*International Journal of Engineering and Science Invention (IJESI)*
*ISSN (Online): 2319-6734, ISSN (Print): 2319-6726*
*www.ijesi.org ||Volume 13 Issue 4 April 2024 || PP 60-66*

# Analytical Assessment of Branded and Unbranded Turmeric Samples Collected in Telangana Region: Implications for Quality Control and Consumer Health

**Priyanka Vatte [1], Syeda Azeem Unnisa [2], E.Revathi[3]**

[1] *Department of Environmental Science, University College of Science, Osmania University, Hyderabad, 500007, Telangana, India*
[2] *Department of Environmental Science, University College of Science, Osmania University, Hyderabad, 500007, Telangana, India*
[3] *Department of Environmental Science, University College of Science, Osmania University, Hyderabad, 500007, Telangana, India*

***ABSTRACT:*** *Curcumin, the major constituent of turmeric (Curcuma longa) is a valuable spice with good anti-inflammatory, antioxidanat and antimicrobial properties. Turmeric powder is popular for its culinary use and has elevated consumer demand. The adulteration of turmeric samples not only nullifies the beneficial effects but also causes various diseases. The present study was conducted to check the adulteration of the branded and unbranded turmeric samples available in Telangana region. A number of tests recommended by FSSAI guidelines were conducted that include percentage determination of moisture content, curcumin content, total ash, and acid insoluble ash on dry basis. In addition to these, tests were also conducted to determine the presence of lead salts, lead chromate, metanil yellow, aniline dyes, and chalk powder. Metanil yellow is the common adulterant which is detected in all the unbranded samples and in 9 out of 14 branded samples. Presence of lead salts was detected in 10 out of 15 unbranded samples. In addition to these some of the unbranded samples were also detected with the presence of aniline dyes, added colour and chalk powder contamination. Lead chromate contamination was observed in one sample each in branded and unbranded samples. Lowest curcumin content was observed only in 3 branded samples. Higher moisture content percentage than the prescribed standard of 10 was observed in 8 unbranded samples versus one branded sample. Abnormal percentage of ash insoluble in dilute HCL was observed only in unbranded sample no 19 which tested positive for all the adulterants. Of total 30 samples only 3 branded samples (sample no 2,3,4) met all the criteria. The results highlight the adulteration and malpractices in selling turmeric powder and demonstrate the need for reliable, rapid, transparent and robust screening methods to tackle this problem.*

***KEYWORDS*** **-** *Metanil yellow, aniline dyes, chalk powder, turmeric powder, moisture content, total ash on dry basis, ash insoluble in dilute HCL, curcumin, lead salts, lead chromate*

---

Date of Submission: 25-04-2024 Date of Acceptance: 02-05-2024

---

## I. INTRODUCTION

Turmeric is a rhizomatous herbaceous perennial plant (Curcuma longa) of the ginger family. It is a valuable spice and is widely known both in medical and scientific fields for its medicinal properties.1 Curcumin, demethoxycurcumin and bisdemethoxycurcumin are the main yellow coloured bioactive substances in this rhizome.2 Turmeric is used in medicine since ancient times as it has the potential for a plethora of events that include antibacterial, anti-inflammatory, antimicrobial, antirheumatic, hypercholesteraemic, antihepatotoxic, antifibrotic, anti-inflammatory, and insect repellent activity.[3,4] India exports turmeric in the form of whole dried rhizomes, as powder and other valued-added forms and positions itself as the leading producer, consumer, and exporter of turmeric. Unfortunately, the adulteration of turmeric powder is being observed with filler materials, synthetic dyes, inert or biological entities that not only add bulk or increase the appearance but also dilutes the main product making it less effective and posing health hazards. This in turn corrodes consumer confidence5.

The Food Safety and Standards Authority of India (FSSAI) 2011 and The Prevention of Food Adulteration Act (PFA) as on 1.10.2004 recommends the acquisition of turmeric (haldi) powder only from the plant Curcuma longa L by grinding the dried rhizomes or bulbous roots of it. Both the guidelines prohibit the addition of any coloring matter including the presence of lead chromate in turmeric powder.[6,7] The Bureau of

Indian Standards suggests a minimum of 3% curcumin for powdered turmeric, whereas the mandatory PFA Act as on 1.10.2004 does not specify any minimum curcumin limit. As per the FSSAI 2011, the minimum percentage of curcuminoid content on a dry basis should not be less than 2% by weight. World organizations like the International Organization for Standardization (ISO), American Spice Trade Association (ASTA) The Food Safety and Standards Authority, India (FSSAI), impose strict regulations on the quality of spices and herbs imported and exported [5,6,7]

The authors Basnet P, Skalko-Basnet N on the basis of frequent studies stated that turmeric is generally Recognized as Safe (GRAS) by the US FDA, and curcumin has been granted an acceptable daily intake level of 0.1–3 mg/kg-Body weight by the Joint Food and Agriculture Organization / World Health Organizations Expert Committee on Food Additives, 1996.8 In the present investigation a few branded and unbranded turmeric samples were collected from the local market and physicochemical evaluation was done to check the adulteration as per the FSSAI standards, 2011 that include estimation of moisture content percentage, percentages of total ash, ash insoluble in dilute HCL and curcumin content on dry basis. In addition to these the presence of adulterants that include artificial colourants like metanil yellow, aniline dyes, added colour, chalk powder, lead salts and lead chromate were also detected.

## II. EXPERIMENITAL-MATERIAL AND METHODS

Sample collection: Different samples of turmeric powder with 500 grams weight were collected from the supermarket at various locations which includes both branded samples that are given sample numbers as 1 to 14 and unbranded samples with sample numbers 15 to 30 respectively. Unbranded samples were collected from various open markets in which loose turmeric powder was obtained. Table 1 summarizes the location of branded and unbranded samples respectively.

Table 1: Naming & Location of the Collected Branded and Unbranded Turmeric Samples

| **Branded Samples** | | **Unbranded Samples (Loose Turmeric Powder From Open Markets)** | |
|---|---|---|---|
| **Sample No** | **Location** | **Sample No** | **Location** |
| 1 | Saroornagar | 15 | Malakpet |
| 2 | Osmangunj | 16 | Miyapur |
| 3 | Dmart Champapet | 17 | Maddanapet mandi Saidabad |
| 4 | Saroornagar | 18 | Erragadda |
| 5 | Dilshuknagar | 19 | Open market roadside |
| 6 | Heritage fresh Saidabad | 20 | L.B Nagar |
| 7 | Dmart Champapet | 21 | Pragathi Nagar |
| 8 | Ashoknagar | 22 | Openmarket |
| 9 | Dmart Champapet | 23 | Nallagandla, Lingampally |
| 10 | Dmart Champapet | 24 | BegumBazar |
| 11 | Heritage fresh Saidabad | 25 | BegumBazar |
| 12 | Honey Rostea Saidabad | 26 | Osmangunj |
| 13 | Heritage fresh Saidabad | 27 | Dilshuknagar |
| 14 | Heritage fresh Saidabad | 28 | Kukatpally |
| | | 29 | Secunderabad |
| | | 30 | Secunderabad |

The apparatus, reagents and the methods used to determine the physiochemical properties of the branded and unbranded turmeric samples and the relevant reference standards are summarized in Table 2.

Table 1: Summary of the Tests, Apparatus, Reagents Used to Determine the Physiochemical Properties of Turmeric Samples

| S. No | Name of the Test | Method | Apparatus | Chemicals/Reagents Used | Prescribed FSSAI 2011 standards[6] |
|---|---|---|---|---|---|
| 1 | Determination of moisture content % on dry basis | Dean and Stark Toluene Distillation Method. FSSAI Manual of Methods for Analysis of Foods Spices and Condiments, 2016 (3.0)[9] | Distillation Apparatus Reflux Condenser, Heating Mantle, Condensed Solvent, Round Bottomed Flask | Chromic acid solution, Toluene | Not to exceed more than 10% by weight |
| 2 | Total ash on dry basis % | FSSAI Manual of Methods for Analysis of Foods Spices and Condiments, 2016(4.0, 5.0)[9] | Muffle Furnace, Tongs, Gloves. | | Not to exceed more than 9% by weight |
| 3 | Ash insoluble in dilute HCL on dry basis % | | Muffle Furnace, Filter Paper, Tongs. | HCL, Distilled water | Not to exceed more than 1.5% by weight |
| 4 | Curcuminoid content on dry basis % | FSSAI Manual of Methods of Analysis of Foods Spices, Herbs and Condiments 2021 FSSAI 10.030:2021[10] | Soxhlet Apparatus, Volumetric Flask, Filter | 95% Alcohol | Not less than 2% by weight |
| 5 | Presence of Metanil Yellow | FSSAI Manual of Simple methods for testing of common adulterants in food, 2019[11] | Pasteur pipettes / Dropper | Concentrated HCl | Negative |
| 6 | Presence of Aniline Dyes | | | Rectified Spirit | Negative |
| 7 | Test for Added Colour | | | 13N H2SO4: 88 ml of concentrated H2SO4 diluted to 250 ml with distilled water<br>Petroleum ether | |
| 7 | Presence of chalk powder | | | Concentrated HCl | Negative |
| 8 | Presence of lead salts | | Pasteur pipettes / Dropper | Concentrated HCl | Negative |
| 9 | Presence of lead chromate | | Pasteur pipettes / Dropper | 1:7 H2SO4. 10 ml of concentrated H2SO4 carefully added to 70 ml of distilled water.<br>Diphenylcarbazide (0.2%): 200 mg of Diphenylcarbazide dissolved in 100ml of 95% alcohol. | Negative |

## III. RESULTS AND DISCUSSION

Summary of result of all the tests is presented in Table 3 and Table 4. Higher percentage of moisture content more than the prescribed standard of 10 was observed in eight unbranded samples (sample numbers 15,18,19,21,22,28, 29 and 30) compared to one branded sample (sample number 8). On average the branded samples have lower moisture content than the unbranded samples. The percentages of total ash on dry basis of all the branded and unbranded turmeric samples complied with the current standards. All the turmeric samples except unbranded turmeric sample 19 have the ash insoluble in dilute HCL on Dry basis percentage within the FSSAI mentioned limits of not more than 1.5% by weight. Unbranded turmeric sample 19 have almost more than double (3.52%) that of prespecified FSSAI value of 1.5%. This sample showed positive for all the tested adulterants except lead chromate. The curcumin content percentage can be correlated with the overall quality and potency of the turmeric powder. Three branded turmeric samples (sample no 5, 6 and 9) have lower curcumin percentages of 1.2%, 1.79%, and 1.93%. These are less than the recommended curcumin percentages of more than 2% by weight as per FSSAI (2011) standards6.

The detection of metanil yellow is seen in 9 out of 14 branded turmeric samples and all unbranded turmeric samples. The presence of aniline dye or added colour was not detected in any of the branded turmeric samples. In unbranded turmeric samples aniline dye was present in 6 samples (Sample Nos 17, 19, 20, 21, 25 and 26) and presence of added colour was seen in three samples (Sample Nos 16, 19 and 25). The detection of chalk powder contamination and lead salts contamination was observed only in unbranded samples. Chalk

powder contamination was seen in unbranded sample no's 17, 19, 22, 24, 26, 27, 29 and 30. Presence of lead salts contamination was seen in 10 out of 16 unbranded samples. Presence of lead chromate was detected in one sample each in branded (sample 1) and unbranded turmeric samples (sample 16).

Table 3. Summary of Analytical Tests in Both Branded and Unbranded Turmeric Samples

| Sample No | Moisture Content % by Weight | Total Ash on Dry Basis % by Weight | Ash Insoluble In Dilute Hcl on Dry Basis % by Weight | Test For Curcumin % by Weight |
|---|---|---|---|---|
| **Branded Turmeric Samples** | | | | |
| 1 | 9.47 | 6.19 | 0.49 | 3.34 |
| 2 | 8.85 | 7.04 | 0.40 | 2.19 |
| 3 | 9.06 | 7.38 | 0.59 | 2.49 |
| 4 | 9.46 | 6.56 | 0.42 | 2.77 |
| 5 | 9.20 | 6.24 | 0.72 | 1.12 |
| 6 | 8.36 | 7.77 | 0.61 | 1.79 |
| 7 | 9.32 | 8.42 | 0.55 | 3.36 |
| 8 | 10.06 | 7.20 | 0.75 | 2.47 |
| 9 | 8.63 | 7.95 | 0.81 | 1.93 |
| 10 | 7.95 | 7.86 | 0.43 | 2.94 |
| 11 | 9.78 | 8.53 | 0.53 | 2.13 |
| 12 | 9.12 | 7.95 | 0.77 | 3.15 |
| 13 | 8.80 | 7.98 | 0.83 | 3.01 |
| 14 | 9.71 | 8.07 | 0.82 | 2.55 |
| **Unbranded Turmeric Samples** | | | | |
| 15 | 10.66 | 5.03 | 0.69 | 3.01 |
| 16 | 9.05 | 7.65 | 0.72 | 2.03 |
| 17 | 9.38 | 8.07 | 0.94 | 3.42 |
| 18 | 11.03 | 8.64 | 0.81 | 2.88 |
| 19 | 11.03 | 7.27 | 3.52 | 2.88 |
| 20 | 8.60 | 8.0 | 0.40 | 2.91 |
| 21 | 10.17 | 6.99 | 0.79 | 2.65 |
| 22 | 10.17 | 7.09 | 0.69 | 3.37 |
| 23 | 9.87 | 8.64 | 1.08 | 2.46 |
| 24 | 9.33 | 8.27 | 0.94 | 2.83 |
| 25 | 9.87 | 6.67 | 0.95 | 2.31 |
| 26 | 9.36 | 8.64 | 1.38 | 2.58 |
| 27 | 9.43 | 7.36 | 0.55 | 2.45 |
| 28 | 10.22 | 6.75 | 1.07 | 3.09 |
| 29 | 10.02 | 8.18 | 0.75 | 2.91 |
| 30 | 10.53 | 7.94 | 0.92 | 2.14 |

The prescribed standards as per FSSAI 2.9.18.2, 2011 guidelines are moisture content not more than 10% by weight, total ash on dry basis not more than 9.0% by weight, ash insoluble in dilute HCl not more than 1.5% by weight, and curcumin % not less than 2% by weight.[6] Please note that the outliers are highlighted in grey.

Table 4. Summary of Preliminary Analytical Tests on the Detection of Various Adulterants in Both Branded and Unbranded Turmeric Samples

| Sample No | Metanil Yellow | Aniline Dyes | Added Colour | Chalk powder | Lead salts | Lead Chromate |
|---|---|---|---|---|---|---|
| **Branded Turmeric Samples** | | | | | | |
| 1 | – | – | – | – | – | Positive |
| 2 | – | – | – | – | – | – |
| 3 | – | – | – | – | – | – |
| 4 | – | – | – | – | – | – |
| 5 | – | – | – | – | – | – |
| 6 | Positive | – | – | – | – | – |
| 7 | Positive | – | – | – | – | – |
| 8 | Positive | – | – | – | – | – |
| 9 | Positive | – | – | – | – | – |
| 10 | Positive | – | – | – | – | – |
| 11 | Positive | – | – | – | – | – |
| 12 | Positive | – | – | – | – | – |
| 13 | Positive | – | – | – | – | – |
| 14 | Positive | – | – | – | – | – |
| **Unbranded Turmeric Samples** | | | | | | |
| 15 | Positive | – | – | – | – | |
| 16 | Positive | – | Positive | – | Positive | Positive |
| 17 | Positive | Positive | – | Positive | Positive | – |
| 18 | Positive | – | – | – | Positive | – |
| 19 | Positive | Positive | Positive | Positive | Positive | – |
| 20 | Positive | Positive | – | – | Positive | – |
| 21 | Positive | Positive | – | – | Positive | – |
| 22 | Positive | – | – | Positive | Positive | – |
| 23 | Positive | – | – | – | – | – |
| 24 | Positive | – | – | Positive | – | – |
| 25 | Positive | Positive | Positive | – | Positive | – |
| 26 | Positive | Positive | – | Positive | – | – |
| 27 | Positive | – | – | Positive | – | – |
| 28 | Positive | – | – | – | Positive | – |
| 29 | Positive | – | – | Positive | – | – |
| 30 | Positive | – | – | Positive | Positive | – |

Table : 4. Summary of the Preliminary test on the detection of various adulterants in both branded and unbranded turmeric samples which is represented in the table 4. In Branded turmeric samples lead chromate was tested positive in sample 1 followed by Metanil Yellow in sample no 6 to 14 where as in unbranded samples. Metanil Yellow is identified as positive where as in Unbranded Samples identified adulterants are Metanil Yellow in sample 15 to 30, Aniline dyes sample no (17,19,20,21,25,26), Added Colour in sample (16,19,25), Chalk powder is in sample (17,19,22,24,26,27,29,30), Lead Salts in sample no (16,22,25,28,30) and Lead Chromate in sample no 16

## IV. DISCUSSION

Our results suggest the detection of metanil yellow in 9 of total 14 branded turmeric samples. It was reported that metanil yellow may cause several toxic effects on various systems of the body even when a minimal dose enters the body for a long duration of time.[12,13,14] It was known to cause degenerative changes in the lining of stomach, kidneys and liver.[15] Metanil yellow was reported to be carcinogenic.[16] and mutagenic.[17] In addition to this it was also proved to be harmful to reproductive organs as it badly effects the ovaries and testes.[18] Metanil yellow was recently reported to have genotoxic activities and should be taken in very control and limited doses.[19] In addition to metanil yellow 10 out of 15 unbranded samples are detected with lead salts contamination which is a cause for concern as it was reported in a review that increased exposure is associated with neuropsychiatric disorders such as attention deficit hyperactivity disorder and antisocial behavior.[20] Even

blood lead level below 5 μg/dl was reported to influence children neurobehavioral performance.[21] Also in one study in New Zealand it was reported that childhood lead exposure was associated with lower cognitive function and socioeconomic status at age 38 years.[22] Presence of lead salts contamination was not detected in any of the branded samples however lead chromate was detected in one sample each in branded and unbranded samples. A research paper reported that lead chromate induced concentration-dependent cytotoxicity in BEP2D cells after a 24h exposure.[23] Some of the unbranded samples were also detected with the presence of chalk powder, aniline dyes and added colour. Chalk powder adulteration was reported with indigestion and aniline dyes contamination with carcinogenic potential.[24] Moisture content to be reduce to a safe limit of 10% for grinding or 6% for safe storage to reduce the risk of microbial contamination.[25] Abnormalities in percentage moisture content above the prescribed standard was observed mostly in unbranded samples (8 in number) versus 1 branded sample.

Physiochemical evaluation plays a key role in quality control and regulatory compliance in the food industry. Adulteration of branded turmeric erodes this trust, potentially exposing consumers to health risks associated with unknown or harmful substances. The unbranded samples have more than one adulterant contamination and are very unsafe to consume. Spices with high commercial value and complex supply chains were often affected with adulteration. This food supply chain was also impacted further with the recent COVD-19 pandemic situations.[26]

## V. CONCLUSION

Metanil yellow an artificial azo dye is the common adulterant that was detected in most of the branded and all unbranded turmeric samples collected in Telangana region. In unbranded samples in addition to metanil yellow adulteration, most of the samples were also detected with the presence of lead salts. Some of the unbranded samples were detected with chalk powder, aniline dyes and added colour in addition to metanil yellow. Only three branded samples (sample 2, 3, 4) met all the criteria as per FSSAI guidelines without the detection of any adulterant. Addressing the issue of turmeric adulteration requires a multi-faceted approach, including routine quality control inspections, good governance, strengthening regulations, consumer education, and industry self-regulation. Implementing, and fostering transparency in the supply chain is essential towards ensuring the integrity and safety of branded turmeric products.

## ACKNOWLEDGEMENTS

Authors are thankful to the State Food Laboratory Nacharam for guiding and supporting to execute the work.

## REFERENCES

*This heading is not assigned a number.*

A reference list **MUST** be included using the following information as a guide. Only *cited* text references are included. Each reference is referred to in the text by a number enclosed in a square bracket (i.e., [3]). References **must be numbered and ordered according to where they are first mentioned in the paper,** NOT alphabetically.

**Examples follow**:

**Journal Papers:**

[1] Hewlings SJ, Kalman DS. Curcumin: A Review of Its Effects on Human Health. Foods. 2017 Oct 22;6(10):92. doi: 10.3390/foods6100092. PMID: 29065496; PMCID: PMC5664031

[2] Nagarnaik, Mukund, et al. "Characterization of Active Constituents in Turmeric Powder and Validation of Method for Curcumin in Samples." Asian Journal of Research in Chemistry, vol. 8, no. 10, 2015, p. 643. DOI.org (Crossref), https://doi.org/10.5958/0974-4150.2015.00102.9

[3] Kumar T, Rai AK, Dwivedi A, Kumar R, Azam M, Singh V, Yadav N, Rai AK. Chemical Characterization for the Detection of Impurities in Tainted and Natural Curcuma longa from India Using LIBS Coupled with PCA. Atoms. 2022; 10(3):91. https://doi.org/10.3390/atoms10030091

[4] Maheshwari RK, Singh AK, Gaddipati J, Srimal RC (2006) Multiple biological activities of curcumin: a short review. Life Sci 78: 2081-2087

[5] Sasikumar B. Advances in adulteration and authenticity testing of turmeric (Curcuma longa L.). J Spices Arom Crops [Internet]. 2020 Jan. 8 [cited 2023 Dec. 14];28(2):96-105. Available from: https://updatepublishing.com/journal/index.php/josac/article/view/6072

[6] FOOD SAFETY AND STANDARDS (FOOD PRODUCTS STANDARDS AND FOOD ADDITIVES) REGULATIONS, 2011 Available at https://www.fssai.gov.in/upload/uploadfiles/files/Compendium_Food_Additives_Regulations_08_09_2020-compressed.pdf

[7] The Prevention of Food Adulteration Act & Rules as on 1.10.2004 Available at: https://www.fssai.gov.in/upload/uploadfiles/files/pfa-acts-and-rules.pdf

[8] Basnet P, Skalko-Basnet N. Curcumin: an anti-inflammatory molecule from a curry spice on the path to cancer treatment. Molecules. 2011 Jun 3;16(6):4567-98. doi: 10.3390/molecules16064567. PMID: 21642934; PMCID: PMC6264403.

[9] Food Safety and Standards Authority of India. Manual of methods of analysis of foods spices and condiment, 2016 Available at:

[10] https://www.fssai.gov.in/upload/uploadfiles/files/Manual_Spices_25_05_2016(1).pdf

[11] 10. Food Safety and Standards Authority of India. Manual of methods of analysis of foods spices herbs and condiments, 2021. Available at https://fssai.gov.in/upload/uploadfiles/files/Manual_Revised_Spices_Herbs_22_06_2021.pdf

[12] 11. Food Safety and Standards Authority of India. Manual of Simple methods for testing of common adulterants in food (Suitable for mobile food testing labs & school/college laboratories), 2019. Available at: https://www.fssai.gov.in/upload/uploadfiles/files/Manual_Methods_Testing_Adulterants_18_10_2019.pdf

[13] 12. Verma, Abhineet; Saha, Satyen; Bhat, Shobha K. Detection of Nonpermitted Food Color Metanil Yellow in Turmeric A Threat to the Public Health and Ayurvedic Drug Industry. Journal of Ayurveda 16(2):p 134-139, Apr–Jun 2022. | DOI: 10.4103/joa.joa_77_21

[14] 13. Choi H. Risk assessment of daily intakes of artificial colour additives in food commonly consumed in Korea J Food Nutr Res. 2012;51:13–22

[15] 14. Rajapaksha GK, Wansapala MA, Silva AB. Detection of synthetic colours in selected foods & beverages available in Colombo district, Sri Lanka Int J Sci Res. 2017;6:801–8

[16] 15. Sarkar R, Ghosh AR. Metanil yellow, a food additive induces the responses at cellular and sub-cellular organisations of stomach, intestine, liver, and kidney of Heteropneustes fossilis (Bloch) EM Int. 2010;29:453–60

[17] 16. Gupta S, Sundarrajan M, Rao KV. Tumor promotion by metanil yellow and malachite green during rat hepatocarcinogenesis is associated with dysregulated expression of cell cycle regulatory proteins Teratog Carcinog Mutagen. 2003;1:301–12

[18] 17. Das A, Mukherjee A. Genotoxicity testing of the food colours amaranth and tartrazine Int J Hum Genet. 2004;4:277–80

[19] 18. Sarkar R, Ghosh AR. Toxicological effect of metanil yellow on the testis of albino rat Int J Basic Appl Med Sci. 2012;2:40–2

[20] 19. Khan IS, Ali MN, Hamid R, Ganie SA. Genotoxic effect of two commonly used food dyes metanil yellow and carmoisine using Allium cepa L. as indicator. Toxicol Rep. 2020 Feb 15;7:370-375. doi: 10.1016/j.toxrep.2020.02.009. PMID: 32123667; PMCID: PMC7038579.

[21] 20. Bellinger, David C. Very low lead exposures and children's neurodevelopment. Current Opinion in Pediatrics 20(2):p 172-177, April 2008. | DOI: 10.1097/MOP.0b013e3282f4f97b

[22] 21. Min JY, Min KB, Cho SI, Kim R, Sakong J, Paek D. Neurobehavioral function in children with low blood lead concentrations. Neurotoxicology. 2007 Mar;28(2):421-5. doi: 10.1016/j.neuro.2006.03.007. Epub 2006 Mar 24. PMID: 16644013.

[23] 22. Reuben A, Caspi A, Belsky DW, Broadbent J, Harrington H, Sugden K, Houts RM, Ramrakha S, Poulton R, Moffitt TE. Association of Childhood Blood Lead Levels With Cognitive Function and Socioeconomic Status at Age 38 Years and With IQ Change and Socioeconomic Mobility Between Childhood and Adulthood. JAMA. 2017 Mar 28;317(12):1244-1251. doi: 10.1001/jama.2017.1712. PMID: 28350927; PMCID: PMC5490376.

[24] 23. Wise SS, Holmes AL, Wise JP Sr. Particulate and soluble hexavalent chromium are cytotoxic and genotoxic to human lung epithelial cells. Mutat Res. 2006 Nov 7;610(1-2):2-7. doi: 10.1016/j.mrgentox.2006.06.005. Epub 2006 Jul 26. PMID: 16872863.

[25] 24. Pantola P and Agarwal P. Detection of Adulteration in Spices. International Journal of Advance Research and Innovation Vol. 9(2), Apr-Jun 2021, pp. 30-35 Doi: 10.51976/ijari.922105 www.gla.ac.in/journals/ijari

[26] 25. Singh G, Arora S, Kumar S. Effect of mechanical drying air conditions on quality of turmeric powder. J Food Sci Technol. 2010 Jun;47(3):347-50. doi: 10.1007/s13197-010-0057-6. Epub 2010 Jul 29. PMID: 23572651; PMCID: PMC3551030.