CODEX ALIMENTARIUS COMMISSION

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Food and Agriculture Organization of the United Nations

World Health Organization

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Agenda Item 15 **CX/CF 21/14/13**

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JOINT FAO/WHO FOOD STANDARDS PROGRAMME

CODEX COMMITTEE ON CONTAMINANTS IN FOODS

14th Session
(virtual)
3-7 and 13 May 2021

DISCUSSION PAPER ON CADMIUM AND LEAD IN QUINOA

(Prepared by the Codex and JECFA Secretariats)

In order to assist the Committee with the consideration of this item,
Codex members and observers are invited to provide advice on the recommendations
for the establishment of maximum levels for cadmium and lead in quinoa
as instructed in CL 2021/22/OCS-CF available on the Codex webpage[1]

BACKGROUND

1. Noting that the existing maximum levels (MLs) for lead and cadmium in cereals in the *General Standard for Contaminants in Food and Feed* (CXS 193-1995) (GSCFF) explicitly excluded quinoa, the 40th Session of the Codex Alimentarius Commission (CAC40, 2017) requested[2] that the Codex Committee on Contaminants in Foods (CCCF) consider including quinoa in the MLs for lead and cadmium in cereals in CXS 193.

2. CCCF12 (2018) considered[3] this request as follows.

3. The JECFA Secretariat proposed as a way forward that the Codex Secretariat examine the history as to why the MLs for lead and cadmium in cereals in CXS 193 exclude explicitly quinoa, while the JECFA Secretariat prepare a review of existing scientific data on lead and cadmium in quinoa. Both would report back to the next session of CCCF.

4. CCCF12 noted that since quinoa was a pseudo-cereal and the growing conditions were different, it might be appropriate to consider quinoa separately and an ML for lead and cadmium in this commodity could be based on data specific to quinoa.

5. CCCF12 also noted that aside from quinoa, the MLs for lead and cadmium in CXS 193 also do not apply to buckwheat and cañihua. It was further noted that the revised Classification of Food and Feed (CXM 4-1989) included pseudo-cereals in the group of cereal grains and that this revision should be taken into account when considering MLs for quinoa.

6. CCCF12 agreed to discuss this matter at CCCF13 based on the paper from the Codex and JECFA Secretariats

7. CCCF13 (2019) considered[4] this matter as follows.

8. The JECFA Secretariat introduced the item and explained that even though it was not possible to complete the paper in time for the meeting, a literature search and gathering of data in GEMS/Food prior to the meeting indicated that available occurrence data on cadmium and lead in quinoa or other pseudo-cereals were limited.

9. Noting that a project for collection of data of heavy metals in quinoa was underway in the European Union (EU), it was generally agreed that it might be appropriate to consider quinoa separately and an ML for lead and cadmium in this commodity could be based on data specific to quinoa.

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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

2 REP17/CAC, para. 81

3 REP18/CF, paras. 11-14

4 REP19/CF, paras. 97 - 103

10. As a way forward the JECFA Secretariat proposed that CCCF could consider to request occurrence data for inclusion in a future analysis to be presented in a discussion paper.

11. CCCF13 agreed that the JECFA Secretariat, would issue a call for data on occurrence data for cadmium and lead in quinoa through GEMS/Food; and based on the information collected, the JECFA Secretariat, with the assistance of the Codex Secretariat, would finalize the discussion paper for consideration by CCCF14.

12. The JECFA Secretariat posted the call for data with a deadline by November 2019, requesting submission of data on cadmium and lead in quinoa through the GEMS/Food database covering approximately the last 10 years.

HISTORY OF ESTABLISHMENT OF MLs FOR LEAD AND CADMIUM IN CEREAL GRAINS IN CXS 193

13. The first session of the Codex Committee on Cereals, Pulses and Legumes (CCCPL01, 1980) considered several cereals and cereal products for which standards or codes of practice could be developed. CCCPL agreed that quinoa and buckwheat fell outside its terms of reference, however, due to close affinity to cereal grains, could be considered in the future should there be justification for standards or codes of practice.[5]

14. CCCPL06 (1988), based on the survey of prevalence of heavy metals including lead and cadmium conducted previously, started consideration of MLs for lead and cadmium in cereal grains except quinoa and buckwheat.[6] CCCPL07 (1990) proposed MLs for lead and cadmium to the Codex Committee on Food Additives and Contaminants (CCFAC) for endorsement and adoption at Step 5 by the Commission, followed by CCCPL08 (1992) and CCCPL9 (1994) continuing considering the MLs.[7]

15. However CCCPL could not reach consensus on MLs for lead and cadmium in cereal grains before being adjourned *sine die* in 1995, and CCFAC took over the role to establish MLs. CCFAC32 (2000) agreed on the ML of 0.2 mg/kg for lead in cereal grains and CCFAC33 (2001) agreed on the ML of 0.1 mg/kg for cadmium in cereal grains, both of which were followed by adoption at Step 8 by CAC24 (2001).[8] The discussions in CCFAC did not touch on exclusion of quinoa or buckwheat as they had taken over the work from CCCPL who had already agreed to not cover these two commodities.

16. Afterwards, following the re-evaluation of cadmium and lead by JECFA73 (2010), CCCF05 (2011) agreed that no further action was needed on MLs for cadmium for various commodities in CXS 193. CCCF06 (2012) agreed to start new work on the revision of the MLs for lead in various commodities including cereals. However CCCF07 (2013) agreed to retain the ML for lead in cereals.[9].

CONCLUSION – Codex Secretariat

17. Based on the summary information provided from the reports of the discussion on cadmium and lead in CCFAC and CCCF, it was not possible to determine the rationale for the exclusion of quinoa and other pseudocereals such as buckwheat and cañihua and from the MLs for cereal grains. It is noted that at the time CCCF considered the outcomes of the JECFA73 evaluation, in 2011 - 2012, the MLs for cadmium and lead in cereal grains already excluded buckwheat, cañihua and quinoa in CXS 193.

JECFA SECRETARIAT ANALYSIS OF CADMIUM AND LEAD IN QUINOA

OCCURRENCE DATA

Data retrieved from the Global Environment Monitoring System - Food Contamination Monitoring and Assessment Programme (GEMS/Food database)

18. Following the call for data on cadmium and lead in quinoa, the JECFA Secretariat received through the GEMS/Food database, 407 results for quinoa and quinoa-based products. From this dataset, the majority (n=383) were analyzed for the Codex food category cereals and cereals-based products for cadmium (n=185) and for lead (n=198). The remaining samples (n=23) were for foods for infants and small children in ready to eat meal or in mix cereals-based products that includes quinoa. To avoid introducing any confounding bias in the interpretation of the data and also because these last samples had low levels for cadmium and for lead ranged from 0.01 (ND) to 0.04 mg/kg, it was decided to present in this discussion paper the data on cereals and cereals-based products that contain only quinoa as such (grain, seed, flour).

5 ALINORM 81/29 para. 120
6 ALINORM 89/29 para. 36
7 ALINORM 91/29 para. 24; ALINORM 93/29 para. 24; ALINORM 95/29 para. 27
8 ALINORM 01/12 para. 122, Appendix XI; ALINORM 01/12A para. 166, Appendix XV; ALINORM 01/41 Appendix IV
9 REP12/CF paras. 118 and 120, Appendix VIII; REP13/CF para. 28

19. Sampling period was ranged from 2013 to 2019. The individual food samples were collected randomly. Submitted data for cadmium were from Canada (n=138), Peru (n=25), USA (21) and Singapore (n=1) and for lead were from Brazil (n=2), Canada (n=132), Peru (n=25), USA (n=38) and Singapore (n=1). Limit of detection (LOD) and Limit of quantification (LOQ) for cadmium were ranged from 0.002 to 0.04 mg/kg and from 0.002 to 0.14 mg/kg respectively. For lead, LOD and LOQ were ranged from 0.0003 to 0.09 mg/kg and from 0.002 to 0.3 mg/kg respectively. Overall, less than 5% of censored data (all below LOD) were noted from each dataset. According to the JECFA procedure, non-detected (ND) data were assumed to be equal to the LOD.

20. No major significant difference were noted in concentrations levels observed between quinoa grains and quinoa grain-based products. Table 1 and 2 provides the distribution of concentration levels in cereals and cereals-based products for cadmium and for lead respectively. The proportion of rejected samples exceeded the codex food standard[10] set in the cereal grains food commodity of 0.1 mg/kg for cadmium and of 0.2 mg/kg for lead were estimated as well as the impact of rejection rates with different proposed MLs were provided for the purpose of CCCF discussion.

Cadmium

Table 1: **distribution of concentration levels of cadmium in quinoa cereals and quinoa cereals-based products (in mg/kg).**

ML (mg/kg)	No. of individual samples	%<LOD	Mean	P50	P75	P95	P97.5	Max	Proportion of quinoa cereal grains rejected (%)
No ML	185	5	0.05	0.05	0.06	0.10	0.14	0.59	0
ML=0.1	176	5	0.04	0.04	0.06	0.08	0.09	0.10	2.8
ML=0.2	184	5	0.05	0.05	0.06	0.09	0.13	0.19	0.5

21. The concentration levels of cadmium in quinoa cereals and quinoa cereals-based products are ranged from <LOD to 0.59 mg/kg with a mean content of 0.05 mg/kg. Table 1 shows that the distribution of concentration levels of cadmium with no ML is following a normal distribution (Mean = P50) and that only few samples exceeds the ML of 0.1 mg/kg set in codex standard for cereal grains whole commodity. In term of trade, applying an ML of 0.1 mg/kg would have an impact rejection rate of 2.8% for quinoa cereal grains at the global level while applying an ML of 0.2 mg/kg would have a lower rejection rate of 0.5%.

Lead

Table 2: **distribution of concentration levels of lead in quinoa cereals and quinoa cereals-based products (in mg/kg).**

ML (mg/kg)	No. of individual samples	%<LOD	Mean	P50	P75	P95	P97.5	Max	Proportion of quinoa cereal grains rejected (%)
No ML	198	46	0.02	0.01	0.02	0.05	0.08	0.25	0
ML=0.2	196	46	0.01	0.01	0.02	0.05	0.06	0.09	1
ML=0.3	198	46	0.02	0.01	0.02	0.05	0.08	0.25	0

22. The concentration levels of lead in quinoa cereals and quinoa cereals-based products ranged from <LOD to 0.25 mg/kg with a mean content of 0.02 mg/kg. Table 2 shows that the distribution of concentration levels of lead with no ML is following a lognormal distribution (Mean > P50) and becomes close to normal (mean=P50) when applying cut-off ML of 0.2 mg/kg. Few samples exceed the ML of 0.2 mg/kg set in codex standard for cereal grains whole commodity. In term of trade, applying an ML of 0.2 mg/kg would have an impact rejection rate of 1% of quinoa cereal grains at the global level while applying an ML of 0.3 mg/kg would have no impact at all on a rejection rate like applying no ML.

[10] General Standard for Contaminants in Food and Feed (CXS 193-1995, Revised 2019)
The current ML for cadmium and lead in cereal grains whole commodity does not apply to buckwheat cañihua and quinoa and were only use in this context as a default ML proxy.

Data retrieved from literature search

23. Two recent publications related to the determination of heavy metals concentrations in quinoa seeds (*Chenopodium quinoa wild*) were available.

24. Bratovcic A. and Saric E. have reported analysis of a quinoa sample purchased at the store in Bosnia and Herzegovina with cadmium level of 0.026 mg/kg[11].

25. Another article published in 2013 from Vollmannova et al have reported analysis in cadmium and lead of 5 cultivars of quinoa seeds that are registered in the EU (Temuco, Quinua, Yulai, Carmen, Ccankolla). Concentration levels observed for these 5 cultivars of quinoa seeds ranged from 0.09 to 0.19 mg/kg for cadmium and from 0.33 to 0.56 mg/kg for lead. Mean concentration was 0.14 mg/kg for cadmium and 0.46 mg/kg for lead[12]. This publication shows that depending of the cultivars and the quality of the soil, some quinoa cultivars seeds could accumulate higher amounts of heavy metals than others (e.g up to almost twice between cultivars Yulai and Temusco). This last observation seems consistent with two others publications dealing with growth and phytoextraction potential of quinoa seeds with concentrations levels of heavy metals in soil concluded that quinoa is known for metal ion tolerance and is suitable for phytoextraction of heavy metals present in the soil[13,14].

CONSUMPTION DATA

Consumption data of quinoa from the GEMS/Food cluster diet

26. Currently there is no food item related to quinoa consumption as such identified in the GEMS/Food classification in cluster diets or in the FAO/Stat Food Supply.

Consumption data of quinoa from the FAO/WHO Chronic Individual Food Consumption database (CIFOCOSs)

27. Limited number of countries[15] with few consumers (overall n=254) have reported consumption of quinoa grain in the CIFOCOSs database. The overall mean consumption was estimated by weighting each of the mean values by the number of subjects/consumers. Total mean consumption (consumers and non-consumers) from all countries can be estimated at 1.15 g/d. This is reflecting the fact that quinoa consumption is not widely distributed within the population. For consumers only and assuming a 60 kg person body weight, the mean consumption is estimate at 0.41 g/kg bw/d in adult population corresponding to 25 g/day. Considering the low number of consumers (<25 at the P90), it is not possible to calculate a statistically robust high percentile. According the JECFA procedure, high percentile (P95) can be estimated by multiplying the mean by a factor of two. In doing so, a high 95th percentile consumer is estimate at 0.82 g/kg bw/d in adult population corresponding to 50 g/day. In children, assuming a similar level of consumption as for adult (25 and 50 g/day for mean and 95th percentile respectively) with a 20 kg/bw, the mean consumption would be 1.23 g/kg bw/d and the percentile 95 would be 2.46 g/kg bw/d.

DIETARY EXPOSURE ESTIMATES

Cadmium

28. Table 3 presents the estimates of dietary exposure and the risk characterization to cadmium for consumers of quinoa grain. Impact of different proposed MLs for quinoa grain on the dietary exposure and risk characterization is provided for discussion at CCCF.

29. Mean concentration values reported in Table 1 in quinoa cereals and quinoa cereals-based products from all the available GEMS/Food data are combined with the consumption data of consumers of quinoa grains reported in FAO/WHO CIFOCOSs individual food consumption data. The resulting dietary exposure estimates to cadmium in adult consumers can be estimated at 0.62 µg/kg bw/month in mean and at 1.23 µg/kg bw/month at the P95. For children, the mean consumer can be estimated at 1.85 µg/kg bw/month and at 3.69 µg/kg bw/month at the P95.

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11 Bratovcic A. and Saric E. determination of essential nutrients and cadmium in the white quinoa and amaranth seeds, Croatian journal of food science and technology (2019) 11 (1) 135-139

12 Vollmannova et al risk of cadmium and lead transfer from the soil into seeds of chosen minor plants, environmental protection and natural ressources, (2013) vol 24, No 2(56): 17-20

13 Haseeb M et al, quinoa response to lead: growth and lead partitioning, international journal of agriculture and biology (2018), 20-338-344

14 Asif Naeem et al., Acid treated biochar enhances cadmium tolerance by restricting its uptake and improving physio-chemical sttributes in quinoa (Chenopodium quinoa Willd.), Ecotoxicology and environmental safety 191 (2020) 110218

15 Austria, Belgium, Bolivia, Estonia, Finland, France, Germany, Ireland, Portugal, Spain, Sweden, United Kindom

30. The last JECFA assessment [16] (JECFA73, 2010) established a PTMI of 25 µg/kg bw/month. The total dietary exposure to cadmium is: 2.2-12 µg/kg bw/month (Adults/mean), 6.9-12.1 µg/kg bw/month (Adults/high level). Children 0.5–12 years of age: 3.9-20.6 µg/kg bw/month. Vegetarians: 23.2 µg/kg bw/month

31. The dietary exposure from the consumption of quinoa grains in population groups could represent approximately 5% of the PTMI in mean and up to 15% at the P95.

32. Moreover, the Table 3 shows that enforcing a maximum limit of 0.1 or 0.2 mg/kg for cereal grains quinoa would have little impact on dietary exposure to cadmium for the general population, compared with the current situation with no codex ML while the Table 1 indicates that the proportion of rejected quinoa cereal grains from the world market would be approximately of 3% with an ML of 0.1 mg/kg and 0.5% with an ML of 0.2 mg/kg.

Table 3: Dietary exposure estimates to cadmium from the consumption of quinoa grain in adults and children consumers, risk characterization and impact of different proposed MLs in quinoa cereal grains

CADMIUM: PTMI JECFA73 (25 bw/ month)	**Pop**	**mean consumer of quinoa grain (g/kg bw/d)**	**P95 consumer of quinoa grain (g/kg bw/d)**	**mean consumer exposure (µg/kg bw/m)**	**P95 consumer exposure (µg/kg bw/m)**	**Risk caracterization (in average,% PTMI)**	**Risk caracterization (P95,% PTMI)**
No ML or ML = 0.2 mg/kg	Adult	0.41	0.82	0.62	1.23	2	5
	children	1.23	2.46	1.85	3.69	7	15
ML = 0.1 mg/kg	Adult	0.41	0.82	0.49	0.98	2	4
	children	1.23	2.46	1.48	2.95	6	12

Lead

33. Table 4 presents the estimates of dietary exposure and the risk characterization to lead for consumers of quinoa grains. Impact of different proposed MLs for quinoa cereal grains on the dietary exposure and risk characterization is provided for discussion at CCCF.

34. Mean concentration values reported in Table 2 in quinoa cereals and quinoa cereals-based products from all the available GEMS/Food data are combined with the consumption data of consumers of quinoa grains reported in FAO/WHO CIFOCOss individual food consumption data. The resulting dietary exposure estimates to lead of adult consumers can be estimated at 0.01 µg/kg bw/day in mean and at 0.02 µg/kg bw/day at the P95. For children, the mean consumption can be estimated at 0.02 µg/kg bw/day and at 0.05 µg/kg bw/day at the P95.

35. The last JECFA assessment [17] (JECFA73, 2010) has established a Point of departure (PoD) of 0.6 µg/kg/d for loss of intelligence quotient of 1 IQ point in children and of 1.3 µg/kg bw/d for 1 mmHg increase in blood pressure in adults. The overall dietary exposure to lead was estimated by JECFA to be: Adults: 0.02-3 µg/kg bw/d (mean), 0.06-2.43 µg/kg bw/d (90th to 97.5th percentile). Children: 0.03 to 9 µg/kg bw/d (mean), 0.2 to 8.2 µg/kg bw/d (90th to 97.5th percentile). The dietary exposure from the consumption of quinoa cereal grains could represent at the P95 up to 1% of the PoD in adults and 8% in children.

36. Moreover, the Table 4 shows that enforcing a maximum limit of 0.1 or 0.2 mg/kg for cereal grains quinoa would have little impact on dietary exposure to lead for the general population, compared with the current situation with no codex ML while the Table 2 indicates that the proportion of rejected quinoa cereal grains from the world market would be approximately of 1% with an ML of 0.2 mg/kg and 0% with an ML of 0.3 mg/kg.

16 http://apps.who.int/food-additives-contaminants-jecfa-database/chemical.aspx?chemID=1376

17 http://apps.who.int/food-additives-contaminants-jecfa-database/chemical.aspx?chemID=3511

Table 4: Dietary exposure estimates to lead from the consumption of quinoa grain in adults and children consumers, risk characterization and impact of different proposed MLs in quinoa cereal grains

LEAD: JECFA73 Point of departure: 0.6 µg/kg/d loss of 1 IQ point in children; 1.3 µg/kg bw/d for 1 mmHg increase in blood pressure in adults	**Population**	**mean consumers (g/kg bw/d)**	**P95 consumers (g/kg bw/d)**	**mean consumer exposure (µg/kg bw/d)**	**P95 consumer exposure (µg/kg bw/d)**	**Risk caracterization (in average,% PoD)**	**Risk caracterization (P95,% PoD)**
No ML or ML = 0.2 mg/kg	Adult	0.41	0.82	0.01	0.02	0.6	1.3
	children	1.23	2.46	0.02	0.05	4.1	8.2
ML = 0.1 mg/kg	Adult	0.41	0.82	0.00	0.01	0.3	0.6
	children	1.23	2.46	0.01	0.02	2.1	4.1

CONCLUSIONS – JECFA Secretariat

37. Data on cadmium (n=185) and lead (n=198) in quinoa submitted through GEMS/Food indicate that no significant differences were noted in concentrations levels observed between quinoa cereal grains and quinoa cereal grain-based products.

38. The concentration levels of cadmium in quinoa cereals and quinoa cereals-based products are up to 0.59 mg/kg with a mean content of 0.05 mg/kg. The concentration levels of lead in quinoa cereals and quinoa cereals-based products are up to 0.25 mg/kg with a mean content of 0.02 mg/kg.

39. The limited data retrieved from the literature search indicate that concentration levels of cadmium and lead in quinoa grains are consistent with those observed from the data submitted by Codex members to GEMS/Food.

40. The analysis performed by the JECFA Secretariat indicate that, in term of consumer protection and trade, enforcing a maximum limit of 0.1 or 0.2 mg/kg for cadmium in cereal grains quinoa would have little impact on dietary exposure to cadmium for the general population, compared with the current situation with no Codex ML, while the proportion of rejected quinoa cereal grains would be approximately of 3% with an ML of 0.1 mg/kg and 0.5% with an ML of 0.2 mg/kg.

41. As for lead in quinoa cereal grains, the analysis performed by the JECFA Secretariat indicate that in term of consumer protection and trade, enforcing a maximum limit of 0.1 or 0.2 mg/kg for lead in cereal grains quinoa would have also little impact on dietary exposure to lead for the general population, compared with the current situation with no Codex ML while the proportion of rejected quinoa cereal grains would be approximately of 1% with an ML of 0.2 mg/kg and 0% with an ML of 0.3 mg/kg.

RECOMMENDATIONS

42. Based on the assessment of the JECFA Secretariat, CCCF is invited to consider whether:

    a. There is any need to establish MLs for lead and cadmium in quinoa or

    b. There is enough evidence to either:

        i. extend the MLs for cadmium and lead in cereal grains to quinoa; or

        ii. establish separate MLs for cadmium and lead in quinoa, and if n the affirmative, which MLs proposed by the JECFA Secretariat would be most appropriate;or

    c. Further investigation of the evidence for (i) the extension of the current MLs for cadmium and lead in cereal grains to include quinoa or (ii) the establishment of separate MLs for cadmium and lead in quinoa is required for consideration by CCCF15 (2022)

    d. Any other views in relation to the information and conclusions provided in this paper.