Committee on Toxicity of Chemicals in Food, Consumer Products and the Environment

Statement on the potential risk from citrinin in the maternal diet

Introduction

1. The Scientific Advisory Committee on Nutrition (SACN) last considered maternal diet and nutrition in relation to offspring health, in its reports on 'The influence of maternal, foetal and child nutrition on the development of chronic disease in later life' (SACN, 2011) and on 'Feeding in the first year of life' (SACN, 2018). In the latter report, the impact of breastfeeding on maternal health was also considered. In 2019, SACN agreed to conduct a risk assessment on nutrition and maternal health focusing on maternal outcomes during pregnancy, childbirth and up to 24 months after delivery; this would include the effects of chemical contaminants and excess nutrients in the diet.

2. SACN agreed that, where appropriate, other expert Committees would be consulted and asked to complete relevant risk assessments e.g., in the area of food safety advice. This subject was initially discussed during the Committee on the Toxicity of Chemicals in Food, Consumer Products and the Environment (COT) horizon scanning item at their January 2020 meeting with a scoping paper being presented to the COT in July 2020. This included background information on a provisional list of chemicals proposed by SACN. It was noted that the provisional list of chemicals was subject to change following discussion by COT who would be guiding the toxicological risk assessment process: candidate chemicals or chemical classes can be added or removed as the COT considered appropriate. The list was brought back to the COT with additional information in September 2020. Following a discussion at the September 2020, COT agreed that papers on a number of compounds should be prioritised, among which was the mycotoxin citrinin.

3. The following statement sets out the advice of the COT on whether UK exposures to citrinin would pose a risk to maternal health, i.e. maternal outcomes during pregnancy, childbirth and up to 24 months after delivery.

Background

4. Citrinin is a mycotoxin produced by several species of fungi of the genera *Aspergillus*, *Penicillium* and *Monascus*. Its occurrence is generally due to formation after harvest under storage conditions. It occurs mainly in grains but is also found in other products of plant origin e.g. beans, fruits, fruit and vegetable juices, herbs and spices as well as in spoiled dairy products.

5. Experimental data indicate that citrinin residues may occur in the edible tissues of pigs (Meerpoel et al., 2020a) and in edible tissues and eggs in chickens (Abdelhamid and Dorra, 1990, Meerpoel et al., 2020a) following oral exposure to highly contaminated feed materials. However, citrinin was not detected in edible animal products in the 2014 Total Diet Study (TDS) so the carryover of citrinin from feed into animal products is not considered further in this assessment (FSA, 2014).

6. Citrinin is also an undesirable contaminant in *Monascus* fermentation products such as red yeast rice (RYR), also known as red mould rice (RMR). RYR is used in Asian cuisine as a food colourant and flavour enhancer and in supplements claiming to decrease plasma triglyceride and cholesterol levels (Wei et al., 2003). In 2019, the maximum level for citrinin in RYR preparations was reduced from 2000 µg/kg to 100 µg/kg in Commission Regulation (EC) No 1881/2006 (amendment: Commission Regulation (EU) 2019/1901). The majority of packaging of RYR supplements either states that the product is not suitable for children and/or women who are pregnant or breast feeding, or recommends that these groups should consult a general practitioner (GP) prior to consumption. Due to the presence of warnings on supplement packaging, and the focus of this assessment being on the maternal diet, RYR supplements are not considered further in this assessment.

Previous assessments

European Food Safety Authority 2012 opinion

7. In 2012, the European Food Safety Authority (EFSA) assessed the risks to public and animal health related to the presence of citrinin in food and feed. Based on the available evidence, EFSA concluded that the establishment of a health-based guidance value (HBGV) would not be appropriate. While a concern for genotoxicity and carcinogenicity could not be excluded, EFSA did not consider the database sufficient to apply a margin of exposure (MOE) approach. Instead, the risk of citrinin was characterised and an intake of 0.2 ug/kg bw per day identified as a level of no concern for nephrotoxicity in humans. The available exposure data did not permit EFSA to reach a firm conclusion regarding the likelihood of consumers exceeding the level of no concern for nephrotoxicity on a daily basis over a prolonged period. A concern for genotoxicity and carcinogenicity could not be excluded at the level of no concern for nephrotoxicity. The derivation of the HBGV is discussed in more detail from paragraph 38.

Netherlands Food and Consumer Product Safety Authority (NVWA) 2015 risk assessment

8. The Netherlands Food and Consumer Product Safety Authority (NVWA) monitors the occurrence of mycotoxins in the Netherlands and advises the Dutch government on food safety risks related to mycotoxins. In 2015, NVWA commissioned the National Institute for Public Health and Environment (RIVM) to undertake a literature search (covering the period 2011 to 2015) to find out whether any new toxicity studies had been published since the EFSA opinion that could be used to derive a benchmark dose (BMD) or a HBGV (RIVM, 2017). The point of departure (POD) selected was 48 µg/kg bw/day, the lower 95% confidence bound of the benchmark dose (lower confidence limit) ($BMDL_{05}$) in a reproductive toxicology study in rats (Singh et al., 2014). In their assessment, RIVM agreed with EFSA's concern regarding the genotoxicity and/or carcinogenicity of citrinin and found a lack of

new evidence published since the EFSA opinion. The approach and outcomes are discussed further from paragraph 42.

Toxicology

9. EFSA carried out a full assessment of citrinin in 2012. Their assessment has been used as a baseline point for the following hazard characterisation. In addition, a literature search covering the period 2012-2024 was carried out, ensuring that relevant data published after the EFSA assessment were also considered here. The key studies used in the RIVM risk assessment (2017) were retrieved as part of this literature search. The following sections therefore summarise all relevant toxicological information up to 2024.

Toxicokinetics

10. The available information on citrinin showed it is eliminated predominantly by renal excretion; approximately 75 % of radiolabelled citrinin (^{14}C-citrinin) given to pregnant Spraque-Dawley rats by subcutaneous administration was recovered in urine (Reddy et al., 1982a). A study by Meerpol et al. (2020b) demonstrated differences in the toxicokinetic properties of citrinin between pigs and chickens, including clearance being much slower in pigs than in chickens (Meerpoel et al., 2020b).

11. An *in vitro* study in Chinese hamster lung fibroblast cells demonstrated that the cytotoxicity of the metabolite dihydrocitrinone was less than that of citrinin (Föllmann et al., 2014) while the interaction of dihydrocitrinone with albumin from different species *in vitro* did not differ significantly (Faisal et al., 2019).

12. A study in human volunteers demonstrated that ingested citrinin undergoes conversion to dihydrocitrinone, which is then excreted in the urine along with the remaining parent compound (Degen et al., 2018).

13. A study by Singh (2012) suggested that citrinin can cross the placenta (discussed further in the Developmental and reproductive toxicity section, see paragraph 31).

Experimental toxicity

Genotoxicity

14. EFSA concluded that the available data indicated that citrinin was not mutagenic in conventional bacterial assays either with or without metabolic activation by S9 fraction (EFSA, 2012). Mutagenicity in the Ames test was reported in a single study when rat hepatocytes were used as the activating system (Sabater-Vilar et al., 1999). In mammalian cells *in vitro*, citrinin did not induce DNA single-strand breaks, oxidative DNA damage or sister chromatid exchanges but did induce micronuclei, aneuploidy and chromosomal aberrations.

15. In *in vitro* assays published since the EFSA opinion citrinin induced a dose-dependent increase in micronucleus frequencies, chromosomal aberrations and sister chromatid exchanges (Anninou et al., 2014; Föllmann et al., 2014; Tsai et al., 2023). Tsai et al. (2023) concluded that citrinin exposure activated cancer and cell cycle-related signalling pathways when human embryonic kidney 293 (HEK293) cells were treated for 3 and 30 days (Tsai et al., 2023).

16. *In vivo*, citrinin induced chromosome abnormalities and hypodiploidy in the bone marrow of mice exposed to oral doses of 5-20 mg/kg bw for eight weeks (Jeswal, 1996).

Carcinogenicity

17. Fischer 344 rats were fed diet containing citrinin at 0.1 % (correspond to an intake of 1000 mg/kg diet or exposures equivalent to approximately 70 mg/kg bw based on 20 g feed intake) for 80 weeks; the kidney was identified as the main target organ, with reported induction of adenomas (Arai and

Hibino, 1983). The first renal tumour was seen at necropsy week 52. Renal adenomas were seen in 35 of the 48 rats that had survived after 40 weeks.

18. In a series *of in vivo* studies, Kuroda et al. (2013) administered citrinin to male Fischer 344 rats by gavage at 20-40 mg/kg bw/day for a maximum of 28 days. The higher dose, which is 2000 times higher than the POD selected by EFSA, is identified by the authors as “the maximal tolerated dose and a nearly carcinogenic dose”. The maximum dose was decreased to 30 mg/kg from day four due to decreases in body weight (bw). Regenerative tubules were observed in the kidney cortex in the high dose group and cell proliferation was significantly increased at both doses. The authors suggested that the increase in cyclin encoding genes (*Ccna2, Ccnb1, Ccne1*) and transcription factor E2f1 indicated induction of cell cycle progression at all tested doses. Cyclin B1 specifically is ubiquitously expressed in humans and plays a key role in controlling the cell cycle transitions.

Nephrotoxicity

19. *In vitro*, the acute cytotoxic effects of both dihydrocitrinone and citrinin were significantly decreased in Madin-Darby canine kidney (MDCK) epithelial cell line, in the presence of albumin (Faisal et al., 2019).

20. *In vivo*, the acute lethal dose of citrinin ranged from 19-134 mg/kg bw depending on species and route of administration (EFSA, 2012). The main changes in pathology following citrinin administration were degeneration and necrosis of the kidneys in all species, indicating nephrotoxicity. Repeat dose studies assessed by EFSA (2012) confirmed the nephrotoxicity of citrinin and highlighted the differences in susceptibility between species, showing that guinea pigs and dogs were more sensitive than hamsters. Histopathological changes were found at necropsy in the kidneys of all species tested (except hamsters), consistent with the acute signs observed.

21. In a 90-day study in male Wistar rats by Lee and Pan (2010), citrinin was given in the diet in the form of fermented RMR containing different

concentrations of citrinin (1, 2, 10, 20 and 200 mg/kg). At the highest dose tested (stated by EFSA to be equivalent to 20 µg/kg bw/day) no toxicologically significant alterations in body weight gain, daily feed intake, organ weight and serum biochemistry or histopathology of livers and kidneys were observed.

22. In a repeat dose study, Jagdale et al. (2020) treated male and female Wistar rats with 25 µg/kg bw/day or 100 µg/kg bw/day citrinin by gavage for 28 days. Adverse histopathological changes were reported in the kidney and spleen at the higher dose. No significant histological changes were reported in animals dosed with 25 µg/kg bw/day.

23. A 60-day study in rabbits suggested that at low concentrations, citrinin (15 mg/kg feed, equivalent to 0.45 mg/kg bw/day; EHC 240) induced lipid peroxidation and apoptosis in a time-dependent manner in the kidney; this, according to the authors, appeared to play a major role in the pathogenesis of nephrotoxicity (Kumar et al., 2014).

Immunotoxicity and Immunomodulation

24. EFSA concluded in 2012 that the data on immunotoxicity of citrinin were incomplete and often non-specific and therefore did not allow for a conclusive evaluation.

25. Since the EFSA opinion, *in vitro* mammalian cell assays reported to show evidence of immunomodulatory and immunotoxic effects of citrinin have been published (Sugiyama et al., 2013: abstract only; Islam et al., 2012; Xu et al., 2022).

26. When immunoglobulin (Ig) levels were measured in mice treated *in vivo* with citrinin (1, 5, or 10 mg/kg bw/day, by gavage) for 14 days, a dose-dependent reduction in IgM was observed in the absence of significant changes in IgA, IgE and IgG (Islam et al., 2012). Changes in the regulation of the different immune cell populations were reported in the spleen, mesenteric lymph nodes and small intestine at 1 mg/kg bw/day. *Ex vivo* exposure of

primary splenocytes and mesenteric lymph node cells demonstrated induction of apoptosis in the mice spleen, lymph nodes and Peyer's patches, which authors commented was through alteration of *Bax/Bcl-2* expression.

Developmental and reproductive toxicity

27. EFSA considered citrinin to show reproductive toxicity with teratogenic and embryotoxic effects based on data from *in vitro* and *in vivo* studies (EFSA, 2012). *In vivo* studies also reported maternal toxicity, including nephrotoxicity, at the same dose, indicating that the reproductive, teratogenic and embryotoxic effects of citrinin may be secondary to maternal toxicity.

28. Toxicokinetic investigations in pregnant Charles River CD1 rats provided no conclusive data about the percentage of citrinin that crosses the placenta (Reddy et al., 1982b). Therefore, EFSA could not determine the extent to which offspring were exposed based on the available data.

29. Since the 2012 EFSA opinion, limited data has been published on the reproductive and developmental effects caused by citrinin; however, where such effects were observed the doses administered were above EFSA's level of no concern for nephrotoxicity.

30. A repeated oral dose toxicity study by Hayashi et al. (2012) exposed female BALB/c mice to 0, 1.25 or 7.5 ppm citrinin for 70 days in drinking water. No effects on body weight, food consumption or clinical signs were observed and except for a slight increase in relative ovary weight, no other effects on kidney, liver or ovary were observed. A second experiment was carried out exposing female BALB/c mice to 0, 15 or 30 ppm citrinin for 90 days in drinking water. A significant decrease in relative liver weight and decreases in water consumption were observed in the lower (15 ppm) dose group, while decreases in body weight were observed in the higher treatment group (30 ppm). Both absolute and relative ovary weights increased, accompanied by large follicles at ≥ 15 ppm (the authors estimated this was equivalent to 2.25 mg/kg bw/day).

31. Singh et al. (2012) administered citrinin (10 mg/kg feed, equivalent to 1 mg/kg bw/day; EHC 240) to pregnant Wistar rats from gestational day 6-20. A significant increase in the percentage of apoptotic cells in kidneys of dams and foetuses as observed. Toxicity, indicated by the presence of apoptotic cells in the kidneys was inferred by the authors.

32. In a later one generation study by the same authors (Singh et al., 2014) male and female Wistar rats were administered citrinin via the diet (1, 3 and 5 mg/kg citrinin in feed, equivalent to 0.1, 0.3 and 0.5 mg/kg bw/day; EHC 240) for 10 weeks prior to mating, during mating and during organogenesis. Clinical signs observed included increased water intake, dullness, rough hair coat and polyuria. Mortality was not observed in the dams. Reproductive effects included reduced foetal bodyweight, reduced crown-rump length and increased number of malformations.

33. Newly fertilised zebrafish eggs were exposed to concentrations of 0.78-50 µM citrinin before individuals reached the free-feeding stage, i.e. while the zebrafish were still embryos prior to reaching the juvenile stage of development. (Csenki et al., 2021). No mortalities occurred, but exposure to 50 µM citrinin led to pericardial oedema, blood accumulation, incorrect heart looping, and reduced size of cardiac chambers.

Epidemiological studies

34. The literature search undertaken for the current assessment retrieved epidemiological studies specifically on pregnant women following citrinin exposure. However, no studies specific to the UK were available.

35. Citrinin and dihydrocitrinone have been reported in urine from different human cohorts from Belgium, Czech Republic, Portugal, Germany, Haiti, Bangladesh, Nigeria, Turkey, and Tunisia (Narváez et al., 2021). Citrinin has also been detected in the breast milk and urine of mothers and the urine of exclusively breastfed infants in two Nigerian communities (Ezekiel et al., 2022).

36. Three biomonitoring studies were carried out to measure the concentration of citrinin and dihydrocitrinone in pregnant women, infants and children in Bangladesh (Ali and Degen, 2020; Kyei et al., 2022, 2023). Citrinin was detected in 61 % of the urine samples collected from pregnant women and dietary exposure to citrinin, based on urinary levels, was estimated to exceed the level of no concern for nephrotoxicity set by EFSA (2012) in 16 % of pregnant women. No evidence was found for an association between higher maternal daily intakes of citrinin, and duration of pregnancy, birth weight, birth length, and head circumference at birth.

Other human studies

37. EFSA considered two reports of (accidental) human exposure (Hetherington and Raistrick, 1931; Ambrose and DeEds, 1946); however, both focussed on inhalation of citrinin powder. EFSA drew no conclusions from these studies, and the effects were not considered to be relevant to the maternal diet due to the route of exposure.

Health based guidance values

European Food Safety Authority

38. In 2012, EFSA concluded that the establishment of a HBGV for citrinin would not be appropriate, given the available data on genotoxicity and the limitations and uncertainties in the database.

39. For compounds that are potentially genotoxic or carcinogenic, EFSA normally recommends the use of the MOE approach. However, EFSA did not consider an MOE approach appropriate for citrinin due to the lack of human dietary exposure data. Instead, EFSA decided to characterise the risk of citrinin and determine a level of no concern for nephrotoxicity in humans. A level of no concern is not a HBGV but is a concentration below which there is no appreciable concern for nephrotoxic effects. This level does not specifically address other end points.

40. The level of no concern was based on a no observed adverse effect level (NOAEL) of 20 µg/kg bw per day determined from a study in rats by Lee and Pan (2010) (detailed in paragraph 21). EFSA applied a default uncertainty factor (UF) of 100 for interspecies (10) and interindividual (10) variation to derive a level of no concern of 0.2 µg/kg bw per day for nephrotoxicity.

41. EFSA however noted that a concern for genotoxicity and carcinogenicity could not be excluded at the level of no concern for nephrotoxicity.

National Institute for Public Health and Environment (RIVM)

42. In 2015, the NVWA commissioned the RIVM to produce a report based on a literature search to determine whether toxicity studies published since the EFSA opinion could be used to derive a BMD or a HBGV.

43. From the studies retrieved, the RIVM selected the developmental toxicity study by Singh et al. (2014) (paragraph 32) and the subchronic toxicity study by Hayashi et al. (2012) (paragraph 30) for BMD analysis.

44. The lowest BMDL derived was the $BMDL_{05}$ of 48 µg/kg bw/day for 'decreased crown rump length' from the Singh et al. (2014) study; the study was considered the appropriate POD for risk assessment. The RIVM noted that effects on the foetuses could be secondary to maternal toxicity. Since information on maternal effects was limited (only maternal body weight was measured), effects on foetuses were considered relevant and the $BMDL_{05}$ on decreased crown rump length the most appropriate. This $BMDL_{05}$ was 2.4 times higher than the NOAEL determined by EFSA in 2012.

45. The RIVM concluded that there were no new scientific articles available in the years 2011 to 2015 on the *in vivo* genotoxicity or carcinogenicity of citrinin. A re-evaluation of the study by Arai and Hibino (1983) (detailed in paragraph 17) on the tumorigenicity of citrinin in rats revealed that the study was not suitable for BMD analysis. Therefore, the RIVM agreed with EFSA's

conclusion regarding the genotoxicity and/or carcinogenicity of citrinin and did not derive a HBGV. The RIVM further supported EFSA's request for a well-designed toxicological study in laboratory animals to further explore the carcinogenic potential of citrinin.

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46. Based on the assessment by EFSA in 2012 and new data published between 2012-2024 the COT agreed that citrinin is nephrotoxic. In addition, and of specific interest to the assessment on maternal toxicity, both *in vitro* and *in vivo* studies indicate that dietary exposure to citrinin may cause reproductive and developmental toxicity, although most of the effects occur at maternally toxic doses.

47. Overall, the new data published since the 2012 EFSA opinion supported previous findings or added to the existing knowledge base regarding citrinin.

48. The COT therefore agrees with EFSA that a HBGV cannot currently be set and that it is appropriate to use the level of no concern for nephrotoxicity to characterise the risk of citrinin to consumers. Whilst the RIVM $BMDL_{05}$ specifically covers reproductive effects, it is 2.4 times higher than EFSA's level of no concern for nephrotoxicity. Therefore, the level of no concern for nephrotoxicity is adequately protective for maternal, reproductive and developmental toxic effects.

Exposure Assessment

49. It was not possible to conduct an exposure assessment to citrinin during pregnancy, childbirth and up to 24 months after delivery due to the absence of data specific to the maternal diet; exposure was instead determined for women of child-bearing age (16-49 years), using consumption

data from the National Diet and Nutrition Survey (NDNS) and occurrence data from the 2014 Total Diet Study (TDS) (Bates et al., 2014, 2016, 2020; Roberts et al., 2018; FSA, 2014).

50. Occurrence data from all food samples analysed for citrinin were below the limit of quantification (LOQ) and the exposures calculated were based on the lower bound (LB) and upper bound (UB) values. In this scenario the LB occurrence value for a given commodity is zero and the actual occurrence may be as low as zero (or as high as the upper bound). Therefore, it is not possible to conclusively determine whether a specific commodity contributes to the overall exposure.

51. Mean total exposure to citrinin for women of child-bearing age was 0-17 ng/kg bw/day, whilst exposure in high consumers (97.5th percentile) was 0-43 ng/kg bw/day. The food groups with the highest UB values were tea, with a mean value of 6.2 ng/kg bw/day and a 97.5th percentile value of 23 ng/kg bw/day; instant coffee, with a mean value of 2.6 and 97.5th percentile value of 17 ng/kg bw/day; and wine, with a mean value of 1.0 ng/kg bw/day, and 97.5th percentile value of 6.5 ng/kg bw/day.

52. Citrinin was not detected in edible animal products in the 2014 TDS and the carryover of citrinin into animal products could therefore not be included in the exposure assessment.

Risk characterisation

53. Citrinin is nephrotoxic and has been reported to affect liver function. It has also been associated with reproductive toxicity and teratogenic and embryotoxic effects, usually at doses that caused maternal toxicity. These adverse effects may be secondary to maternal toxicity.

54. Based on the data available, including data published since the most recent EFSA opinion in 2012, the COT did not think it appropriate to establish

a HBGV but agreed with EFSA's approach of using a level of no concern for nephrotoxicity in humans of 0.2 µg/kg bw per day. Whilst the $BMDL_{05}$ of 48 µg/kg bw per day derived by the RIVM was specific to reproductive effects, EFSA's level of no concern was lower and was considered adequately protective for maternal, reproductive and developmental toxic effects. All other adverse effects reported after citrinin exposure occurred at higher doses.

55. In 2012, EFSA did not consider there to be sufficient data to conclude on the immunotoxic effects of citrinin. While some additional data has been published since EFSA's opinion, the database is still very limited and did not allow the COT to draw any conclusions.

56. The available data did not indicate that citrinin caused gene mutations; however, citrinin may have a threshold effect on microtubules and/or spindle assembly. The COT noted that the renal adenomas detected in rats in the Arai and Hibino (1983) study were uncommon, but the duration of the study did not allow firm conclusions to be drawn. Due to the limitations in the database, the COT concluded that a risk of genotoxicity and carcinogenicity cannot be excluded although citrinin shows no evidence of DNA-reactive mutagenicity.

57. Mean and 97.5th percentile total estimated exposures for citrinin were 0-17 and 0-43 ng/kg bw respectively, below the level of no concern for nephrotoxicity of 0.2 µg/kg bw per day set by EFSA.

58. While EFSA did not establish a human HBGV, the estimated exposures were over 1000-fold lower than the POD derived by the RIVM from an animal study (48 µg/kg bw per day) based on reproductive effects. Hence, the estimated exposures here were not of toxicological concern for nephrotoxicity or reproductive and developmental effects.

Uncertainties

59. The following uncertainties and limitations in the assessment were identified:

- The current assessment is based on consumption data from the National Diet and Nutrition Survey for women of maternal/childbearing age (16-49) and therefore may not be representative of maternal diet. In addition, the inclusion of the upper bound values for wine, beer, alcopops and cocktails in the assessment may lead to an overestimation of exposure when considering pregnant women because the NHS recommends that those who are pregnant or planning to become pregnant should not drink alcohol.

- Whilst there are suggestions that citrinin can cross the placenta (Singh, 2012), there is limited evidence to support this, and hence there remains uncertainty whether, and to what extent, citrinin can affect the foetus.

- RYR as a food additive and/or as a supplement was not considered in this assessment because consumption data was not available and an exposure assessment could not be carried out. However, the majority of packaging of RYR supplements in the UK state that the product was either not suitable for women who are pregnant or breast feeding, or, it was recommended these groups should consult a general practitioner (GP) prior to consumption. Higher exposure to citrinin may occur in communities which use RYR as an additive. This may lead to underestimation of exposure for certain population groups.

- Different ethnic groups and their specific dietary behaviours have not been characterized, hence there could be an over- or underestimation of exposure.

- Possible additive/synergistic effects with other mycotoxins have not been considered in this assessment. This could lead to

underestimation of the toxicological effects where multiple mycotoxin exposures occur.

- Due to the limitations in the database a risk of genotoxicity and carcinogenicity cannot be excluded. A well-designed toxicological study would be required to further explore the genotoxic and carcinogenic potential of citrinin.

- The transfer of citrinin from feed to animal products was not considered further in this assessment because citrinin was not detected in animal products in the TDS. This could lead to an underestimation of exposure, should newer TDS data report transfer of citrinin into animal products.

- It should be noted that the TDS data used to calculate exposure were from 2014. Changes in population exposure to citrinin may have occurred since then. Dietary patterns may also have changed; for example, widespread adoption of vegan/vegetarian diets and increased consumption of plant-based drinks may not be fully represented in the data.

Conclusions

60. Based on the data available the COT concluded that a HBGV could not be established and agreed with EFSA's approach, using a level of no concern of 0.2 µg/kg bw per day for nephrotoxicity. The COT further considered this level to be adequately protective for maternal, reproductive and developmental effects. The RIVM set a $BMDL_{05}$ of 48 µg/kg bw per day as a POD for reproductive effects, which was higher than the POD used to derive the level of no concern for nephrotoxicity, adding further confidence.

61. Estimated exposures for citrinin were not of toxicological concern for nephrotoxicity or reproductive and developmental effects. In addition, citrinin

was not detected above the LOQ in any of the food groups considered, further confirming that dietary exposure to citrinin is low and supporting the conclusion that levels of citrinin in the diet are not of concern to UK consumers.

62. However, due to limitations in the database a genotoxic and/or carcinogenic risk cannot be excluded. There is a need for further research to explore the potential genotoxic and carcinogenic effects of citrinin.

Statement COT/2025/04

List of Abbreviations and Technical terms

BMD	Benchmark dose
BMDL	Benchmark dose (lower confidence limit)
$BMDL0_5$	the lower 95% confidence bound of the BMDL
bw	Body weight
COT	Committee on the Toxicity of Chemicals in Food, Consumer Products and the Environment
EFSA	European Food Standards Agency
FSA	Food Standards Agency
GP	General Practitioner
HBGV	Health based guidance value
Ig	Immunoglobulin
LB	Lower bound
LOQ	Limit of quantification
MOE	Margin of exposure
NOAEL	No observed adverse effect level
NVWA	Netherlands Food and Consumer Product Safety Authority
POD	Point of departure
ppm	Parts per million
RIVM	National Institute for Public Health and Environment
RMR	Red mould rice
RYR	Red yeast rice
SACN	Scientific Advisory Committee on Nutrition
SCE	Sister chromatid exchange
TDS	Total Diet Study
UB	Upper bound
UF	Uncertainty factor

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