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World Health Organization

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JOINT FAO/WHO FOOD STANDARDS PROGRAMME

CODEX COMMITTEE ON CONTAMINANTS IN FOODS

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Bangkok, Thailand

DISCUSSION PAPER ON THE DEVELOPMENT OF A CODE OF PRACTICE FOR THE PREVENTION AND REDUCTION OF TROPANE ALKALOIDS IN FOOD AND FEED

(Prepared by the Electronic Working Group, chaired by China, co-chaired by Saudi Arabia)

Codex members and observers wishing to submit comments on the recommendations for the development of a *Code of practice for the prevention and reduction of tropane alkaloids in food and feed* should do so as instructed in CL 2025/41-CF, available on the Codex webpage[1]

BACKGROUND

1. Considering the scientific advice provided by the FAO/WHO Expert Meeting (2020) on Tropane Alkaloids (TAs)[2], the 15th session of the Codex Committee on Contaminants in Foods (CCCF15, 2022) noticed the need for follow-up actions for TAs[3]. CCCF16 (2023) reconsidered this item and agreed to establish an Electronic Working Group (EWG)[4] to prepare the discussion paper on TAs to look into the need and feasibility of possible follow-up actions.

2. The first discussion paper on TAs in Foods (CX/CF 24/17/11)[5] was prepared by an EWG, chaired by China, co-chaired by Saudi Arabia, for discussion at the CCCF17.

3. CCCF17 (2024)[6] agreed to re-establish the EWG chaired by China and co-chaired by Saudi Arabia to prepare a revised discussion paper including a proposal for a new code of practice and a project document for consideration by CCCF18; and to request the Secretariat of the Joint Expert Committee on Food Additives (JECFA) to issue a call for data on TA contamination in food and feed, with guidance to indicate the stage of sampling.

WORK PROCESS

4. Appendix I presents a new work proposal based on the discussion paper's summary and conclusions. Appendix II contains the draft Code of Practice (CoP), and Appendix III contains the analysis results of TA data in food and feed.

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1 Codex webpage/Circular Letters: http://www.fao.org/fao-who-codexalimentarius/resources/circular-letters/en/
Codex webpage/CCCF/Circular Letters: http://www.fao.org/fao-who-codexalimentarius/committees/committee/related-circular-letters/en/?committee=CCCF
CCCF working documents, including the reports, are available on the Codex webpage: https://www.fao.org/fao-who-codexalimentarius/committees/committee/related-meetings/pt/?committee=CCCF

2 https://cdn.who.int/media/docs/default-source/food-safety/jecfa/summary-and-conclusions/tropane-alkaloids-expert-meeting_30-march-3-april-2020_executive-summary.pdf?sfvrsn=f6c51fc1_5
https://openknowledge.fao.org/server/api/core/bitstreams/6f846395-4481-46ca-850d-8953ae8ccb38/content

3 REP22/CF15, para. 222, 224(iii)

4 REP23/CF16, paras. 106-113.

5 This document can be downloaded at:
https://www.fao.org/fao-who-codexalimentarius/meetings/detail/en/?meeting=CCCF&session=17

6 REP 24/CF17, paras. 107-109.

5. The draft documents were circulated twice, and comments were received from Brazil, China, France, Japan, Mexico, and the United States of America (USA). The list of participants in the EWG is presented in Appendix IV.

6. After the second round of comments, additional data was obtained with assistance from the GEMS/Food Administrator. Members will note significant differences in the analytical results compared with previous versions. In response to member feedback, the results in the table were streamlined and negative findings removed, focusing solely on positive results to highlight commodities with high contamination levels.

KEY POINTS OF DISCUSSION

Title of CoP

7. Some members suggested that the title should clearly indicate that this CoP focuses on control measures for *Datura* weeds. In Codex commodity standards such as CXS 171-1989, the term "Jimson weed (*Datura spp.*)" is used. To maintain consistency with Codex documents, a proposed title could be "Code of Practice for the Prevention and Reduction of Tropane Alkaloids from *Datura* Weeds (Jimson weeds) in Food and Feed".

8. However, since the CoP addresses not only Jimson weed control in agricultural fields but also food processing practices and consumer-level mitigation measures, retaining the original title remains more appropriate. And in the future, the CoP may include other TA-containing plants, e.g., *Atropa belladonna.*

Scope of CoP

9. Provisions related to animal feed were excluded from the first draft of the CoP for TAs, as the European Food Safety Authority (EFSA) (2008)[7] risk assessment findings - TA residues in edible animal tissues, milk, and eggs pose negligible risks to human consumers - indicated minimal transfer risks to livestock-derived products. EFSA's conclusion was supported by two key factors: (1) the short biological half-life of TAs in animals, and (2) the rapid onset of pharmacological symptoms (e.g., behavioral changes) before severe toxicity develops, allowing timely intervention to remove exposed animals from the food chain.

10. While the initial draft excluded feed provisions due to negligible human health risks, however, member feedback highlighted the importance of addressing animal welfare and productivity. Although TA transfer to livestock products is negligible, TA-contaminated feed directly harms animal health (e.g., neurological effects) and reduces farm productivity (e.g., growth suppression, mortality). Therefore, proactive feed controls are justified to protect both animal welfare and agricultural efficiency by the One Health approach.

11. Additionally, since equine species exhibit heightened sensitivity to belladonna alkaloids, one member suggested expanding the CoP's scope to include other TA-containing plants (e.g., *Atropa belladonna*), a modification that is particularly critical for these animals.

12. Ultimately, the CoP was expanded to include feed control. The guidelines reference the *Code of Practice on Good Animal Feeding* (CXC 54-2004) as a foundational framework, with specific amendments to explicitly avoid *Datura* plant parts (e.g., seeds, leaves) from being mixed into feed formulations. However, proposals to regulate other TA-containing plants (including *Atropa belladonna*) will be considered in the future due to insufficient research. The CoP needs further information collection before expanding the scope, ensuring future amendments are evidence-based.

About TA data related to processing stages

13. It was noted that more data on TA occurrences in harvested crops during post-harvest and preprocessing stages could contribute to a better understanding of the efficacy of mitigation measures and application of Good Agricultural Practices (GAPs). Given this, it is crucial to specify the sampling stage when submitting occurrence data or responding to data calls. This is critical because processing steps like cleaning and sorting may remove TA-containing seeds.

14. However, the database currently contains only discrete point data regarding TA contamination levels in various food commodities. This limitation prevents the establishment of contamination pathways/transmission routes, since samples cannot be linked owing to insufficient related information about processing stages. Consequently, the effects of food processing on TA levels cannot be determined based on existing datasets.

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7 EFSA(2008). Tropane alkaloids from *Datura sp* as undesirable substances in animal feed - Scientific Opinion. The EFSA Journal, 2008.

15. The analysis of TA research data revealed that contamination control fundamentally relies on field management practices. Notably, although processing-stage data are lacking, this does not impede the development of the CoP. This finding suggests that while processing-stage monitoring could provide supplementary insights for risk assessment, the implementation of robust agricultural practices remains the primary strategy for effective TA contamination control.

CONCLUSIONS AND RECOMMENDATIONS

16. CCCF is invited to consider whether the data/information provided in this paper (including Appendices) is sufficient to support new work on a code of practice for the prevention and reduction of tropane alkaloids contamination in food and feed, and in the affirmative, to consider the points below:

(i) Review the project document in Appendix II and make any necessary adjustments to ensure a robust rationale for the development of the CoP, to forward it to CAC48 (2025) for approval as new work.

(ii) Review the outline for the proposed revised CoP as presented in Appendix II to guide the EWG in further developing the CoP following approval of new work by CAC48, in particular as to whether the structure and general content are reasonable and if further improvements could be made, e.g. addition of new sections, further development of current sections, and whether data/information to support such revisions is available for consideration by the EWG in further developing the CoP.

Note: Risk management measures for inclusion in Codex codes of practice should be readily available, applicable worldwide, and proven to be effective across different production scales, including small- and medium-sized businesses.

(iii) Re-establish the EWG to further develop the CoP based on the guidance provided by CCCF, for consideration by CCCF19 (2026).

17. If the discussion paper needs further development, CCCF is invited to identify gaps and data/information that should be further developed to guide the EWG's work, for consideration by CCCF19.

APPENDIX I

Discussion paper on tropane alkaloids

(For information)

INTRODUCTION

1. The data/information provided in this Appendix builds on/complements the data/information provided in the discussion paper submitted to the 17th Session of the Codex Committee on Contaminants in Foods (CCCF17, 2024) (CX/CF 24/17/11)[1].

2. The Annex to this Appendix consolidates data and information from the GEMS/Food database on levels of tropane alkaloids (TAs) in food and feed that was assessed by the Electronic Working Group (EWG) to develop this document, including the proposed code of practice (CoP) in Appendix III.

INFORMATION AVAILABLE TO DEVELOP A CoP

3. Last year, CX/CF 24/17/11 provided comprehensive information on toxicology, data summary, health risk, and management measures related to TAs in food. As this discussion paper aims to advance the discourse, it will not reiterate prior findings. Instead, it focuses on strategies to control TA contamination, including key TA-containing plants, the occurrence of TAs in food, and feasible mitigation measures.

4. Atropine and scopolamine, the most relevant TAs in foods, exhibit both pharmacological and toxicological properties. Current risk assessments prioritize acute toxicity concerns over chronic effects, as single high-dose exposures pose immediate public health threats. Consequently, TA risk management strategies should emphasize proactive control of scenarios with the potential for abrupt exposure spikes.

5. Dietary exposure to high levels of TAs primarily originates from two mechanisms: 1) unintentional contamination: occurs when TA-containing plants (e.g., *Datura stramonium*) are inadvertently mixed into food products—particularly staple crops—during agricultural processing or storage; 2) misidentification incidents: arise when consumers mistakenly ingest toxic plant organs, such as confusing datura leaves with edible leafy greens.

6. To address these risks, the CoP for TAs should focus on two key points: 1) supply-chain interventions: establishing standardized protocols for phytosanitary monitoring and mechanical sorting systems to exclude TA-contaminated botanical material from food supplies; 2) public health mobilization: launching evidence-based awareness campaigns utilizing visual recognition tools and community workshops to enhance risk perception of toxic plant misidentification.

TA-containing plants

7. TAs are naturally present in numerous plants, including those from the Brassicaceae, Solanaceae, and Erythroxylaceae families, with detectable levels even in common foods, such as *Solanum tuberosum* (potato), *S. melongena* (eggplant), *Capsicum annuum* (bell pepper) and *Brassica oleracea* (broccoli, Brussels sprouts).

8. Nevertheless, the majority of human TA intoxication cases result from accidental ingestion of *Datura* species, predominantly through contaminated food or misidentification of toxic plants. These incidents occur because *Datura* species contamination can introduce dangerously high TA concentrations into food products or animal feeds.

9. *Datura* species may infiltrate the food chain at multiple stages, from field cultivation and harvesting to processing. Post-harvest, residual *Datura* seeds may evade removal procedures and be unintentionally incorporated into food ingredients, such as being milled into flour.

10. TA also has medicinal applications. However, improper self-medication or dosage errors can lead to poisoning. This dual nature underscores the necessity of public education and strategic agricultural practices, such as avoiding the co-cultivation of crops with *Datura*.

11. To establish a robust defense against TA contamination, integrated strategies are required: targeted eradication of *Datura* in farmland combined with consumer awareness campaigns. This dual approach would form a comprehensive risk mitigation framework to safeguard food supply chains.

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1 This document can be downloaded at: https://www.fao.org/fao-who-codexalimentarius/meetings/detail/en/?meeting=CCCF&session=17

Occurrence of TAs in food and feed

12. Atropine (the racemic mixture of (-)- and (+)-hyoscyamine) and scopolamine emerged as the predominant TAs in terms of both frequency of occurrence and concentration levels, while anisodamine, pseudotropine, and norscopolamine showed minor contributions. Based on this finding, atropine and scopolamine data in food and feed commodities from the GEMS/Food database were subsequently analyzed.

13. In CCCF17, there was a consensus that more occurrence data on TAs related to harvested crops during post-harvest and pre-processing stages could contribute to a better understanding of the efficacy of mitigation measures and the application of good agricultural practices (GAPs). Therefore, there was a call for data on TAs in food and feed.

14. The GEMS/Food database has collected more data than last year. With the assistance of the GEMS/Food Administrator, an extensive dataset of TAs in food and feed spanning 2006-2023 was obtained. The compiled data includes 15,735 entries for scopolamine (14,903 in food, 832 in feed), 15,835 entries for atropine (14,992 in food, 843 in feed), and 834 entries for the combined total of both substances in food.

15. The detection rates of scopolamine, atropine, and the combined total in food are 7.76%, 10.48%, and 6.00%, respectively, which align closely with the results reported in the JECFA 2020 assessment. The detection rates of scopolamine and atropine in feed are 17.43% and 16.61%, respectively. The highest contamination levels of TAs were observed in cereals, primary cereal-based products, and cereal-based feed, followed by spices, herbs, and oil seeds. In contrast, vegetable oils, snack foods, and other processed products exhibited lower contamination risks.

16. Analysis of positive data reveals that no food category exhibits widespread high-level contamination with TAs; rather, contamination appears as sporadic high-level contamination incidents. Specifically, for cereals and cereal-based products (including cereal-based food for infants), herbs, spices, condiments, feed, and tea are more prone to inadvertent contamination by TA-containing plants. Such contamination may remain undetected, thereby resulting in isolated high-contamination events.

17. From a food processing perspective, critical control points for TA management should focus on rigorous supervision at the raw material stage. Appendix III provides detailed analytical findings.

18. Although the GEMS/Food database currently contains expanded data on TA levels (primarily atropine and scopolamine) across various food commodities, none of these records demonstrate correlations with processing effects. Crucially, systematic data documenting processing-stage variations remain unavailable.

19. Targeted investigations into TA degradation dynamics during food processing remain scarce. Existing studies indicate that conventional processing methods exhibit limited effectiveness in TA reduction. Current evidence suggests that preventive strategies—including strict control of *Datura* species contamination in agricultural fields and prevention of accidental misidentification of their toxic plant parts as edible materials—constitute the most reliable approach to mitigating TA contamination risks.

Feasible measures

20. *Datura spp.* are herbaceous, leafy, flowering annual plants. They are classified as broad-leaf weeds and can be effectively controlled by applying broad-spectrum herbicides or herbicides specifically targeting broad-leaf weeds.

21. *Datura* is not a particularly challenging weed to control. Effective management can be achieved through adherence to established weed control protocols, such as those outlined in the “Recommendations for Improved Weed Management[2]” and “Integrated Weed Management (IWM)[3]”.

22. Current food processing technologies show no conclusive evidence of effectively degrading TAs. Therefore, control measures should focus on strict screening of raw materials, prevention of cross-contamination during processing, and final product verification prior to distribution.

23. **Farmland Planning and Weed Control**: Rational crop rotation and soil management are emphasized to disrupt weed growth environments. Chemical or mechanical weeding should be timed to early crop stages or post-harvest intervals, with priority given to pre-flowering removal of weeds like *Datura*. Border areas and pastures require targeted management, such as planting competitive perennials and using mulch free of TA plant seeds.

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2 FAO. 2006. Recommendations for improved weed management. https://openknowledge.fao.org/handle/20.500.14283/a0884e

3 FAO. Integrated Weed Management (IWM). https://www.fao.org/agriculture/crops/thematic-sitemap/theme/spi/scpi-home/managing-ecosystems/integrated-weed-management/en/

24. **Seed Management**: Strict seed selection and inspection protocols (e.g., sieving, wind/water sorting) are mandated to eliminate weed seeds. Certification by authorities ensures seed purity, preventing cross-contamination during storage and planting.

25. **Monitoring and Removal**: Regular field inspections and species-specific monitoring plans are critical for early weed detection. Physical removal methods (hand-weeding, mechanical tillage) and chemical herbicides must be applied judiciously, adhering to safety intervals and resistance management. Irrigation water filtration and post-irrigation seed collection further reduce soil weed banks.

26. **Harvest and Post-Harvest**: Pre-harvest inspections and equipment cleaning prevent TA plant mixing during harvest. Screening processes (size exclusion, visual checks) ensure compliance with food safety standards. Traceability systems and occasional TA testing in finished products are recommended for processors.

27. **Training and Consumer Awareness**: Farmers and food handlers require training in weed identification, safe removal, and disposal practices. Consumers should be educated on the risks of TA-contaminated foods, symptoms of poisoning, and the importance of sourcing from reputable suppliers.

Annex

LEVEL OF TROPANE ALKALOIDS IN FOOD AND FEED

1. With the assistance of the GEMS/Food Administrator, an extensive dataset of tropane alkaloids (TAs) in food and feed from 2006 to 2023 was obtained. The compiled data includes 15,735 entries for scopolamine (14,903 food, 832 feed), 15,835 entries for atropine (14,992 food, 843 feed), and 834 entries for the combined total of both substances in food.

2. The detection rates of scopolamine, atropine, and the combined total in food are 7.76%, 10.48%, and 6.00%, respectively, which align closely with the results reported in the JECFA 2020 assessment. The detection rates of scopolamine and atropine in feed are 17.43% and 16.61%, respectively.

3. To better characterize food categories with positive samples, only those with detected contamination are analyzed in Tables 1-5. For clarity, the range of positive results (minimum to maximum values) is provided in the final column of each table.

4. Analysis of detection rates within individual food categories reveals that sample size significantly impacts detection rates due to the sporadic contamination caused by accidental mixing with *Datura* species. Additionally, certain food categories may exhibit false-positive TA results. For example, pumpkin samples (n=2) showed identical positive values (1.02 µg/kg). However, pumpkins naturally do not contain atropine and are unlikely to be cross contaminated with *Datura*. This suggests potential analytical interference leading to false positives.

5. Additionally, the reported limits of detection (LODs) vary widely, ranging from 0.0002 to 30,000 µg/kg, indicating significant methodological inconsistency. While this variability is notable, the objective is not to establish MLs for TAs. Given the acute toxic health hazards associated with TAs, food categories with high contamination levels were prioritized.

6. The highest contamination levels of TAs were observed in cereals, primary cereal-based products, and cereal-based feed, followed by spices, herbs, and oil seeds. In contrast, vegetable oils, snack foods, and other processed products exhibited lower contamination risks. From a food processing perspective, critical control points for TA management should focus on rigorous supervision at the raw material stage.

7. To understand the contamination level patterns in positive samples, food categories containing over 59 positive samples[4] were selected and data distribution analysis on their contamination levels was conducted. As shown in Tables 6 and 7, the mean values of positive test results across several food categories are all greater than the medians, indicating that even within the positive results, the data distribution is skewed, with a small number of extreme values pulling up the mean.

8. Analysis of positive data reveals that no food category exhibits widespread high-level contamination with TAs; rather, contamination appears as sporadic high-contamination incidents. However, for cereals and cereal-based products (including cereal-based food for infants), herbs, spices and condiments, feed, and tea are more prone to inadvertent contamination by TA-containing plants. Such contamination may remain undetected, thereby resulting in isolated high-contamination events.

9. **Notes**: Peppermint (*Mentha × piperita*) is not typically classified under "starchy roots and tubers". This discrepancy may stem from misinterpretation of classification systems, translation errors, or context-specific categorization practices.

4 CCCF16 agreed to a provisional minimum number of 59 samples for a 95th percentile estimation with 95% confidence (REP23/CF16 paras. 93, 94, 98 (vi)(a)).

Table 1: Summary statistics for Scopolamine concentrations (µg/kg) in the different food samples 2006-2023

FOOD CATEGORIES (detective rate%)	FOOD CODE (detection rate%)	N	YEAR	POSITIVE	MAXIMUM	POSITIVE RANGE
Cereals and cereal-based products (7.34%, 510/6948)	Cereal grains (6.72%, 37/551)	551	2014-2023	37	**1020**	0.075-1020
	Cereals and cereal-based products (8.19%, 88/1074)	1074	2013-2023	88	**460**	0.057-460
	Millet (10.50%, 94/895)	895	2014-2023	94	**198.484**	0.092-198.484
	Buckwheat (4.41%, 44/998)	998	2015-2023	44	**2300**	0.086-2300
	Maize (7.51%, 68/906)	906	2015-2023	68	**1600**	0.061-1600
	Maize flour (6.27%, 21/335)	335	2015-2023	21	**550**	0.057-550
	Wheat (1.77%, 4/226)	226	2015-2019	4	1.5	0.38-1.5
	Wheat flour (1.80%, 4/222)	222	2016-2019	4	1.9	0.1-1.9
	Wheat germ (100.00%, 1/1)	1	2019	1	0.1	0.1
	Oats (9.82%, 11/112)	112	2017-2023	11	**220**	0.1-220
	Rye (16.58%, 33/199)	199	2015-2023	33	**460**	0.1-460
	Barley (4.55%, 1/22)	22	2019	1	0.1	0.1
	Sorghum (10.53%, 8/76)	76	2015-2023	8	73.3	0.7-73.3
	Quinoa (1.15%, 1/87)	87	2016	1	0.47	0.47
	Bran, unprocessed cereal grain (except buckwheat, cañihua, quinoa) (31.25%, 5/16)	16	2017	5	2.7	0.1-2.7
	Whole meal bread (6.45%, 2/31)	31	2017-2019	2	2.5	0.1-2.5
	White bread (7.50%, 3/40)	40	2016	3	0.264	0.085-0.264
	Bread & other cooked cereal products (8.55%, 56/655)	655	2015-2023	56	**300**	0.051-300
	Cereal-based dishes (5.78%, 29/502)	502	2015-2022	29	**220**	0.051-220
Legumes and legume-based products (8.04%, 9/112)	Legumes and pulses (4.76%, 3/63)	63	2017	3	2.02	1.67-2.02
	Soya bean (dry) (11.36%, 5/44)	44	2017-2021	5	2.02	1.09-2.02
	Bean-based meals (20.00%, 1/5)	5	2021	1	1.3	1.3
Nuts and oilseeds (10.05%, 19/189)	Poppy seed (4.76%, 1/21)	21	2021	1	1.1	1.1
	Oilseed, except peanuts (9.30%, 4/43)	43	2017-2019	4	**389.58**	4.8-389.58
	Oilseeds (4.00%, 1/25)	25	2017	1	**389.58**	389.58
	Linseed (5.45%, 3/55)	55	2015-2023	3	0.1	0.095-0.1
	Sunflower seed (22.22%, 10/45)	45	2015-2023	10	54	0.1-54
Herbs, spices and condiments (12.18%, 85/698)	Camomile or chamomile (7.84%, 12/153)	153	2016-2023	12	5	0.17-5
	Dill (16.67%, 2/12)	12	2019-2021	2	21	9-21
	Coriander, seed (33.33%, 2/6)	6	2016	2	22	22-22
	Spices (3.57%, 1/28)	28	2021	1	3.52	3.52
	Herbs (13.11%, 24/183)	183	2019-2023	24	**931**	0.2-931
	Basil (7.14%, 3/42)	42	2019-2021	3	12.2	0.2-12.2
	Anise seed (30.77%, 4/13)	13	2021	4	**109.51**	4.37-109.51
	Fennel, seed (20.00%, 5/25)	25	2016-2022	5	**143.37**	7.18-143.37
	Herb, spice, or condiment (10.96%, 8/73)	73	2018-2022	8	49.96	1.72-49.96
	Mints (30.43%, 14/46)	46	2014-2021	14	34.1	1.02-34.1
	Rosemary (8.33%, 1/12)	12	2019	1	58	58
	Cumin seed (9.09%, 3/33)	33	2019-2021	3	77	4.6-77
	Tarragon (12.50%, 1/8)	8	2016	1	0.7	0.7
	Thyme (2.63%, 1/38)	38	2023	1	11.31	11.31
	Savory, summer, winter (15.38%, 4/26)	26	2022-2023	4	**1067.9**	9-1067.9
Starchy roots and tubers (34.21%, 13/38)	Peppermint (Mentha × piperita) (34.21%, 13/38)	38	2014-2016	13	34.1	1.02-34.1
Fats and oils (1.52%, 9/593)	Rape seed oil, edible (1.39%, 5/359)	359	2017-2018	5	55.8	1.4-55.8
	Fats and oils (1.71%, 4/234)	234	2018-2019	4	24.6	4.9-24.6
Food for infants and young children (4.42%, 118/2669)	Cereal-based food for infants and young children (4.01%, 97/2416)	2416	2014-2023	97	**220**	0.053-220
	Ready-to-eat meal for infants and young children (8.63%, 17/197)	197	2015-2019	17	0.91	0.1-0.91

FOOD CATEGORIES (detective rate%)	**FOOD CODE (detection rate%)**	**N**	**YEAR**	**POSITIVE**	**MAXIMUM**	**POSITIVE RANGE**
	Fruit juice and herbal tea for infants and young children (10.53%, 2/19)	19	2015-2016	2	0.4	0.224-0.4
	Yoghurt, cheese, and milk-based dessert for infants and young children (5.41%, 2/37)	37	2015-2016	2	0.4	0.224-0.4
Snack food (10.09%, 22/218)	Snack food (10.96%, 8/73)	73	2017-2023	8	**220**	0.1-220
	Popcorn (9.66%, 14/145)	145	2016-2023	14	9	0.72-9
Beverage (50%, 2/4)	Alcoholic beverage (33.33%, 1/3)	3	2018	1	0.2	0.2
	Coffee (Beverage) (100.00%, 1/1)	1	2017	1	10	10
Tea (11.90%, 238/2000)	Tea, green (75.00%, 12/16)	16	2017-2019	12	16.3	0.2-16.3
	Teas and herbal teas (solid) (13.63%, 179/1313)	1313	2014-2023	179	**220**	0.17-220
	Tea (infusion) (12.04%, 26/216)	216	2017-2022	26	16	0.2-16
	Tea, green, black (black, fermented and dried) (4.62%, 21/455)	455	2015-2023	21	16.4	0.15-16.4
Dried Fruits (100.00%, 1/1)	Dried Fruits (100.00%, 1/1)	1	2018	1	0.1	0.1
Vegetables and vegetable products (8.70%, 2/23)	Spinach (bunch) (8.70%, 2/23)	23	2022	2	4.19	0.77-4.19
Milks (100.00%, 2/2)	Milks (100.00%, 2/2)	2	2017	2	0.7	0.1-0.7
Honey (6.52%, 12/184)	Honey (6.52%, 12/184)	184	2019-2023	12	5.1	0.5-5.1
Other foods (12.76%, 50/392)	Dietary supplements (22.08%, 34/154)	154	2018-2023	34	85.4	0.5-85.4
	Composite food (1.50%, 2/133)	133	2021-2022	2	**220**	0.5-220
	Other foods (foods which cannot be included in any other group) (13.33%, 14/105)	105	2017-2020	14	23.2	0.2-23.2

Table 2: Summary statistics for scopolamine concentrations (µg/kg) in feeds 2009-2022

FOOD CODE	LOCAL NAME	N	YEAR	POSITIVE	MAXIMUM	POSITIVE RANGE
Feed	Calves (pre-ruminant) / Complete feed	6	2010-2021	4	6.4	5-6.4
	Cereal grains and products derived thereof (feed)	25	2015-2020	3	33	1.1-33
	Sorghum	3	2010, 2021	2	44	10.185-44
	Maize grain (feed)	5	2020	3	1.7	1-1.7
	Maize middlings (feed)	1	2018	1	17	17
	Millet	4	2011	3	**705.023**	10.221-705.023
	Complementary feed (incomplete diet) (feed)	13	2019-2021	11	**125**	1.3-125
	Complete feed (feed)	2	2019	1	3.7	3.7
	Compound feed (feed)	28	2019-2022	14	35	1.8-35
	Dairy cows / Complementary feed (feed)	2	2022	1	14	14
	Distillers' grains and solubles (feed)	3	2021-2022	2	**170**	19-170
	Fattening cattle / Complete feed	5	2011	1	5	5
	Fattening chickens (broilers) / Complementary feed (feed)	1	2021	1	1.4	1.4
	Fattening chickens (broilers) / Complete feed (feed)	12	2011，2020-2022	9	70	1.5-70
	Fattening goats / Complementary feed	1	2011	1	3	3
	Fattening goats / Complete feed	7	2011	4	15	4-15
	Fattening sheep / Complementary feed	3	2011	1	5	5
	Fattening sheep / Complete feed	7	2011	5	7	3-7
	Growing/Fattening pigs / Complementary feed (feed)	1	2022	1	1.3	1.3
	Growing/Fattening pigs / Complete feed	26	2010-2011, 2019-2021	15	21	1-21
	Horses / Complementary feed (feed)	4	2020-2021	2	24	1.8-24
	Horses / Complete feed (feed)	7	2019-2022	5	43	1.4-43
	Lambs (weaning diets) / Complete feed (feed)	1	2022	1	20	20
	Laying hens / Complete feed	10	2011, 2020	3	12	2.1-12
	Oil seeds, oil fruits, and products derived thereof (feed)	1	2020	1	3.3	3.3
	Other plants, algae, and products derived thereof	32	2009	4	**106.48**	10.56-106.48
	Other seeds, fruits, and products derived thereof	2	2011	1	29.92	29.92
	Pet food, cats / Complete feed (feed)	2	2021	2	25	1.6-25
	Pet food, dogs / Complementary feed (feed)	2	2022	1	3.9	3.9
	Piglets (weaning diets) / Complete feed (feed)	8	2011, 2021-2022	3	27	3-27
	Poultry (starter diets) / Complete feed	2	2011	2	5	3-5
	Rabbits / Complementary feed (feed)	1	2020	1	**180**	180
	Rabbits / Complete feed (feed)	7	2020-2022	6	**100**	1.7-100
	Rape seed - expeller (feed)	9	2019-2020	2	4	1.2-4
	Sheep / Complementary feed (feed)	1	2021	1	57	57
	Sows / Complete feed (feed)	1	2022	1	12	12
	Soya (bean) expeller	40	2010	9	20.352	4.966-20.352
	Soya (bean) meal	5	2010	1	6.852	6.852
	Sunflower seed expeller	15	2010-2020	12	**300**	2.1-300
	Sunflower seeds (feed)	1	2022	1	9.7	9.7
	Turkeys / Complete feed (feed)	2	2020-2022	2	14	13-14
	Unspecified Complete feed (feed)	1	2022	1	5.3	5.3

Table3: Summary statistics for atropine concentrations (µg/kg) in the different food samples 2006-2023

FOOD CATEGORIES (detective rate%)	FOOD CODE (detection rate%)	N	YEAR	POSITIVE	MAX	POSITIVE RANGE
Cereals and cereal-based products (10.02%, 698/6964)	Cereal grains (9.20%, 48/522)	522	2014-2023	48	**2200**	0.001-2200
	Maize (13.34%, 121/907)	907	2015-2023	121	**1600**	0.001-1600
	Maize flour (10.15%, 34/335)	335	2015-2023	34	**550**	0.054-550
	Buckwheat (5.65%, 58/1027)	1027	2014-2023	58	**5900**	0.058-5900
	Wheat (3.98%, 9/226)	226	2015, 2017, 2019, 2021, 2022	9	0.93	0.1-0.93
	Barley (4.55%, 1/22)	22	2019	1	0.1	0.1
	Rice (2.67%, 2/75)	75	2015	2	0.93	0.93
	Rye (16.58%, 33/199)	199	2015-2023	33	**1500**	0.1-1500
	Wheat flour (4.05%, 9/222)	222	2015, 2016, 2018-2020	9	9.2	0.1-9.2
	Sorghum (9.21%, 7/76)	76	2015, 2016, 2021-2023	7	**304**	1.13-304
	Millet (14.00%, 125/893)	893	2014-2023	125	**136.301**	0.063-136.301
	Oats (10.71%, 12/112)	112	2017, 2019, 2022, 2023	12	**220**	0.1-220
	Bran, unprocessed cereal grain (except buckwheat, cañihua, quinoa) (31.25%, 5/16)	16	2017	5	0.1	0.1
	Wheat germ (100.00%, 1/1)	1	2019	1	0.1	0.1
	White bread (20.00%, 8/40)	40	2015, 2016	8	0.9	0.093-0.9
	Wheat whole meal (4.35%, 1/23)	23	2022	1	1.9	1.9
	Whole meal bread (6.45%, 2/31)	31	2017, 2019	2	0.8	0.1-0.8
	Cereal-based dishes (7.17%, 36/502)	502	2015-2023	36	**220**	0.064-220
	Bean-based meals (20.00%, 1/5)	5	2021	1	3.88	3.88
	Cereals and cereal-based products (10.14%, 109/1075)	1075	2013-2023	109	**1700**	0.04-1700
	Bread & other cooked cereal products (11.60%, 76/655)	655	2015-2022	76	**1700**	0.053-1700
legumes and legumes-based products (5.79%, 14/242)	Soya bean (dry) (13.51%, 10/74)	74	2017, 2019, 2021, 2023	10	10.5	1.06-10.5
	Lentil (dry) (0.95%, 1/105)	105	2023	1	0.3	0.3
	Legumes and pulses (4.76%, 3/63)	63	2017	3	4.365	3.61-4.365
Nuts and oilseeds (11.11%, 21/189)	Oilseed, except peanut (13.95%, 6/43)	43	2016-2019	6	**463.14**	0.054-463.14
	OILSEEDS (12.00%, 3/25)	25	2016-2017	3	**463.14**	0.055-463.14
	Sunflower seed (17.78%, 8/45)	45	2015, 2019, 2021, 2022	8	75	0.1-75
	Linseed (5.45%, 3/55)	55	2015, 2021	3	0.4	0.11-0.4
	Poppy seed (4.76%,1/21)	21	2021	1	1.2	1.2
Herbs, spices and condiments (10.32%, 88/853)	Herb, spice, or condiment (12.00%, 9/75)	75	2018, 2021	9	**109.8**	1.98-109.8
	SPICES (3.33%, 1/30)	30	2021	1	5.36	5.36
	Coriander, seed (33.33%, 2/6)	6	2016	2	35	35
	Fennel, seed (24.00%, 6/25)	25	2016, 2021-2022	6	**414.43**	4.17-414.43
	Thyme (2.63%, 1/38)	38	2023	1	2.93	2.93
	Camomile or chamomile (7.10%, 11/155)	155	2016	11	3.743	0.4-3.743
	Cumin seed (3.03%, 1/33)	33	2021	1	**383**	383
	Dill (8.33%, 1/12)	12	2019	1	81	81
	Rosemary (8.33%, 1/12)	12	2019	1	**200**	200
	Anise seed (30.77%, 4.13)	13	2021	4	**290.47**	8.920-290.47
	Basil (7.14%, 3/42)	42	2021	3	17.200	5.790-17.200
	Spelt (0.91%, 1/110)	110	2021	1	0.1	0.1
	HERBS (11.89%, 22/185)	185	2015, 2020-2023	22	**777**	0.103-777
	Marjoram (8.89%, 4/45)	45	2019, 2022	4	11.27	1.41-11.27
	Mints (34.78%, 16/46)	46	2014-2016, 2021	16	**129**	0.101-129
	Savory, summer, winter (19.23%, 5/26)	26	2022-2023	5	**1001.2**	2-1001.2

FOOD CATEGORIES (detective rate%)	**FOOD CODE (detection rate%)**	**N**	**YEAR**	**POSITIVE**	**MAX**	**POSITIVE RANGE**
Starchy roots and tubers (39.47%, 15/38)	Peppermint (Mentha × piperita) (39.47%, 15/38)	38	2014-2016	15	**129**	0.101-129
Fats and oils (0.34%, 2/593)	Fats and oils (0.43%, 1/234)	234	2018	1	0.02	0.02
	Rape seed oil, edible (0.28%, 1/359)	359	2017	1	10	10
Food for infants and young children (7.77%, 208/2677)	Cereal-based food for infants and young children (7.18%, 174/2424)	2424	2014-2023	174	**220**	0.05-220
	Fruit juice and herbal tea for infants and young children (21.05%, 4/19)	19	2015-2017	4	23	0.12-23
	Ready-to-eat meal for infants and young children (12.69%, 25/197)	197	2015-2023	25	7.9	0.098-7.9
	Yoghurt, cheese, and milk-based dessert for infants and young children (13.51%, 5/37)	37	2015-2018	5	23	0.017-23
Snack food (13.76%, 30/218)	Snack food (15.07%, 11/73)	73	2017, 2019, 2022	11	**220**	0.1-220
	Popcorn (13.10%, 19/145)	145	2017-2020, 2023	19	5.4	0.001-5.4
Beverage (12.90%, 4/31)	Coffee (Beverage) (100.00%, 1/1)	1	2017	1	10	10
	Soft drinks (7.41%, 2/27)	27	2017	2	4.6	4.6
	Alcoholic beverage (33.33%, 1/3)	3	2018	1	0.2	0.2
Tea (16.69%, 335/2007)	Tea (Infusion) (12.04%, 26/216)	216	2017-2019, 2022	26	93.19	0.0046-93.19
	Tea, green (68.75%, 11/16)	16	2017-2019	11	10	0.2-10
	Tea, green, black (black, fermented and dried) (5.05%, 23/455)	455	2014-2017, 2019, 2023	23	37.8	0.3-37.8
	TEAS AND HERBAL TEAS (SOLID) (20.83%, 275/1320)	1320	2014-2023	275	**650.9**	0.046-650.9
Vegetables and vegetable products (16.00%, 4/25)	Pumpkins (100.00%, 2/2)	2	2017	2	1.02	1.02
	Spinach (bunch) (8.70%, 2/23)	23	2022	2	7.75	1.13-7.75
Dried Fruits (100.00%, 1/1)	DRIED FRUITS (100.00%, 1/1)	1	2018	1	0.1	0.1
Milks (100.00%, 2/2)	MILKS (100.00%, 2/2)	2	2017	2	0.1	0.1
Honey (7.07%, 13/184)	Honey (7.07%, 13/184)	184	2019, 2023	13	8.8	0.8-8.8
Other foods (19.35%, 77/398)	Dietary supplements (26.88%, 43/160)	160	2018-2023	43	**1287.1**	0.5-1287.1
	Composite food (6.77%, 9/133)	133	2021-2023	9	**220**	0.63-220
	Other foods (foods which cannot be included in any other group) (23.81%, 25/105)	105	2019	25	82.82	0.48-82.82

Table 4: Summary statistics for atropine concentrations (µg/kg) in feeds 2019-2022

FOOD CODE	LOCAL NAME	N	YEAR	POSITIVE	MAX	POSITIVE RANGE
Feed	Calves (pre-ruminant) / Complementary feed (feed)	3	2021	2	15	6.9-15
	Laying hens / Complete feed	8	2011	1	3	3
	Cereal grains and products derived thereof (feed)	5	2015	1	**240**	240
	Rye	25	2010	1	4	4
	Sorghum	1	2021	1	**250**	250
	Maize middlings (feed)	1	2018	1	**107**	107
	Maize grain (feed)	5	2020	2	8.1	5.3-8.1
	Millet	4	2011	3	**877.954**	32.706-877.954
	Calves (pre-ruminant) / Complete feed	3	2011	1	15	15
	Other seeds and fruits, and products derived thereof	2	2011	1	90.64	90.64
	Horses / Complete feed	1	2010	1	4	4
	Dairy cows / Complementary feed (feed)	2	2022	1	5.1	5.1
	Rabbits / Complete feed (feed)	6	2021	1	46	46
	Rabbits / Complementary feed (feed)	1	2020	1	**740**	740
	Pet food, dogs / Complementary feed (feed)	2	2022	1	16	16
	Pet food, dogs / Complete feed (feed)	1	2020	1	1	1
	Sunflower seeds (feed)	1	2022	1	43	43
	Sunflower seed expeller	15	2011, 2018-2020, 2022	12	**700**	2.1-700
	Sows / Complete feed (feed)	1	2022	1	19	19
	Sheep / Complementary feed (feed)	1	2021	1	**180**	180
	Soya (bean) expeller (feed)	3	2022	1	1.4	1.4
	Oil seeds, oil fruits, and products derived thereof (feed)	1	2020	1	14	14
	Unspecified Complete feed (feed)	1	2022	1	16	16
	Growing/Fattening pigs / Complementary feed (feed)	1	2022	1	2.5	2.5
	Lambs (weaning diets) / Complete feed (feed)	1	2022	1	42	42
	Complementary feed (incomplete diet) (feed)	13	2019-2021	12	**510**	1.8-510
	Complete feed (feed)	14	2019-2020	10	32	1.6-32
	Compound feed (feed)	15	2020, 2022	9	**100**	1.6-100
	Distillers' grains and solubles (feed)	2	2021-2022	2	**620**	24-620
	Fattening cattle / Complete feed	5	2011	2	7	4-7
	Fattening chickens (broilers) / Complete feed (feed)	9	2020-2022	7	93	9.7-93
	Fattening chickens (broilers) / Complementary feed (feed)	4	2021	1	5.2	5.2
	Fattening goats / Complete feed	7	2011	4	44	3-44
	Fattening goats / Complementary feed	1	2011	1	10	10
	Fattening sheep / Complementary feed	3	2011	2	24	3-24
	Fattening sheep / Complete feed	7	2011	3	15	11-15
	Growing/Fattening pigs / Complete feed	26	2010, 2019-2022	17	82	1.2-82
	Piglets (weaning diets) / Complete feed (feed)	3	2020-2022	3	**110**	1.9-110
	Horses / Complementary feed (feed)	4	2020-2021	3	31	2.2-31
	Horses / Complete feed (feed)	7	2019-2022	5	**170**	2.5-170
	Laying hens / Complete feed (feed)	2	2020	2	6.4	6.4-43
	Poultry (starter diets) / Complete feed	2	2011	2	26	8-26
	Rabbits / Complete feed (feed)	6	2020-2022	5	**300**	7.2-300
	Other plants, algae and products derived thereof	32	2009	4	**248.16**	10.56-248.16
	Pet food, cats / Complete feed (feed)	2	2021	2	69	3.8-69
	Rape seed-expeller (feed)	9	2019, 2021	2	19	1.3-19
	Turkeys / Complete feed (feed)	2	2020, 2022	2	42	1.5-42

Table 5: Summary statistics for the Sum of scopolamine and atropine concentrations (µg/kg) in the different food samples 2006-2023

FOOD CODE (detection rate%)	N	YEAR	POSITIVE	MAXIMUM	POSITIVE RANGE
Cereal grains (13.33%, 2/15)	15	2023	2	59	1.7-59
Cereals and cereal-based products (33.33%, 1/3)	3	2023	1	1	1
Buckwheat (5.48%, 4/73)	73	2022-2023	4	**6800**	1700-6800
Maize (10.10%, 10/99)	99	2021-2023	10	56	0.4-56
Millet (5.41%, 2/37)	37	2023	2	5.2	1.7-5.2
Sorghum (11.76%, 2/17)	17	2023	2	21	14-21
Herb, spice or condiment (11.11%, 1/9)	9	2023	1	**260**	260
Herbs (8.33%, 1/12)	12	2021	1	**1708**	1708
Dill (33.33%, 3/9)	9	2022-2023	3	**220**	18-220
Parsley (12.00%, 3/25)	25	2022-2023	3	**310**	18-310
Fennel, seed (33.33%, 3/9)	3	2023	1	5.5	5.5
Basil (5.56%, 18/29)	18	2023	1	29	29
Thyme (1.92%, 1/52)	52	2023	1	6.4	6.4
Tarragon (20.00%, 1/5)	5	2023	1	38	38
Savory, summer, winter (100.00%, 1/1)	1	2023	1	**1250**	1250
Honey (2.94%, 1/34)	34	2023	1	0.8	0.8
Popcorn (100.00%, 1/1)	1	2023	1	1.3	1.3
Teas and herbal teas (solid) (12.50%, 11/88)	88	2023	11	17.7	0.6-17.7
Tea, green, black (black, fermented and dried) (2.41%, 2/83)	83	2023	2	11	1.8-11
Ready-to-eat meal for infants and young children (14.29%, 1/7)	7	2023	1	0.2	0.2

Table 6: Summary statistics for scopolamine concentrations (µg/kg) in the positive food samples and feed samples 2006-2023

FOOD CATEGORIES including Feed (detection rate%)	N	mean	P50	P75	P95	P99	MAX (the sample's local name)
Herbs, spices, and condiments (12.18%, 85/698)	85	72.53	9.90	42.80	409.15	952.90	1067.9 (Savory, dry)
Cereals and cereal-based products (7.34%, 510/6948)	510	41.75	1.66	7.65	220.00	550.00	2300 (Buckwheat)
Feed (17.43%, 145/832)	145	27.98	9.80	20.00	105.18	270.16	705.023 (Millet)
Food for infants and young children (4.42%, 118/2669)	118	8.00	0.40	1.62	16.29	220.00	220 (Biscuits, rusks, and cookies for children)
Tea (11.90%, 238/2000)	238	11.98	4.00	10.00	43.64	133.66	220 (Herbal infusion materials from leaves and herbs)

Table 7: Summary statistics for atropine concentrations (µg/kg) in the positive food samples and feed samples, 2006-2023

FOOD CATEGORIES including Feed (detection rate%)	N	mean	P50	P75	P95	P99	MAX (the sample's local name)
Cereals and cereal-based products (10.02%, 698/6964)	698	76.74	1.60	8.06	220.00	1700.00	5900 (Buckwheat flour)
Herbs, spices and condiments (10.32%, 88/853)	88	80.99	11.04	57.40	407.45	806.14	1001.2 (Savory, dry)
Feed (16.61%, 140/843)	140	70.03	16.00	51.67	310.65	724.40	877.954 (Millet)
Other foods (19.35%, 77/398)	77	32.96	5.98	14.40	84.78	476.10	1287.1 (Herbal formulations and plant extracts)
Tea (16.69%, 335/2007)	335	26.60	8.60	20.40	95.23	287.69	650.9 (Raspberry (red and yellow) infusion leaves)
Food for infants and young children (7.77%, 208/2677)	208	6.55	0.57	1.81	22.69	207.3111	220 (Biscuits, rusks, and cookies for children)

APPENDIX II

PROPOSAL FOR NEW WORK ON THE DEVELOPMENT OF A CODE OF PRACTICE FOR THE PREVENTION AND REDUCTION OF TROPANE ALKALOIDS CONTAMINATION IN FOOD AND FEED

(For consideration by CCCF)

1) Purpose and scope of the project

The purpose of the proposed new work is to develop a code of practice (CoP) *to prevent and reduce tropane alkaloids contamination in food and feed*. The scope of the work is to complete a CoP to prevent and reduce tropane alkaloids (TAs) contamination in food and feed, particularly derived from *Datura*, for various stakeholders including farmers, food and feed manufacturers, competent authorities, and consumers.

2) Relevance and timeliness

Food aid contaminated with TAs was determined to cause food poisoning outbreaks in the Republic of Uganda and the Republic of South Sudan in 2019. These events affected more than 300 people and even resulted in deaths. The *Joint FAO/WHO expert meeting on tropane alkaloids*[1] (FAO/WHO, 2020) provided expert scientific advice on TAs in processed and unprocessed food products. To develop appropriate risk management measures in the United Nations World Food Programme (WFP) supply chains, it was recognized that limits expressed as physical toxic *Datura stramonium* seed contamination of cereals and grains will be beneficial for screening purposes at the field level. An *FAO/WHO guidance document on physical Datura stramonium seed contamination*[2] was developed and published in 2020 to address this. The 17th Session of the Codex Committee on Contaminants in Foods (CCCF17, 2024) agreed to follow up on the findings of these documents and consider the development of a code of practice and project document for consideration by CCCF18.

3) Main aspects to be covered

This work will address measures for preventing TA contamination in food, including mitigation strategies related to preventing /handling the growth of plants that produce TAs, with special attention to *Datura* weeds. It will also address post-harvest measures such as sorting and extra precautions for processed cereal-based food for infants and young children.

4) Assessment against the criteria for the establishment of work priorities

(a) Consumer protection from the point of view of health and fraudulent practices. To protect consumer health, exposure to TAs should be prevented or reduced. A CoP providing recommendations to governments, farmers, and food business operators will help prevent contaminated food from entering the market.

(b) Diversification of national legislations and apparent resultant or potential impediments to international trade. Currently, best practices and legislations. Development of a CoP is needed to ensure that information on recommended practices for preventing and reducing TA exposure is available to all member countries. It will also provide the means to enable exporters to ensure reduced risk of TAs and to assist in compliance with any MLs that may be established in the future.

(c) Scope of work and establishment of priorities between the various sections of the work. The CoP will address all relevant measures for preventing or reducing TAs at the different steps in the food chain.

(d) Work already undertaken by other international organizations in this field. Several bodies and organizations, such as Joint FAO/WHO Expert Committee on Food Additives (JECFA), Food and Agriculture Organization (FAO), World Health Organization (WHO), and World Food Programme (WFP), have undertaken work on TAs and can be consulted in developing a CoP. These organizations have made recommendations but have not offered a CoP.

5) Relevance to Codex Strategic Goals

(a) Goal 1: Address current, emerging, and critical issues in a timely manner. Establishing a CoP to prevent or reduce TAs in food will address the current need for guidance to ensure consumers' health.

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1 https://cdn.who.int/media/docs/default-source/food-safety/jecfa/summary-and-conclusions/tropane-alkaloids-expert-meeting_30-march-3-april-2020_executive-summary.pdf?sfvrsn=f6c51fc1_5
https://openknowledge.fao.org/server/api/core/bitstreams/6f846395-4481-46ca-850d-8953ae8ccb38/content

2 https://openknowledge.fao.org/server/api/core/bitstreams/cdcafea7-63dd-4c7c-a767-34b168a3904c/content

(b) **Goal 2: Develop standards based on science and Codex risk-analysis principles.** This work will apply risk analysis principles in developing a CoP, using scientific data and recommendations from FAO/WHO and other recognized expert bodies to support a reduction in consumers' exposure to TAs.

(c) **Goal 3: Increase impact through the recognition and use of Codex standards.** The proposed CoP ensures that information on recommended practices to avoid and prevent TAs consists of current best practices and is available to all member countries, especially those with fewer resources to devote to this topic.

(d) **Goal 4: Facilitate the participation of all Codex Members throughout the standard-setting process.** Developing a CoP through the Codex Step process will inform all Codex members and observers_about recommended practices to prevent and reduce TAs.

(e) **Goal 5: Enhance work management systems and practices that support the efficient and effective achievement of all strategic plan goals.** A CoP will help develop and implement effective and efficient work management systems and practices by providing basic guidance for countries and producers to keep highly TA-contaminated food out of the marketplace.

6) Information on the relationship between the proposal and other existing Codex documents

Standard for certain pulses (CXS 171-1989), *Standard for sorghum grains* (CXS 172-1989), *Standard for maize* (corn) (CXS 153-1985), *Standard for wheat and durum wheat* (CXS 199-1995) and *Standard for oats* (CXS 201-1995) include a provision that the products "shall be free from the following toxic or noxious seeds in amounts which may represent a hazard to human health", including *Datura* species. The weed control measures in the *Code of practice for weed control to prevent and reduce pyrrolizidine alkaloid contamination in food and* feed (CXC 74-2014) are also relevant.

7) Identification of any requirement for any availability of expert scientific advice

The Joint FAO/WHO Expert Meeting (FAO/WHO, 2020) and other risk assessment bodies, such as the European Food Safety Authority (EFSA) (EFSA CONTAM Panel, 2008, 2013, 2016, 2018, and 2022), have already provided expert scientific advice.

8) Identification of any need for technical input to the standard from external bodies

There is no identified need for additional technical input from external bodies.

9) The proposed timeline for completion of the new work, including the starting date, proposed date for adoption at Step 5, and the proposed date for adoption by the Commission.

Work will commence in 2025 following CCCF18's recommendation and CAC48's approval. Completion is expected by 2028.

APPENDIX III

**PROPOSED CODE OF PRACTICE FOR
THE PREVENTION AND REDUCTION OF TROPANE ALKALOIDS CONTAMINATION IN FOOD AND FEED**

(For information)

INTRODUCTION

1. Tropane alkaloids (TAs) are natural plant toxins occurring in several plant families, such as Brassicaceae (*B. oleracea*), Solanaceae (*Atropa belladonna L., Datura stramonium L., and Hyoscyamus niger L.*) and Erythroxylaceae (including coca). TAs are found in all parts of these plants and are responsible for their toxic effects. TA content varies by plant tissue and species but typically ranges from 0.01% to 3%.

2. The group of TAs comprises more than 200 compounds, and the wide range of compounds occurring especially in the Solanaceae family arises from the esterification of tropine with a variety of acids. The most studied tropane alkaloids are atropine (the racemic mixture of (-)-hyoscyamine and (+)-hyoscyamine) and scopolamine. TAs exert their pharmacological and toxicological effects mainly by acting as competitive antagonists of the muscarinic acetylcholine receptors, in both the central and peripheral nervous systems.

3. While crops grown for human consumption do not naturally contain a significant level of TAs, bulk commercial grains and seeds, such as wheat, rye, soybeans, linseed, and maize, may be contaminated by TAs due to field contamination by TA-containing plants. There have been numerous reports of human poisonings, including fatalities, due to accidental and/or deliberate ingestion of *Datura* plant parts. Establishing control strategies to reduce consumer exposure is critical.

4. Although several plant families contain TAs, *Datura* species are the most virulent invasive species. Of the 15–25 *Datura* species estimated to exist, *D. stramonium L.* is considered one of the world's most widespread weeds. *D. stramonium* is extensively distributed in temperate and tropical areas and is likely to be found in almost any summer crop (reported as a weed in more than 40 crops in almost 100 countries)[1].

5. *Datura* species commonly grow in various locations, including crop fields, and produce TAs such as hyoscyamine and scopolamine. These compounds may accidentally contaminate cereals, oilseeds, vegetables, and cereal-based foods at occasionally high levels. Additionally, *Datura* species compete with food crops for resources, leading to economic losses.

6. *Datura* species may enter the food network at a number of points, including during cereal/oilseed/vegetable cultivation (e.g., from compost containing weed seeds), harvesting (accidentally co-harvested with cereal grains due to mechanical harvesting methods, as well as harvested due to their structural similarity to cereal grains) and processing. Post-harvest, these weeds (seeds) may not be fully removed and may get ground into flour during food production processes.

7. Grazing animals generally avoid consuming *Datura* species due to the plants' high TA content, which renders them both toxic and unpalatable. However, under specific conditions (e.g., forage scarcity or accidental contamination), ingestion may occur, posing severe health risks to livestock. Fortunately, TAs exhibit a short biological half-life, and observable pharmacological symptoms typically manifest before the onset of life-threatening toxicosis. Consequently, exposed animals are unlikely to enter the food chain, as clinical signs would prompt farmers to withhold them from slaughter. Additionally, studies demonstrate negligible TA transfer rates from contaminated feed to milk, eggs, or edible tissues. Thus, residual TA levels in animal-derived products pose minimal risk to consumers.

8. However, feed and livestock producers should implement the *Code of Practice on Good Animal Feeding* (CXC 54-2004) and maintain vigilance in identifying and eradicating toxic plants (e.g., *Datura* spp.) to safeguard animal welfare and prevent economic losses.

9. Adequate application of good practices (e.g., good agricultural practices (GAPs), good manufacturing practices (GMP)) and food safety and quality management systems (e.g., hazard analysis and critical control point (HACCP) and ISO 22000), from the start of cereal cultivation through to the final stages of manufacturing of food and feed products can reduce contamination. Farm management based on GAP has become the primary strategy for controlling TA contamination.

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[1] Commonwealth Agricultural Bureaux International (CABI). 2019. Invasive Species Compendium. *Datura stramonium* (jimsonweed). (also available at https://www.cabi.org/ isc/datasheet/18006).

SCOPE

10. This document provides guidance on recommended practices to prevent and reduce TA contamination in foods and feeds, particularly derived from *Datura*, for various stakeholders, including farmers, food and feed manufacturers, competent authorities, and consumers.

RECOMMENDED PRACTICES BASED ON GOOD AGRICULTURAL PRACTICES (GAP)

Farmland planning and preparation

11. The main pathways and key factors for the contamination of the human food supply by TAs are the infestations of cereal grains such as wheat and millet, buckwheat, sorghum, corn, and other crops by weeds such as *Datura stramonium*.

12. During the cultivation planning phase, rational spatial arrangement of crop planting areas is essential to avoid creating environments conducive to weed proliferation, particularly for species like *Datura stramonium*. Additionally, implementing sound crop rotation practices, such as alternating susceptible crops (e.g., cereals, legumes) with non-susceptible crops (e.g., root vegetables), can disrupt the life cycle of TA-containing weeds (e.g., *D. stramonium*) while improving soil fertility and structure. Enhanced soil health promotes vigorous crop growth, indirectly suppressing weed competition, thereby increasing overall yield efficiency.

13. In addition to crop rotation, implementing cover crops (e.g., rye, clover, or mustard species) can suppress weed emergence by competing for light, nutrients, and soil space while improving soil structure and fertility. Cover crops can further inhibit *Datura* germination by producing allelopathic compounds that negatively affect weed seed viability.

14. Another key approach is adopting conservation tillage or no-tillage systems, which help maintain soil integrity and reduce the redistribution of weed seeds within the seedbank. Unlike traditional plowing and harrowing, which may inadvertently promote the spread of Datura seeds, minimal soil disturbance techniques help prevent the seeds from being brought to the surface, where they are more likely to germinate. When soil preparation is necessary, shallow tillage or stale seedbed techniques—where weeds are encouraged to germinate and then eliminated before crop planting—can be used to reduce the initial weed burden.

15. Proper field sanitation should also be considered, including cleaning farm equipment and establishing buffer zones around fields to prevent weed encroachment. Using certified weed-free seeds and ensuring that irrigation water sources are not contaminated with *Datura* seeds are additional preventative measures that contribute to long-term weed management. Integrating these strategies into farmland planning will create a more resilient agricultural system that minimizes the risk of TA contamination in food crops.

16. Pasture management must also be done in accordance with GAPs, such as appropriate sowing time and depth, adequate fertility and moisture at sowing, which is important to ensure good weed control.

Seed management

17. Seeds should be carefully selected before sowing to ensure they are free from weed seeds, particularly from invasive species such as *Datura stramonium*. This can be achieved through mechanical and physical separation methods such as sieving, wind-sorting, and water-selecting measures to remove weed seeds, which help remove contaminant seeds based on size, weight, and density. Additionally, during import and export, seed inspection programs by national or local authorities or other accredited inspection agencies should be conducted to verify the purity of seeds to ensure that no weed seeds are included during planting.

18. Besides physical separation and regulatory inspections, certified seeds from accredited suppliers should be prioritized to ensure high genetic purity and minimal weed contamination. Implementing seed treatment methods, such as thermal or chemical disinfection, can further reduce the presence of dormant weed seeds and enhance overall seed health. Farmers should also adopt proper storage practices to prevent cross-contamination with weed seeds during handling and transportation.

Weed control and management

19. A comprehensive weed monitoring plan for weeds such as *D. stramonium* should be developed based on the climate, environmental conditions, soil characteristics, and the specific requirements of cultivated crops. This plan should define monitoring schedules, frequency, and key areas. Regular field inspections should be conducted to monitor the growth of weeds and promptly detect their presence, including the types, quantity, and distribution of weeds. National or local authorities should train and encourage farmers to routinely inspect their fields for TA-containing plants, ensuring early detection and management.

20. Farmers should be encouraged to visually inspect materials before composting them to prevent the inclusion of weed seeds that could later germinate and spread in agricultural fields. Composting practices should prioritize using weed-free plant residues to minimize the risk of reintroducing *Datura* and other harmful species into the soil.

21. Preventing weeds from reaching the flowering and seed production stages is crucial to avoiding further contamination of farmland. Accurate species identification, based on morphological traits and growth patterns, should guide classification and appropriate removal strategies. Datura stramonium, for example, must be controlled early in the season before seedpods develop, as late-stage intervention is significantly less effective in preventing seed dispersal.

22. Chemical control is the most effective method for managing *Datura* infestations during cultivation, but mechanical weeding is also a viable method. The best timing for mechanical weed removal is at the early stages of crop development, as dense crop canopies later suppress weed growth naturally. In cereal crops such as wheat and millet, pre-planting weeding and periodic removal during the first six weeks of growth are recommended. If feasible, a final weeding two weeks before harvest can further minimize contamination by toxic plants. In legume crops, where dense infestations may occur, mechanical or manual weeding might be the only effective option. Special attention should also be given to field borders, as these areas often serve as persistent weed reservoirs.

23. Integrated Weed Management (IWM) is a holistic approach that combines multiple control strategies to minimize weed infestations while reducing reliance on chemical herbicides. Effective IWM programs incorporate cultural methods, such as crop rotation and cover cropping, to suppress weed growth and mechanical strategies like targeted tillage and manual removal to eliminate invasive species physically. Chemical control remains an essential tool, but should be used in rotation with different herbicide modes of action to prevent resistance development. Biological control methods, such as introducing natural weed predators or allelopathic plant species, can further enhance long-term weed suppression. Implementing IWM as part of an overall weed control strategy ensures sustainable and effective management of *Datura stramonium* and other TA-producing plants while promoting soil health and biodiversity.

Removal and Reduction of TA-Containing Plants

<u>Physical methods</u>

24. Hand Weeding: Manual removal of weeds using tools such as hoes, hand weeders, or trowels is an effective method for small-scale infestations or areas where precision is required. This technique ensures complete weed removal by extracting the entire root system, preventing regrowth. Tools such as knives or pruning shears may be used to cut shallow-rooted or fast-growing weeds at the base, ideally before flowering. To prevent reinfestation, all removed plant material should be promptly collected and disposed of outside the field, avoiding composting unless properly treated to eliminate viable seeds.

25. Mechanical Cultivation Weeding: Mechanical cultivation equipment disrupts weed growth by cutting off their roots and burying seedlings. However, mechanical tillage sometimes triggers secondary weed emergence, particularly in species with staggered germination patterns like *Datura stramonium*. Mechanical weeding also aerates and loosens the soil, which is beneficial for crop growth, but it must be done carefully to prevent excessive soil disturbance, erosion, and crop damage. Controlling the depth and frequency of tillage is crucial to maintaining soil integrity and minimizing weed proliferation.

26. Rotary Tillage Weeding: A rotary tiller cuts and mixes weeds into the soil, causing root damage and eventual death. This method is effective for large-scale weed control but requires caution, as excessive tillage can spread weed seeds deeper into the soil profile, prolonging their viability. Additionally, repeated tillage can disrupt soil structure and microbial communities, potentially reducing soil fertility over time.

27. Mulching: Applying organic (e.g., straw, rice husks) or synthetic (e.g., plastic film) mulch to the soil surface helps suppress weed growth by blocking sunlight and restricting oxygen flow to emerging seedlings. Mulching also aids moisture retention, temperature regulation, and soil enrichment as organic materials decompose. However, mulch should be sourced appropriately, fully decomposed, and free of contaminants to prevent inadvertently introducing weed seeds. In no-tillage systems, mulch can play a crucial role in reducing Datura stramonium emergence by limiting seed-to-soil contact.

28. Irrigation Water Filtration: To prevent weed seed dispersal through irrigation, interception devices such as fine-mesh nylon filters (<2 mm pore size) should be installed at water inlets. These filters help prevent Datura stramonium seeds from entering fields via contaminated irrigation sources. Regular maintenance of filtration systems is essential to ensure effectiveness and avoid clogging.

29. Floating Seed Removal: After field irrigation, weed seeds often accumulate in water channels, field corners, or on the surface of irrigation ponds. Collecting and removing these seeds promptly reduces the soil seed bank and prevents their reintroduction into agricultural areas. Using skimming devices or sedimentation basins can enhance the efficiency of this method.

30. Soil solarization: It is a non-chemical method that uses solar heat to kill weed seeds, including Datura stramonium. This technique involves covering moist soil with a transparent plastic sheet for four to six weeks during the hottest part of the year. The trapped solar energy raises soil temperatures to levels that destroy weed seeds, pathogens, and some soil pests. Solarization is most effective in regions with high temperatures and intense sunlight and is particularly useful in reducing seed viability in the upper soil layers.

31. Flame weeding: Flame weeding, also known as thermal weeding, is a technique that uses directed heat from propane torches to kill young weeds by disrupting their cellular structure. This method effectively manages weeds in organic farming systems or areas where mechanical or chemical control is not desirable. Datura stramonium is particularly susceptible to flame weeding in its early growth stages. However, flame weeding should be used cautiously in dry conditions to avoid fire hazards, and multiple applications may be required for full effectiveness.

Chemical methods

32. Herbicide Selection and Application: Chemical weed control should begin with the careful selection of appropriate herbicide, taking into account the target weed species, growth stage, and the crop's tolerance to herbicides. Farmers must use only herbicides registered and approved by national or local regulatory authorities, strictly adhering to label instructions to ensure food safety, environmental protection, and crop health. Priority should be given to herbicides that are selective, effective against *Datura stramonium* and other invasive species, and have a short residual period to minimize environmental impact. Highly toxic, persistent, or hazardous herbicides should be avoided whenever possible, particularly those with carcinogenic, teratogenic, or mutagenic properties.

33. Optimal Timing of Herbicide Application: Herbicides should be applied at the most effective stage of weed development to maximize control and minimize the need for repeated applications. Pre-emergent herbicides play a crucial role in preventing the germination of *Datura stramonium* and other invasive weeds by forming a chemical barrier in the soil. These herbicides should be applied before weed seeds germinate, typically before or at the time of crop planting, ensuring early suppression and reducing competition with the main crop. On the other hand, post-emergent herbicides should be applied during the early seedling stage of weeds, as young plants are more susceptible to chemical treatments, requiring lower doses for effective control. Applications during the most vulnerable weed growth stages improve efficiency and reduce the need for repeated treatments. However, care must be taken to avoid herbicide application during crop growth stages that are particularly sensitive to chemical exposure, as this can cause phytotoxicity and yield losses.

34. Farmers should also consider soil texture, moisture levels, and weather conditions when determining herbicide application rates and timing. Many pre-emergent herbicides require adequate soil moisture to activate their chemical properties, while post-emergent applications are most effective when weeds are actively growing under optimal environmental conditions. Proper calibration of herbicide sprayers and adherence to recommended dosages help maximize efficacy and minimize off-target effects.

35. To prevent the development of herbicide-resistant weed populations, farmers should implement a herbicide rotation strategy, alternating active ingredients with different modes of action. This practice helps delay resistance buildup and ensures long-term weed control effectiveness. Additionally, integrating herbicides with non-chemical weed management strategies, such as mechanical weeding and cover cropping, can further reduce reliance on chemical treatments. Proper post-application safety intervals must be observed to ensure that herbicide residues in agricultural products comply with food safety regulations before harvest.

Harvesting and transportation

36. Pre-Harvest Monitoring: Before harvesting, it is essential to monitor adjacent fields and surrounding areas for the presence of *Datura spp.* and other TA-containing plants that could pose a contamination risk. Special attention should be given to fields with a history of *Datura* infestations, as seeds can remain viable in the soil for several years. Early identification and removal of these plants before harvest can significantly reduce contamination risks.

37. Harvesting Considerations: *Datura spp.* tend to germinate and develop later in the season, meaning they may still be in a green, sap-filled stage when cereal crops reach maturity. During harvest, mechanical harvesting equipment can crush *Datura* plants, leading to sap leakage, which may contaminate edible grains. Proper pre-harvest field inspections should be conducted to mitigate this risk, and efforts should be made to remove any Datura plants before harvest begins.

38. Preventing Co-Harvesting of TA-Containing Plants: Strict measures should be implemented to prevent *Datura* and other TA-containing plants from being co-harvested with food crops. This includes thorough pre-harvest inspections, targeted weed removal, and the use of clean, well-calibrated harvesting equipment to minimize plant fragments in the final yield. All harvested material should be screened to ensure that toxic plant seeds, roots, stems, and leaves are not mixed with food crops at any stage of the process.

39. Equipment Cleaning and Sanitation: To prevent contamination and the spread of *Datura* seeds, all agricultural machinery, including combines, conveyors, and transport vehicles, should be thoroughly cleaned before and after harvesting operations. Equipment sanitation protocols should be strictly followed, especially when moving between fields to avoid transferring weed seeds to uncontaminated areas.

40. Farmers should ensure harvested crops meet local, regional, or national standards for noxious weed contamination in cereal grains. As part of a Good Agricultural Practices screening program for cereal grains and legumes, size exclusion and visual inspection of screenings could be implemented at an early-stage post-harvest to ensure the final product meets the generic Codex standard[2] of being free from noxious weed seeds in amounts that would represent a hazard to human health, or national/local government quality/safety requirements for the products.

Staff Training

41. Weed Identification and Control Training: National and local authorities and agricultural extension services should provide specialized training programs for personnel involved in field management to enhance their weed identification and control skills. Training should include identifying TA-containing plants, such as those shown in Annex I, enabling field managers to recognize and effectively manage toxic weeds. Particular attention should be given to sectors utilizing mechanical harvesting and sorting technologies, as these systems may not always detect toxic plant fragments, depending on the crop and processing method. Additionally, incorporating digital training tools, such as mobile applications and online platforms featuring AI-based weed identification, can facilitate real-time recognition and support decision-making in the field.

42. Proper Removal and Disposal of TA-Containing Plants: Farmers should receive comprehensive training on the safe and effective removal of TA-containing plants, emphasizing methods such as digging, cutting, or hand hoeing. Once removed, these plants must be collected in designated, properly marked bags for safe disposal. National and local authorities should provide clear guidelines on disposal procedures, ensuring that toxic weeds are not left at field edges or repurposed for composting, as this may contribute to further contamination. Regular field inspections should be conducted to identify and promptly eliminate toxic weeds in compliance with national/local regulations, where available.

RECOMMENDED PRACTICES BASED ON GOOD MANUFACTURING PRACTICES (GMP)

43. Raw materials for processing: Food/feed processors should implement control measures to monitor incoming ingredients and verify that suppliers provide materials free from *Datura spp.* weeds and their seeds. This is particularly critical for ingredients potentially contaminated with TAs, including cereal grains such as buckwheat, millet, maize, and rye; legumes and oilseeds such as soybeans, linseed, sunflower seeds, and hempseed; herbs and spices like fennel seeds, cumin seeds, and anise seeds; and herbal teas.

44. Food/feed processing and Equipment Sanitation: During processing, raw materials must be carefully screened and inspected to prevent the entry of *Datura spp.* weeds or their seeds into the production line. High standards of cleanliness for processing equipment and pipelines are essential to avoid cross-contamination and to halt the spread of *Datura* seeds during production, thereby ensuring the overall safety of the food production process.

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2 *Standard for certain pulses* (CXS 171-1989); *Standard for sorghum grains* (CXS 172-1989); *Standard for maize* (Corn) (CXS 153-1985); *Standard for wheat and durum wheat* (CXS 199-1995); *Standard for oats* (CXS 201-1995).

45. Employee Training: The food/feed industry where contamination of *Datura* plants may occur must ensure that all personnel involved in production receive comprehensive training on food/feed safety, including the correct identification of *Datura spp.* in both dried and fresh states—covering roots, stems, leaves, flowers, and seeds. In particular, adherence to GMP/HACCP procedures is crucial during raw material handling and equipment operation to thoroughly remove contaminants and prevent the introduction of TAs into the production chain.

46. Product Traceability: Establishing an effective product traceability system is essential. This system should enable the rapid identification and recall of affected products in the event of TA contamination, ensuring that any potential risks are addressed swiftly and efficiently.

47. Food/feed processors could also consider occasional testing of finished products for TAs to verify that their control measures are functioning effectively. Although Codex has not established MLs for TAs, manufacturers could consider intervention levels for TAs in food (e.g., 30 µg/kg for super cereal, 10 µg/kg for super cereal plus and lipid-based nutrient supplements) as recommended by the *Joint FAO/WHO expert meeting on tropane alkaloids*[3] (FAO/WHO, 2020).

CONSUMER PRACTICES

48. National or local competent authorities should educate consumers about the potential risks of consuming TA-contaminated grains, vegetables, and common TA-containing plants. Educational materials should highlight specific plant parts that are often mistaken for edible portions, as detailed in Annex II.

49. Consumers should choose reputable sources when purchasing and consuming grains, vegetables, and other foods. They should carefully review food labels and instructions and avoid products of unknown or suspicious origin, especially wild-harvested foods, to prevent accidental consumption of toxic plant parts such as those from mandrake, *Datura*, or belladonna.

50. Given that plant extracts containing TAs have long been used in human medicine, it is strongly recommended that consumers adhere to medical guidance. Proper storage practices must be maintained by keeping food and medical products strictly separated to prevent accidental cross-contamination.

51. Consumers should be informed of the symptoms associated with TA ingestion, which may include dry mouth, headache, hallucinations, palpitations, vomiting, diarrhea, and blurred vision. In severe cases, symptoms can escalate to coma, respiratory failure, or other life-threatening conditions. It is critical that if these symptoms occur, consumers should immediately discontinue consumption of the suspected food, contact emergency services, or seek hospital care. Preserving any remaining material for testing can also aid in diagnosis and treatment.

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3 https://cdn.who.int/media/docs/default-source/food-safety/jecfa/summary-and-conclusions/tropane-alkaloids-expert-meeting_30-march-3-april-2020_executive-summary.pdf?sfvrsn=f6c51fc1_5
https://openknowledge.fao.org/server/api/core/bitstreams/6f846395-4481-46ca-850d-8953ae8ccb38/content

Annex I

Pic 1 *Datura stramonium* leaf

Pic 2 *Datura stramonium* flower

Pic 3 *Datura stramonium* seeds

Annex II

Table 1: Pictures of some *Datura* plants and some similar-looking vegetables (still collecting)

Datura innoxia

Spinach

Datura stramonium

Datura stramonium

Datura stramonium

Datura Metel

Fruit and seeds of Datura stramonium

Dried opium poppy seedpod and seeds (Papaver somniferum)

Flower of Datura stramonium (jimsonweed)

Flower of pumpkin

APPENDIX IV

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