International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

A Review on Food Safety Challenges in Chilli (Capsicum Annuum L) and Mitigation Measures

Lakshmikanthan Aniraiventrakannan[1], Dr D Chamundeeswari[2], Dr J Mukkadan[3]

[1]Head Quality Mane Kancor Ingredients Limited, Cochin
[2]Principal and Faculty of Pharmacy, Meenakshi Academy of Higher Education and Research
[3]Research Director, LFMRC, Angamaly, Cochin

Abstract

Capsicum annuum L., often known as hot pepper or chilli pepper, is a vital vegetable crop and spice in the Solanaceae family. Since ancient times, people have used chilies as a flavoring, ingredient in food, and family medicine for a variety of illnesses, such as high blood pressure, arthritis, skin problems, and high cholesterol. They have also been used as a carminative, snack, stomachic, and refreshment, as well as a means of relieving pain in neuropathy and as a counterirritant in the treatment of lumbago and stiffness. Its organic design is to stop herbivorous creatures, parasites, and different microorganisms. The expression "capsicum" comes from the Greek word "kapsimo," and that signifies "to chomp". Dried chilli is susceptible to contaminants such as mould dirt and pesticides that must be removed to maintain the safety and quality of products.

Keywords: Chilli, Capsicum annuum L, solvent extract, Oleoresin, Pesticide, Contaminations and food safety

1. Introduction

Chillies are the ripe fruits of the species of genus *Capsicum* and are used as a condiment, culinary supplement or vegetable. Chilli pepper is the most widely consumed spice in the world which is valued for its antioxidant and antiinflammatory effects (Jiang, 2019). India is one of the leading exporters of chilli pepper exporting 0.41 million tonnes per annum worldwide (Agrocrops, 2020). During 1996–97, India produced 0·884 Mt of chillies from an area of 926 Mha. Although, India is considered the largest producer of chillies in the world, its export is only 5–8% of its production (Singhal, 1999). Aflatoxigenic and non-aflatoxigenic fungi can contaminate chilli pepper during pre- and postharvest processes due to India's tropical climate (Golge et al., 2013). In addition to remarkable health-promoting chemical elements including vitamins, minerals, flavonoids, carotenoids, and capsaicinoids, chili includes significant amounts of pigments with potential health advantages, such as lutein, anthocyanin, and chlorophyll. And capsaicin, the major active compound responsible for the pungent taste of these species has been proven to have a positive role in health (Hernández-Pérez, T et al., 2020).

Bioactive components - Red pepper contains 0.2–2% capsaicinoids, which are responsible for the pungency or bite in capsicums. The alkaloid capsaicin makes up around 50–70% of all capsacinoids, whereas dihydrocapasaicin makes up 20–25%. Together, these two alkaloids give the fiery notes from the midpalate to the throat. Additionally, red pepper includes recently identified non-pungent substances

known as capsinoids, which include dihydrocapsiate and capsiate (Jiang, 2019). Scoville invented the SHU as a pungency measurement, and capsaicinoid content is a key indicator of a chili pepper's pungency. (Figure 1A and B).

a

Scoville heat unit (SHU)	Category	Type
>80,000 SHU	Very highly pungent	Habanero 100,000 to 300,000
25,000-70,000	Highly pungent	Chile piquín 30,000 to 50,000
3,000-25,000	Moderately pungent	Serrano 5,000 to 15,000
700-3,000	Mildly pungent	Anaheim 500 to 1,000
0-700 SHU	Nonpungent	Pimiento 0

b

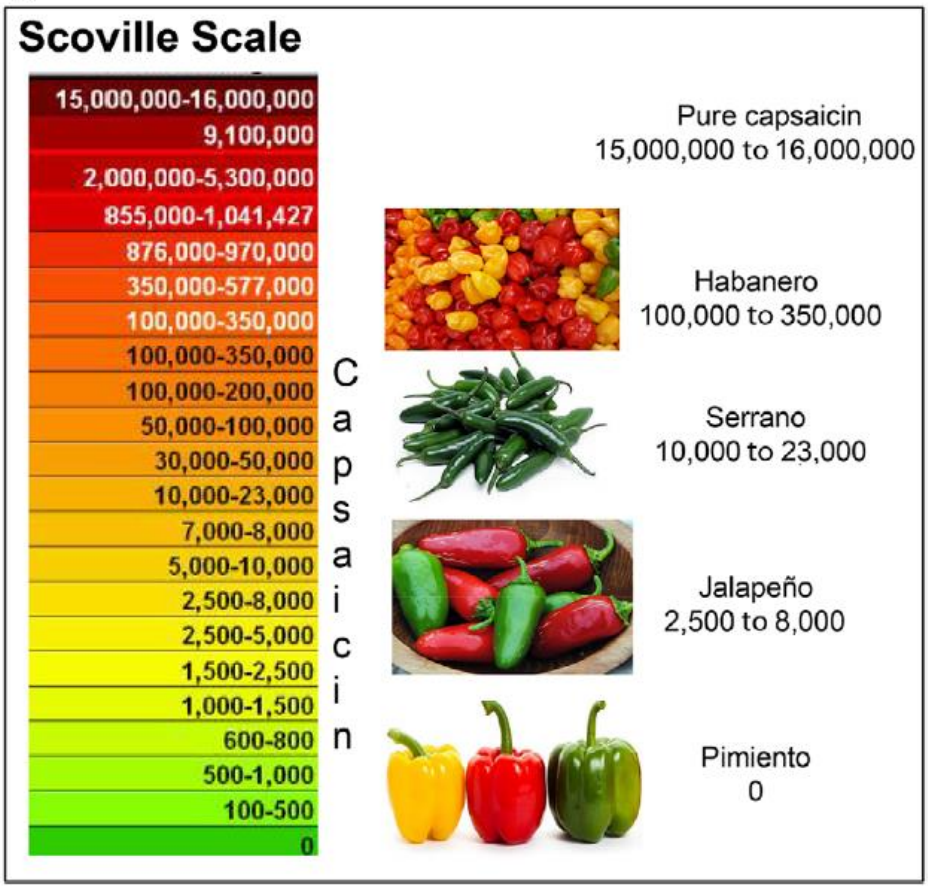

FIGURE 1: Pungency of *Capsicum* varieties in Scoville heat units. (a) Five categories of chili peppers and their corresponding Scoville heat units plus some specific examples of chilis; (b) different levels and extreme values of the Scoville scale (Scoville, W. L. (1912))

2. Usages of Chilly

Chilli is used in various forms such as dried, wet, smoked, whole, sliced, cubed, pureed and extracts, and it is added to several dishes, including soups, stews and main dishes. Dietary use of chilli is linked to health advantages, including a lower incidence of hypertension, since it is a rich source of minerals, vitamins, carotenoids, flavonoids, and capsaicinoids (Rosa et al., 2002), (Olatunji & Afolayan, 2018), obesity (Shi et al., 2018) and mortality (Lv et al., 2015). The primary microflora in paprika and chilli products include Salmonella spp., Escherichia coli, Bacillus pumilus, Bacillus cereus, Bacillus subtilis, Clostridium, Staphylococcus aureus, yeasts and moulds (Candlish et al., 2001).

3. Chilly cultivation

Chillies which contain high moisture content (300–400% db) after harvest are highly perishable and hence processing and storage of chillies are of considerable importance both to the farmers as well as to the processor and consumer. The rack life of crisply collected chillies is evaluated to be 2–3 days based on 12–15% aggregate misfortune. It is basic to decrease the dampness substance and give air circulation to the chillies after gathering to anticipate the advancement of microflora and ensuing misfortune of quality or add up to decay (Singh & Alam, 1982). New chilli is by and large dried in the aged condition in the open daylight without any pretreatment (Sarker et al. 2012). But, sun drying has a few issues, such as inclined to defilement, long drying time and climate reliance. Moreover, sun drying influences color and comes about in shrinkage of the item, which leads to a last ugly item. This is since the external layer of the natural product tissue obstructs to exchange water from the internal surface (Ganiy et al. 2010). In spite of the fact that shade drying holds numerous imperative properties, it has a few impediments as like happen in sun drying e.g. moo vitality productivity, conflicting quality guidelines, defilement issues, that are undesirable for the nourishment industry (Dwivedy et al. 2012). In differentiate, hot discuss drying or mechanical drying is a quick drying handle, indeed in spite of the fact that it is vitality devouring. The product qualities particularly color, texture, flavor, ascorbic acid, b-carotene, phenolics and other nutrients are often deteriorated by thermal drying due to the development of browning pigment and direct contact with air and light (Wiriya et al. 2009).The most important quality attributes in chillies are the colour and the pungency. The red colour of chillies is mainly due to the carotenoid pigments (Anu & Peter, 2000). Capsaicin is the chemical that gives chilies their pungency (Purseglove et al., 1981). As a result, chiles must be dried fast without losing their color or spiciness. In fresh chilli pepper tissues, the most abundant compounds in ripe fruit were a mixture of fatty acid and carotenoid derived degradation products such as 2- hexenal, hexanal, trans-2-nonenal, trans-2-octenal, β-ionone epoxide and dihydroactinidiolide. The amino acid and organic aroma compounds, methyl salicylate and guaiacol, were also present (Berry, H. M., et. al., 2021).

The Habanero chili pepper (HCP) cultivar holds significant regional value in the state of Yucatan, mostly because to its 2010 designation of origin, which ensures its validity, quality control, and global product identification by emphasizing its capsaicinoids concentration. The most well-known HCP cultivars are grown in Yucatan, Mexico, and are prized in the culinary industry and market for their flavor and level of pungency (Pino, J., et al., 2011). The pungent flavor in HCP is due to the presence of the most important capsaicinoids: capsaicin and dihydrocapsaicin, which are located in seeds, pericarp, and placental tissue. Since both capsaicin and dihydrocapsaicin are soluble in organic solvents, it is crucial to determine the solvent's solubility and polarity while establishing suitable process conditions for extracting capsaicinoids from HCP. Environmental conditions have an impact on the amount of capsaicinoids in HCP, which makes

it a crucial characteristic that has to be assessed before processing, selling, and eating (Miglio et al., 2008).

4. Contamination with pesticides Spices and Microbial Contamination:

Spices can enable the growth of a wide variety of microorganisms at various phases of their processing, including cultivation and harvesting. Thus, they are well known as a notable contaminant in foods (Eliasson L et. al., 2015). As a common practice in developing countries, harvested spices are spread and dried on open fields, tar roads, concrete floors, or rooftops (Kaleemullah S, et. al., 2005). Before being sold, no treatments are used to lower the microbial burden. The post-harvest handling of spices by unhygienic and improper methods exacerbates the proliferation of microorganisms. Freshly picked spices are typically contaminated by microorganisms from the surrounding air, such as dust and animal feces. Additional potential sources of microbial contamination for spices include the existence of naturally occurring bacteria from plants, unclean food processing areas, air, dust, contaminated water sources or irrigation systems including human or animal waste, improper pre- and post-harvest handling during processing, storage and distribution (Parveen S et. al., 2014). Consequently, this may reduce the durability of the foods added with spices uncooked or minimally processed foods that can be a great threat for health (Samira B et. al., 2009). Due to the abundance of phytonutrients such ascorbic acid, flavonoids, phenolic compounds, and carotenoids (α-carotene, β-carotene, capsanthin), the matrix structure of chili is complicated (Song et al., 2019) and most mycotoxins are identified in trace quantities, increasing the difficulty of detection (Mi et al., 2022).

5. Oleoresin

Due to its low relative polarity, hexane facilitates the extraction of substances and dyes (carotenoids) from Capsicum oleoresins, and in some studies of conventional solvent extraction, it has been shown to yield a higher extraction yield than ethanol (Fernández-Ronco et al. 2013). Generally, dried red capsicum is extracted as a mash in a large heated volume of n-hexane; the extracted liquid is recovered and the hexane is evaporated or distilled from the sample, collecting the solvent and leaving behind an oleoresin.

However, capsaicinoids are partially soluble in hexane. Finally, conventional extraction using n-hexane as a solvent is used in non-conventional methods such as MAE (Williams et al. 2004), UAE (Fernández-Ronco et al. 2013), and SFE (Duarte et al. 2004), although with less favorable results to extract capsacinoids in comparison with other more polar solvents such as acetone. Only mild or non-pungent fruits can be used for this to obtain non-pungent Capsicum oleoresins (Richins et al. 2010).

Table 1: Some experimental conditions to obtain Capsicum spp. oleoresins by organic solvent extraction

Solvent used	Extraction type	Temperature (°C)	Time required	Sample (g)/solvent (mL) ratio	Reference
Ethanol (70 %)	Maceration	70	30 min	1:10	Gao et al. 2005
Ethanol, acetone, acetonitrile	Maceration with shaking	50	1 h	1:6.6	Chinn et al. 2011

Hexane	Soxhlet extraction	69	6 h	1:30	De Aguiar et al. 2013
Methanol	Maceration	Room temperature	144 h × 3 times	1:10	Conforti et al. 2007

6. Chemical contamination

Azo dyes are the most common synthetic food colorants. They are composed of an aromatic ring linked with a naphthalene or benzene ring by an azo bond. Azo dyes include authorised colours (Chromtrope FB, Gardenia Yellow, Ponceau 4R, Sunset Yellow, Amaranth and Tartrazine) and illegal dyes (Sudan dyes and Orange II) (Xue, H et. al., 2012). Synthetic azo dye 1-phenylazo-2-naphthol (Sudan I) finds use in paint and textile colorants, as well as floor and shoe polishes. Sudan I can cause tumors in the liver and bladder of mice, and is a possible human carcinogen and mutagen, therefore it has been classified as the third category carcinogen by the International Agency for Research on Cancer (IARC). Sudan I is thus prohibited in all national and international food regulatory acts as a food additive. Recently in some places this harmful dye was used as an additive of foodstuffs illicitly to boost up the typical reddish color of chilli powder for commercial benefits (Yuvan .J, 2008).

7. Analyzing techniques

Piao, C., & Chen, L. (2012), in order to separate Sudan dyes from samples of chili powder, a straightforward technique based on magnetic molecularly imprinted polymers (MMIPs) has been devised. Using Sudan IV as a template molecule, methacrylic acid as a functional monomer, and ethylene glycol dimethacrylate as a cross-linking agent, the Fe_3O_4 nanoparticles were encapsulated in a SiO_2 shell and functionalized with -CH=CH_2. This process was followed to create the MMIPs. Fourier transform infrared spectroscopy, a scanning electron microscope, and a physical property measurement equipment were used to characterize the prepared MMIPs. The isothermal absorption experiment, kinetics absorption experiment and selectivity of MMIPs were tested. By using high performance liquid chromatography, the analytes were identified. Under the optimal conditions, the limits of detection of the four Sudan dyes are 6.2, 1.6, 4.3 and 4.5 ng g^{-1}, respectively. The precision expressed as relative standard deviation ranging from 4.8% to 9.1% was obtained. In all three fortified levels (25, 250 and 2500 ng g^{-1}), recoveries of Sudan dyes were in the range of 79.9–87.8%.

Determination of chlorophyll and b-carotene content

Chlorophyll and b-carotene contents were determined using the method described by Nagata and Yamashita (1992) with little modification. Using a UV/VISspectrometer (T80 UV/VIS Spectrometer, PG Instruments LTD.), the optical densities of all the supernatants were measured at 663, 645, 505, and 453 nm after the pigments in the sample were removed concurrently with acetone-hexane (4:6). Using the following formulas, the amounts of chlorophyll "a" and chlorophyll "b" were calculated in milligrams per 100 grams:

$$\text{Chlorophyll a } (\text{mg}/100\text{ g}) = 0.999\text{A}_{663} - 0.0989\text{A}_{645}$$

$$\text{Chlorophyll b } (\text{mg}/100\text{ g}) = -0.328\text{A}_{663} + 1.77\text{A}_{645}.$$

The following formula was used to determine the β-Carotene concentration in mg/100 mL (Igbokwe et al. 2013):

$$\beta\text{-Carotene (mg/100 g)} = 0.216A_{663} - 0.304A_{505} + 0.452A_{453}$$

where A_{663}, A_{645}, A_{505} and A_{453} are the absorbance at 663, 645, 505 and 453 nm, respectively.

Pungency test

Using the protocol outlined by Hossain and Bala (2007), the pungency of the chilli samples was ascertained by extracting 4 g of powdered chilli using acetone until a colorless acetone solution was obtained. The extract was then poured into a beaker and allowed to stand at room temperature for 3 hours, during which time 5 mL of acetone was taken and heated on a water bath until it was completely dry. To this, 5 mL of 0.1 N NaOH solution was added followed by 3 mL of 3% phosphomolybdic acid solution and was kept at room temperature for 1 h. Finally, optical density was measured at 650 nm using a spectrophotometer (T80 UV/ VIS Spectrometer, PG Instruments LTD.). The pungency index of chilli powder was determined by measuring the optical density of the samples; the greater the optical density, the more capsaicin and thus the more pungent content.

References

1. Anandhi K, Khader KM (2011) Gene effects of fruit yield and leaf curl virus resistance in interspecific crosses of chilli (C. annuum L. and C. frutescens L.). J Trop Agric 49:107–109
2. Apichartsrangkoon, A., Chaikham, P., Srisajjalertwaja, A., Chunthanom, P., & Dajanta, K. (2013). Aroma volatile profiles of Thai green chili paste (Nam Prig Noom) preserved by ultra-high pressure, pasteurization and sterilization. *International Food Research Journal*, *20*(4), 1739.
3. Bahramian, S., Soleimanian-Zad, S., Sheikh-Zeinoddin, M., & Kabir, G. H. (2009). Establishment of an Inexpensive Procedure to Reduce the Microbial Load of Spices Used in Mayonnaise Industry. *Botany Research International*, *2*(4), 235-238.
4. Bhatt, B. S., Chahwala, F. D., Rathod, S., & Singh, A. K. (2016). Identification and molecular characterization of a new recombinant begomovirus and associated betasatellite DNA infecting Capsicum annuum in India. *Archives of virology*, *161*, 1389-1394.
5. Candlish, A. A. G., Pearson, S. M., Aidoo, K. E., Smith, J. E., Kelly, B., & Irvine, H. (2001). A survey of ethnic foods for microbial quality and content aflatoxin. *Food Additives & Contaminants*, *18*(2), 129-136.
6. Chan, M. T., Nor-Khaizura, M. A. R., Mahyudin, N. A., Jamaludin, N. S., Khairul, N. S. A., & Yahya, U. I. I. (2021). Antibacterial activity of black cumin, clove, and ginger essential oils against specific spoilage organisms of ready-to-eat chilli shrimp paste. *International Food Research Journal*, *28*(2), 393-400.
7. Eliasson, L., Isaksson, S., Lövenklev, M., & Ahrné, L. (2015). A comparative study of infrared and microwave heating for microbial decontamination of paprika powder. *Frontiers in Microbiology*, *6*, 1071.
8. Fondong, V. N. (2013). Geminivirus protein structure and function. *Molecular plant pathology*, *14*(6), 635-649.
9. Golge, O., Hepsag, F., & Kabak, B. (2013). Incidence and level of aflatoxin contamination in chilli commercialised in Turkey. Food Control, 33(2), 514-520.

10. Hernández-Pérez, T., Gómez-García, M. D. R., Valverde, M. E., & Paredes-López, O. (2020). Capsicum annuum (hot pepper): An ancient Latin-American crop with outstanding bioactive compounds and nutraceutical potential. A review. *Comprehensive Reviews in Food Science and Food Safety*, *19*(6), 2972-2993.
11. Ismail, N., & Revathi, R. (2006). Studies on the effects of blanching time, evaporation time, temperature and hydrocolloid on physical properties of chili (Capsicum annum var kulai) puree. *LWT-Food Science and Technology*, *39*(1), 91-97.
12. Jiang, T. A. (2019). Health benefits of culinary herbs and spices. *Journal of AOAC International*, *102*(2), 395-411.
13. Kaleemullah, S., & Kailappan, R. (2005). Drying kinetics of red chillies in a rotary dryer. Biosystems Engineering, 92(1), 15-23.
14. Khan, M. S., Raj, S. K., & Singh, R. (2006). First report of Tomato leaf curl New Delhi virus infecting chilli in India. *Plant Pathology*, *55*(2).
15. Kumar S, Kumar R, Kumar S, Singh M, Rai AB, Rai M (2009) Reaction of Pepper leaf curl virus field resistance of chilli (C. annuum L.) genotypes under challenged condition. Veg Sci 36:230–232.
16. Kumar Y, Hallan V, Zaidi AA (2011b) Chilli leaf curl Palampur virus is a distinct begomovirus species associated with a betasatellite. Plant Pathol 60:1040–1047.
17. Lv, J., Qi, L., Yu, C., Yang, L., Guo, Y., Chen, Y., ... & Li, L. (2015). Consumption of spicy foods and total and cause specific mortality: population based cohort study. *Bmj*, *351*.
18. Mandeel, Q. A. (2005). Fungal contamination of some imported spices. *Mycopathologia*, *159*, 291-298.
19. Nigam, K., Suhail, S., Verma, Y., Singh, V., & Gupta, S. (2015). Molecular characterization of begomovirus associated with leaf curl disease in chilli. *World J Pharm Res*, *4*(3), 1579-1592.
20. Olatunji, T.L. & Afolayan, A.J. (2018). The suitability of chili pepper (Capsicum annuum L.) for alleviating human micronutrient dietary deficiencies: a review. Food Science and Nutrition, 6, 2239–2251
21. Parveen, S., Das, S., Begum, A., Sultana, N., Hoque, M. M., & Ahmad, I. (2014). Microbiological quality assessment of three selected spices in Bangladesh. *International Food Research Journal*, *21*(4), 1327.
22. Rosa, A., Deiana, M., Casu, V., Paccagnini, S., Appendino, G., Ballero, M., & Dessí, M. A. (2002). Antioxidant activity of capsinoids. *Journal of Agricultural and Food Chemistry*, *50*(25), 7396-7401.
23. Scoville, W. L. (1912). Note on *Capsicum*. *Journal of the American Pharmaceutical Association*, *1*(5), 453–454. https://doi.org/10.1002/ jps.3080010520.
24. Sharif, Z. M., Jalil, N. J., & Othman, M. S. (2019). Analysis of chili paste and black bilimbi sambal from SMEs'(Small Medium Enterprise) in ascertaining safe consumption.
25. Shi, Z., Riley, M., Brown, A., & Page, A. (2018). Chilli intake is inversely associated with hypertension among adults. *Clinical nutrition ESPEN*, *23*, 67-72.
26. Sido, R. F., Huang, R., Liu, C., & Chen, H. (2017). High hydrostatic pressure inactivation of murine norovirus and human noroviruses on green onions and in salsa. *International journal of food microbiology*, *242*, 1-6.
27. Singhal, V. (1999). Chillies In: Indian Agriculture. *Indian Economic Data Research Centre, New Delhi*.

28. Siti Mazlina, M. K., Ying, L. S., Shaidatul Shima, M. S. I., & Iryane, I. (2014). Design development of a unit operation for chilli paste process. *American Journal of Food Technology*, *9*(1), 15-27.
29. Wang, B., Yang, X., Wang, Y., Xie, Y., & Zhou, X. (2018). Tomato yellow leaf curl virus V2 interacts with host histone deacetylase 6 to suppress methylation-mediated transcriptional gene silencing in plants. *Journal of virology*, *92*(18), 10-1128.
30. Pino, J., Fuentes, V., & Barrios, O. (2011). Volatile constituents of Cachucha peppers (Capsicum chinense Jacq.) grown in Cuba. *Food Chemistry*, *125*(3), 860-864.
31. Miglio, C., Chiavaro, E., Visconti, A., Fogliano, V., & Pellegrini, N. (2008). Effects of different cooking methods on nutritional and physicochemical characteristics of selected vegetables. *Journal of agricultural and food chemistry*, *56*(1), 139-147.
32. Berry, H. M., Lai, F., Kende, A., Rickett, D. V., Baxter, C. J., Enfissi, E. M., & Fraser, P. D. (2021). Understanding colour retention in red chilli pepper fruit using a metabolite profiling approach. *Food Chemistry: Molecular Sciences*, *2*, 100013.
33. Yuan, J., Liao, L., Lin, Y., Deng, C., & He, B. (2008). Determination of Sudan I in chilli powder from solvent components gradual change–visible spectra data using second order calibration algorithms. *analytica chimica acta*, *607*(2), 160-167.
34. Piao, C., & Chen, L. (2012). Separation of Sudan dyes from chilli powder by magnetic molecularly imprinted polymer. Journal of chromatography A, 1268, 185-190.
35. Xue, H., Xing, Y., Yin, Y., Zhang, T., Zhang, B., Zhang, Y., ... & Xi, R. (2012). Application of an enzyme immunoassay for the quantitative determination of azo dye (Orange II) in food products. *Food Additives & Contaminants: Part A*, *29*(12), 1840-1848. Website Source: https://www.agrocrops.com/in-en