conc. HCl is corrosive and can cause burns. Handle it with care. Use a dropper or Pasteur pipette to add acid	Take one g of turmeric/chilli powder in a tube. Add 1 ml conc. HCl. Observe the change in color.	The appearance of magenta color shows the presence of yellow oxides of lead in turmeric powder
Lead Chromate in Turmeric Powder	1:7 H2SO4 and Diphenycarbazide (0.2%)	Conc. H2SO4 is corrosive and can cause burns. Handle it with care. Use Pasteur pipette to add acid.	Ash about 2 grams the sample. Dissolve it in 4-5 ml of 1:7 sulphuric acid (H2SO4) and filter. Add 1ml of 0.2% diphenylcarbazide. Observe any change in color.	A pink color indicates presence of lead chromate.
Metanil Yellow in Turmeric Powder	Conc. HCl	Conc. HCl is corrosive and can cause burns. Handle it with care. Use Pasteur pipette to add acid	Take one-gram turmeric powder in a test tube. Add 5 ml of water. Add a few drops of concentrated HCl. Observe any change in color.	Appearance of pink/violet color which disappears on dilution with water shows the presence of unadulterated turmeric. If the color persists, indicates the presence of metanil yellow.
Aniline Dyes in Turmeric Powder	Rectified spirit	Rectified spirit is flammable. Store appropriately.	Take one-gram turmeric powder in a test-tube and add water to make a	Immediate separation of yellow color in the rectified spirit layer

			suspension. Add 1- 2 ml of rectified spirit. Observe the color of the rectified spirit layer.	indicates the presence of dyes.
Chalk Powder in Turmeric Powder	Conc. HCl	-	Take about 1 g of turmeric powder in a test tube containing 2-3 ml of water. Add a few drops of conc. Hydrochloric acid.	Effervescence indicates the presence of chalk powder.
Added Starch in Powdered Spices other than Turmeric Powder	Iodine solution (1%)	Add a few drops of Iodine solution to the spice powder in a petri dish. Observe the development of blue color if any	-	A blue color shows the presence of starch.
Brick Powder in Chilli Powder	Chloroform-Carbon tetrachloride mixture	Chloroform and Carbon tetrachloride are suspect carcinogens. Avoid inhaling vapor and contact with eyes, skin and clothing. Use only with adequate ventilation.	Take chloroform/Carbon tetra chloride mixture in a beaker. Pour the sample in a beaker containing a mixture of chloroform and carbon tetrachloride. Observe the bottom of the beaker.	Brick powder and dirt will settle at the bottom.
Added Color in Chilli, Turmeric and Other Curry Powders	13N H_2SO_4 and Petroleum ether	Concentrated H_2SO_4 is corrosive and can cause burns. Handle it with care. Use Pasteur pipette to add acid. Petroleum ether is highly flammable. Store away from open flame	Extract one gram of the sample with 3-4 ml petroleum ether. Add 13N H_2SO_4 to the extract. Observe color of lower acid layer.	Appearance of red color (which persists even upon adding little distilled water) indicates the presence of added color. If the color disappears upon adding distilled water, the sample is not adulterated.
Oil Soluble Color in Chilli Powder	50% HCl and Petroleum ether	Take 2 g of the sample in a test tube, add few ml of ether and shake. Decant ether layer into a test tube containing 2 ml of dilute HCl (50%) and shake. Observe color of the lower acid layer	Concentrated HCl is corrosive and can cause burns. Handle it with care. Use Pasteur pipette to add acid. Petroleum ether is highly flammable. Store away from open flame	Red color of the lower acid layer indicates the presence of oil soluble color.
Sudan Dye III in Chilli Powder	Acetonitrile reagent and Hexane	Take one g of chilli powder in a test-tube. Add 2 ml of hexane to it, and shake well. Allow it to settle. Decant the clear solution into another test tube. Add 2 ml of acetonitrile reagent and shake well. vi. Observe color of	Hexane is inflammable. Keep away from open flame.	The appearance of a red color in the lower acetonitrile layer indicates the presence of Sudan red III.

		lower acetonitrile layer		
Rhodamine B in Chilli Powder	Acetone	Acetone is highly flammable solvent. Keep away from open flame. Store in appropriate cabinet	Take 2 grams sample in a test tube. Add 5 ml of acetone. Observe color of acetone layer	Immediate appearance of red color indicates presence of Rhodamine-B.
Papaya Seeds in Black Pepper	Ethyl alcohol (97.2% (v/v) and Iodine reagent	-	Float 15g seeds in a beaker containing 150 ml alcohol. Stir the seeds with a glass rod. Mature black pepper berries will sink. Spoon of all the floating berries and examine. Cut the seeds into two halves and examine visually. Add a drop or two of iodine reagent. Observe the developed color	A blue color indicates it is pepper due to the presence of starch. A pale color indicates it is papaya, due to the presence of dextrin. Papaya is a dicot; a thin line partition shows two cotyledons. Pepper is a monocot, the seed halves will show a central hole
Common Salt in Coriander Powder	Silver nitrate reagent (0.1 M)	Silver nitrate solution causes skin to discolor	Suspend one gram of the sample in wate. Add a few drops of silver nitrate reagent. Look for a white precipitate	A white precipitate indicates the presence of sodium chloride.
Chalk in Asafoetida	Conc. HCl and Carbon Tetrachloride	Conc. HCl is corrosive and can cause burns. Handle it with care. Use Pasteur pipette to add acid. Petroleum ether is highly flammable. Store away from open flame	Shake sample with CCl4. Allow to settled down. Decant the top layer. Add dil. HCl to the residue. Effervescence indicates the presence of chalk in sample.	-
Colophon Residue in Asafoetida	Acetic anhydride and Conc. H2SO4	Conc. H2SO4 is corrosive and can cause burns. Handle it with care. Use Pasteur pipette to add acid. Acetic Anhydride is a highly corrosive chemical and contact can severely irritate and burn the skin and eyes.	Dissolve about 100 mg of asafoetida (or 0.5 g of compounded asafoetida) in 10 ml of acetic anhydride. Heat gently and then cool. Add one drop of Concentrated H2SO4. Observe the color.	A bright purplish-red color, rapidly changing to violet, indicates the presence of colophon is present.
Foreign Resins in Asafoedita	Ferric chloride (6%) and Rectified spirit	-	Take 1 g of asafoetida, powder it thoroughly, and take it in a test-tube. Add some rectified spirit. Filter/ decant the solution. To 5 ml of filtrate add few drops of ferric chloride (6%) solution. Observe any color change	Olive green color shows the presence of adulteration with other resins.
Dried Tendrils of Maize Cob in	-	Take a few strands of saffron. Add hot water 70-80 °C.	-	Pure saffron when allowed to dissolve in

Saffron		Observe the diffusion of color		water will continue to give its saffron color so long as it lasts. Genuine saffron will not break easily like artificial saffron.

Regulatory Framework and Measures to Combat Spice Adulteration in India

India has established a regulatory framework to address the issue of spice adulteration, albeit with varying degrees of effectiveness. The Food Safety and Standards Authority of India (FSSAI) is the primary regulatory body responsible for setting standards and regulations related to food safety, including spices. The Prevention of Food Adulteration Act, 1954, serves as a legislative framework to ensure the purity and safety of food products, including spices, by prohibiting adulteration. Additionally, the Agmark certification mark is employed to assure consumers of the quality and authenticity of agricultural products, including spices. Despite these measures, challenges persist in enforcement due to factors such as limited resources, corruption, and the complex nature of the spice industry's supply chain. Strengthening regulatory enforcement, increasing penalties for adulteration, and enhancing collaboration between regulatory agencies and stakeholders are essential steps to effectively combat spice adulteration in India.

To combat adulteration effectively, several measures can be implemented (Jeeva, 2019). Firstly, stricter enforcement of regulations and the imposition of harsh penalties for adulteration can serve as deterrents against malpractices (Jeeva, 2019). Secondly, raising consumer awareness about the risks associated with adulteration and empowering them to identify pure spices can diminish the demand for adulterated products (Jeeva, 2019). Thirdly, leveraging technology and innovation, such as spectroscopy and chromatography, can enhance the accuracy of adulterant detection, thereby ensuring the purity of spices (Jeeva, 2019). Fourthly, implementing traceability systems to monitor the origin and supply chain of spices can foster accountability and transparency throughout the production process (Jeeva, 2019). Finally, providing support and incentives to farmers and authentic producers can incentivize the cultivation and production of high-quality, unadulterated spices, promoting integrity within the spice industry (Jeeva, 2019).

Indian Council of Medical Research (ICMR) Guideline

In its latest guidelines, ICMR advocates for the preference of whole spices over powdered counterparts, which are more susceptible to adulteration and consequently pose health risks. Under Guidelines 12—'Consume safe and clean foods', ICMR offers advice on selecting safe foods and ensuring their freedom from infestation, molds, foreign particles, and artificial colors. Emphasizing the nutritional benefits of spices, which contribute flavor and are rich in antioxidants while aiding in managing various health conditions, ICMR advises caution when purchasing spices for culinary purposes.

The medical research body advises individuals to opt for whole spices over powdered ones, citing the higher likelihood of adulteration in the latter. "Since powdered spices are more prone to adulteration, whole spices, characterized by uniform color, size, and shape, should be preferred. It is recommended to always purchase certified products", states ICMR. Recent concerns over pesticide levels in MDH and Everest spice mixes have further underscored the importance of such cautionary measures. Collaborating with the National Institute of Nutrition, ICMR has released 17 new dietary guidelines tailored to different age groups, aimed at aiding Indians in making informed food choices.

These guidelines encompass safety measures for purchasing daily groceries such as vegetable oils, milk, milk products, spices, fruits, vegetables, eggs, and meat. Highlighting the potential risks stemming from microbial and chemical contamination, natural enzymes, as well as adulterants and environmental factors, ICMR outlines safety protocols for buying various food items. Stressing the importance of sourcing vegetable oils from reliable sources to mitigate the risk of adulteration, particularly when buying unpackaged oils, ICMR also advises purchasing butter, ghee, and khoa from trusted sources only. Additionally, the apex body recommends opting for pasteurized milk and advises against consuming fruits and vegetables showing signs of discoloration, physical damage, shrinkage, bruising, wilting, or evidence of insects and molds.

3. CONCLUSION

The presence of adulterants in spice powder can result in severe financial repercussions for importers, ranging from product recalls and damage to brand reputation to legal penalties. Real-life instances underscore the significant losses suffered as a consequence. Adulteration in Indian spices is a multifaceted problem that poses significant health risks, undermines consumer trust, and affects economic and cultural values. Addressing this issue requires a concerted effort from regulatory bodies, producers, consumers, and the international community. By implementing stricter regulations, enhancing consumer awareness, and leveraging technology, India can combat adulteration effectively and preserve the integrity of its spice heritage.

Acknowledgement

Not Applicable

Author Contributions

Both of the authors have contributed equally while preparing the manuscript.

Ethical approval

Not Applicable

Informed consent

Not applicable.

Funding

This study has not received any external funding.

Conflict of Interest

The author declares that there are no conflicts of interests.

Data and materials availability

All data associated with this study are present in the paper.

REFERENCES

1. Bharathi SK, Sukitha A, Moses JA, Anandharamakrishnan C. Instrument-based detection methods for adulteration in spice and spice products-a review. J Spices Aromat Crops 2018; 27 (2):106–118. doi: 10.25081/josac. 2018.v27. i2.1099
2. Biswas S. MDH and Everest: Indian spices face heat over global safety concerns. BBC 2024.
3. Chachan S, Kishore A, Kumari K, Sharma A. Trends of food adulteration in developing countries and its remedies. Food Chem 2021; 165-87. doi: 10.1002/9781119792130.ch6
4. Choudhary A, Gupta N, Hameed F, Choton S. An overview of food adulteration: Concept, sources, impact, challenges and detection. Int J Chem Stud 2020; 8(1):2564-2573.
5. Cilak GO, Mujdeci GN, Kabak B. Legislation on aromatic herbs in food. In: (Charis MG, editor.) Aromatic Herbs in Food. Academic Press; Cambridge, MA, USA, 2021; 405–438.
6. Essuman EK, Teye E, Dadzie RG, Sam-Amoah LK. Consumers' knowledge of food adulteration and commonly used methods of detection. J Food Qual 2022; 2022:10. doi: 10. 1155/2022/2421050
7. Galvin-King P, Haughey SA, Elliott CT. Herb and spice fraud; the drivers, challenges and detection. Food Control 2018; 88:8 5-97. doi: 10.1016/j.foodcont.2017.12.031
8. Harke S, Pawar AR, Patil YY. Quality and Adulteration in Ethnic Spices and Food Ingredients in Local Market. Int J Food Agric Nat Resour 2023; 4(3):21-26. doi: 10.46676/ij-fanres .v4i3.155
9. Jaiswal S, Yadav DS, Mishra MK, Gupta AK. Detection of adulterants in spices through chemical method and thin layer chromatography for forensic consideration. Int J Dev Res 2016; 6(08):8824-8827.

10. Jeeva C. Food adulteration, it's impact on youngster's health-prevention and challenges. Asian J Multidimensional Res (AJMR) 2019; 8(5):150-62.
11. Kaavya R, Pandiselvam R, Mohammed M, Dakshayani R, Kothakota A, Ramesh SV, Cozzolino D, Ashokkumar C. Application of infrared spectroscopy techniques for the assessment of quality and safety in spices: a review. Appl Spectros Rev 2020; 55(7):593-611. doi: 10.1080/05704928.2020.1713801
12. Kushwaha AK, Thakur P, Singh S, Gahlot T. Food Adulteration: Havoc Leading to an Extorted Economy. Sustain Agric Food Secur 2021; 243-77. doi: 10.1201/9781003242543
13. Malik S. Food Adulteration Awareness: A Powerful Weapon to Combat the Food Quality Contamination. Int J Sci Res Sci Technol 2019; 6(2):61-68. doi: 10.32628/IJSRST196175
14. Manasha S, Janani M. Food adulteration and its problems (intentional, accidental and natural food adulteration). Int J Res Finance and Marketing 2016; 6(4):131-140.
15. Maquet A, Lievens A, Paracchini V, Kaklamanos G, De-La-Calle-Guntinas MB, Garlant L, Papoci S, Pietretti D, Ždiniaková T, Breidbach A, Omar-Onaindia J, Boix-Sanfeliu A, Dimitrova T, Ulberth F. Results of an EU wide coordinated control plan to establish the prevalence of fraudulent practices in the marketing of herbs and spices. EUR 30877 EN, Publications Office of the European Union, Luxembourg, 2021. doi: 10.2760/309557
16. Modupalli N, Naik M, Sunil CK, Natarajan V. Emerging non-destructive methods for quality and safety monitoring of spices. Trends Food Sci Technol 2021; 108:133–147. doi: 10.1016/j.tifs.2020.12.021
17. Mohiuddin AK. Health hazards with adulterated spices: Save the "onion tears". Asian J Res Pharm Sci 2020; 10(1):21-25.
18. Negi A, Pare A, Meenatchi R. Emerging techniques for adulterant authentication in spices and spice products. Food Control 2021; 127:108113. doi: 10.1016/j.foodcont.2021.108113
19. Osman AG, Raman V, Haider S, Ali Z, Chittiboyina AG, Khan IA. Overview of analytical tools for the identification of adulterants in commonly traded herbs and spices. J AOAC Int 2019; 102(2):376-385. doi: 10.5740/jaoacint.18-0389
20. Pantola P, Agarwal P. Detection of adulteration in spices. Int J Adv Res Innov 2021; 9(2):165-167.
21. Rani R, Medhe S, Srivastava M. HPTLC–MS based method development and validation for the detection of adulterants in spices. J Food Meas Charact 2015; 9(2):186-194. doi: 10.1007/s11694-015-9223-x
22. Sasikumar B, Swetha VP, Parvathy VA, Sheeja TE. Advances in adulteration and authenticity testing of herbs and spices. In Advances in food authenticity testing, Woodhead Publishing; Sawston, UK, 2016; 585-624.
23. Srirama R, Santhosh Kumar JU, Seethapathy GS, Newmaster SG, Ragupathy S, Ganeshaiah KN, Uma Shaanker R, Ravikanth G. Species adulteration in the herbal trade: causes, consequences and mitigation. Drug Saf 2017; 40(8):651-661. doi: 10.1007/s40264-017-0527-0
24. Tomar P, Alka G. Food adulteration and its impact on health. Int J Home Sci 2022; 8(2):164-168.